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June 23-26, 2004
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ATDC'04

PREFACE

The integration of Central and East European countries in the European Union is one of the most important processes for the future of Europe. There are many barriers which have to be overcome during this integration; one of them is the big technological gap between West European countries and the developing countries of Middle and East Europe. International scientific, technical and academic cooperation has to be focused on making this situation better. In the framework of the DAAAM International we are supporting these activities by organising annual DAAAM International Conferences on Advanced Technologies for the Developing Countries. The 1st DAAAM International ATDC Conference was organised in 2002 by the Faculty of Mechanical Engineering, Slavonski Brod, Croatia, whereas the 2nd ATDC Conference was held in 2003 at the Faculty of Mechanical Engineering, University of Tuzla, Bosnia and Herzegovina.

Having long term experience of organizing international scientific and academic cooperation DAAAM International Vienna decided to give the organisation of the 3rd DAAAM International Conference on Advanced Technologies for Developing Countries to the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, University of Split, Croatia.

This conference is the third one in an open cycle of conferences which will be in the future organized yearly in the countries of Middle and East Europe. The organizers of conferences will be organized as open permanent network of partner institutions and organisations. At the moment there are several institutions and organisations from different countries which are strongly interested to be a partner in this fascinating project.

The main objective of the Conference is to provide a forum for exchanging knowledge, experience, results and information related to broad aspects of the advanced technologies and manufacturing. The most important aim of this conference is to exchange information, initiate and support the partnership and the cooperation between Western European countries and developing countries of the Middle and East Europe.

The scope of the Conference covers scientific, technological and practical concepts concerning research, development and realisation of contemporary technology and manufacturing, offering a unique opportunity for experts to meet and exchange ideas.

We are inviting all the experts, researchers and practitioners who want to share their knowledge, theoretical or practical experience on advanced technologies and manufacturing to join us.

We are glad to say that our colleagues and friends were very active and met this idea enthusiastically. Their commitment and enthusiasm was one of the main driving forces in the course of organizing this conference. Hereby we wish to thank, on behalf of the Organizing Committee and worldwide DAAAM International community, all the authors, reviewers and members of committees, co-organisers and sponsors for their efforts that made this conference possible and successful.

This conference is dedicated to the memory of our professor Zdenko Kordić who unfortunately passed away this year. He was highly respected for his work. As the president of the University of Mostar (1992-1999) and as the professor at the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split he left an indelible trace. He has been for many years the most distinguished figure in the field of mechanical engineering and his passing will be deeply deplored by his students, his colleagues and by all who knew him.

President of Organising Committee
of ATDC-2004 Conference

Professor, Dr. Ivica Veža
Split, 2004-06-23

President of DAAAM International
Conference Chairman and Founder

Professor Dr. DDr.h.c. Branko Katalinic
Vienna, 2004-06-23

ATDC 2004 Topics

The Conference includes topics from all fields of advanced technology and manufacturing, but on the base of statements given in the abstracts we have decided to refine and revise the set of topics. Topics of interest are included in five conference sections:

A) Product Development
B) Production Technologies and Materials
C) Information Technologies in Production
D) Quality Assurance
E) Production Management

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Product Development

3rd DAAAM International Conference on
Advanced technologies for Developing Countries - ATDC'04
June 23-26, 2004
Split, Croatia

DESIGN OF CENTRIFUGAL TURBOPUMPS BY NUMERICAL ANALYSIS OF ENTIRE FLOWING TRACT

S. Balić and J. Duhovnik

Abstract

Method of calculation and water turbopump design in the automotive engine circulation cooling system is defined in this work. It is based on the CAD technology application for turbopump elements forming and for numerical grid generation, as well as on CFD technology (based on finite volume method) for numerical analyses of the fluid circulation in the elements of these pumps. It is intended for engineering and developing works of calculation and water turbopump design in the automotive engine circulation cooling system, in the phase before examination of the prototypes on the experimental equipments.

In the numerical calculations, exact calculation has been applied for the first time on the automotive turbopumps, with rotation of impeller, using of moving grids. The final calculations are realized on the whole flowing tract model of chosen automotive turbopump.

Method was practically applied and confirmed by results of experiments on chosen models of automotive turbopumps.

Keywords: automotive engine water turbopump, numerical flow simulation, finite volume method, moving grids

1. Introduction

Centrifugal turbopumps, or generally turbomachines, have complex phenomena of flow and interaction between fluid and pump working elements, with a great number of influence factors with different character and number of their mutual dependent influences. In respect to modern possibilities of computer aided design, calculations and simulation (CAD, CFD, FVM, FEM, …) there are constant attempts to define effective procedures by which it would be possible to look at the whole problem of turbo machines design by application of effective methods of virtual analysis, with aim to provide useful solutions as fast and as cheap as possible. Besides that, it is expected from the methods that deviations between obtain results and real states will not excide the level of acceptable error.

Despite the mentioned attempts, it's a common practice to perform CFD (Computational Fluid Dynamics) analysis of fluid flow in the centrifugal pumps and compressors using approximate calculations procedures with unacceptable high level of different approximations and simplifications. It is either procedure to perform the calculation with rotation of coordinate systems (The multiple Rotating Reference Frames (MRF) model) [6], or the calculation is being performed on the model with one internal flow impellers channel (or on one segment of entire flow), with the appropriate addition of impeller's rotational movement parameters [3, 6, 8, 10].

This paper presents that CFD analysis of flow in turbopump can and should be performed in such manner to take into consideration entire flow of fluid trough it, and that it should be done using exact calculation, with rotation of impeller. This procedure gives closest approximation of real state in turbopump. This procedure of calculation, on full model of fluid flow in one turbopump, has special importance in their final design analysis, when, beside getting overview of fluid flow, all work characteristics of turbopump model can be exactly calculated: flow Q, effort H, general effort Δp, efficiency factor η, resulting radial force $\mathbf{F}_r$ and torque M_z on fictive impeller, and also appropriate Q-Δp curves can be constructed.

As an experimental model, based on which virtual models were generated and numerical calculations realized, an automotive turbo pump with an open radial impeller and cylindrical vanes was chosen. The pump is built into motor cooling systems of some types of cargo vehicles from a well-known automotive manufacturer. The meridian section is shown in Figure 1, and a drawing of the impeller from the chosen pump is shown in Figure 2.

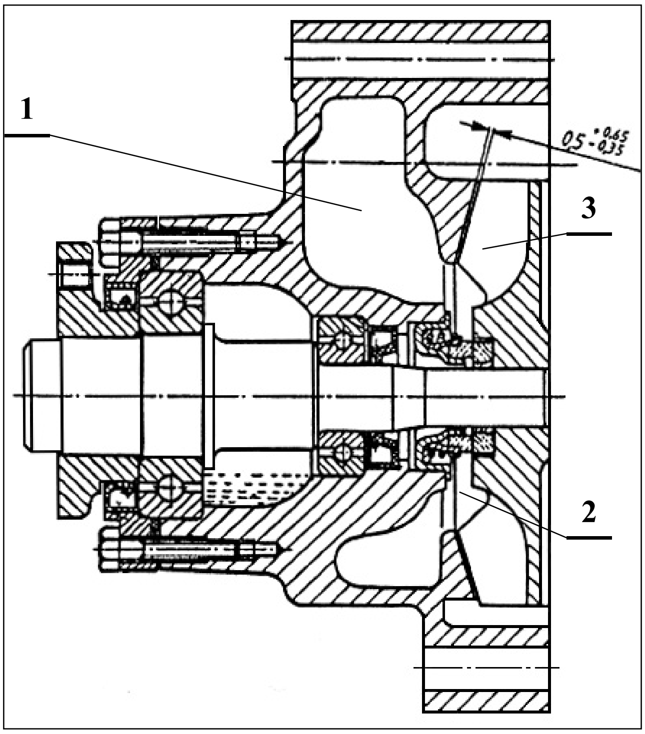


Figure 1. Meridian section of the chosen autonotive turbopump
1. pump collector-feeder, 2. inlet port,

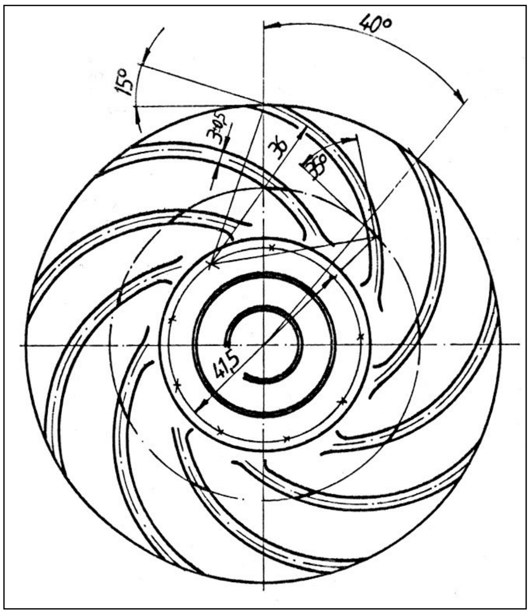


Figure 2. Radial impeller vane shape of the analyzed turbopump (D_{1m} = 55,5 mm, D_2 = 107 mm, β_1 = 36°, β_2 = 15°)

2. Mathematical model and numerical method

In [4] the mathematical model of transport processes that can be simulated with software *Comet* is presented. It includes the mass, momentum and energy balance equations in integral form, a space conservation law, which has to be satisfied if the problem is solved using a moving grid, constitutive relations required for the problem closure, models of turbulence in fluid flow, and boundary conditions.

Elements of the numerical method: diskretization principles, derivation of algebraic equation systems, solution procedure, implementation of boundary conditions are also given in [4].

2.1 Governing equations

The water flow in a turbopump flow passage is considered viscous and turbulent. It is fully described by the time-averaged equations of continuity and momentum conservation, which are accompanied by the turbulence model equations. Equations are given for the control volume CV bounded by (possibly moving) surface S in the integral form similar for all conserved properties. They all contain local and convective rates of change on the left hand and diffusive and source terms on the right hand side [4]. The continuity equation is:

$$\frac{\mathrm{d}}{\mathrm{d}t}\int_V \rho \,\mathrm{d}V + \int_S \rho(\mathbf{v}-\mathbf{v}_s)\cdot \mathrm{d}\mathbf{s} = 0, \tag{1}$$

where ρ is the density of continuum, $\mathbf{v}$ is the fluid velocity, $\mathbf{v}_s$ is the computational grid velocity, and $\mathbf{s}$ is the outward pointing surface vector.

The momentum equation is:

$$\frac{\mathrm{d}}{\mathrm{d}t}\int_V \rho\,\mathbf{v}\,\mathrm{d}V + \int_S \rho\,\mathbf{v}(\mathbf{v}-\mathbf{v}_\mathrm{s})\cdot\mathrm{d}\mathbf{s} = \int_S \mathbf{T}\cdot\mathrm{d}\mathbf{s} + \int_V \mathbf{f}_\mathrm{b}\,\mathrm{d}V, \tag{2}$$

where $\mathbf{T}$ is the Cauchy stress tensor, and $\mathbf{f}_\mathrm{b}$ is the resultant body force per unit volume.

Since turbopump CFD calculations involve moving grid, the equation of space conservation must be solved:

$$\frac{\mathrm{d}}{\mathrm{d}t}\int_V \mathrm{d}V - \int_S \mathbf{v}_s\cdot\mathrm{d}\mathbf{s} = 0. \tag{3}$$

Because the flow in the turbine is turbulent, it is difficult to resolve the equations (1) and (2) on a small time scale. Instead, time averaging of flow variables is used, which replaces the flow variable ϕ by its mean value $\overline{\phi}$ and fluctuation ϕ':

$$\phi(\mathbf{r},t) = \overline{\phi}(\mathbf{r}) + \phi'(\mathbf{r},t). \tag{4}$$

Using such averaged quantities in equation (2) results in *Reynolds-averaged Navier-Stokes* (RANS) equations:

$$\frac{\mathrm{d}}{\mathrm{d}t}\int_V \rho\,\mathbf{v}\,\mathrm{d}V + \int_S \rho\,\mathbf{v}(\mathbf{v}-\mathbf{v}_s)\cdot\mathrm{d}\mathbf{s} = \int_S (\mathbf{T} - \rho\overline{\mathbf{v}'\mathbf{v}'})\cdot\mathrm{d}\mathbf{s} + \int_V \mathbf{f}_b\,\mathrm{d}V. \tag{5}$$

The RANS equations contain term $\overline{\rho\mathbf{v}'\mathbf{v}'}$, known as *Reynolds stresses*. This term needs special treatment, since it may not be expressed in terms of basic flow variables. It may be calculated by using a turbulence model, which relays on adequate engineering assumptions. The standard k-ε model [4] was used in our case, which is well known and tested, and widely used in engineering practice. It introduces two additional partial differential equations, which close the system of RANS equations [4]:

$$\frac{\mathrm{d}}{\mathrm{d}t}\int_V \rho k\,\mathrm{d}V + \int_S \rho k(\mathbf{v}-\mathbf{v}_s)\cdot\mathrm{d}\mathbf{s} = \int_S (\mu + \frac{\mu_t}{\sigma_k})\,\mathrm{grad}\,k\cdot\mathrm{d}\mathbf{s} + \int_V (P + P_B - \rho\varepsilon)\,\mathrm{d}V\ , \tag{6}$$

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}t}\int_V \rho\varepsilon\,\mathrm{d}V + \int_S \rho\varepsilon(\mathbf{v}-\mathbf{v}_s)\cdot\mathrm{d}\mathbf{s} = \int_S (\mu + \frac{\mu_t}{\sigma_\varepsilon})\,\mathrm{grad}\,\varepsilon\cdot\mathrm{d}\mathbf{s} +\\ + \int_V \left(\mathrm{C}_1 P\frac{\varepsilon}{k} - \mathrm{C}_2\rho\frac{\varepsilon^2}{k} - \mathrm{C}_3\rho\varepsilon\,\mathrm{div}\,\mathbf{v}\right)\mathrm{d}V,\end{aligned} \tag{7}$$

where k is the kinetic energy of turbulence, ε is its dissipation rate and μ_t is the turbulent diffusivity. The production of turbulent kinetic energy by shear P is modeled as:

$$P = 2\mu_t\dot{\mathbf{D}}:\dot{\mathbf{D}} - \frac{2}{3}(\mu_t\mathrm{div}\,\mathbf{v} + \rho k)\,\mathrm{div}\,\mathbf{v}\ . \tag{8}$$

The quantities: C_1, C_2, C_3, σ_k and σ_ε are empirical coefficients.

2.2 Boundary conditions

In the present study, the given equations are solved for a special case of flow in full model of the automotive turbopump's entire flowing tract.

The pump flow passage calculation domain is bounded mainly by walls, where no-slip boundary condition was applied. The fluid velocity in the vicinity of the wall was approximated by using wall function [4], which assume logarithmic region in the velocity profile. Some of the walls (contact surfaces of impeller and fluid – boundary regions [4]) move during the transient flow, with noted velocity.

Model pump's inlet is the passage 2 shown in Figure 3, and the model's outlet is the spiral's passage 3 shown in Figure 7. At the inlet and at the outlet the total and static pressure were prescribed, respectively.

3. Model of turbopump's entire flowing tract

In the design of turbopumps models certain prerequisites, mainly resulting from the character of applied numerical method, have to be met. One of the main prerequisites is that common geometric base (based on the results from conventional calculations and preliminary design) has to be defined from the moment of the start of modeling, so that later, during the creation of numerical model, all the parts of an analyzed domain could be linked together. Based on the obtained geometrical base, it is necessary that all the activity of creating the geometric models and their division into sections and segments are coordinated and simultaneous for all the parts of the turbopump, i.e. the analyzed domain.

One of the automotive turbopumps specifics is the existence of the two inlet ports. Through the first, during the period of normal operation of a warm motor, cooled water from a radiator is drawn, while the other is operational during the period of the motor heating, when water with the temperature lower than the working is directed around the radiator directly into the pump. There are two turbopumps solution variants in use that provide the two inlet ports. In the first variant (used in the analyzed pump), a fan is mounted on the pump shaft (in line: radiator-fan-pump-motor block), preventing the possibility of water flow in direction of the impeller axis. Because of that the function of feeding the pump with water from two sources is realized by incorporation of additional space in front of the impeller in the pump housing. The space is surrounding the pump shaft, and the two inlet ports are added from the lateral sides (the part 1 in Figure 1). Model of the additional space, called a *collector-feeder* in internal terminology, with the two inlet ports clearly noticeable, is shown in Figure 3.

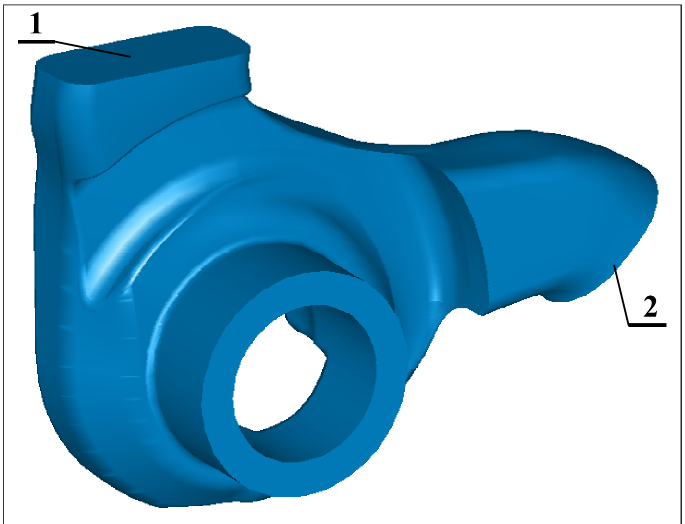


Figure 3. Collector-feeder model with two inlet ports
1) inlet from a radiator, 2) inlet from a motor

In a realization of 3D numerical analysis exact calculation procedure is used with rotations of the impeller. In this procedure it is necessary to form sliding interfaces between the water in the entrance in the impeller and in the spiral, and the water in internal flow impeller channels which rotates together with the impeller. In addition, contact areas creating the sliding interface (flat, cylindrical, or conical) in the numerical model, have to be the same, i.e. they have to be aligned, and no gaps on them are allowed. In brief, one region cannot form sliding interface with two ore more regions [4].

Inlet and outlet vane edges of radial impellers can be differently shaped (Figure 4). For impellers with a chamfered inlet edge vane and an outlet vane ending sharply in one point (as in Figure 4a), the sliding interfaces can be easily created accordingly to the mentioned condition. However, for the impellers with vanes with the certain width on the inlet and the outlet circumference (as in Figure 4b) additional rings need to be created, rotating together with the impeller, in order to form the sliding interfaces. In such way, in the model of the analyzed pump, a thin conical ring was cut off from the 3D model (Figure 5) of the water in the impeller inlet. The ring is through the arbitrary interface connected to the water model of the internal flow impeller channels (Figure 6) and rotates with it at the same angular velocity. The inside conical area of the ring makes the sliding interface with the adjacent area of the remaining part of the water in the impeller inlet.

The second sliding interface is formed on the outlet impeller circumference, where the water from the internal impeller tracts enters into the spiral. Ring is formed in this spot with thickness equal to the clearance between the impeller and the spiral, rotating (with the speed of the impeller) together with the water in the internal impeller's tracts. The external area of the ring makes a sliding interface with the spiral area it contacts. In the analyzed automotive turbopump, the ring was formed using internal flow impeller channels. One segment of the ring is shown in Figure 6. External diameter of the ring in this case is equal to the impeller external diameter D_2.

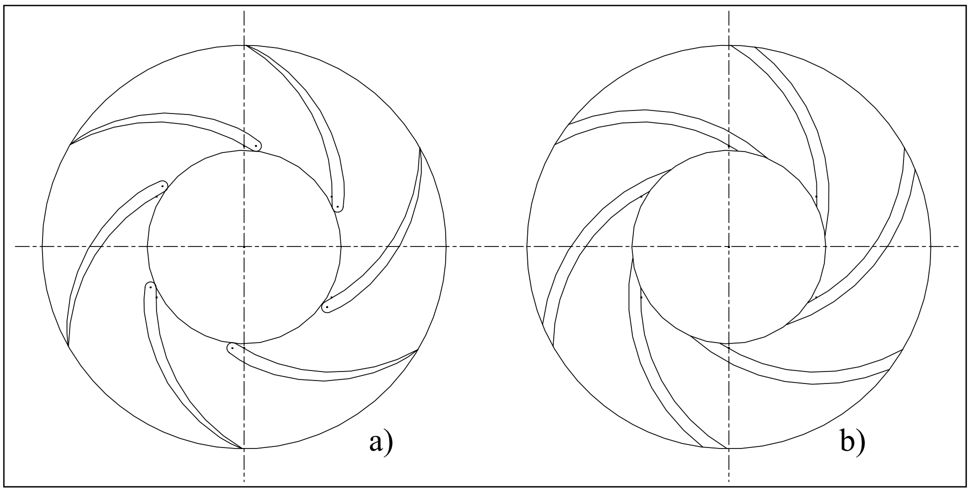
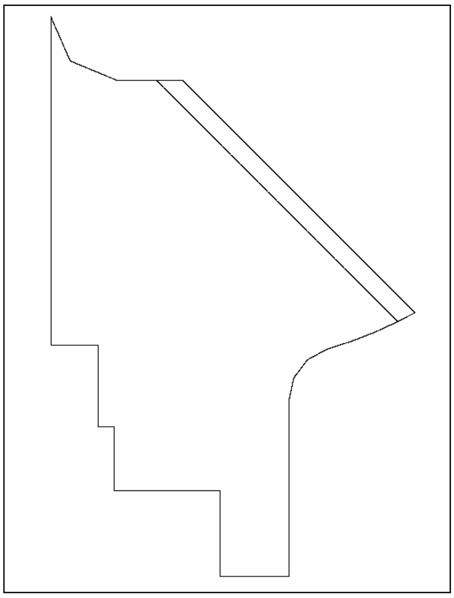


Figure 4. Radial impeller of centrifugal turbopump
a) with chamfered (on inlet) and sharp edges (on outlet),
b) with certain vane width on impeller inlet and outlet



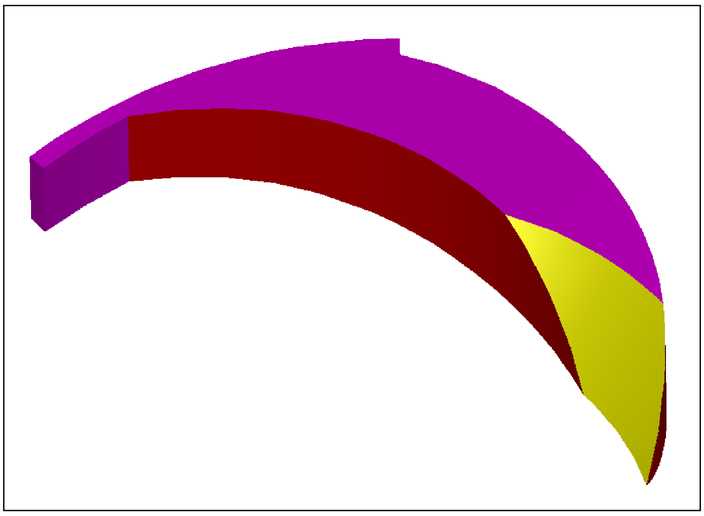


Figure 6. Modified model of internal flow impeller channel, for analysis with rotation of fictive impeller

Figure 5. Forming of conical ring on impeller inlet model, in order to provide sliding interface

4. Grid generation and grid motion

Because of complex geometry of flow parts models trough turbopump, and need for creation of interface between rotating and non-rotating parts of fluid, the specific type of grid generation mentioned models was used. The grid of the analyzed automotive model's entire flowing tract, for the analyses with rotation of the fictive impeller, is shown in Figure 7.

Numerical grid is created using hexahedron control volumes (CVs), and locally using prism CVs.

The connection between rotating impeller flowing tracts and fixed parts of pump flowing tract is realized by two sliding interfaces. The first, representing the connection between inlet part of the flowing tract and the rotating impellers flowing tracts, is shown in Figure 8 with a separated rotating ring. The second sliding interface, connecting the impeller flowing tracts and the spiral, realized by an additional ring on the impeller outlet is shown in Figure 9.

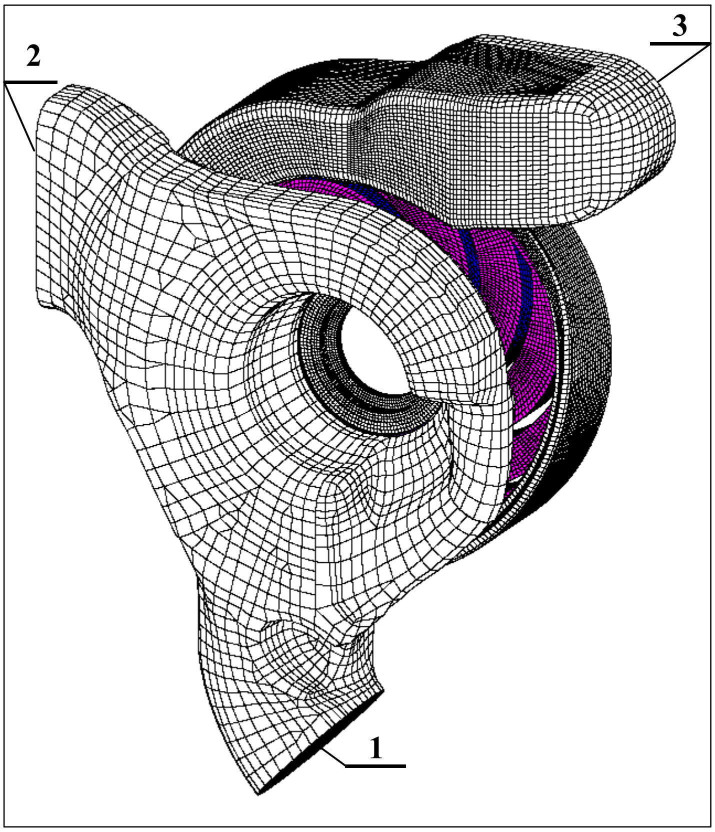


Figure 7. The mesh of analysed automotive turbopump model's entire flowing tract
1) motor inlet, 2) radiator inlet, 3) pump outlet

When the flowing tract grid of the analyzed pump was generated, arbitrary interface [4] was applied in several cases. Higher quality was obtained by it, as in case of the spiral, and in the certain parts of the domain that was the only way to generate H-type grid.

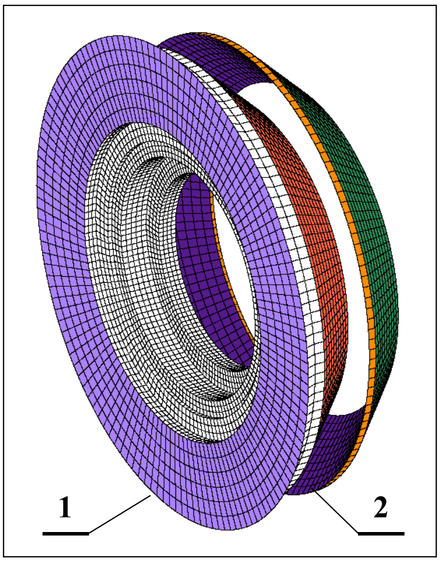


Figure 8. Grids of two impeller inlet subvolumes
1) fixed part, 2) rotating ring

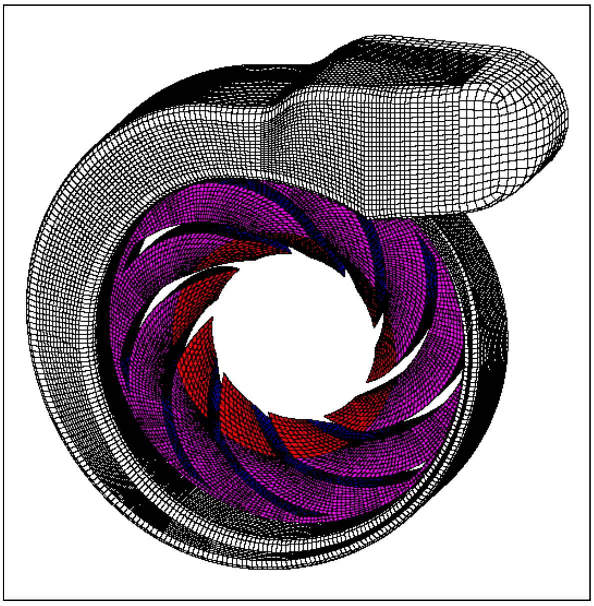


Figure 9. Internal flow impeller channel (with rotating ring) and spiral grid of analysed model

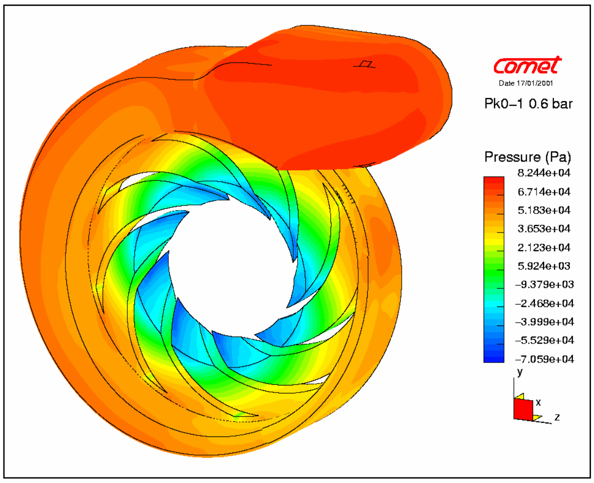
5. Results and discussion

5.1 3D-calculation of fluid flow

For realization of CFD analysis, the exact transient calculation procedure was used, with turbopump's impeller rotation, based on finite-volume numerical method, using moving grids with cells of arbitrary topology [5, 9]. The calculation was performed with ten iterations per step because after the tenth iteration satisfactory accuracy was achieved, close to assigned. Flow with settled changes of monitored values was achieved after 2 to 5 revolutions.

Results of performed transient analysis with impeller rotation, on entire flow tract of centrifugal turbopump, show that it's possible to get simulations of working fluid's flow in all parts of working elements of these pumps, with all details needed in such analysis, and with precision of simulation's results will not deviate more than ± 5 % from real condition.

Based on numerical calculation results it's possible to obtain a presentation of fluid flow's pressure and velocity (as well as relative velocity) distribution, values of all relevant parameters (flow Q, effort H, general effort Δp, efficiency factor η, resulting radial force $\mathbf{F}_r$ and torque M_z on fictive impeller), and Q-Δp diagrams. The Q-Δp diagrams can be used to obtain data about realized pumps design efficiency, as well for making decisions about possible needed redesign of pump parts. Distribution of pressure and velocity in one model's part of analyzed automotive turbopump's entire flowing tract are shown in Figure 10.



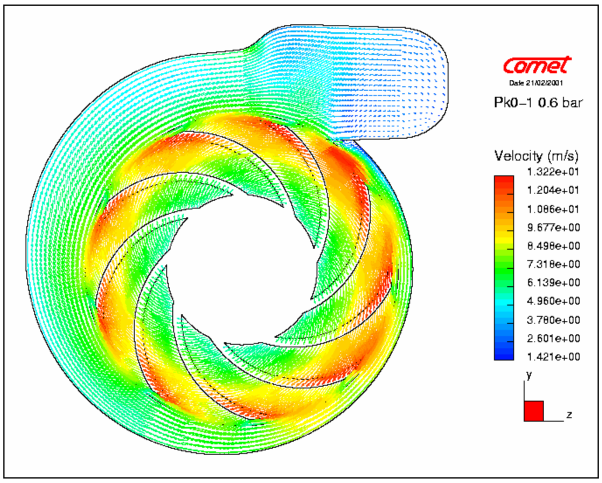


Figure 10. Distribution of pressure and velocity in one model's part of analyzed automotive turbopump's entire flowing tract
a) distribution of pressure *p*, b) distribution of velocity *v*

5.2 Comparison of the numerical and experimental results

To confirm results of numerical analysis in practice, the results of performed experimental tests on experimental assembly have been used. Comparative Q-Δp curves of analyzed turbopump and its numerical model have been constructed (Figure 11), and they show satisfactory level of accordance. Curve a) was obtained by experiment results (for experiment at n = 3000 min^{-1}).

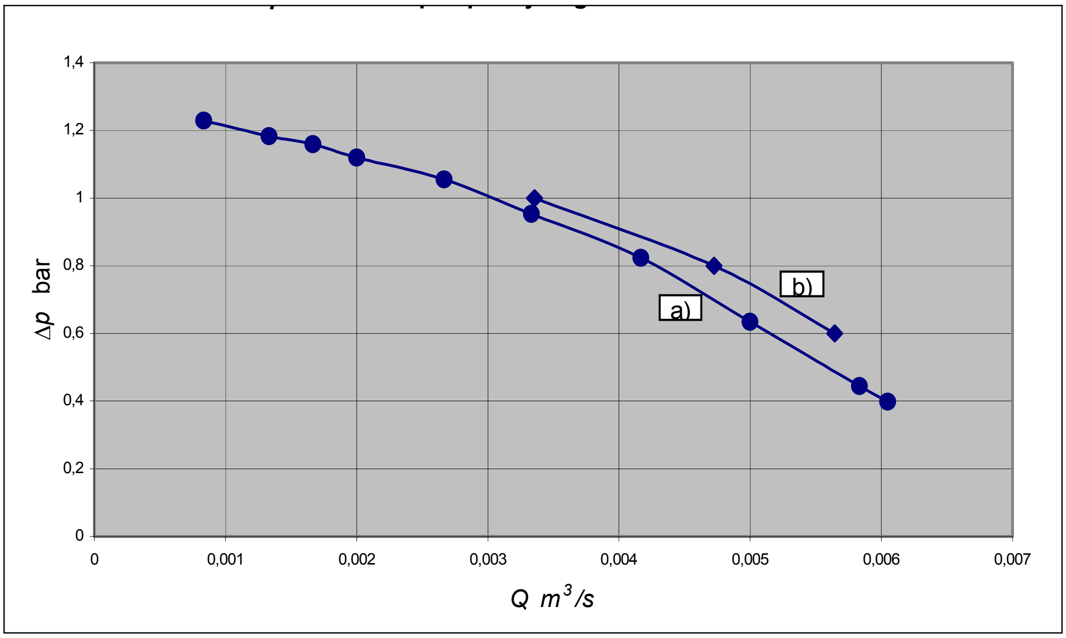


Figure 11. Q-Δp curves of the analyzed automotive turbopump at n = 3000 min^{-1}
a) based on the experiment results,
b) based on results from the numerical calculations

Average values from numerous measurements on the same pump were used. Curve b) is result of numerical calculations, carried out on the analyzed pump model, using exact calculation procedure with fictive impeller rotation, at the same angular velocity. The values obtained by numerical models are around 10% larger that the experimental one for the same general effort levels Δp. A cause of this is that losses on connection nipples were not taken into account. When these losses are included, the mentioned difference comes to about 5%.

6. Conclusion

Using CFD analysis in flow calculation of entire flowing tract of centrifugal turbopumps, in a manner suggested in this paper, can be successfully included in their calculation procedure and design, because they enable flow simulations of high degree of coincidence with real condition.

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THE INFLUENCE OF THE GEARS GEOMETRY ON VALUE OF THE FORCE ACTING ON TOOTH OF HCR GEARS

R. Basan, B. Križan and M. Franulović

Abstract

High transverse contact ratio gears (abbr. HCR gears) are non-standard spur gears with a transverse contact ratio $2<\varepsilon_\alpha<3$. This paper deals with the influence of various geometrical parameters such as pressure angle, tooth height, teeth number, transmission ratio, addendum modification coefficients sum and its distribution on the value of force acting on teeth pair in the relevant contact point. The influence of these parameters on mentioned force calculated according to the theoretical load distribution was determined. The analysis resulted with diagrams and analytical expressions which quantify the dependence of the relevant tooth force on the geometry of HCR gears.

Keywords: gears, high contact ratio, theoretical load distribution

1. Introduction

High transverse contact ratio (HCR) gears are non-standard involutes gears with a value of transverse contact ratio ε_α between 2 and 3. This is achieved mainly by decreasing the value of normal pressure angle α_n and/or increasing the tooth height h. Most important feature of these gears is that they have double and triple teeth pairs contact alternatively during the mesh. On the other hand, during the mesh of low contact ratio gears (abbr. LCR gears), one and two teeth pairs are alternatively engaged, and consequently, loaded more heavily. Because of this, HCR gears have higher load capability and enable more uniform torque transmission than LCR gears which grants them increased use in vehicles and in other industrial applications. In comparison with LCR gears, HCR gears have following drawbacks: worse tribological characteristics, diminished scoring resistance and higher required accuracy during manufacture. However, all of these nominal drawbacks can be either neutralized or minimized so advantages of HCR gears over LCR gears remain significant and their increased use justified.

2. Load distribution on teeth pairs in mesh

Tooth load changes during the mesh of corresponding teeth pair. This tooth load i.e. force acting on the tooth during the mesh has different values along the path of contact. A change of the tooth load can be described with various load distributions on teeth pair in mesh. According to the hypothetical load distribution – represented with dashed line in diagram in Fig. 1, it is assumed that every tooth of accurately machined and absolutely rigid HCR gear pair is loaded only with 1/2 and 1/3 of total normal force F_{bt} alternatively. This approach is much simplified and generally inadequate for gearing analysis.

Real gear and its teeth are not absolutely rigid but somewhat elastic and when more accurate calculations are required this fact can not be neglected. This is taken into account in theoretical load distribution where determination of the tooth load is then based on tooth real elastic deformations δ, corresponding tooth stiffness's *c'* and their change during the mesh.

On diagram in Fig. 1 load shares F_{bti} of total tooth normal force F_{bt} along the path of contact calculated according to the theoretical load distribution are represented with a continuous line.

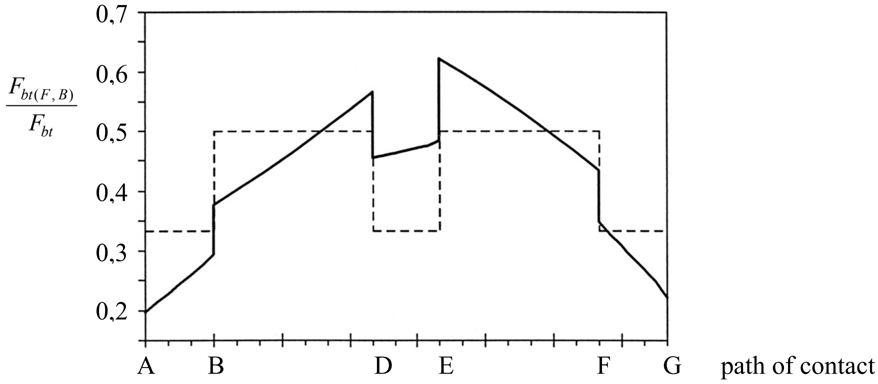

Figure 1. Example of load distributions on path of contact of HCR gear:
– – – - hypothetical load distribution, ——— - theoretical load distribution

The information on the value of tooth load is necessary in order to calculate levels of tooth root stresses of contacting teeth pairs. Various methods are developed to determine mentioned stresses and they also use different values of force which is acting on tooth during the mesh. Widely used procedures for calculation of tooth root stresses are defined in corresponding standards [3] and [4]. In them, following expression for the calculation of tooth root stresses in pinion and wheel of HCR-gear pair is used:

$$\sigma_{F01,2} = \frac{F_t}{b \cdot m_n} \cdot Y_{FS(D,E)} \tag{1}$$

where F_t is the total tangential force and $Y_{FS(D,E)}$ denotes the value of the tip factor calculated for teeth contact in point D for the pinion and E for the wheel.

The analysis given in [5] has revealed that levels of stress in tooth root of HCR gears calculated according to (1) are significantly higher than actual ones. So a modification was suggested in the form of following expression:

$$\sigma_{F01,2} = \frac{0{,}5F_t}{b \cdot m_n} \cdot Y_{FS(F,B)} \tag{2}$$

where F_t is the total tangential force and $Y_{FS(F,B)}$ denotes maximum value of tip factor calculated for teeth contact in point F for the pinion and B for the wheel [1].

3. Influence of HCR gears geometry on force acting on tooth in mesh

In expression (2), 1/2 of total tangential force is used as a fixed value for calculations of tooth root stresses regardless of gears geometry. In diagrams of theoretical load distribution for different HCR gears it can be seen that the load in contact points F and B on pinion and wheel respectively, is not equal to $0{,}5F_t$ as suggested in expression (2). Although expression (2) gives more accurate results than expression (1), further improvements in accuracy of analytical determination of tooth root stresses in HCR gears are possible. The analysis of large number of HCR gears was performed in order to determine influence of gears geometry on relevant force acting on tooth in mesh. According to [5], forces acting on tooth flanks in meshing points F for pinion and B for wheel were analyzed. Using own software solution, values of following geometrical parameters were varied within listed limits in order to determine their influence on relevant tooth force value $F_{bt(F,B)}$:

normal pressure angle	α_n = 16°...<u>18°</u>...24°	bottom clearance factor	c^*_1 = 0,1...<u>0,2</u>...0,4
tooth addendum factor	h_{a0}^* = 1...<u>1,6</u>...1,8	bottom clearance factor	c^*_2 = 0,1...<u>0,2</u>...0,4
pinion teeth number	z_1 = 25...<u>30</u>...45	add. modification coeff.	x_1 =0...<u>0,4</u>...1
transmission ratio	u = 1...<u>4</u>...8	add. modification coeff. sum	Σx =0...<u>1,0</u>...1,5
normal module	m_n = 1...<u>5</u>...20		

While the value of certain parameter was changed throughout respective range, the values of other parameters were kept constant and equal to underlined values. Only resulting gearings with transverse contact ratio ε_α>2 were considered. Altogether, values of tangential force share F_{bti} acting on meshing points F and B along path of contact for pinion and wheel were calculated for 320 HCR gear pairs. Using this data, diagrams which describe influence of geometrical parameters on value $F_{bt(F,B)}/F_{bt}$ were then created and shown on Fig. 2 to Fig. 10.

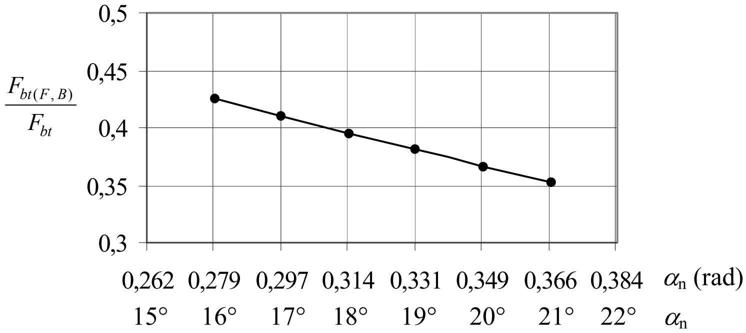

Figure 2. Influence of normal pressure angle α_n on load share acting on point F on pinion i.e. point B on wheel along the path of contact

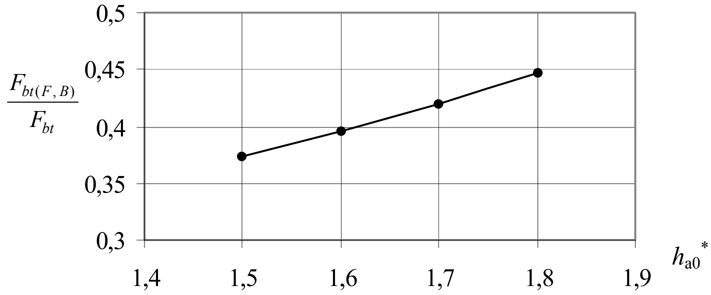

Figure 3. Influence of tooth addendum factor h_{a0}^* on load share acting on point F on pinion i.e. point B on wheel along the path of contact

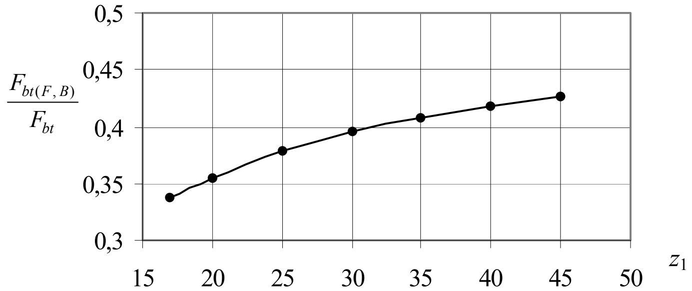

Figure 4. Influence of pinion teeth number z_1 on load share acting on point F on pinion i.e. point B on wheel along the path of contact

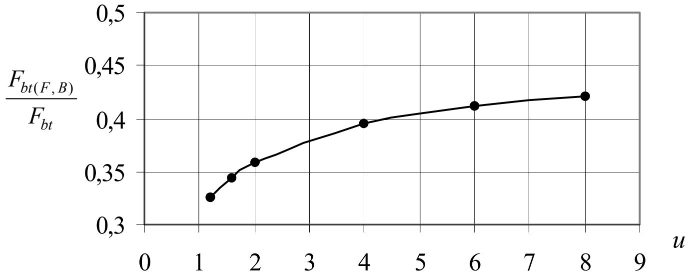

Figure 5. Influence of transmission ratio *u* on load share acting on point F on pinion i.e. point B on wheel along the path of contact

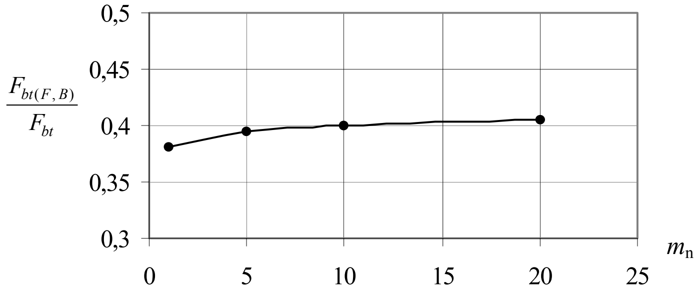

Figure 6. Influence of normal module m_n on load share acting on point F on pinion i.e. point B on wheel along the path of contact

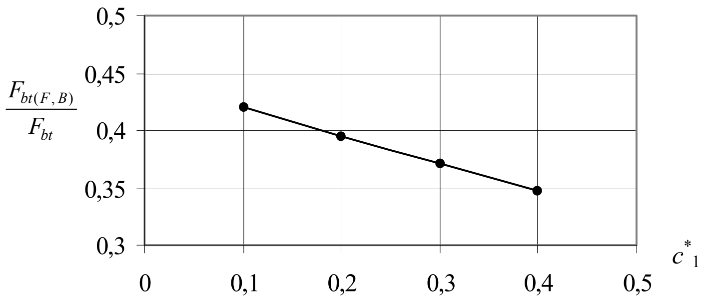

Figure 7. Influence of bottom clearance factor c^*_1 on load share acting on point F on pinion i.e. point B on wheel along the path of contact

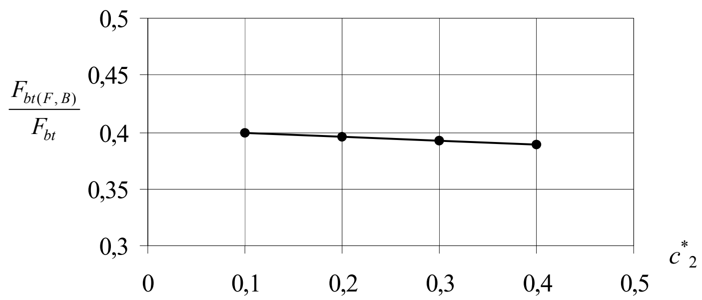

Figure 8. Influence of bottom clearance factor c^*_2 on load share acting on point F on pinion i.e. point B on wheel along the path of contact

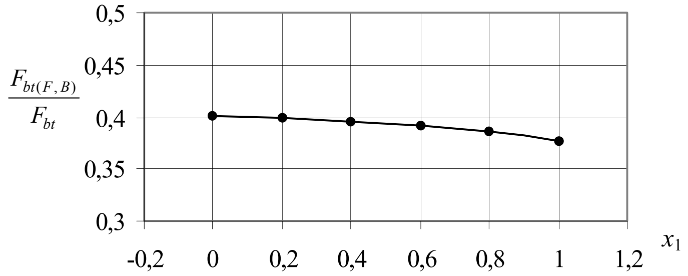

Figure 9. Influence of addendum modification coefficient x_1 on load share acting on point F on pinion i.e. point B on wheel along the path of contact

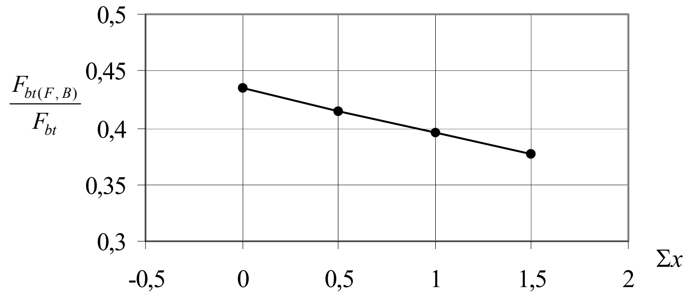

Figure 10. Influence of add. modification coefficient sum Σx on load share acting on point F on pinion i.e. point B on wheel along the path of contact

4. Analytical expressions for calculation of force acting on tooth

Further analysis of calculated data and diagrams confirmed that every geometrical parameter influences the load share $F_{bt(F,B)}/F_{bt}$ independently from other parameters. Thus, precise influence of every parameter was quantified in the practical form of respective auxiliary factor. These factors present basis for analytical calculation of tangential force $F_{t(F,B)}$ acting on meshing points F and B on tooth flanks of pinion and wheel respectively:

$$F_{t(F,B)} = 0{,}5\, F_t\, C_{\alpha_n} C_{h_{a0}} C_{z_1} C_u C_{m_n} C_{c_1} C_{c_1} C_{\Sigma x} C_{x_1} \quad (3)$$

where F_t is the total tangential force and

$$C_{\alpha_n} = -1{,}645\alpha_n + 1{,}308 \quad (4)$$

$$C_{h_{a0}} = 0{,}354(h^*_{a0})^2 - 0{,}54h^*_{a0} + 0{,}957 \quad (5)$$

$$C_{z_1} = -0{,}0002(z_1)^2 + 0{,}0202z_1 + 0{,}573 \quad (5)$$

$$C_u = 0{,}1278\ln(u) + 0{,}812 \quad (6)$$

$$C_{m_n} = 0{,}977m_n^{0{,}0206} \quad (7)$$

$$C_{c_1} = -0{,}6038\,c_1 + 1{,}1242 \quad (8)$$

$$C_{c_2} = -0{,}0827c_2 + 1{,}0156 \quad (9)$$

$$C_{\Sigma x} = -0{,}1\Sigma x + 1{,}1 \quad (10)$$

$$C_{x_1} = -0{,}051x_1^2 - 0{,}007x_1 + 1{,}0124 \quad (11)$$

are auxiliary factors for respective geometrical parameters.

Accuracy of expressions (3) to (11) was tested and verified on additional 120 different HCR gear pairs. In some examples, calculated values of tangential force $F_{t(F,B)}$ were less than $0,4F_t$ which is a difference and accuracy improvement of more than 20% in comparison to the fixed value $0,5F_t$ used in expression (2) given in [5].

5. Conclusion

The actual load distribution along the path of contact of HCR gears and its calculation is complex task so standards and various guidelines for load and tooth root stress calculations tend to simplify it. These approximations introduce errors into calculations, which, although being beneficial regarding safety, should be minimized. In this paper, analytical expressions for calculation of tangential force $F_{t(F,B)}$ acting on meshing points F and B on tooth flanks of pinion and wheel, respectively, are provided. Since they are based on theoretical load distribution, dependence of relevant tangential force $F_{t(F,B)}$ on HCR spur gears geometry is accurately defined. These expressions present a simple and adequate method for an analytical calculation of relevant tooth force in HCR spur gears and offer significantly better accuracy than standard procedures when used for an analytical determination of tooth root stresses.

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"CROCKA" GRID STRUCTURES – NEW APPLICATIONS

B. Čalić

Abstract

Based on Space Joint Patent Application several space joint types were developed and implemented in various grid structures.

Application of bigger cube space joint type was realized in different fields. In this paper newest grid structures applications are described: Large TV Suspension Bridge; Large Tie Node Grid Structure and Tie Node Grid Structures Support Structure.

Keywords: grid structures, space joint, "CROCKA" building system, suspension bridge, node, rod

1. Introduction

Basically an asymmetrically space joint was registered, developed and implemented in various fields, [1], [2]. Requirements for bigger as well as stronger grid structures results in new space joint solutions. These requirements are solving with symmetrical space joint body obtained by mirroring procedure. New dismantling joint types enable higher grid structures loads support.

2. Space joint body solutions

The basic space joint body is of cubical shape with up to 12 guiding cylindrical holes. Space joint body represents the main part (bearing part) of the grid node fastening structure. Holes within space joint body enables placing of the fastening means (screws, bolts). There are several space joint body geometry solutions.

First space joint body solution (80 mm) is realized with eight (8) 35 mm polyamide asymmetrical cubes (four left-handed cubes and four right-handed cubes) are used to keep twelve (12) stainless steel screws guiding tubes (Φ14 x 2 mm), Fig. 1.

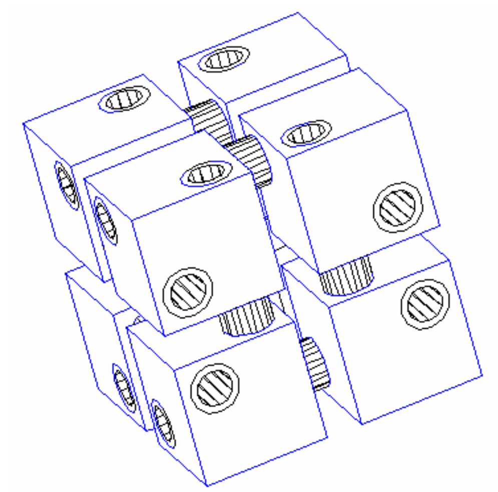

Figure 1. Space joint body - Hybrid type

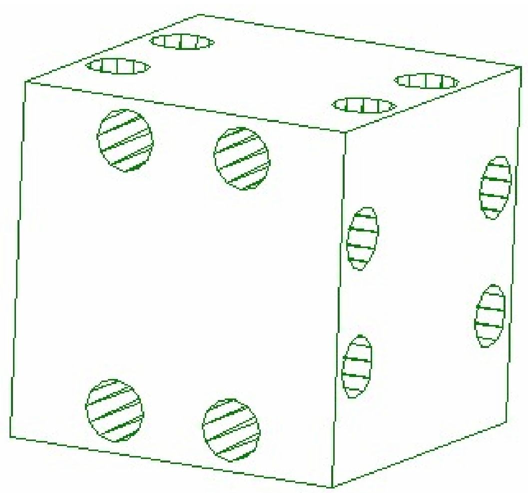

Figure 2. Space joint body – Standard type

Space joint body often used is shown on Fig. 2. There are 12 holes of the same diameter as the steel tubes inner diameter shown on the Fig. 1. Distance between holes axis are the same as on Fig. 1.

Fig. 3 shows space joint body with all guiding holes opened by side. This type of space joint body is very useful for light grid structures where structure is not exposed to bigger loads.

The space joint shown on the Fig. 4 is similar to that shown on the Fig. 3 but with just half of guiding holes opened by side.

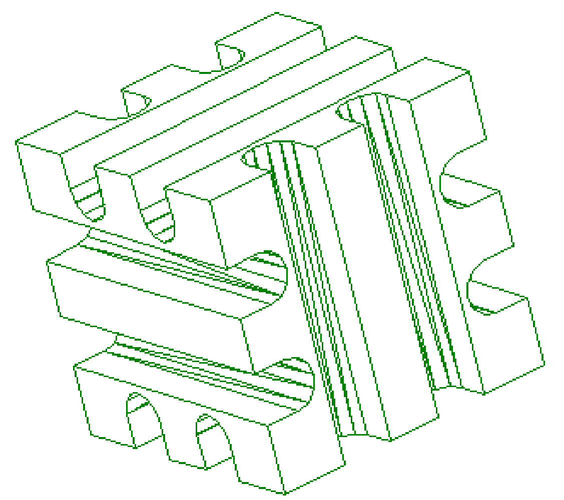

Figure 3. Space joint body – All holes opened

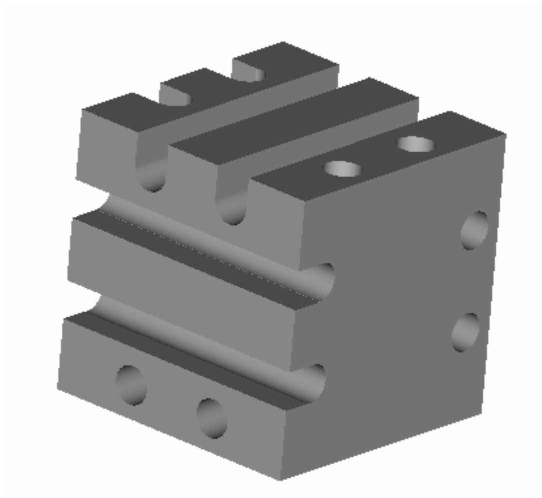

Figure 4. Space joint body - Half holes opened

On the Fig. 5 the standard space joint solution is shown. This joint enables fastening of up to 6 rods in the grid structure nodes. Fig. 5 shows joint which consists of: space joint bearing body, 3 flanged tubes, 3 blend flanges, and 12 fastening screws.

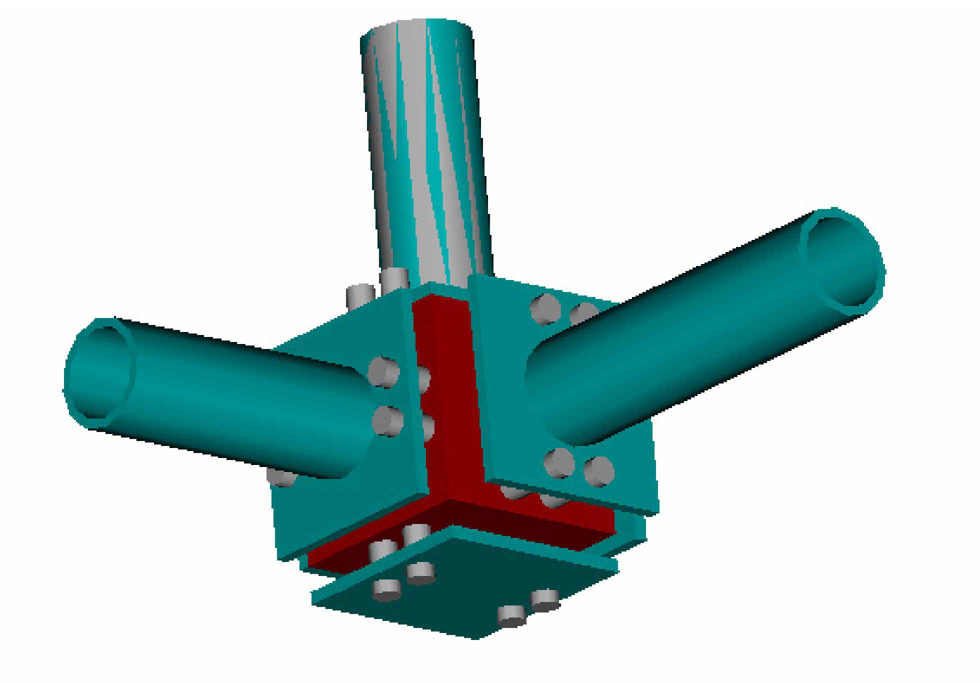

Figure 5. Space joint – Node structure solution

3. 2-D and 3-D modulus examples

In this paragraph a typical 2-D and 3-D linear modules are shown.

2-D linear modulus consist of: 4 cubes with corresponding blind flanges, screws and nuts; 2 longitudinal flanged tube rods; 2 transverse flanged tube rods; 4 inclined tube rods.

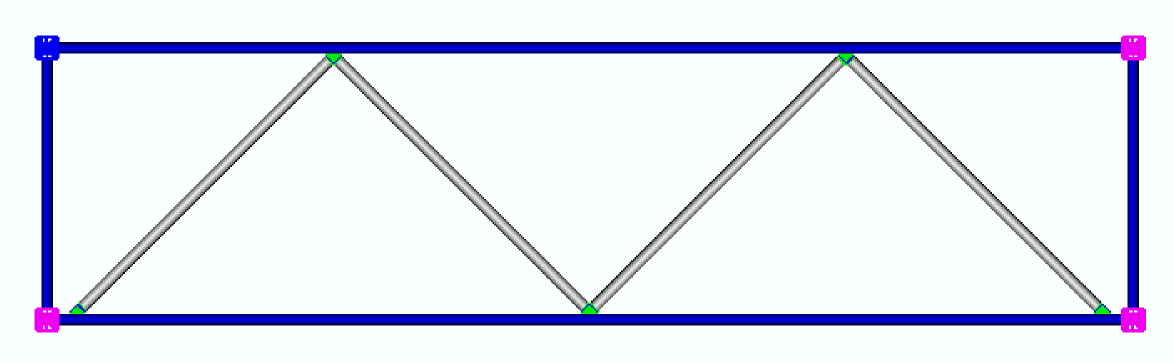

Figure 6. 2-D grid structure modulus

3-D linear 4 m modulus are formed from 2 2-D linear modulus with welded inclined tubes, 2 additional transverse rods and corresponding additional inclined rods with flanges by ends. Mounting procedure is as follows: 2-D linear modules with welded inclined rods are connected with additional 4 transfers flanged rods; 8 inclined flanged rods are connected to longitudinal flanged rods.

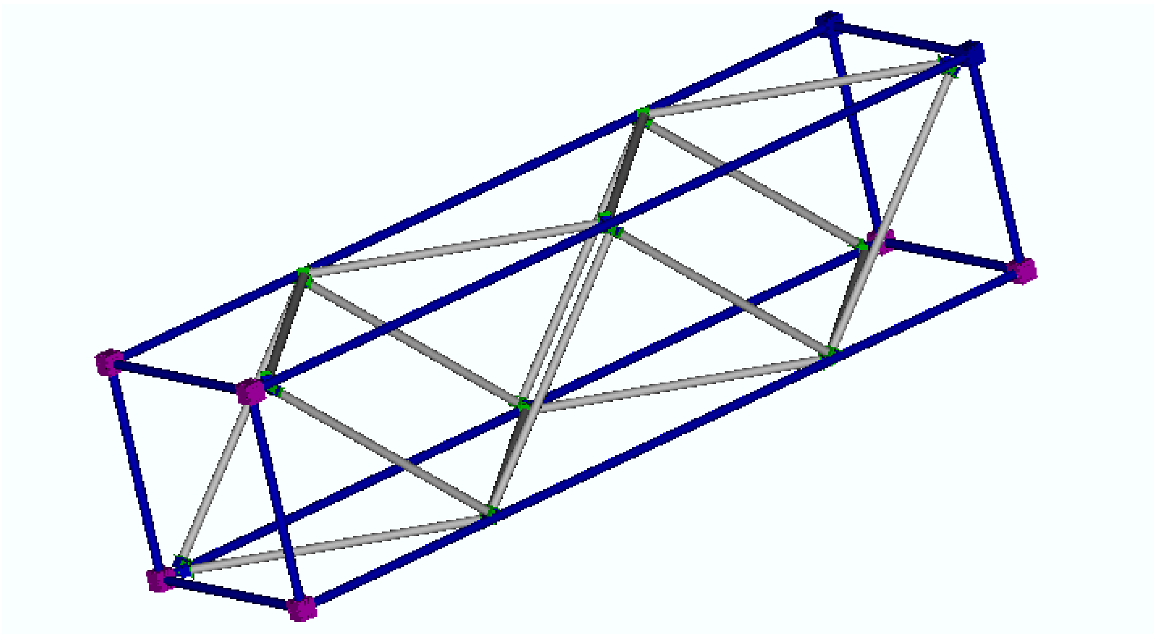

Figure 7. 3-D 4 m linear modulus

4. New grid structures applications

New grid structures shown in this article are based on the 2-D, and 3-D grid structures modules, and in some cases additional flanged rods, as well as additional space joint components. A first grid structure shows the stage support structures. Second grid structure application relates to light grid support structure that could be used in various fields, Fig. 8. Third example of new grid structure application, Fig. 9, shows 18 m high TV suspension bridge realized in Kraljevica, June-September 2003. All grid structures used in Kraljevica were used in the world largest tie - “Tie around Arena” realized in October 2003.

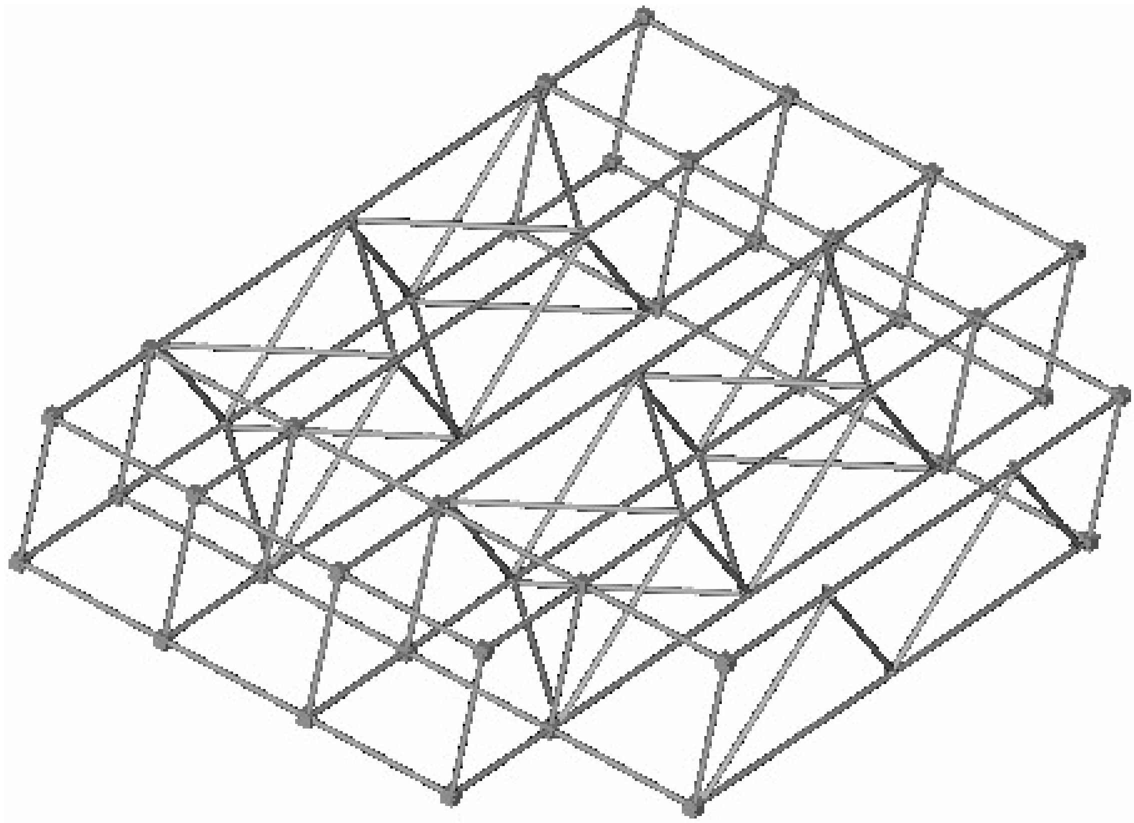

Figure 8. Stage support grid structure

An example of stage support structure is shown, Fig. 8. All grid structure segments are of standard dimensions (space joint body-cube, screws and nuts, flanged rods). In case of non-standard stage heights, is required, support grid structure has to be redesigned. Redesign could include, if necessary, corrections flanged rods dimensions, as well as space joint body length corrections. In some cases the screw material and diameter has to be corrected to.

An example of store building support grid structure is shown on Fig. 9.

Suspension TV bridge realized last year in Kraljevica, Croatia, is shown on Fig. 10. Whole bridge main and auxiliary parts were constructed from "CROCKA" 2-D and 3-D components. Bridge main dimensions were: suspension bridge span was 24 m, bridge supports was 18 m in hight. Both suspension bridge and TV lights support structures was ensured by means of concrete blocks and by means of steel ropes.

All grid structures used in Kraljevica was moved to Pula in October 2003. In Pula very large grid structures were prepared. Tie node support grid structure was 18 m and 10 m wide. Tie node was of very large dimensions: 16.5 m x 15 m x 3.5 m. On www.academia-cravatica.hr the world biggest tie – Tie around Arena is shown.

On the base of realized grid structures, Fig. 8-10, various similar grid structures could be designed.

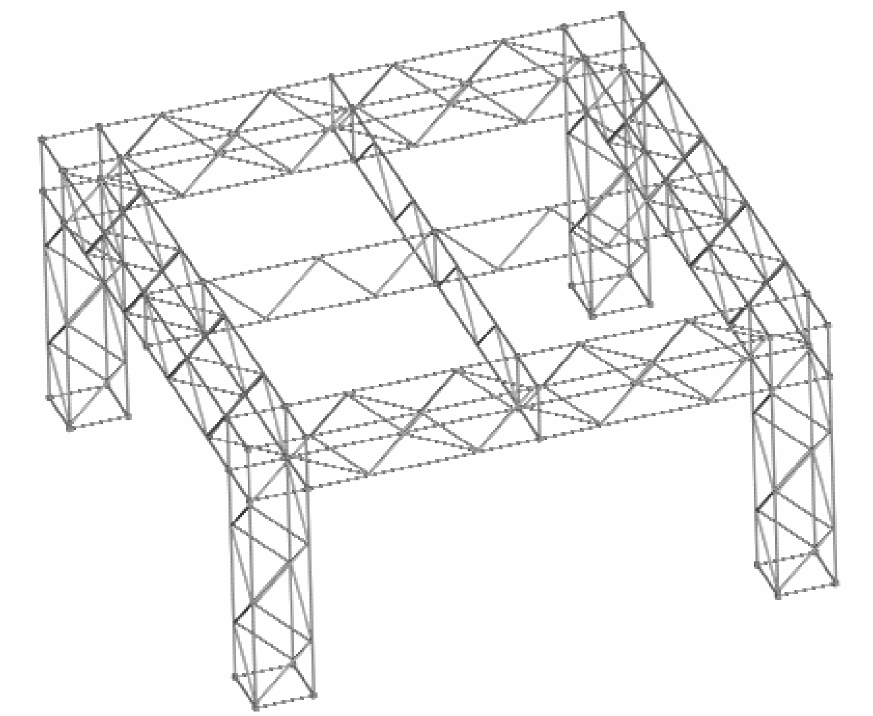

Figure 9. Light grid support structure (10 m x 10 m x 9 m)

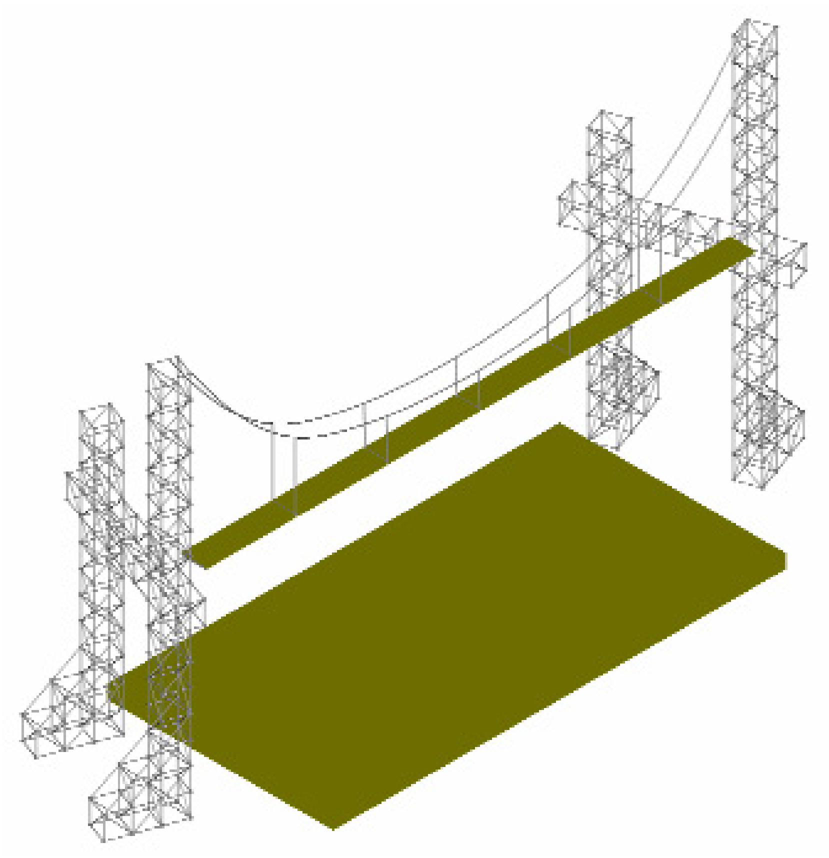

Figure 10. TV suspension bridge – Kraljevica, Croatia, 2003

5. Conclusions

The space joints used in new grid structures applications are of cubical body shape.

All until now used space joint body used are of 80 mm cube shape.

Grid structures modules used was of 1 m, 2 m and 4 m in length, and of square cross-section.

By using the standard 2-D and 3-D structures various 3-D grid structures could be designed and built.

When grid structures components are prepared in good tolerances mounting and dismounting procedures are simple, accurate and fast.

For grid structures exposed to the bigger forces and moments corresponding design calculation has to be done in order to be real structure components accepted.

Space joint bodies used in described structures were mainly prepared from hybrid type, and in some cases from one wooden part.

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DIFFERENCIES BETWEEN NEW PRODUCT DEVELOPMENT SUCCESS FACTORS IN SMEs

J. Hirvelä, I. Fecikova and T. Kekäle

Abstract

Dan Steinbock [6] has identified Nokia's success factors and survival strategies since year 1865 that have been repeated during the history. Those factors are continuous concentrated on innovation and growth, mastering the whole value chain (operations, product development, marketing, sales and service), working on global markets (instead of domestic), and listening to the customer. Product development is very often the central part of strategy within the company that focuses on customer.

Managing new product development (NPD) depends on balancing efforts toward four key objectives: market introduction date, product's unit recurring cost, product performance and development project expense. When we have knowledge about the success factors of NPD in small & medium size enterprises (SMEs), it should be possible to improve the control of NPD processes. Why should we control a new product development process? "There is only one reason to control a development process, which is the influence of economic performance." [5]

This paper is focused on: what kind of strategies and success factors could we find in low amount of companies research, in small and medium size enterprises, especially in the field of their new product development processes. Empirical data have been collected in two different countries, in Finland (University of Vaasa) and in Slovakia (Technical University of Kosice) by students of each university. Results from the case interviews related to new product development success factors were analysed with the analytic hierarchy process (AHP).

Keywords: New Product Development, Analytic Hierarchy Process and Success factor.

1. Introduction

Mobile communication business has been an enormous success in the world and especially in Finland during last years. According to fact that Finland nowadays has also several other successful and innovative software companies and electronics manufacturers, it's quite amazing how few researches and studies have been done in the field of New Product Development (NPD). Perhaps this area is difficult to study, e.g. because NPD is in many cases the real core competence of a company [4].

To open up this situation, authors have wanted to know more about NPD with this study. How NPD is different in different companies, e.g. between software companies and electronic equipment manufacturers? Is NPD different for main constructor companies than for sub-constructor companies? What are the NPD success factors of SMEs?

In his book of Nokia, Dan Steinbock [6] has identified the success factors and survival strategies of this Finnish company since 1865. Nokia's success seems to be based on continuous concentration on innovation and growth, mastering the whole value chain (operations, product development, marketing, sales and service), working on global markets (instead of only domestic) and listening to the customer. Nowadays Nokia's "devices" are supplied to the customers, as they could call it, through "Demand Supply Network".

Product development is often the key part of strategy within the company that focuses on customers. Managing NPD can be balancing efforts toward different types of key objectives. Those can be e.g. development project expense, market introduction date, product performance and product's unit recurring cost. Quality of those all objectives should also always be remembered. When we know more about the NPD success factors in SMEs, it should be possible to improve the control of NPD processes. The only reason why we then should control a development process is to try to influence the economic performance of the process. [5] It's possible to measure the success of NPD e.g. with the increased sales, profitability and value of the stocks.

There are many factors in a NPD project that can affect if the project will be a success or a failure. According to some previous research a close co-operation with customers and right timing have been the most important success factors of NPD projects. For example insufficient testing equipment have been the main reason for some NPD project failures [1].

In this study the researchers have wanted to find out what kind of strategies and success factors it's possible to find in small and medium size enterprises and especially in the field of new product development. Product, as we understand it, is more than just a physical product or a thing. It can also be a service, system or a functional entity. Brand, guarantees, image, maintenance or warranties affect significantly to the product's value on the markets. [3]

2. About empirical data

Empirical data for this study have been collected mainly during university courses in University of Vaasa in Finland and in Technical University of Kosice in Slovakia. During these courses several groups of students become acquainted with NPD in practice and in the same time they also learned about research methods in the field of Industrial Management. University students got an interviewing questionnaire [2] including questions for comparing and surveying success factors of new product development. This questionnaire is based on a simplified solution of the analytic hierarchy process (AHP). [7] By interviewing product development experts in SME case companies with this questionnaire it was possible to find out what kind of NPD factors affect on the success of a SMEs products.

During making these interviews in case companies, university students did have an excellent opportunity to become familiar with the small or medium sized company and it's products. They also saw how NPD is done in practice. During case company visits students could also make observations of the employees, facilities and organisation culture. From the experts' answers to our questionnaire and of the case company visit information students made reports of their small studies. This all is an important part of our teaching (or better learning) method we called research based learning (RBL).

Most of the empirical data for this study is from Finland. Finland is a country of about 5 million inhabitants in the northern part of Europe and today a member of EU. The neighbouring countries are Sweden, Norway, Estonia, and Russia. Before 1945, Finland was an agricultural country with a narrow industrial sector exporting only the wood-processing products. Within the wood industry, the main industries today are the metal industry, chemicals, textiles, and construction. Some high-technology fields, e.g. telecommunications equipment, of which Nokia is the greatest company example, have also made an enormous growth. SMEs are the most important companies for the industry in Finland. Finland's most important trading partners are Germany, Sweden, Great Britain, the United States, and Russia.

For comparison there is added some empirical data from Slovakia too. Slovakia is a country of about 5,4 million inhabitants in the eastern part of Europe and will be a member of EU this year 2004.. The neighbouring countries are Czech Republic, Poland, Austria, Hungary and Ukraine. Before 1993, Slovakia was a part of Tschekoslovakia, after that The Slovak Republic. The main industries today are the metal industry, electric energy, gas, coke, oil, rubber products and agriculture. Slovakia has been called the world's next Hong Kong or Ireland, because it's a small place that is an economic powerhouse with well educated and higly skilled workforce. Slovakia's most important trading partners are both old and new EU countries like Germany, Austria, Czech Republic and Poland.

3. Results of this study

In Figure 1 two typical results of this study is presented with radar diagrams. Most of the cases in this study are more people oriented modern companies like e.g. in Figure 1 Case 16. Many of the cases are still significantly more product oriented companies e.g. in Figure 1 Case 15. [4]

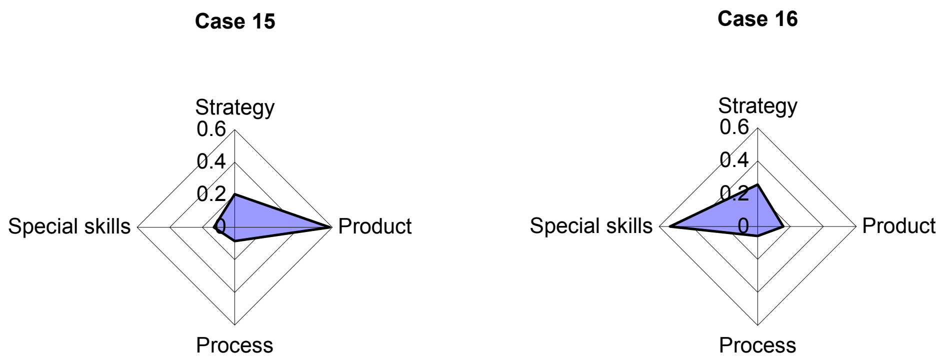

Figure 1. Radar diagrams of two typical results in this study

Following are the results of this study. Totally 39 expert interviews have been done for this study. Expert's answers to the questionnaire have been analysed with 'Expert Choice'-software. In Table 4 are the results from Slovakia (12 cases) and from Finland (27 cases). According to interviewed 39 expert's opinions e.g. 36 % of them thinks that the "Special skills" are the most important factor of NPD for the success of products in their company.

Table 1. The most important NPD success factors

1 The most important factors of NPD for the success of products in your company:	**Slovakia**	**Finland**	**All results**
1.1 Special skills	33 %	37 %	36 %
1.2 Characteristics / Properties of the product	33 %	26 %	28 %
1.3 Strategic definition of NPD	25 %	29 %	28 %
1.4 NPD process	9 %	8 %	8 %
1.1 Special skills			
1.1.1 People, organisation, work teams, work groups	67 %	63 %	64 %
1.1.2 Business processes (core, product and delivery processes)	25 %	26 %	26 %
1.1.3 Information systems, IT solutions	8 %	4 %	5 %
1.1.4 Technology, equipment, internal infrastructure	0 %	7 %	5 %
1.2 Characteristics / Properties of the product			
1.2.1 Technical performance of the new product	50 %	22 %	31 %
1.2.2 Product unit manufacturing costs	17 %	33 %	28 %
1.2.3 Time-to-market of the new product	17 %	30 %	26 %
1.2.4 Design of the product and marketing	16 %	15 %	15 %
1.3 Strategic definition of NPD			
1.3.1 Investing in developing different product versions	42 %	33 %	36 %
1.3.2 Investing in developing break-through technologies	50 %	27 %	33 %
1.3.3 Investing in developing product platforms / families	0 %	33 %	23 %
1.3.4 Investing in basic research	8 %	7 %	8 %
1.4 New product development process			
1.4.1 Studying customer needs	42 %	52 %	49 %
1.4.2 Testing manufacturability of the new product	26 %	11 %	15 %
1.4.3 Product prototype and testing performance	8 %	15 %	13 %
1.4.4 Developing stage of ideas	8 %	11 %	10 %

1.4.5 Developing stage of product concept	8 %	7 %	8 %
1.4.6 Market research	8 %	4 %	5 %

4. Conclusions

To improve NPD productivity in SMEs we should first know what are the success factors of NPD. According to this study 'Special skills' are the most important new product development success factors. People (employees) working in the company, organisation (e.g. how the works are organised) and work teams/groups are the most important success factors for new product development for a company. Most of SME case companies interviewed for this study seems to be *not product-oriented*, but more *people-oriented* modern companies.

There are still companies, especially sub-constructors for larger corporations, that are more product-oriented and the most important NPD success factor for them are the properties of their product. The larger the company is the more important success factor is the strategic definition of NPD. Characteristics and properties of the products are more important success factors of NPD for Slovak companies than for Finnish SMEs. Especially the technical performance of the new product is an important success factor in Slovakia. In Finland product unit manufacturing costs and time to market are more important success factors for a new product. Developing product versions and break-through technologies is strategically more important for Slovak companies than for Finnish. Product platform thinking is strategically more important again for Finnish companies. According the observations during this study also e.g. many software companies have invested in employees and their knowledge. According the same observations hardware companies have focused more to develop and manufacture competitive products.

To improve NPD success in SMEs it seems to be most important to invest in people and their continuous education. Organising the jobs well and taking care of that teams are working well increases the possibilities of NPD success. Developing the own products, whatever those then are, and keeping them up to date is another path to a successful future.

Results of this study have been very educational and useful and the results will be used within continuous research in the field of NPD. Good results of this study make also possible the further development of the new teaching method for universities called research based learning (RBL).

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THE MULTIPLE ATTRIBUTE DECISION MAKING IN ANALYSIS OF THE DESIGN PARAMETERES OF CHAIR

Ž. Ivandić, T. Ergić and M. Kljajin

Abstract

The weight of the human body transfers by sitting over bones and surrounded soft tissue on the chair and vice versa. Design of the chair suitable for the human body from the ergonomic point of view becomes necessary. Research was done at several workplaces with five different shapes of seats. Testing sample included 37 male and 33 female participants who work while sitting down. Their anthropometrical characteristics were measured: height, weight, sitting pressure, hip and chest circumference, and body posture while working. Seat characteristics were also analysed, including: seat dimensions (width, length), seat shape, seat inclination, seat hardness. The main goal of this research was to determine, out of available chair, which design parameters of chair is more important and must be acceptable into the design process. The paper uses an original model for decision making seating parameters when selecting an acceptable chair. Multiple attribute decision-making model give to the aim for the design of chair.

Keywords: selection the chair, design parameters, decision-making, evaluation, graph theory

1. Introduction

Humans are designed for walking, not sitting. Sitting involves a seat of very complex actions. All actions are affected by great number of influence factors, which will involve few main sitting aspects, such as: biomechanical, anthropometry, and discomfort. These influence factors are investigated at several workplaces. The work is done by writing on computers or reading on office desk. Testing sample included 37 male and 33 female participants who work while sitting down. Participants were of different age groups and gender. Their anthropometrical characteristics were measured: height, weight, sitting pressure, hip and chest circumference, and body posture while working. Seat characteristics were also analysed, including: seat dimensions (width, length), seat shape, seat inclination and seat hardness. The main goal of this research was to determine, out of available seats, which seat is acceptable for the given group of participants based on comfort (pressure magnitude and distribution while sitting). The interaction between particular influence factors was performed by application of hierarchic model.

2. Biomechanical aspects of sitting

2.1 Disk Pressure

When the spine is in the normal erect position, relatively even pressures are distributed over the discs. When moving from a standing to an unsupported sitting position, all radiographic studies confirm that the pelvis rotates backwards and the lumbar spine flattens when sitting. It causes irregular loading of spine. Disc pressure was found to be 35% lower when standing than when sitting. However when the lumbar spine curvature is reduced, flattened, or reversed, shear forces are produced. The lumbar disc tends to protrude posteriorly, applying pressure on the ligaments, and thus giving rise to lower back pains. Many authors have discovered that this can be corrected (prevented) with well-designed support. An increase in the backrest inclination resulted in less disc pressure as more weight was transferred to the backrest. Use of lumbar support not only transfers some portion of the weight to the support but also changes the posture of lumbar spine towards its natural standing posture (lordosis), reducing the deformation, and hence reducing disc pressure. Slope of sitting plane affects on degree of rotation of pelvis.

2.2 Sitting Pressure

As a result of sitting redistribution of pressure and pressure amount on contact surfaces occurs. Maximal pressure can occur under thigh (Reg. femoris dorsalis) or sitting bones (Tubera ossis ischii). Amount and distribution of pressure are important because different parts of body cannot tolerate the same amount of pressure. Pressure under thigh bones causes lowering of body circulation and therewith leg shuddering. Highest amount of pressure is tolerated in area of sitting bones.

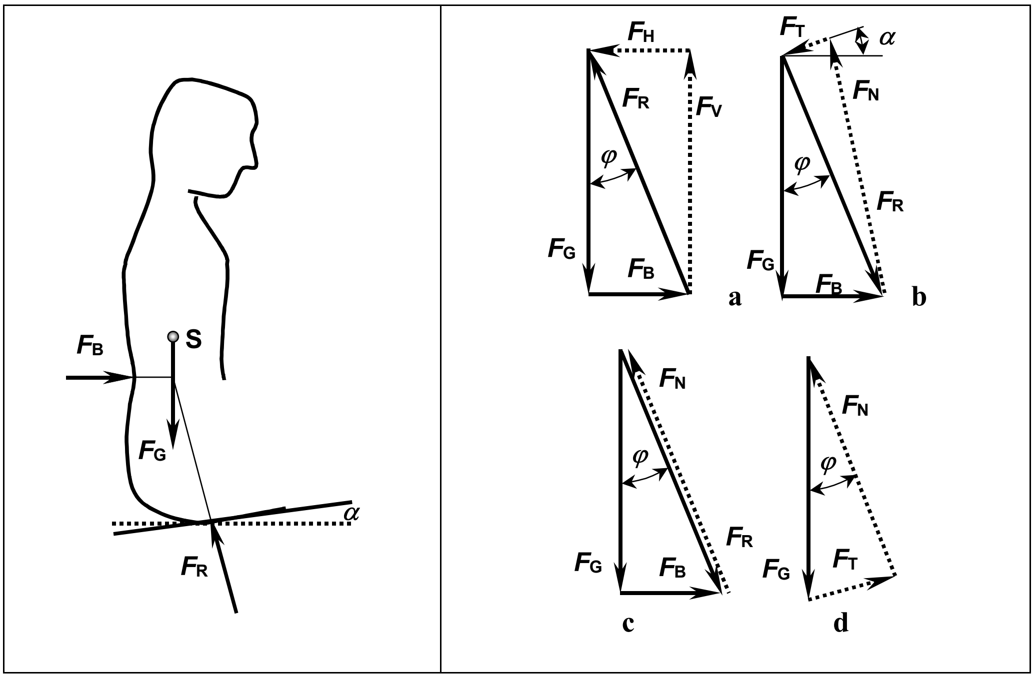

Figure 1. Forces analysis by sitting in the chair with vertical back

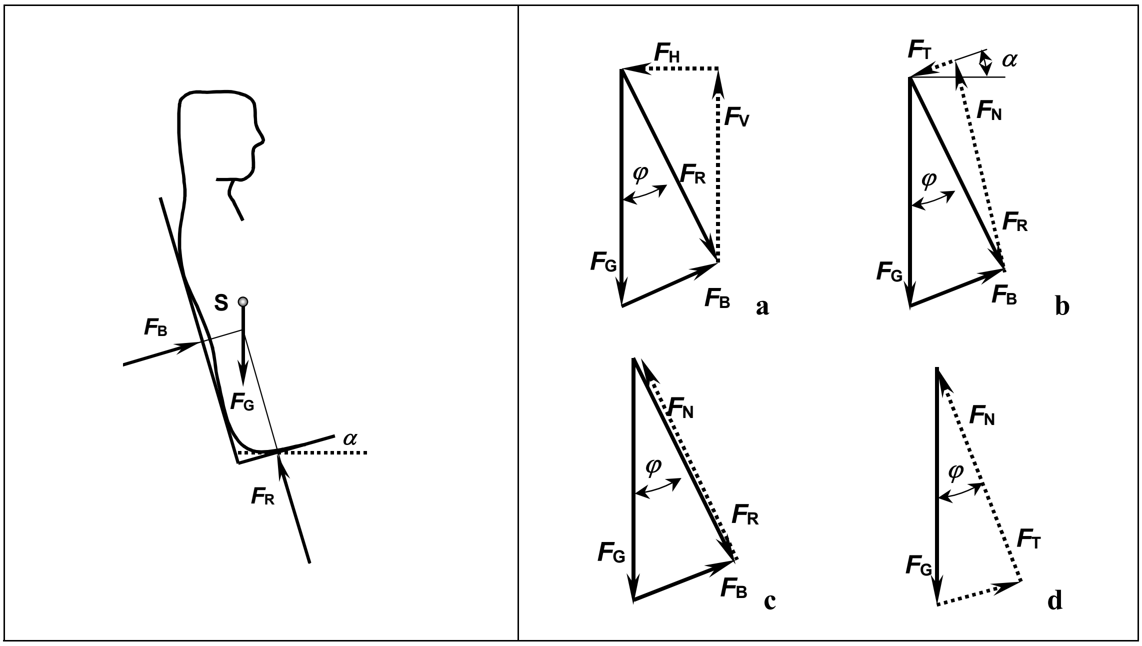

Figure 2. Force analysis by sitting in chairs with inclined back

Higher value of pressure under sitting bones (in underweight people) causes obstruction of circulation and metabolism, and the consequence is decrease or stoppage in oxygen delivery to body cells. Presence of shear forces on contact area dramatically makes worse phenomena mentioned before [1] (Goossens, 2000). Biomechanical models show that sitting plane has to be sloped for angle α to eliminate shear forces. When the sitting plane is sloped but without leaning shear forces occurs also. Comparing of resultant force F_R by vertical and inclined back of chair, it can be noted that resultant force F_R is less by inclined back and with this normal component F_N and shear component F_T of total force. Therefore, the angle between horizontal and vertical sitting plane should be between 90 – 100^o by chairs with leaned back.

3. Anthropometry in seat design

Although body dimensions are not sufficient data for the design of seats, it is obvious that they are essential.

3.1 Third order headings

One can conclude from this picture that individual position drastically influences the measurement results. If the sitting plane is so low that legs may touch the ground, the greatest pressures appear under Tuber ossis ischii. Here the region below the thigh is unloaded what is the case also by sitting on the leading part of the seat. If the sitting plane is too high and feet don't touch the ground, the pressure is transferred through the large field under thighs and maximal pressure appears on the edge under knee (popliteal). The popliteal height, the vertical height from the foot to the angle at the underside of the knee, should be taken under consideration when designing the seat height. In general the optimal seat height is close to popliteal height. Where this cannot be achieved, a seat, which is too low, is preferable to one, which is too high [2].

3.2 Seat Depth

When the internal depth of a seat, the buttock – popliteal length, i.e. the horizontal distance from the back of the uncompressed buttocks to the underside angle at the back of the knee, should be considered. If this length were shorter than the seat pan the seat would be uncomfortable at the soft posterior part of the knee, hindering the blood supply. The person would try to shift forward and lose proper backrest support. If the length were too short the thighs would not be properly supported.

3.3 Seat Width

Clearance between the armrests must be adequate for the largest user. The hip breadth measurement is bigger in females as compared to males, which should be considered while designing seats.

3.4 Backrest

The higher the backrest the more effective it is to support the weight of the trunk. In case of seats where the mobility of the shoulders is of greater importance a medium level backrest can be used. A medium backrest would give support up to the shoulders. As discussed earlier backrest inclination has the greatest effect on muscle activity, it decreases in the spinal region with an increase in backrest angle. The lowest muscle activity was recorded (Hosea 1986) at a 120 degree backrest angle. However, this will drive the buttocks forward

3.5 Characteristics of Human

Individual characteristics of human affects on amount and distribution of pressure during sitting. Characteristics of whole population are measured on specially designed chair. Some characteristics of samples are given in the tables 1 and 2. Sport type of constitution with larger muscle mass produces also larger pressures, but smaller than very thin constitution. Thick persons have the smallest pressure variation. Extra thick persons (especially older woman) have the same pressures that are a little bit changed with different sitting conditions. Thin individuals have smaller areas under thigh bones and front edges are displaced toward Tuber ossis ischii.

Table 1. Statistical values of measured parameters for male

	Age years	h cm	m kg	$\frac{m}{h^2}$	p_{max} kPa	p_{ave} kPa	A cm^2
Average value	35,5	180,3	82,1	25,29	42,88	17,85	452
Standard deviation	15	6,63	13,6	4,11	1,58	2,416	89
Minimal value	18	170	61	16,92	31	14,06	284
Maximal value	58	196	118	34,94	59,5	22,45	607

Table 2. Statistical values of measured parameters for female

	Age years	h cm	m kg	$\frac{m}{h^2}$	p_{max} kPa	p_{ave} kPa	A cm^2
Average value	31,6	165,6	66,1	24,15	36,7	12,1	546
Standard deviation	11,3	7,21	14,2	5,28	7,30	2,37	176
Minimal value	19	148	49	17,86	26	8,34	337
Maximal value	54	179	120,2	42,59	55,5	19,5	1215

4. Seat Comfort Evaluation

Concept of comfortable sitting was related to seat softness, but seat softness does not guarantee comfortable sitting. Measurement of comfortable sitting is distribution and amount of specific pressure on contact surface of sitting human and amount of angle of rotation of pelvis and lumbar part of spine also. Discomfort is a subjective experience, which can result from a combination of physiological and psychological processes, time on task and muscle fatigue. Estimation of such discomfort requires physiological measurements because it appears to provide an objective corollary of subjective experience (Lueder, 1983)

4.1 Evaluation model with Potential Method (PM)

All parameters, which have influence on the chair design, are grouped on the different levels of hierarchic structure.

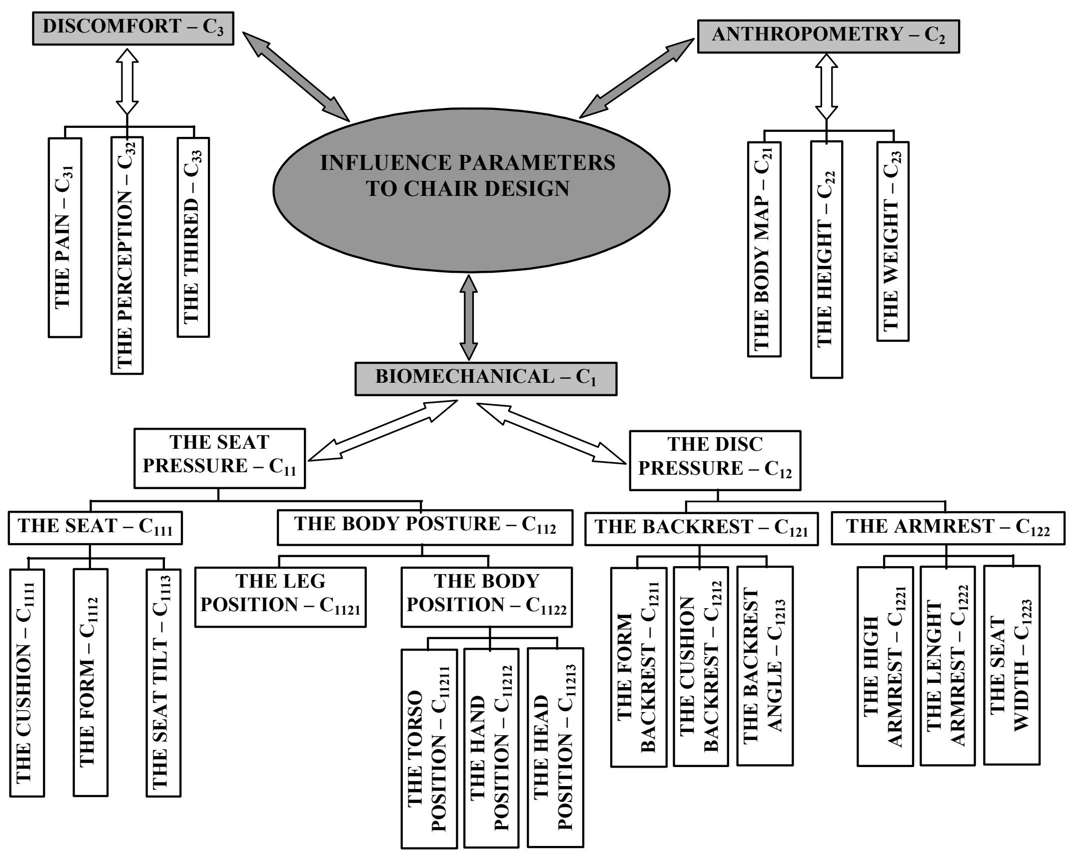

Figure 3. The hierarchical model used for evaluation

Hierarchic structure of evaluation model (Fig. 3) is given with finite levels number [3,4]:

$$H_i, \forall i = 1,...,n; n_{\max} = 6 \tag{1}$$

In that case, the evaluation model every hierarchic level of analysed parameters presents by one graph, using the potential method - PM [5,6]:

$$G_i = (V, R), \forall i = 1,...,n \tag{2}$$

Evaluation procedure, described by mathematical formalisms, is determining the complete and unique hierarchic structure of model for $H_n \mapsto n = 6$.

Table 3. Numerical values of evaluation model via potential method

```
The grade of influence parameters to chair design
Results of ranking procedure:
Showing weights:       Verbose = weight + potential + all levels
   Nodes:  The grade parameters influences to chair design   1.000   ( X = 0.00 )
    Level: GROUPS ( Norm= 1.000 )
Comp_1 Weight=1.000 InvInc=0.108 ( Angle=6.15 deg )
   Nodes: BIOMECHANICAL   0.828   ( X = 2.33 ), ANTROPHOMETRICAL   0.130   ( X = -0.33 )
            PSIHOLOGICAL   0.041   ( X = -2.00 )
    Level: SUBGROUPS ( Norm= 1.000 )
Comp_1 Weight=0.828 InvInc=0.000 ( Angle=0.00 deg )
   Nodes: C11   0.076   ( X = -1.66 ), C12   0.753   ( X = 1.66 )
Comp_2 Weight=0.130 InvInc=0.463 ( Angle=24.84 deg )
   Nodes: C21   0.050   ( X = 0.22 ), C22   0.038   ( X = -0.17 ), C23   0.042   ( X = -0.04 )
Comp_3 Weight=0.041 InvInc=0.281 ( Angle=15.69 deg )
   Nodes: C31   0.015   ( X = 0.11 ), C32   0.013   ( X = -0.10 ), C33   0.014   ( X = -0.01 )
    Level: CRITERION ( Norm= 1.000 ) Comp_1 Weight=0.076 InvInc=0.000 ( Angle=0.00 deg )
   Nodes: C111   0.041   ( X = 0.11 ), C112   0.035   ( X = -0.11 )
Comp_2 Weight=0.924 InvInc=0.000 ( Angle=0.00 deg )
   Nodes: C121   0.822   ( X = 1.51 ),C122   0.102   ( X = -1.51 )
Level: SUBCRITERION ( Norm= 1.000 ) Comp_1 Weight=0.041 InvInc=0.281 ( Angle=15.69 deg )
   Nodes: C1111   0.015   ( X = 0.11 ),C1112   0.013   ( X = -0.01 ), C1113   0.013   ( X = -0.10 )
Comp_2 Weight=0.035 InvInc=0.000 ( Angle=0.00 deg )
   Nodes: C1121   0.018   ( X = 0.03 ), C1122   0.017   ( X = -0.03 )
Comp_3 Weight=0.822 InvInc=0.108 ( Angle=6.15 deg )
   Nodes:C1211   0.631   ( X = 1.92 ), C1212   0.053   ( X = -1.64 ), C1213   0.138   ( X = -0.27 )
Comp_4 Weight=0.102 InvInc=0.000 ( Angle=0.00 deg )
   Nodes: C1221   0.036   ( X = 0.10 ), C1222   0.034   ( X = 0.00 ), C1223   0.032   ( X = -0.10 )
Level: ELEMENTS ( Norm= 1.000 ) Comp_1 Weight=1.000 InvInc=0.254 ( Angle=14.25 deg )
   Nodes: C11221   0.341   ( X = 0.03 )
            C11222   0.327   ( X = -0.03 )
            C11223   0.332   ( X = -0.01 )
```

Presented evaluation results are defined by comparison of ordered pair of elements of hierarchic structure (Fig. 3) and presented by graph G_i, which is determined by relation:

$$(v_i, u_j) \in \rho_{ij} \subset R \Rightarrow (u_j, v_i) \in \rho_{ji} \not\subset R, \rho_{ji} \neq \rho_{ij}, i = 1,...,n; j = 1,...,m \tag{3}$$

Graph G_i of each level is uniquely determined by incidence matrix **B**:

$$[B] = \alpha \rightarrow [\cdots \quad \overset{v}{-1} \quad \overset{u}{1} \quad \cdots] \tag{4}$$

Numerical value of graph element is the potential of the element. Element of graph is the node, whom the evaluation parameter is assigned. The potential of any node $\mathbf{X}$ presents the numerical value, which analysed element has on the own hierarchic level related to other elements on the same level. Real function $\mathbf{X} : V \rightarrow \Re$ in the set of nodes presents the potential of each element. Real function $\mathbf{F} : R \rightarrow \Re$ in the set of arcs is the flow. Potential of the elements **X** and the flow **F** are determined as the vector of *n* elements:

$$\left(n := cardV \rightarrow [\mathbf{X}] = \begin{bmatrix} X_1 \\ . \\ . \\ X_n \end{bmatrix}, m := cardR \rightarrow [\mathbf{F}] = \begin{bmatrix} F_1 \\ . \\ . \\ F_m \end{bmatrix} \right) \rightarrow \mathbf{F} = \mathbf{B} \cdot \mathbf{X} \tag{5}$$

If the direction of the preference is defined as $F_\alpha = F_{ji} := \log_a a_{ij}, a \succ 1$ and vector of the potentials as **X,** then the vector of priorities w and its components w_i is determined as:

$$w = a^X, a \succ 0 \rightarrow w_i := a^{X_i}, i = 1,...,n \rightarrow w_i = a^{X_i} = a^{\frac{1}{n}\sum_{j=1}^{n} F_{ji}} = a^{\frac{1}{n}\sum_{j=1}^{n} \log_a a_{ji}} = \left(\prod_{1}^{n} a_{ij} \right)^{\frac{1}{n}}, i = 1,...,n \tag{6}$$

The evaluation by potential method (PM) is applied to rank the influence parameters by hierarchic levels.

5. Conclusions

The results shown the dominant influence of the biomechanical parameters C_1 (0,828) on the chair design. Biomechanical parameters are important due to its effects on the comfort and health of the man. Anthropometric factors C_2 (0,130) is less influenced, because they have strong impact on the chair dimensions, but low on the chair shape. The influence of the lumbago spine loading is emphasised C_{12} (0,753) related to buttocks loading C_{11} (0,076). By definition of the chair design parameters and its shaping, it is necessary to consider all analysed parameters. These investigations could be continued by measurements of few additional parameters (contact pressure distribution), as well as by statistical methods of evaluation application due to anthropometric and biomechanical measured parameters. Also, it should be significant to use evaluation of the parameters inside the subgroups of considered hierarchic model.

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DEVELOPMENT OF DIESEL-ELECTRIC SPECIAL MACHINE

V. Koroman, D. Mikulić and B. Ružojčić

Abstract

This article describes the concept and characteristics of demining MV-5DE machine with diesel-electric propulsion. Compared to hydrostatic concept, diesel-electric propulsion concept is regarded as technically more advanced. Development of the machine is at the early stage of prototype demonstration and machine testing would provide basis for analytical judgment for acceptability of technical concept. Diesel engine is connected to the generator, which produces electric energy transferred to the electric motor with permanent magnets. The electric motor is providing power for machine movement and soil digging flail. Initial calculations are implying towards better performance and higher power efficiency. During this project, the technology challenge of high power static conversion in reduced space and high ambient operating temperature should be solved. Demining machine traction characteristics are sufficient for effective soil digging and for destroying AP mines. It is considered that more advanced technologies will enable multi role use of machine for humanitarian demining tasks and for special tasks of removal of low intensity conflict consequences. Electrical propulsion technology is intensively developed and introduced as a future crucial factor for new military capabilities of NATO members. The biggest advance in humanitarian demining in Republic of Croatia is achieved in field of machine demining. Croatia set up development and production of genuine demining machines. It is well known that the basic MV-4 demining machine was, due to its qualities, sold to the number of NATO countries. Through this technology project of Ministry of Science and Technology, a new diesel-electric propulsion technology is being developing, in order to produce environment friendly demining machines. Even more, in the nearest future, the same technology can also support broad industrial applications in Croatian.

Keywords: demining machines, diesel-electric propulsion, ecological demining machine

1. Introduction

In accordance with development goal for modern demining machines, this article describes concept and characteristics of future ecologically acceptable MV-5DE machine with diesel-electrical drive. In comparisons to hydrostatic drive concept, it's the best way to evaluate a new concept of diesel-electric drive. Machine development is in the early stage of prototype testing. After factory testing, an in application field test will provide analytical and expert evaluation of technical solutions.

2. What is MV-5DE?

In western countries a concept of diesel-electric (DE) drive is being developed for commercial and military vehicles. DE drive offer better vehicle performances, better operability, and easy spare parts manufacturing as well as lower maintenance cost. Diesel engine has a directly coupled electric generator, used as electric power source. Electric energy is transmitted by Power Electronics inverters system to electric motors with embedded permanent magnets. Electric motors are connected to the tracks movement chain wheel over a gearbox or to the drive flail for digging the soil. Searching for better technical solutions is a continuous task of development teams. Development and construction of this Croatian machine, was supported by STIRP project under the supervision of MTZ of Republic of

Croatia. Traditional MV-4 demining machine is due to its good performances, already sold to numerous western countries. New MV-5DE machine, based on experience, development and cooperation with partners, will be technically advanced, providing a multipurpose application, for humanitarian minecleaning tasks and for special requirements in removal of low intensity conflict consequences. (LIC, Low Intensity Conflict). The machine technical features will provide searching and destruction of different mine targets.

Machine chassis is a track and working tool is a flail that by digging the soil destroys hidden barred AP mines. Flail consists of rotor on which chain-flails are mounted with hammers for soil digging. In accordance with demining quality, machine has to treat the soil considering technological speed. During the machine movement, flail has to dig the soil up to the certain depth and density for safe destruction of smallest mines based on crushing or activating principle.

Basic requirements for development of 5t DE demining machines are:

- Safe cleaning of AP mines up to the their depth;
- Intensive use in hardest working conditions, I to IV category;
- Ecology complied machine, use of mineral oils and lubricants excluded;
- Diesel engine prime mover, optimal working point with low exhaust gases emission, complied with standard 97/68/EC, Standard (ll)
- Operating in extreme temperature conditions;
- Demining capacity (500-2000 m^2/h);
- Remote control;

Figure 1. The humanitarian minecleaning machine / Demining machine MV-5

Machine chassis fits for different upgrades. Except basic machine version, chassis allows use of different superstructure modifications, as machine for removal of suspicious obstacles and objects, robot for removal of UXOs, light reconnaissance engineering vehicle, amphibious vehicles, etc. Based on such a multipurpose program, necessary logistics for life cycle, economic profit and technological progress, sustainability and propulsive development is being imposed. Development of training simulators with future machine versions is part of domestic scenario of this program that is completely being developed in Croatia.

3. Basic characteristics of DE drive

Development of diesel-electric drive is based on advantages in comparison to classic machine drive:

- Fast force / torque adjustment on drive wheels
- Elimination of hydrostatic or mechanical transmitter (differential, gear-box, cardan shaft)
- Optimal operation of diesel motor with ecological characteristics
- Easier and safer conduction of drive power and breaking
- Automation by using drive-by wire system and DSP technology
- Static conversion of energy with minimal losses
- Simple production process, increased machine reliability and functionality
- Lower maintenance and life cycle costs
- Modern structure of new design with permanent magnets provides smaller dimensions and overall weight of assemblies and vehicle compared to achievements of equivalent induction motors electric drive
- Design flexibility – better space distribution
- Better processing autonomy
- Better vehicle performances
- Lower fuel consumption
- Lower exhaust gases emission
- Optional: silent mobility and processing

Electric drive produces a constant rotating torque in wide range of the shaft rotating speed – from zero to full speed rotation. The applied electric motor drive is organized based on motor current and speed control loop. Problems noticed at power conversion by static converters are primarily high environment temperature in which electronic components have to operate, The biggest challenge, assembly's components procurement costs - in the nearest future will be override by volume production of assemblies and product modularity.

4. Drive concept

Diesel motor is equipped with a three-phase alternating current generator (380V), which is directly connected to the motor shaft. Generator's rotor act as diesel motor's driving wheel. Machine movement is achieved over two independent electric motors of each track, and two electric motors are rotating a shaft with demining flail. Lifting and lowering of flail's arm is achieved hydrostatically by two hydro-cylinders. Diesel motor operates in optimal working conditions at the constant speed where generator achieves nominal power, rotating speed, frequency, voltage and current.

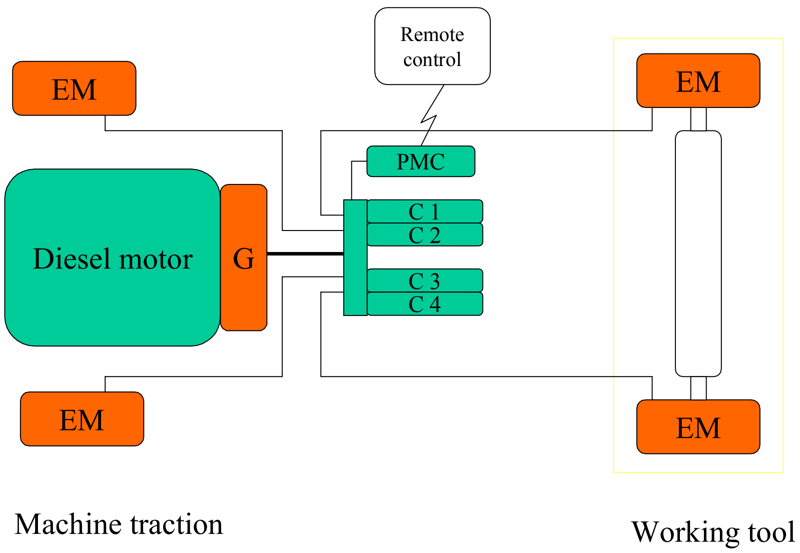

Figure 2. DE drive basic schema

5. Machine power

The total resistance torque to flail rotation includes static and dynamic torque of flail elements rotation, until the impact of the hammer against the ground or loss of kinetic energy and change of angular velocity and reduction of the number of flail revolutions. Since this phenomenon of energy exchange is not completely known in practice, the starting assumption is the cyclical operation of each flail: hammer acceleration, and almost stopping at cutting or crushing the ground layer. This calculation of rotation resistance torque forms the digging resistance torque.

$M_k = z\, J\, \alpha$ [Nm], $P_k = M_k\, \omega$ [W]
z_n - number of hammers in contact (4, 6, 8)
J - inertia of hammer and chain / flail
α - hammer angular acceleration (ω / t), ω – hammer angular velocity

For the movement of the tracked machine, the machine movement and operation resistances are calculated at steepest climbs, as well as the required velocities.

$R_g = R_k + R_i + R_\alpha$ [N], $P_g = R_g\, v$ [W]
R_k - rolling resistance of the tracked vehicle,
R_i - vehicle inertia resistance,
R_α - vehicle resistance in climbing.

The required machine power consists of the power for operation and the power for machine movement: $P_u = P_k + P_g$. The amount of the loss for transmission, engine cooling, air filtering (degree I / radial fan, degree II / combined filter), for driving secondary devices, etc. should be added to this power. The required power for machine operation and movement has been calculated, and the total amounts to 110-150 kW (150-200 HP). Out of this, more than 90% of power is used for ground digging and the rest for the machine moving. Power distribution with this machine is very much the same. Also is assumed that for safe flail operation at demining process, up to 70 kW is required to achieve on one-meter shaft length.

As an option DEG can charge on board batteries for energy storage and delivery within silent mobility, silent watch and vehicle operating in accordance with specific NATO requirements. Energy for electric drive system is provided from generator or batteries or from both sources at the same time assuring machine movement and operation, increasing the power as resistance is being enlarged. It means that machine has to operate in regular *electric mode,* which results in insignificant thermal and acoustic emissions. Energy stored in batteries allows the machine spreads its role to the areas such as Special Forces, reconnaissance missions, etc.

6. Components of DE drive

Selection of electric motor for machine movement

One track starting torque:
$M_g = P_g / 2\, \omega$ [Nm], where P_g - power necessary for machine movement,
Electric motor nominal torque for one track:
$M_{hm\, g} = M_g / i_{pr} \eta_{pr}$ [Nm]

Selection of electric motor for flail operation

P_k – power needed for digging the soil

Electric motor torque for flail operation:
$M_k = P_k / 2\omega$ [Nm]; $M_{hm\, m} = M_k / 2\, i_{lr}\, \eta_{lr}$ [Nm]

This is followed by the selection of the electric motor, nominal power, torque, and other characteristics (catalogue). i_{lr} *- transmission relation of the gearbox - chain,* η_{lr} *- efficiency of the chain wheel*

7. Comparisons of hydrostatic and electrical power transmission

Comparisons criteria of two power transmissions:

1. Adaptability to diesel motor operation
2. Efficiency regarding the load change
3. Transmission losses
4. Design simplicity
5. Possibility of positioning within machine
6. Operational parameters adjustment
7. Energy supply for internal and external consumers
8. Starting torque
9. Weight of overall power transmission system
10. Overall dimensions; required space

	Hydrostatic power transmission	**Electric power transmission**
1.	Twisting the pump panel regarding position of shaft axis	AC generated output power is transformed by static converter into three-phase variable voltage and frequency system supplying permanent magnets based electric motors
2.	85% in a very wide area	90-95% in overall operating range
3.	Increased flowing causes significant losses; heat caused by losses has to be necessarily released	Losses slightly increase with output power; heat dissipation is released by forced ear ventilation
4.	Very narrow piston and cylinder tolerance, oil has to be of high cleanness	Drive design with permanent magnets is simple and generally very robust
5.	Free dispositions with high pressure oil pipes interconnection	Free components disposition, simpler connecting with cables
6.	Twisting the pump panel towards shaft axis, change of rotation speed	With constant generator voltage, the variation of the rotation speed is done by magnetic field vector control within the motor drive obtaining maximal efficiency
7.	No universal conversion of energy; larger number of distribution – bigger losses	Universal energy conversion, wide range of users
8.	If the oil pressure is equal with the pressure at highest power, momentum is the same	The torque is within overall shaft speed range the same, constant and proportional to motor current
9.	Pump and hydro-motor have approx. same weight and at one power-unit are better that electrical power transmission	Generator has considerable weight, e.g. weight of rotor iron core and stator ~400 kg, copper weight ~40 kg. Electric motors are also heavier than hydro-motors of equivalent torque.
10.	Pump and hydro-motor are compact and of small dimensions; problem is special oil cooler	Generator and electric motors for flail operation need more space. Power and control electronic as well traction motors can fit within same machine chassis. No need for hydrostatic oil cooler.

8. Conclusion

DE drive of light mine clearing machine is developed. The electric energy generated by the three phase AC diesel generator set is distributed to permanent magnets electric motor drives connected over a gear box to track chains and over chain transmission to the soil digging flail. Overall energy management and machine control is cared out by digital processing microcomputers connected over a CAN field bus in a common central control system.

Regarding development trends of hybrid machines, design of new MV-5DE machine provides ecologically acceptable working machine regarding criteria for environment protection. Maintenance of DE power transmission is considered the simplest, no need for oil change and dependency to oil quality. Traction features of mine clearing working machine are sufficient for efficient soil digging for demining and destruction of AP mines. Prototype testing program, so-called *demonstrator,* in a workshop and polygon will prove machine performances for real demining conditions and reveal possibilities of further improvement.

Technology of electrical drive is being developed for some time now and spread as a main future factor for new military capabilities of NATO members. Each western country has its *own development program* for electrical or hybrid-electrical commercial and military vehicles. Technology of hybrid-electric vehicles provides better advantages for special systems. We are facing some human and technical challenges that have to be conquered by users pragmatically as well as by industry. With this new demining machine project Republic of Croatia gains new knowledge and technology of diesel electric propulsion.

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A COMPARATIVE ANALYSIS OF ANALYTICAL AND NUMERICAL SOLUTIONS FOR A UNIFORMLY LOADED CANTELIVER BEAM SUBJECTED TO LARGE DISPLACEMENTS

D. Kostović and Ž. Lozina

Abstract

In this paper, the methods for solving large displacements of a cantilever beam subjected to a uniformly distributed load and large displacements are analyzed. The methods for nonlinear numerical analysis of beam structures are presented in chronological order. We start the analysis with a method that uses a classical stiffness matrix for small displacements. The other methods for solutions of geometrically nonlinear beam structures comprise development of respective finite element matrices based on continuum mechanics. A virtual work approach and total and an updated Lagrangian approach for large displacement of beam structures are presented and compared with other approaches from relevant literature. A comparative analysis of methods for nonlinear numerical solutions of a geometrically nonlinear cantilever beam with a uniformly distributed load is performed, in order to determine which methods are most suitable for engineering application in terms of accuracy, numerical efficiency, and robustness. The results obtained for all numerical methods are then compared with the exact analytical solutions.

Keywords: nonlinear numerical analysis, line systems, analytical solution, Taylor series, accuracy, numerical efficiency, robustness, large displacement

1. Introduction

Since the first applications of computers to nonlinear numerical analysis of structures, various nonlinear beam elements have been presented by Argyris [2], Bazant and Nimeiri [5], Oran and Kassimaili [11], Reissner [12] and Crisfield [7]. A matrix displacement approach is developed for the numerical analysis of elastic problems of beams and frames by Yung [14].

The total Lagrangian formulation is based upon the Reisner kinematic relations as developed by Haefner and Willam [8]. An updated Lagrangian and a total Lagrangian formulation of a three-dimensional beam element are developed by Bathe and Bolourchi [3, 4]. Studies of large deflections, that require nonlinear analytical solutions, have been concerned mainly with single members. Rohde [13] studied large deflections in cantilever beams subjected to uniformly distributed loads.

The scope of the research of methods for nonlinear analysis for solutions of a cantilever beam with uniformly distributed loads is accuracy, reliability and numerical efficiency. The analytical solution of large displacements of a cantilever beam with a uniformly distributed load that involves ten members of Taylor series is exact up to six decimal digit.

Analysis is performed on standard bench test example, using the a finite element programs developed in Master's Thesis [10]. The numerical results are compared to analytical solution.

2. Analytical solution of large displacements of cantilever beam with uniformly distributed load

This method is developed by ROHDE [14].

Linear solution, vertical displacement of a cantilever beam with uniformly distributed load, towards Alfirević [1] is $v = \dfrac{qL^4}{8EI}$

The calculation of an analytical solution of large displacements of a cantilever beam with a uniformly distributed load is more accurate, if more elements of Taylor series are introduced into the calculation. Comparison, of analytical solutions of large displacements of a cantilever beam subjected to a uniformly distributed load is performed towards number elements of Taylor series.

Table 1. Exact analytical solutions for large displacements of a cantilever beam with a uniformly distributed load obtained for ten elements of Taylor series

Load q [N/m^2]	Load parameter $k=qL^3/EI$	Horizontal displacement u/L	Vertical displacement v_{lin}/L	Vertical displacement v/L
10	0.57142	-0.00290	0.07142	0.07114
20	1.14285	-0.01137	0.14286	0.14059
30	1.71429	-0.02480	0.21429	0.20689
40	2.28571	-0.04232	0.28571	026896
50	2.85714	-0.06295	0.35714	0.32615
60	3.42857	-0.08575	0.42857	0.37819
70	4.00000	-0.10988	0.50000	0.42513
80	4.57143	-0.13464	0.57143	0.46723
90	5.14286	-0.15951	0.64286	0.50485
100	5.71429	-0.18410	0.71429	0.53841
110	6.28571	-0.20813	0.78571	0.56835
120	6.85714	-0.23142	0.85714	0.59508
130	7.42857	-0.25386	0.92857	0.61898
140	8.00000	-0.27538	1.00000	0.64040
150	8.57143	-0.29597	1.07143	0.65965
160	9.14286	-0.31561	1.14286	0.67698
170	9.71429	-0.33433	1.21429	0.69264
175	10.00000	-0.34335	1.25000	0.69990

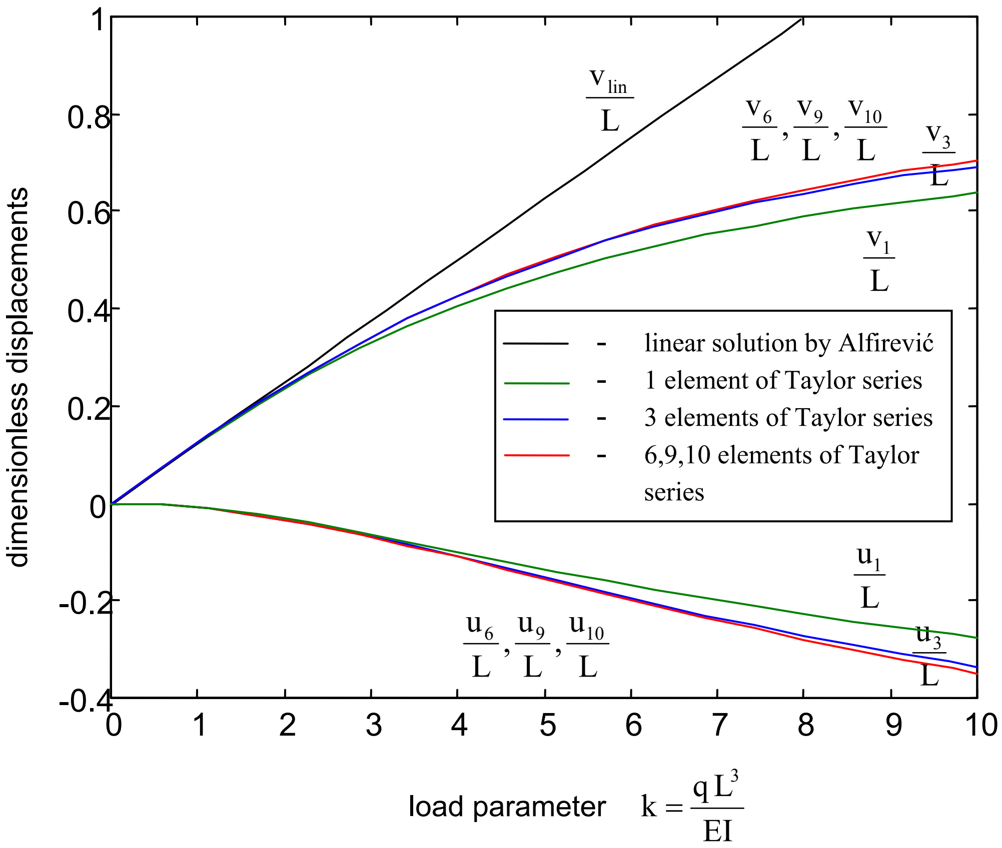

Figure 1. Comparison of analytical solutions of a cantilever beam subjected to large displacement due to uniformly distributed load towards number elements of Taylor series

Table 2. The comparison, of analytical solutions for large displacement of a cantilever beam due to uniformly distributed load towards number members of Taylor series

	Number elements of Taylor series				
	n=1	**n=3**	**n=6**	**n=9**	**n=10**
k Load parameter	4.00000	4.00000	4.00000	4.00000	4.00000
v Vertical displacement	0.405652	0.425884	0.425129	0.425131	0.425131
Number of exact decimal digits	1	3	4	6	6

Analytical solutions of large displacements of a cantilever beam with a uniformly distributed load are compared with number elements of Taylor series . For load parameter k=4.00000, analytical solutions of cantilever beam with a uniformly distributed load for ten and one elements of Taylor series analytical solutions are identical up to one decimal digit. For ten and three elements of Taylor series, analytical solutions are identical up to three decimal digits. For ten and six elements of Taylor series, analytical solutions are identical up to four decimal digits. Finally, for ten and nine elements of Taylor series, analytical solutions are identical up to six decimal digits. So, we conclude that Taylor series solution of large displacements of a cantilever beam due to uniformly distributed load, where ten members of Taylor series are calculated , is exact up to six decimal digit and we call it analytical solution.

3. A Comparative Analysis of Methods for Nonlinear Numerical Solutions of a Uniformly Loaded Cantilever Beam Subjected to Large Displacement

We start the analysis with a method that uses a classical stiffness matrix for small displacements.

This method is developed by T. Y. Yung [14]. The present development is based on the assumption that the material is linearly elastic and the displacements are not small in comparison with the length of the beam. The solution procedure includes first formulating the stiffness equations for a beam element based on the small deflection theory, but with the inclusion of effect of axial force, then applying a linearized midpoint tangent incremental approach and coordinate transformation at every step. If the displacements obtained at every step are small with reference to the local coordinates such that the squares of the slope increment are negligible in comparison with unity, the small deflection theory should hold.

A simple beam element is developed for the solution of large deflection problems by Lothar Haefner and Kaspar J. Willam [8]. The total Lagrangian formulation is based on the kinematics relations proposed by Reissner for finite rotations and stretching as well as shearing of plane beams.

The third method is developed by K.J. Bathe [3,4]. An updated Lagrangian formulation of a three-dimensional beam element is presented for large displacement and large rotation analysis. The formulations are derived from the continuum mechanics based upon Lagrangian incremental equilibrium equations. The beam elements are assumed straight, and the conventional beam displacement functions are employed to express the displacements of the elements in convicted coordinates. The element has been implemented for use in elastic, elastic-plastic, static, and dynamic analysis.

Analysis is performed on a cantilever beam with a uniformly distributed load. The numerical solutions obtained for all methods are compared with exact analytical solutions by Rohde [14]. In addition, in all analyses shear deformations are neglected.

A cantilever beam subjected to a uniformly distributed load was analyzed together with the results for vertical and horizontal displacements of the free end shown and in Figure3.1.

The results obtained for all numerical methods compared with the analytical solutions.

Analysis of the Bathe and Haefner methods for determining large displacements of a cantilever beam reveals a variance of between 0% and 1.5% measured against the analytical solutions. Young's method results in a difference in the range of 0% to 3% compared with the analytical solutions.

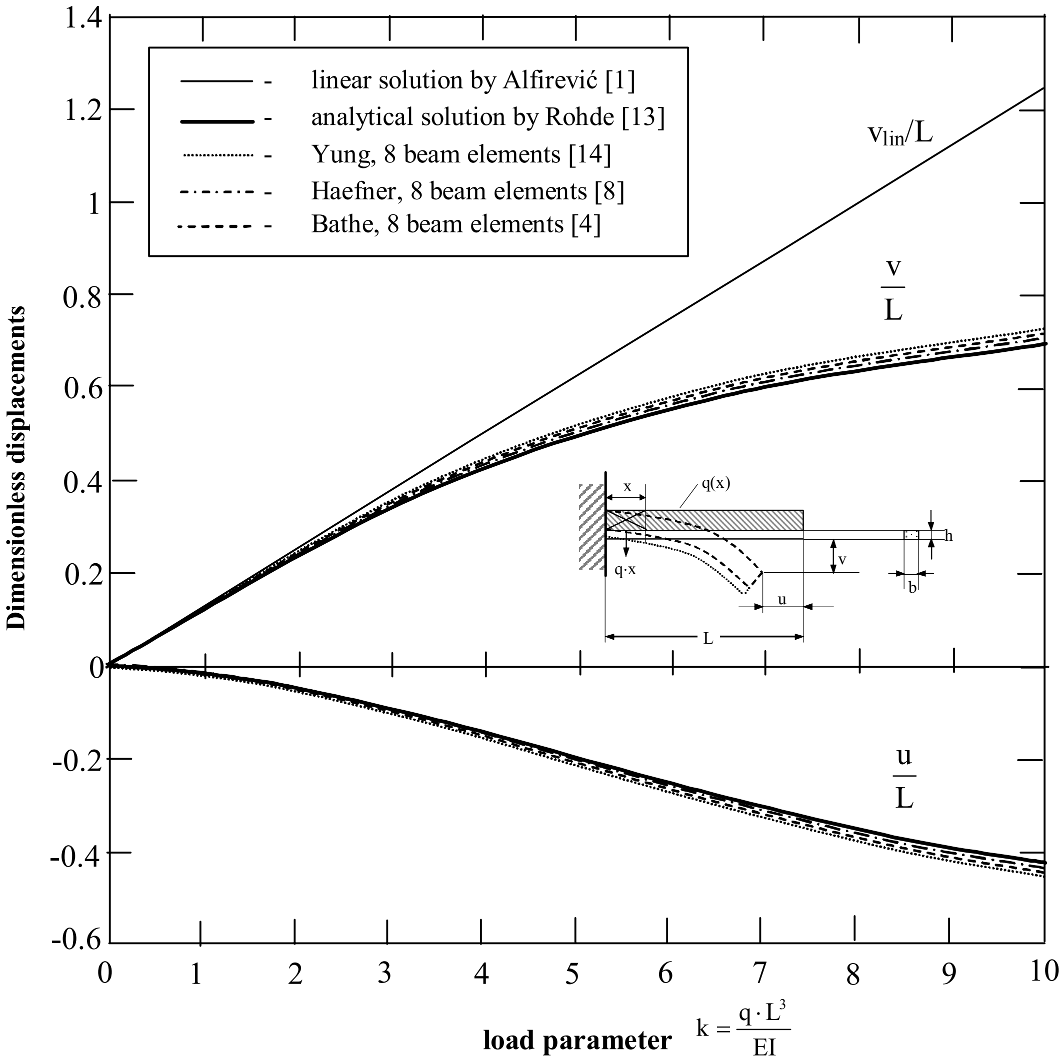

Figure 2. Large displacement analysis of a cantilever beam subjected to a uniformly distributed load

4. Conclusion

Nonlinear numerical analysis was performed on a cantilever beam with a uniformly distributed load. The results obtained for all numerical methods are compared with the analytical solutions. The **numerical methods** are compared against each other, using criteria of **accuracy**, **reliability**, and **numerical efficiency**. The analyzed examples show that the numerical solution obtained by these methods converge monotonically towards an exact analytical solution.

For discretisation with eight beam elements, in respect of the finite element mesh, the methods used by **Bathe** [3,4] and **Haefner** [8], followed by **Yung** [14] correspond most closely to the analytical solution. The results for large displacements of a cantilever beam with a uniformly distributed load in terms of numeral iterations are most closely aligned to the analytical solution by method of Bathe, followed by the procedures of **Yung**, and then **Haefner**. Therefore the **Bathe** method is more efficient than the methods used by **Haefne**r and **Yung**.

The methods employed by **Bath**e and **Haefner** are based upon the full **Newton-Raphson** method for solving nonlinear problems. The **Yung** method is based upon incremental loads, and has not removed control error. To reduce of the error it is necessary to repeat the process with other incremental loads. To summarize, the methods adopted by **Bathe** and by **Haefner** are extremely reliable, while the **Yung** method is less reliable. Measured against the criteria of accuracy, reliability and numerical efficiency the **K.J. Bathe** method provides the best results.

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A SIMPLIFIED FEM MODEL OF A COMPLEX FRANCIS TURBINE GEOMETRY USED FOR THE STRESS REDUCTION EVALUATION

L. Krstulović-Opara, Ž. Domazet and D. Franičević

Abstract

When using numerical modeling techniques, the evaluation of stress reduction strategies for complex geometries, e.g. the Francis turbine of the reversible hydropower plant, requires enormous computing capabilities. Such geometries based on the higher order curves and surfaces can only be modeled by CAD program packages. Importing geometries to numerical packages based on FEM or BEM approaches, requires some simplifications described in the presented paper. The stress reduction strategy, applied on ruptured turbine rotor, is modeled by axisymmetric FEM model and obtained results are presented herein.

Keywords: FEM, BEM, Francis turbine

1. Introduction

Complex geometries, such as the turbine rotor of a 155 MW reversible hydropower plant is, can't be modeled directly in FEM (Finite Element Method) or BEM (Boundary Element Method) by using the pre-processing facilities available in majority of commercial codes. These geometries, with surfaces and edges based on the higher order polynomials, such as nurbs and splines [1], can only be modeled in CAD (Computer Aided Design) packages, e.g. ProE (Pro/ENGINEER, http://www.ptc.com). Importing geometries from the CAD packages, into the FEM or BEM packages, often causes incompatibilities what is not the case for geometries based on primitive surfaces (plane, cylinder, sphere).

Modeling a stress distribution requires vast number of elements when a FEM approach is used. Stress concentrations around corners and joints require high mesh densities in the neighborhood of these zones. Increasing the mesh density in the 3D simulations leads to the enormous number of DOF's (degrees of freedom), what requires processing on high performance computers (i.e., a common PC can't satisfy such requirements). Reducing the 3D problems to the 2D case (plane strain, plane stress or axisymmetric) significantly reduces computing requirements, enables meshes with high number of elements and results in a more precise description of the stress distribution. As the 3D mesh sometimes can't be avoided (e.g. due to the complexity of the problem, non uniform loadings or modal analysis) computational limits require analysis performed on simplified 2D model. Transforming results from 3D model (i.e., the loading as the input variables) to the 2D model, requires particular attention, which is going to be illustrated on the turbine simulation presented herein.

The main goal of the research was to calculate the percentage of stress reduction achieved after the reparatory welding together with the changes in the blade geometry.

2. The turbine rupture and the repair

The 14.8 tons Franics turbine characterized by the 155 MW of maximum power, 600 rpm, and flow of 20.5 m^3/min, was seriously damaged due to the fracture propagation that appeared on 4 of 7 blades . All ruptures started in the same region (Figure 1), what excludes the production defects of the cast X3CrNi 13.4 alloy as the cause of rupture. To reduce the stress concentration in the region of crack initialization, during the welding reparatory works (performed by the SALONA VAR d.o.o., http://www.salonavar.hr together with the BRODOSPLIT shipyard machining facilities), the curvature radius was increased in the region where crack started (Figure 2). The stress reduction in the crack initialization zones, achieved by the reparative works, is presented in the text below.

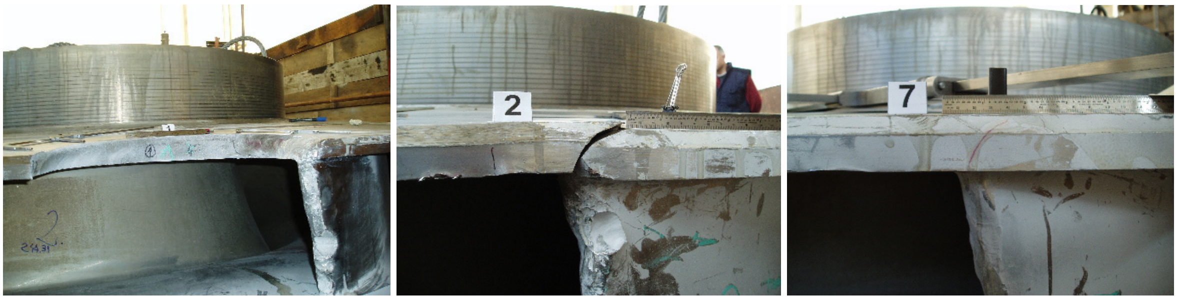

Figure 1. The turbine rupture

Figure 2. The welding repair and the changes in geometry by increasing the curvature radius

3. The CAD model

The complex geometry of the turbine rotor could only be modeled by using the CAD software, such as the ProE. The geometry was later imported to the FEM (ADINA, http://www.adina.com) and BEM packages (BEASY, http://www.beasy.com , not presented in this paper). The 3D body geometry created by the ProE was used for the geometry definition of the 3D FEM analysis in ADINA. Results from the 3D FEM model (stress distribution, deformation, reaction, modal analysis, etc.) were used as the input loading of the 2D model. The 2D model enabled a precise description of the stress distribution in the region where crack started. As well as the 3D, the 2D geometry was modeled in the ProE by cross sectioning the original geometry (Figure 3). The results from the 3D FEM analysis (loading), were also used to model the 2D fracture propagation within the BEM package BEASY (not presented herein).

As commercial BEM packages are not highly developed, as more common FEM packages, the 3D BEM models are often reduced to the simpler 3D geometries where nurbs surfaces are simplified by more primitive surfaces. In this particular case the simplification of geometry will not lead to the acceptable model and results. Therefore, the 2D axisymmetric BEM fracture propagation model was used together with the loading obtained from the 3D FEM model.

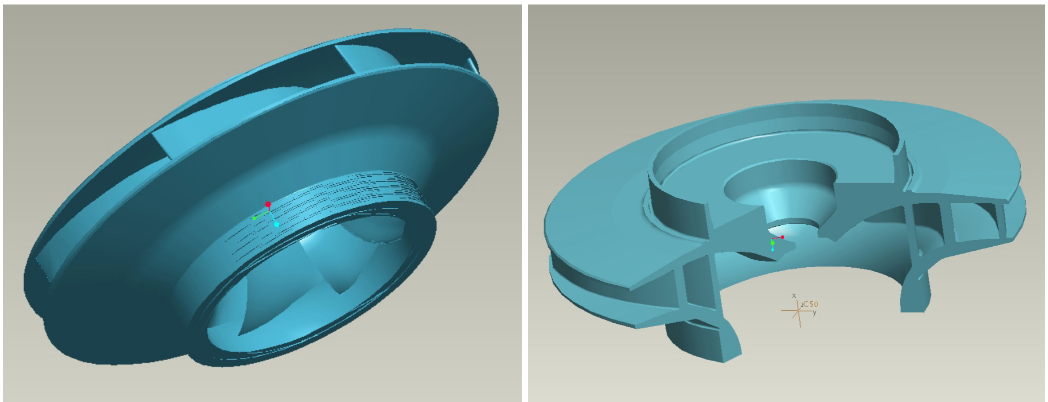

Figure 3. The 3D body and cross sectioning of the 3D body (modeled in the ProE)

4. The 3D FEM analysis

The 3D CAD geometry was imported (IGES format) to the FEM package ADINA. The turbine was modeled by using the 4 nodes tetrahedral elements (481349 elements, 107635 nodes, 322905 degrees of freedom and total solution time of 1179 s), the free form - Delaunay automatic mesh generation and the linear elastic material model [2].

The modal analysis (Figure 4) showed that the possible cause of rupture couldn't be vibrations at natural frequencies (72 Hz, 82 Hz, 83 Hz, 102 Hz, 138 Hz, etc.). The mode shapes showed that vibrations at natural frequencies are not causing crack opening scenarios for regions where rupture occurred. The turbine was modeled at the working regime of 600 rpm, where each of seven blades was loaded by 1/7 of the full power.

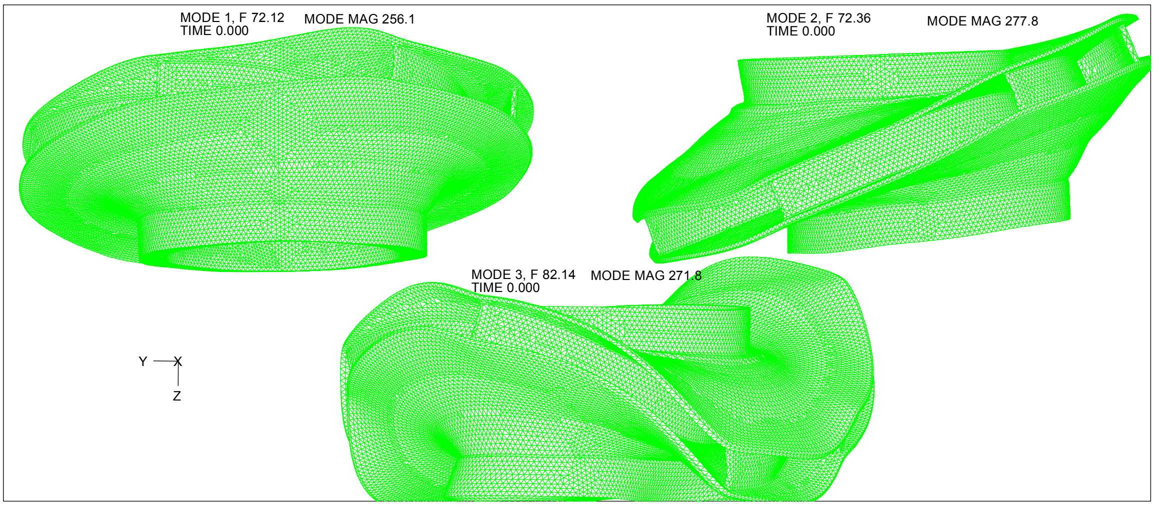

Figure 4. The modal shapes and the natural frequencies

The analysis showed that the most critical case of turbine loading is the rotation of the dry turbine at 900 rpm (centrifugal loading and gravity). This is the case that occurs during the startup in the pump regime of the reversible Franics turbine. This is performed by drying the turbine (with compressed air), spinning at 900 rpm, connecting the generator to the electrical power system and opening the water valves. This process is characterized by significant vibrations resulting from non uniform water flow. For such case effective stress calculations showed the concentration of stresses exactly at the points where the cracks started. Figure 5 shows the region of outer blade edge. Figures are obtained as the radial cross sections in the consequent circular cuts around the blade's outer edge.

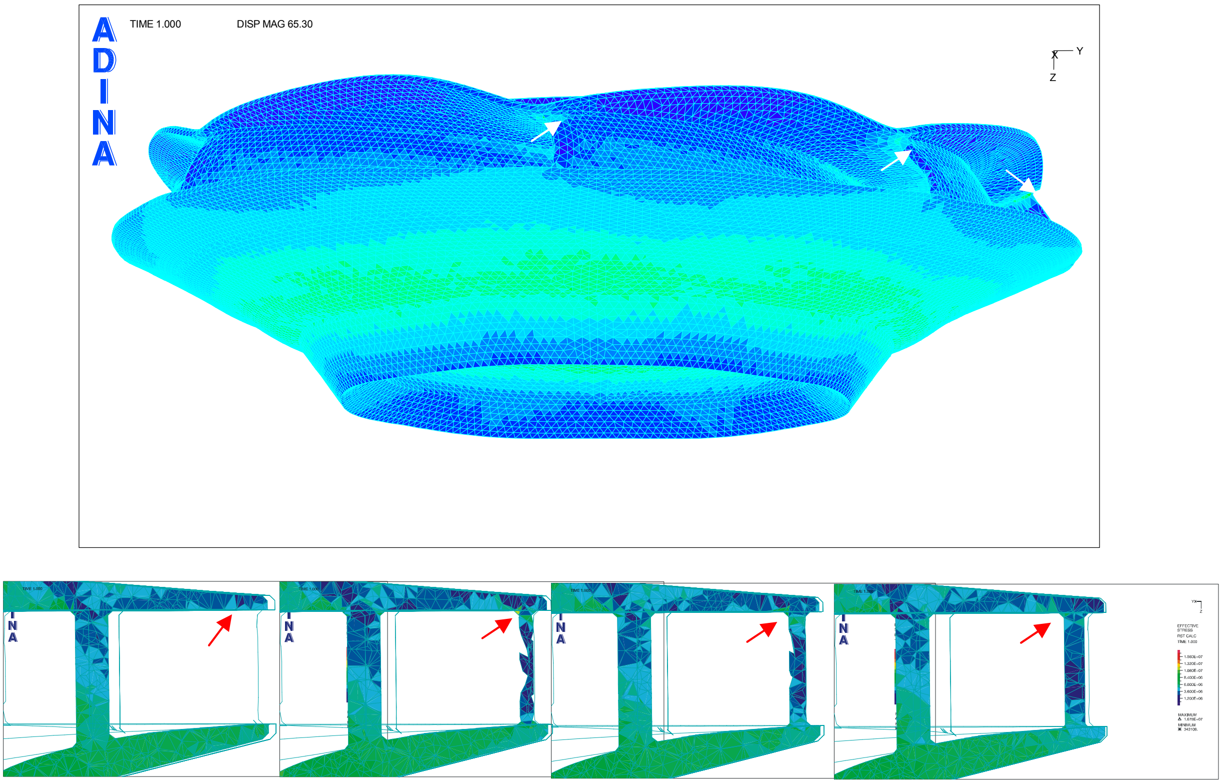

Figure 5. The effective stress distribution around the blade's edge

5. The 2D FEM analysis

As a more precise analysis of the stress distribution in the zones where crack appeared was not possible due to the computation limits, the precise stress distribution was modeled as the 2D case. Modeling the turbine as a plane strain problem will give a good approximation of the real 3D case, but applying loadings (displacements) from the 3D model is hardly possible. As the most critical case is the pure centrifugal loading, the 2D axisymmetric model represents an acceptable approximation of the 3D case. For this particular model problem appears due to the fact that the radial stiffness of blades cannot be modeled in axisymmetric plane. If the 2D axisymmetric turbine is loaded with 900 rpm, due to the lack of radial blade stiffness, the response will be wrong. Therefore the load has to be reduced (from 900 rpm to 76 rpm). The reduced load is evaluated by comparing the effective stress distribution and deformed shape of the 3D and the 2D axisymmetric case (Figure 6).

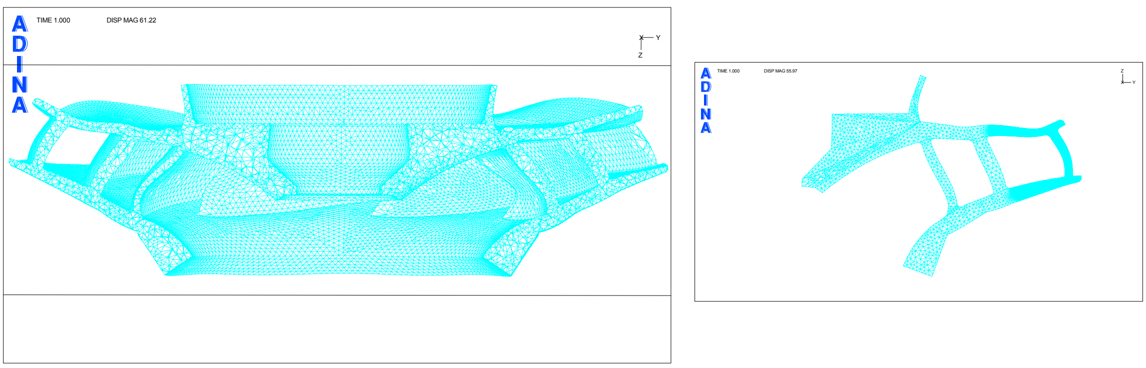

Figure 6. The 3D and the 2D axisymmetric FEM model

The 2D axisymmetric turbine is modeled by using the 6 node triangular isoparamteric finite elements (40623 elements, 82889 nodes, 165778 degrees of freedom and total solution time of 19 s), free form - Delaunay automatic mesh generation and linear elastic material model [2].

The effective stress distribution for the zone where crack started, in the case of the curvature radius R6 mm and R20 mm, is depicted in Figure 7.

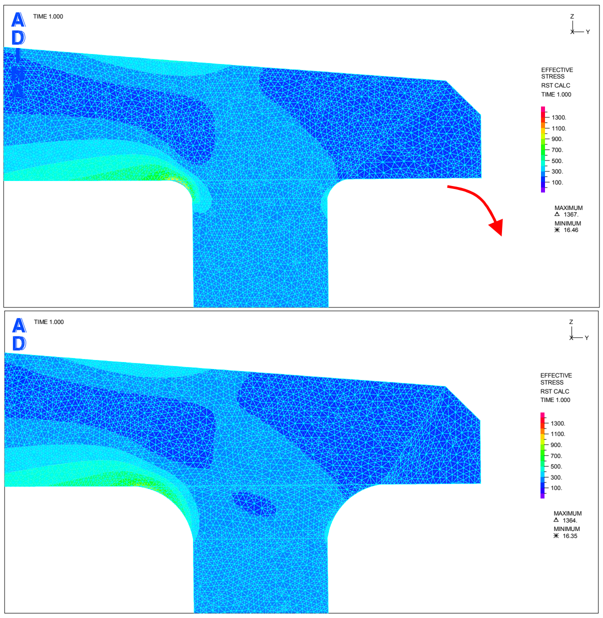

Figure 7. The effective stress distribution for the curvature of R6mm and R20mm

The diagrams in Figure 8 show effective stress distribution for the nodes along the straight white dashed line in Figure 7, and on the curvature surface (the red curved line in Figure7).

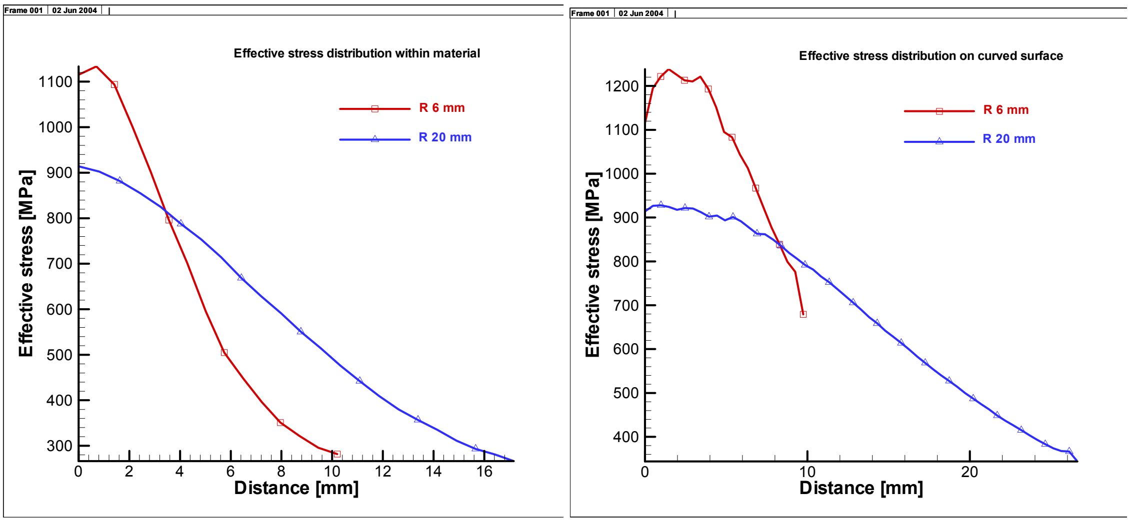

Figure 8. The effective stress distribution along the surface and across the material

When comparing results for both cases, the stress reduction of 26 % is achieved after increasing the curvature radius from 6 to 20 mm. The distance in Figure 8 is measured according to the arrow direction in Figure 7.

6. Conclusion

The presented paper concerns two main topics, the modeling of complex geometries and the stress concentration reduction for the case of ruptured Francis turbine rotor.

The needs for simplifications in modeling the complex geometries requires simplifications from the 3D to the 2D models. The link between these models is hardly achievable. For the particular example of the complex turbine geometry it is described how results from the 3D model could be approximated by the 2D axisymmetric model. The reduction of code size and evaluation time (from 322905 DOFs to 165778 DOFs, and from the total solution time of 1179 s to 19 s) enables modeling of stress distribution in regions that could not be modeled using the 3D model.

The welding reparative works included changes in turbine geometry, i.e. the curvature of the region where crack started has been increased. This curvature smoothing enabled the 26% reduction of effective stress for the region where crack started. Although the stress intensity factor K can be calculated within the ADINA, the factor K has been calculated by using the BEM software BEASY as more appropriate method for obtaining the fracture propagation simulation. The BEM model and obtained results are not described in this paper.

Acknowledgement

The collaboration with SALONA VAR d.o.o. - welding expert company (http://www.salonavar.hr), which significantly contributed this work, is gratefully acknowledged.

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THE VON KARMAN – GABRIELLI DIAGRAM ANALISE FOR THE PURPOSE OF CHOOSING THE DIRECTION OF THE NEW FORM SHIP DESIGN IN CROATIAN SHIPBUILDING

R. Markovina and D. Marasović

Abstract

The paper presents the analytical review on the Von Karman – Gabrielli diagram for the different vehicles (and L/D: v; or W/T: v relations), as the diagram of force weight relations to vehicle's speed (P/W: v) related to "technological line" of today's vehicles possibilities. Namely, the domain of optimal relations force weight to speed is determined, and the domain of efficacious activities of a different "new generation vehicles", applicable in Croatian shipbuilding, i.e., the domain in which there is a chance to do research work in new vehicles design. At the end, some new design of vehicles is presented either in classical or new forms, which, according to the Von Karman – Gabrielli diagram, could be successfully developed and designed in Croatian shipbuilding.

Keywords: technological line, classical form ship, new form vehicles, development, design, Croatian shipbuilding

1. Introduction

It is well known that Croatian shipbuilding produces great value capital vessels which have a strong influence on Croatian industry, citizens' standard and social situation, and as an export industry plays a positive role in the trade balance of Republic of Croatia. Croatian shipbuilding is, also, a generator of its metal industry development and the different products of other industries are incorporated in its final products, together with knowledge, works and services. Also, the Croatian shipbuilding has a direct influence on the economic life as a whole and it is Croatia's strategic industry. It is a profitable basic industry, and it has a chance to be competitive in the world taking into consideration its new owners, new organisation, technological modernisation, business rationalisation and… new-sophisticated projects.

2. Today's position of transport vehicles

Today's transport of goods and passengers has three principal characteristics:

- fastness,
- security, and
- comfort ability.

From this point of view, the existing forms of vehicles have to be divided in several categories:

- displacement ships,
- semi-displacement ships,
- planning ships,
- hydrofoil assisted ships,
- hydrofoil boats,

- air cavity vessels,
- SES (surface effect ships),
- air cushion vehicle,
- Wing -In -Ground effect vehicle, or
- Ekranoplans.

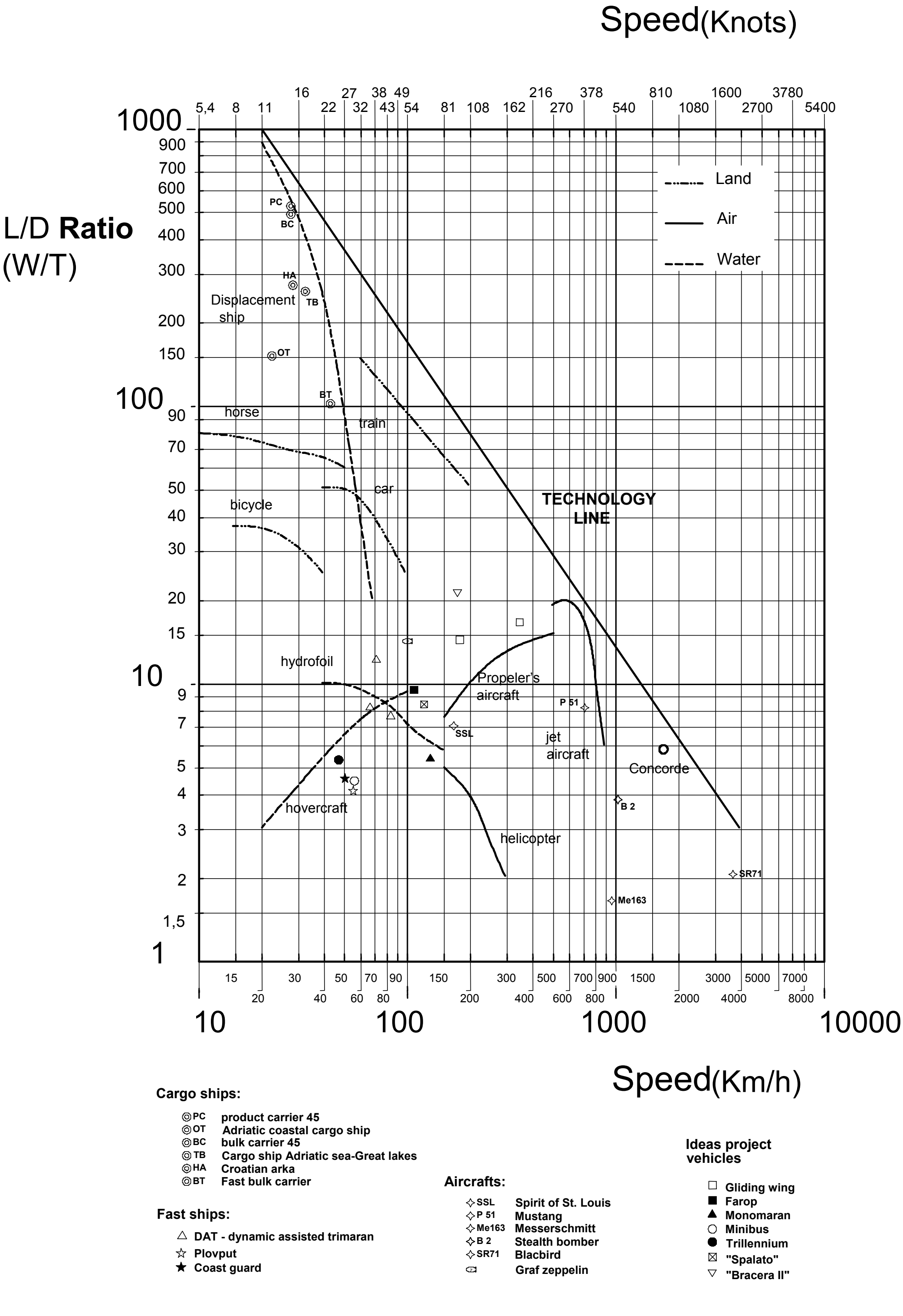

Figure 1. Modificated Von Karman – Gabrielli diagram

To correctly present an actual state of the utilization of vehicles it is useful to start with the Von Karman – Gabrielli diagram [6], modified by authors, in which it is possible to see the domain of the some actual idea project vessels, and its place between actual seagoing and aircraft projects, presented in Fig.1.

This diagram shows the ratio *L/D* (buoyancy and resistance) to *v* (speed), and it can be taken as *W/T* (weight and propulsion force) to *v* (speed) of vehicle, starting from bicycle and displacement ships, over air cushion vessels, automobile, aircrafts and helicopters up to "Concorde". The speed is presented in km/h and in knots calculated by authors. In that diagram, the TECHNOLOGY LINE is marked, i.e. the limit line of actual technological transport vehicles possibility. It is a task of new generation of naval architects, designers and constructors of new vehicles of the 21st century to shift this technology line more "to the right".

Namely, the technical and technological development, research of new building materials, engines, production resources, and ideas, based on actual results of aircraft industry is a warranty for these hypotheses.

By analysing considerately Von Karman – Gabrielli diagram, a triangle area "A" can be seen in the central quadrant, under technology line, in which there are no domain of actual transport vehicles, and also that the domain responds to the speeds *v = 50 to 250* knots, and relation *L/D (or W/T) =15 to 50,* as is shown on Fig. 2.

In this domain in diagram there is a space to research an efficacy of new speed and high speed vessels, i.e. the vessels of new generation, as well as a WIG – effect vessels and ekranoplans.

[L/D is relation of buoyancy and resistance, because in stationary flight the weight is equal buoyancy, and propulsion force is equal resistance, than L/D is equal W/T, i.e. the relation of weight and propulsion force. At the big flying vehicles L/D is about 20, and at smallest is about 15].

"A" The detached domain of research

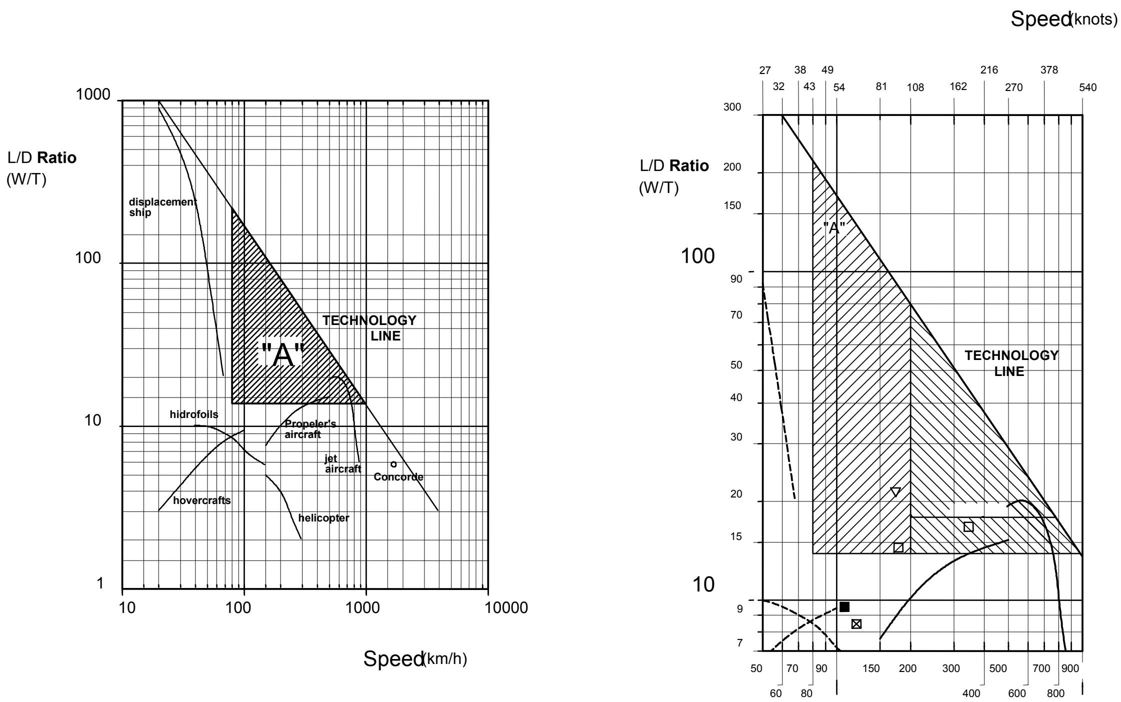

Figure 2. The detached domain «A» of Von Karman – Gabrielli diagram

Regarding today's transport speed, there are vehicles up to 250 km/h or 135 knots, but they are not used for group- transport, and are in the function of short relations transport. At longer distances, they are no acceptable, because their cruise speed is limited to 100 km/h or 54 knots, which is a minimum speed of ekranoplans. Using the high – speed vessels, and WIG – effect vehicles - ekranoplans, for passenger transport, the crossed road can be increased up to fourth times for the same period of time, regarding the fact that a magnitude of speed in domain "A" on Von Karman – Gabrielli diagram corresponds just to these requirements. Their advantage over other vehicles would be in possibility of rising in the air and descending without classical runway, but a disadvantage would be a restricted use on great lakes, at coastal regions, with numerous islands nearby, and there where big waves are produced.

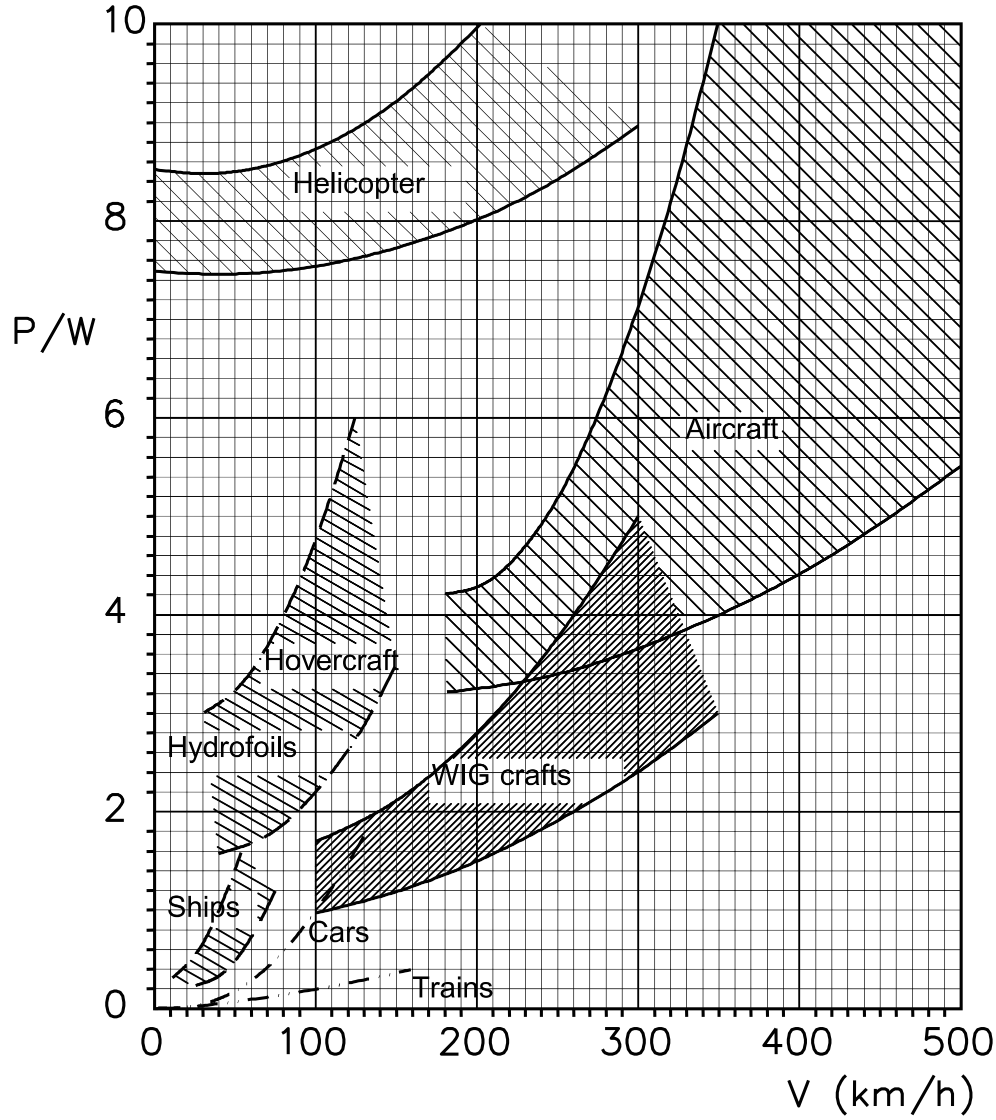

Figure 3. The power and weight ratio to speed diagram of up to date build vehicles

The ratio *P/W (*power and weight) to *v* (speed) diagram, regarding typical groups of existing vehicles is shown on Fig. 3 [6], and Fig. 4 [6], shows only its part, i.e. a space between the ships, hydrofoil boats, air cushion vehicles and ekranoplans, marked as "B", in which domain a positioning of new generation vessels are expected, regarding ratio of *P/W* to *v*, and in which area the next research and development forces have to be concentrated.
(In Fig.3 and Fig.4 ratio P/W is normalised, car at 100 km/h = 1)

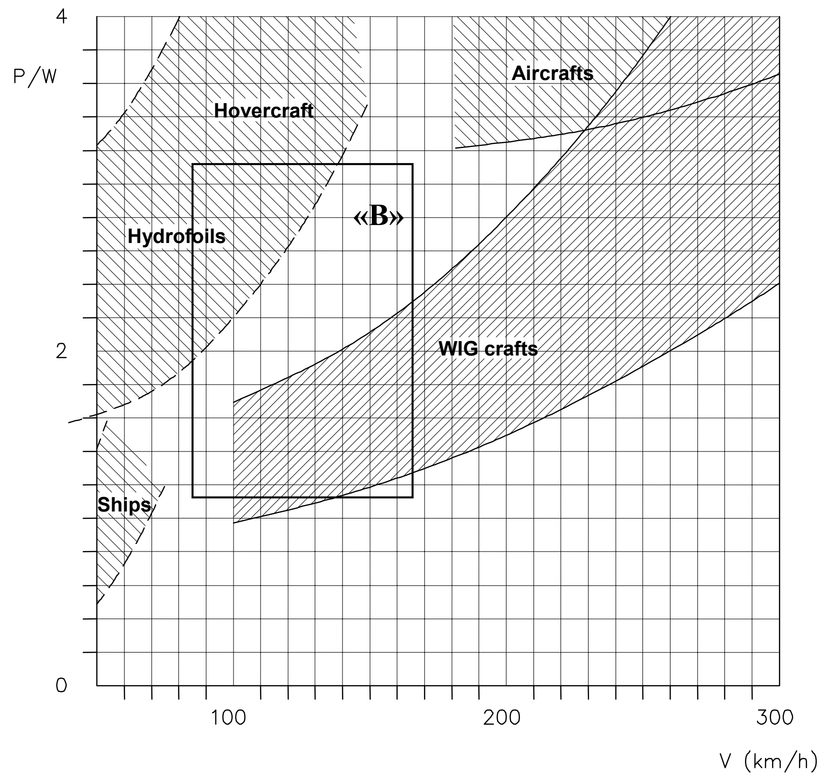

Figure 4. The detached domain of power and weight ratio as a function of speed diagram for the new research

[P/W is a ratio of power and weight, where the efficacy of vehicles is presented by a quantity of consumed fuel per passenger and per one km, and is proportional to inverse number of transport efficacy TE, which is determined as product of L/D and the vehicle's speed)

3. A possible Croatian shipbuilding response

The Croatian shipbuilding, if it wants to keep pace with advanced shipbuilding and naval architect world has to orientate itself, as soon as possible, to designing and building of high sophisticated vessels and high – speed vehicles, which presupposes:

- another organisation,
- technological modernisation,
- production augmentation,
- cost controlling in each phase of production,
- entering into partnership at the State level,
- animating and stimulating research, innovations and education,
- production based on knowledge and science,
- partnership relations with sub- contractors and other suppliers, based on communal product,
- new sophisticated final products, and a high – speed vessels,
- greater volume of production for Croatian shipping companies etc.

Some preliminary project solutions are presented in the following figures.

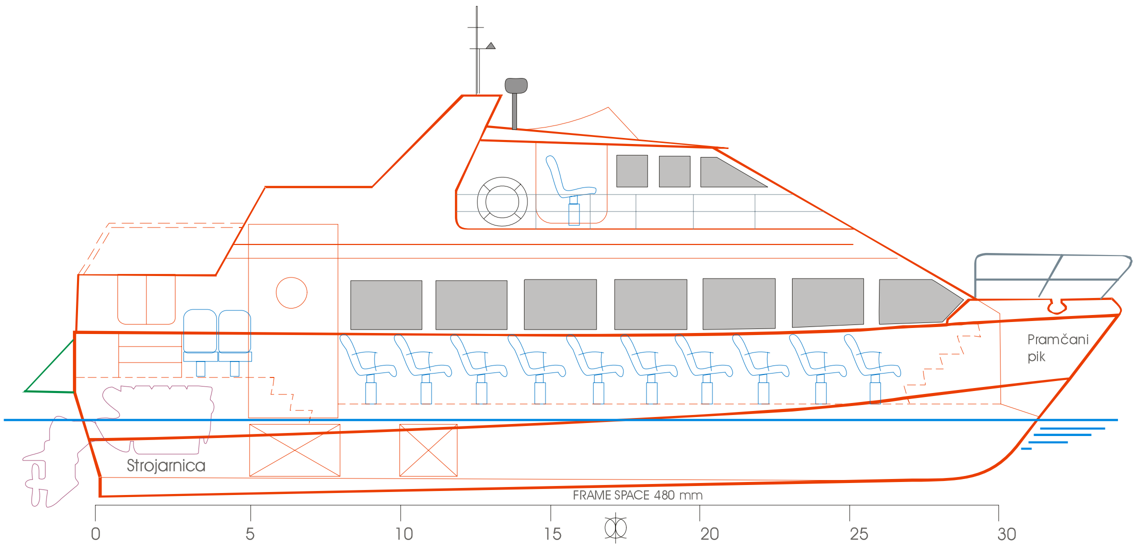

Figure 5. "SEA-MINIBUSS"- (the sea-buss [4], idea-project of Prof. R. Markovina, Ph.D.nav.arch. from Split and I. Lipanović, nav. arch. from Lumbarda - island Korčula (speed 25 – 28 knots, MONO-HULL)

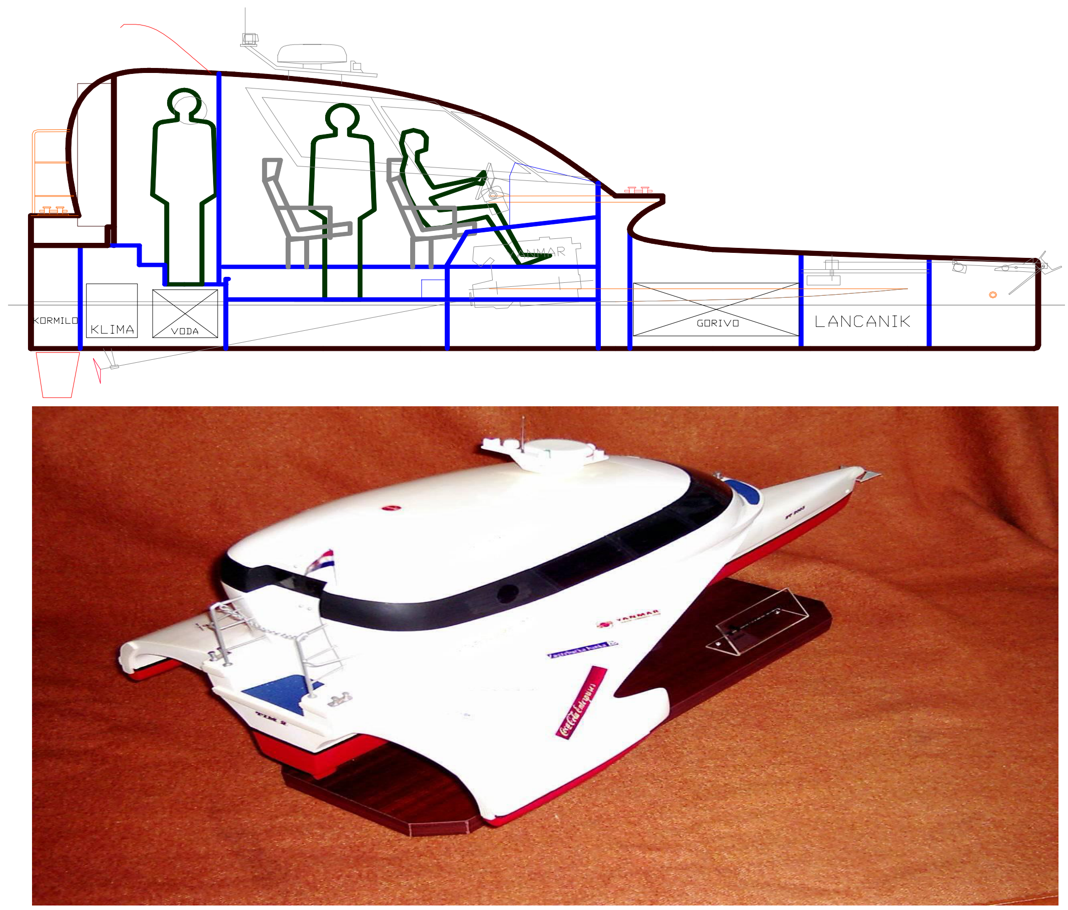

Figure 6. "TRILLENNIUM 8000", (sea car, idea project of G. Čurin, B.Sc nav.arch. from Split, speed 22 – 25 knots, small TRIPLE-HULL)

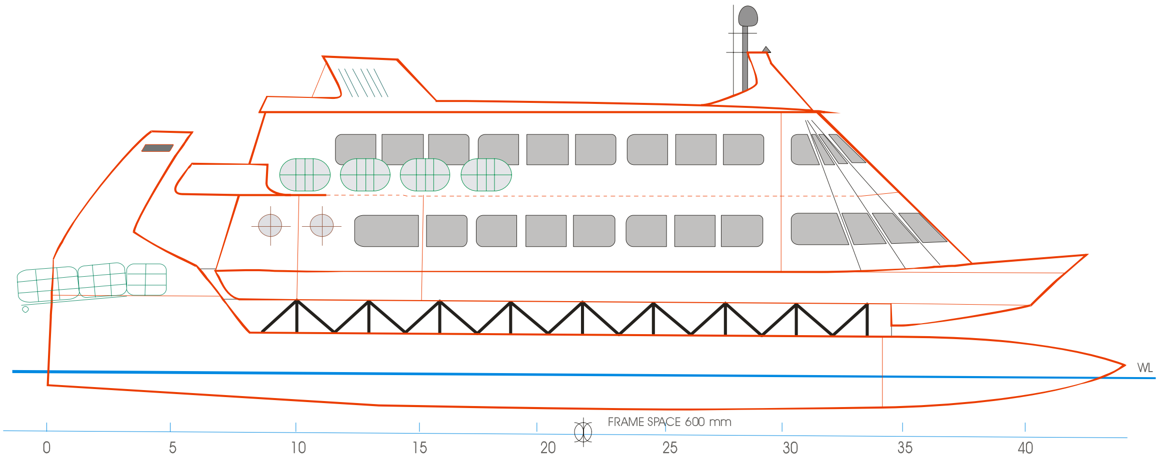

Figure 7. "FAROP", – catamaran with superstructure on stable amortising field [1], idea project F. Dizdarević, B.Sc.air.constr. – USA and Prof, R. Markovina, Ph.D.from Split (speed: 35 do 60 knots, MONO-HULL, TWIN-HULL, TRIPLE-HULL)

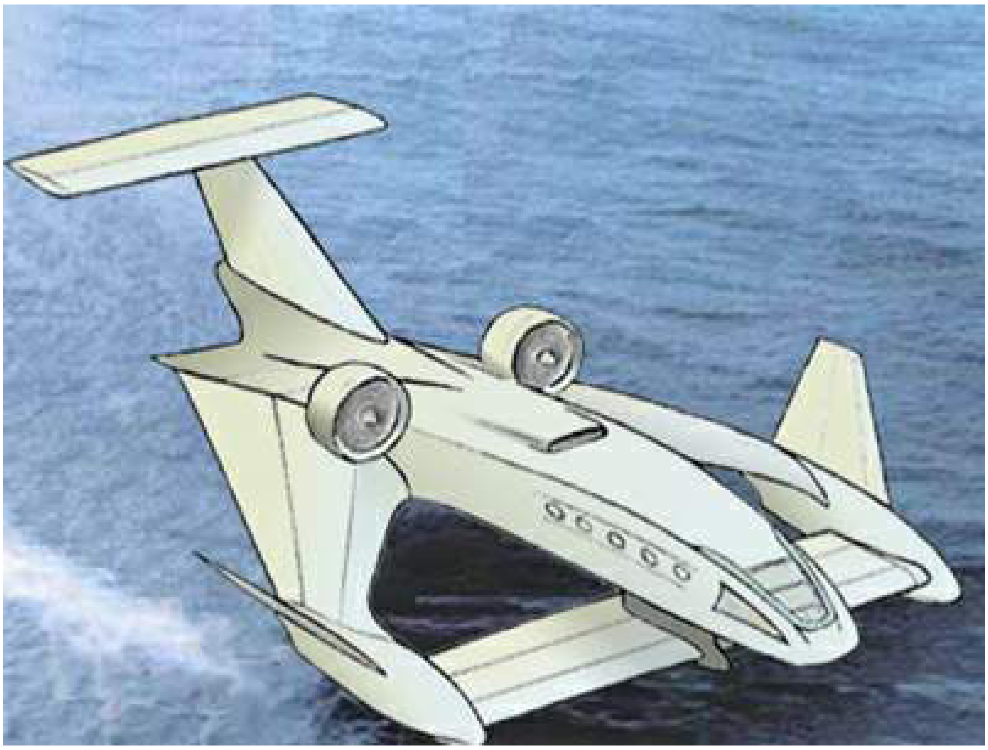

Figure 8. « BRACERA II» - vehicle for transport of 20 passengers, idea project D. Marasović, Bc.S. from Split (speed about 120 knots, EKRANOPLAN)

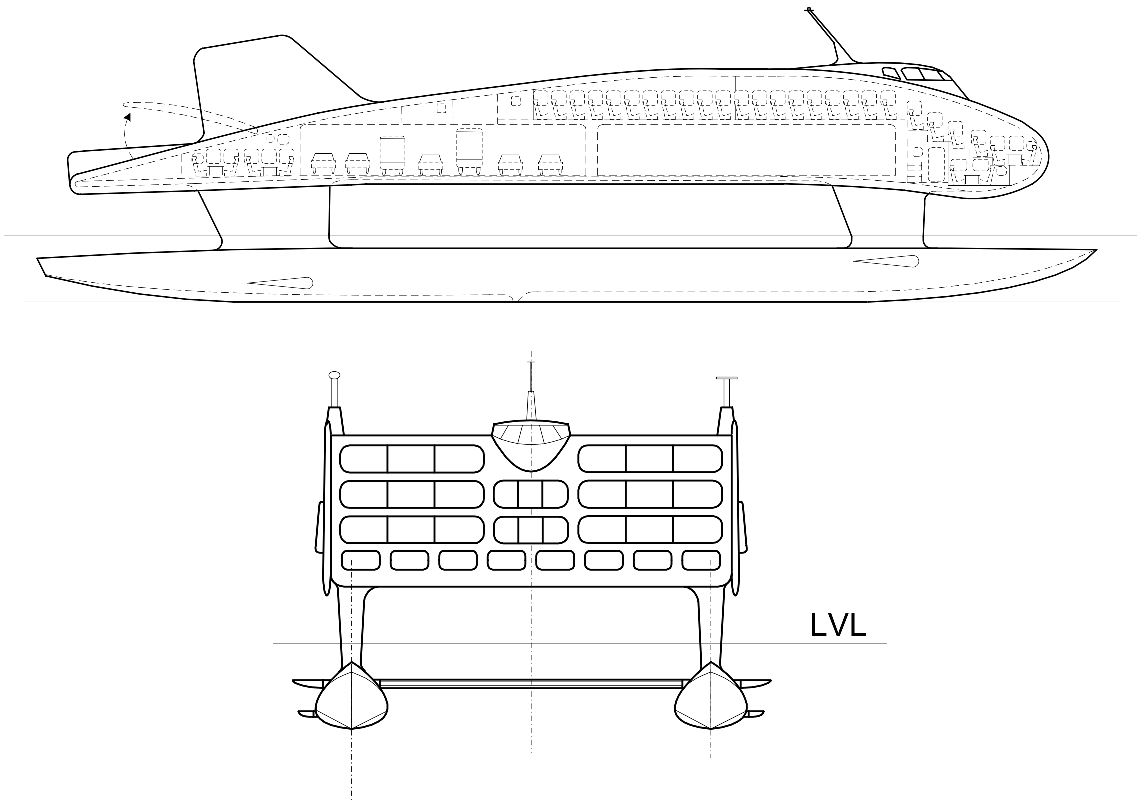

Figure 9. “GLIDING WING”, variant SPALATO [3], (idea project Prof. R. Markovina, Ph.D. from Split and F. Dizdarević, B.Sc. air.constr. – USA, which in the first version would have a speed about 60 – 80 knots, without WIG – effect, bat in the second version a speed about 80 - 120 knots, with possibility of flying by WIG- effect, TWIN-HULL and/or TRIPLE-HULL)

On the base of presented super high speed idea projects of vehicles [1], several years ago some research about Adriatic and Mediterranean needs for high speed passenger transport [4], as conversion actual “white fleet” was done , and the results is present in Table 1.

One of possible sophisticated project, which Croatian shipbuilding could be design and offer in world shipping market, as concurrent homemade product is SHIP FOR WASTE BEARING, which is today in Croatian coastal and islands towns actual, and Mediterranean to, with high ecological performances. There are, also, a nice sophisticate floating objects design like FLOATING RESTAURANT, FLOATING APPARTMENTS, FLOATING PARKINGS, FLOATING HOTEL etc.

Croatian shipbuilding has needs and possibilities to start with these very sophisticated projects, as the new projects of super high speed vessels, which would have a market, and which would be very useful both for local people and for tourists [2]. The first step is reanimation of the research function, which actually does not exist, bringing together actors in naval architecture science and starting with projects design, working parallelly on shipyards’ restructuring, application of new materials and modern technologies, and finally on technological modernisation.

In this sense we propose the following:

1. Croatian shipbuilding has to be reconstructed on the basis of decreasing total production costs, especially ensuring business efficacy in the non favourable market conditions, which, in shipbuilding industry, changes cyclically (recession) and with continuous increase in efficacy of all essential functions of production process.

Table 1. Results of research of needs for high-speed passenger transport in Adriatic and Mediterranean coast

No.	Characteristic	Type 1 Sea-minibus	Type2 Farop- amort.superstr.	Type3 Gliding wing – “Spalato”
1.	Number of hulls	Mono-hull	twin-hull	twin-hull
2.	Number of passengers	60 – 80	150 – 200	300 – 400
3.	Speed	20 – 25 knots	25 – 35 knots	40 – 60 knots
4.	100% year efficiency.	10 months	8 months	10 months
5.	60 % year efficiency.	12 months	12 months	12 months
6.	Users	-Island people -Season tourists.	- Island people -Weekend tourists, -Season tourists.	-“Shopping tourists “-Religion” tourists, -Season tourists, -Excursion tourists.
7.	Preliminary needs for Adriatic sea	10 – 12 pcs.	6 pcs.	4 pcs.
8.	Preliminary needs for Mediterranean sea	40 – 50 pcs.	15 – 20 pcs	10 – 15 pcs.
9.	Preliminary price prototype (USA$)	400.000	4,000.000	8,000.000
10.	Preliminary price in series per unit (USA$)	320.000	3,000.000	6,000.000

2. Certain activities, which are not completely shipbuilding, and which could survive on the market have to be separated from shipyard’s system by its own organisation (small and medium), but some parts of its capacity can be placed in shipyard (as partners in building of a ship as common product, with common risk for profit and/or loosing and rest of its capacity could be placed on the market.
3. Croatian shipbuilding, as its Far East and European competitors must have the same conditions provided by the State [5], as:
   - offering on the shipping market the attractive products in form, design, quality, price, payment’s conditions and delivery time,
   - providing the financial resources for our own production with acceptable conditions,
   - modern and acceptable organisation and coordination in ship production, systematically directed to the coasts to ensure a profit, need for existence, research, innovation, development, investments…etc,
   - rational developing of technological and human potentials, needs for competition and surviving on the shipping market,

- introduce well-educated and successful managements for good business policy, with well chosen and qualified collaborators, who would be capable to introduce modern methods and models in shipbuilding process, would support research and development function, would control production process and would create appropriate measure for the realisation of production programs.

4. Conslusion

Von Karman – Gabrielli diagram presents domains in which we could expect the research of a new generation of vehicles under the current technology line.

In modified Von Karman – Gabrielli diagram it is possible to see in which domains of L/D in a function of the speed takes place of some old and current forms of transport vehicles and actual idea projects of the fast ships and the super high speed vehicles.

Croatian shipbuilding as compared with a world competition has some benefits:

- the idea projects for starting the design process of high speed and super high speed vehicles,
- the high quality designers, constructors, science and production people, and other professions in shipbuilding,
- good support institutions in ship design and production in scientific and education areas,
- good quality and recognized product,
- numerous workers (one own's and cooperates) employed,
- good and qualified working power,
- a great and good tradition in shipping market,
- good associate industry (small and medium firms) which have to be developed more than they are today in different domains which shipbuilding industry needs.

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ANALYSIS OF DRIVE REGULATION IMPACT ON CRANE LOAD MOVEMENT

P. Muratović and F. Islamović

Abstract

Aim of this paper is dynamic load impact analysis of regulation and automation of drive mechanism for reach shifting. Calculation of each machine system implies mathematical analysis intending to reduce inevitable model simplifications and negligence. Cranes, that are in operations without stationary states, range of dynamic loads could be determined only using dynamic analysis of complex mathematical models. When determining amplitude loads, dynamic analysis of elastic model is necessary.

Model with structural matrix is used for analysis of dynamic load and swinging impact on regulation and automation of rotary cranes drive mechanism for reach shifting.

Keywords: Regulation, drive, Cranes, Model, Reach.

1. Introduction

Recent researches of crane drive automation impact are related to selection of strategy that would be applied during regulation. Aim of this paper is dynamic load impact analysis of regulation and automation of drive mechanism for reach shifting of revolving cranes. The crane is regarded for working cycles with cargo catching, lifting, transferring and unloading.

2. Model definition

In static calculations, impact induced by dynamic loads are taken over dynamic factors that are estimate of expected dynamic effects. Regarding crane assembly that are not exposing stationary states in operation, the answer concerning dynamic loads extent could be reached merely using dynamic analysis of complex mathematical models. Rigid system models are giving answers regarding dynamic loads average course lines, but for analysis of amplitude loads extent, elastic model dynamic analysis is necessary requesting computers of notable capabilities.

For dynamic load impact analysis of regulation and automation of drive mechanism for reach shifting of revolving cranes over their dynamic and load swing, a model with structural matrix is used for describing the conduct of beam or spindle. Figure 1. present diagram derived from crane operation simulation during unloading for one half of working cycle. Elastic parts of construction are indicated with B. Reduced masses and inertial features comprise rigid elements that are connected to elastic parts. The Rope is presented as spring with attenuation.

Simulation of crane operation in time domain is performed with programming system ADAMS using variable load. Rope when lifting the load and winding spindle for changing the reach, are exposed to movements. Simulation is performed for rigid models with adequate movements and models with various elastic components content. Static load analysis for several positions in working area is also performed.

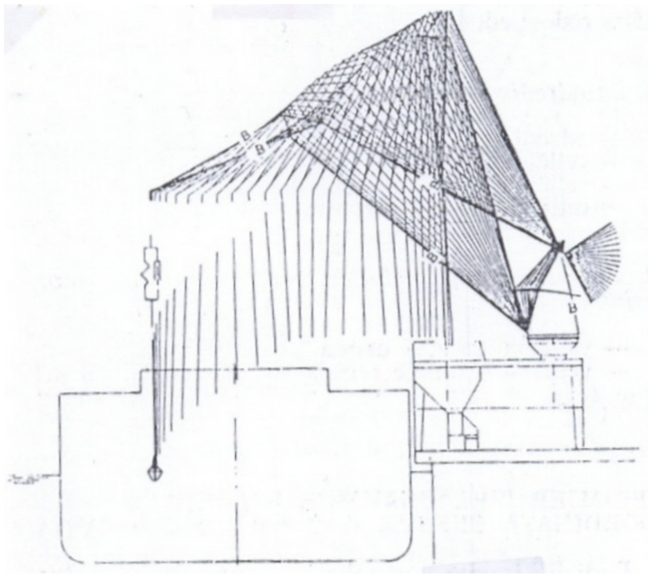


Figure 1. Diagram of crane movements

3. The results of model analysis

Since the model analysis is performed for more possible variants of cranes changing reach and lifting driving set, for rigid and elastic systems with various degrees of freedom, in this paper several characteristic examples are presented.

Simulation of rigid crane system, with load hanging on rope, and driving set for changing the reach is having programmed drive and drive that is analog to asynchronous electric motor driving set. The movement is accomplished from maximal to minimal reach respectively. Diagrams on Figure 2. display path lines of load (code -- 07.3) and cranes boom pike (code – 04.3) for simulations with code 4 – and 6.

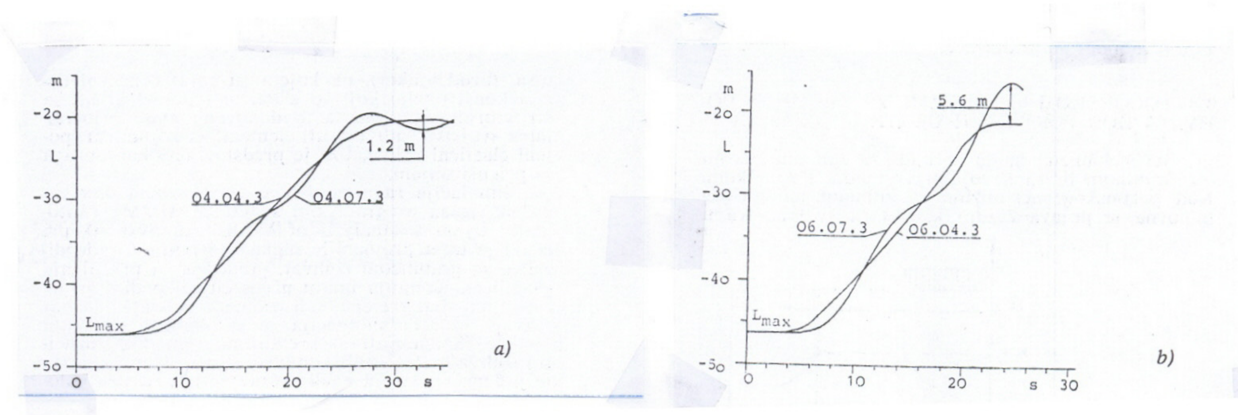


Figure 2. Load and crane boom path line diagrams

As displayed on diagrams, different motions principles of driving set for changing the reach will impose different load swinging as pendulum. When classic electric drive is involved, oscillation amplitudes during breaking phase could extent over 5 meters.

Figure 3. display diagrams of load horizontal moving speed (code --.08.3) and cranes boom pike (code – 05.3).

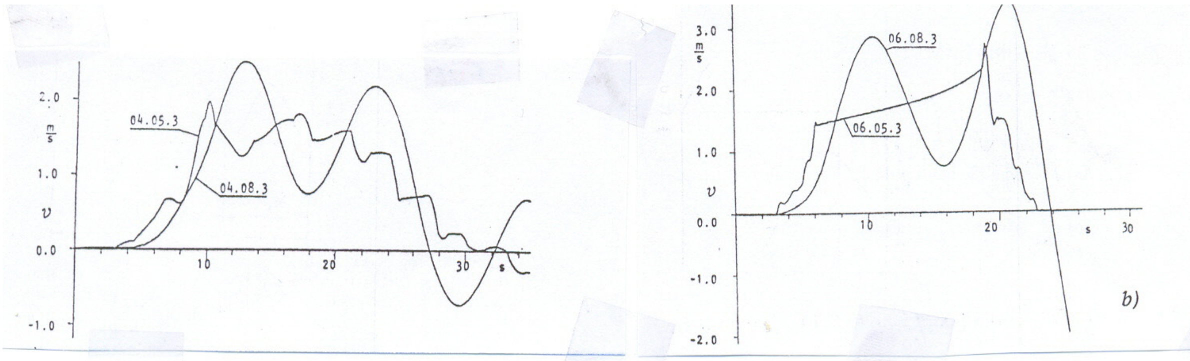
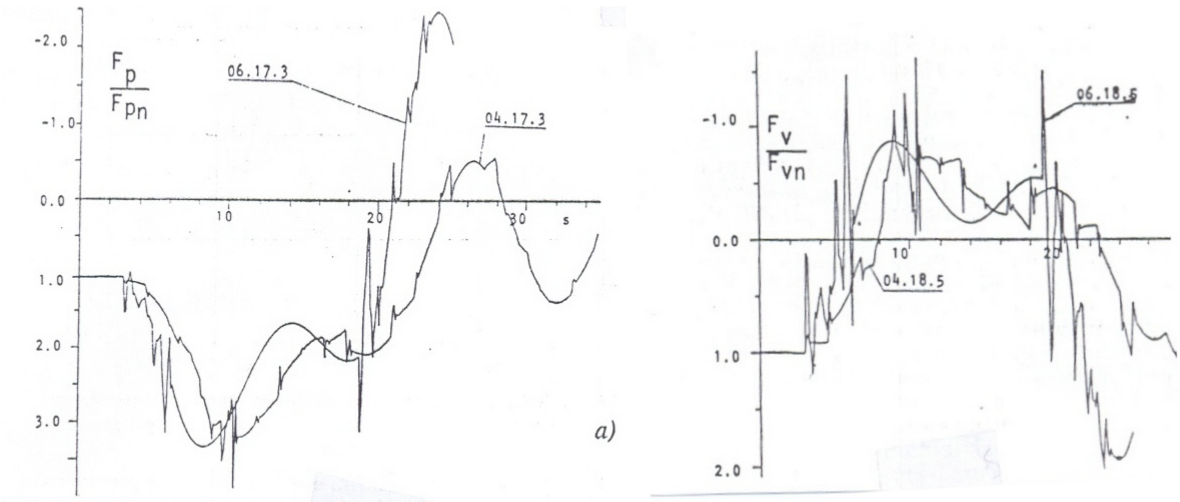


Figure 3. Load horizontal moving speed and booms pike speed diagrams

From booms pike speed diagrams there could be observed speed increase for reduced reach with constant speed of driving set, representing the basic reason for laborious crane manual manipulation. Increase of absolute booms pike speed in a range of reduced load reach, and sudden breaking are inducing loads speed increase during oscillations.

Figure 4. display diagrams of forces extent in upper joint of compressed boom for both simulations (Figure 3.) and winding spindle coaxial forces diagrams for simulations with code 04. —and 06. — in Figure 7b. Active paths for both simulations are the same.



a) b)

Figure 4. Diagrams of transversal forces in upper joint of compressed boom (a) and winding spindle (b)

Movement diagrams derived from simulations similar to previous but with elastic construction parts are presented in Figure 5. Three-dimensional system like this one, in dynamic simulation has 28 degrees of freedom and integration start with 262 equations. In diagrams B denotes structural matrix, and based on these, structural suppression matrix are formed. Rope is presented in model like spring with suppression.

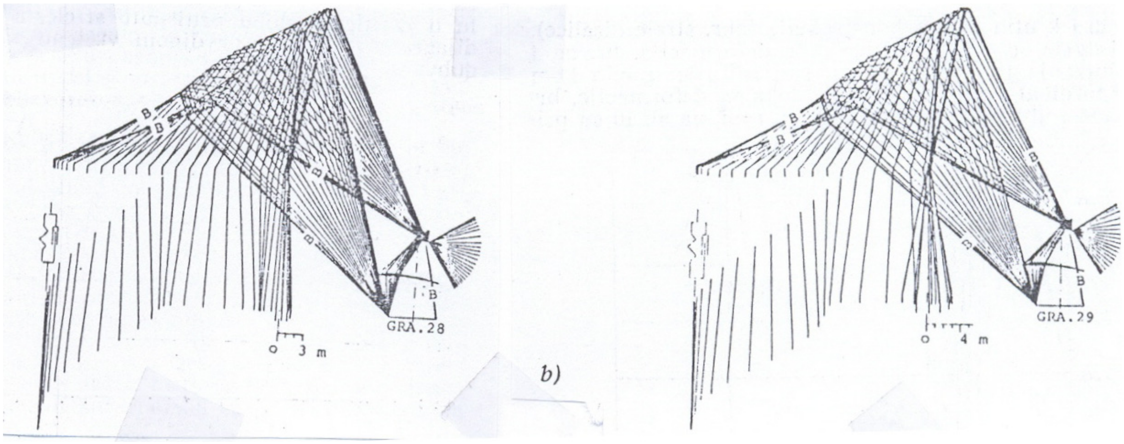


Figure 5. Position diagrams for dynamic simulation

To observe more precisely load swinging, Figure 6. present diagrams of load coordinate and boom spike difference in case of drive set for changing reach with programmed movement and for asynchronous electric motor.

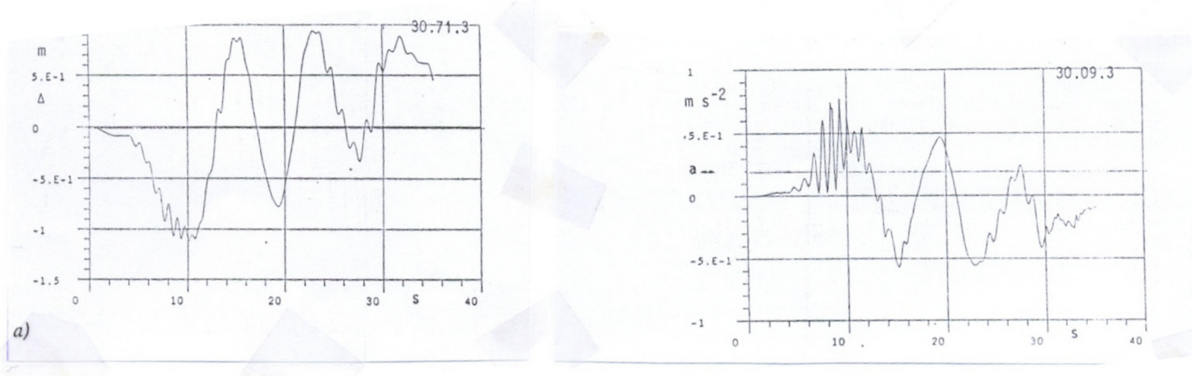


Figure 6. Load position and boom spike difference

Movement diagrams in simulation present that crane acquired load, start lifting after that, with changing the reach with time delay in regard to lifting.

Simulations like these are producing diagrams of forces extent for all crane characteristic points, bending moments, that is torsion in restrained elastic and rigid parts of construction. Also, deformations extent, speed and acceleration of construction parts are produced too.

Figure 7. present diagram of transversal forces for upper boom joint and for both cases of changing reach drive set.

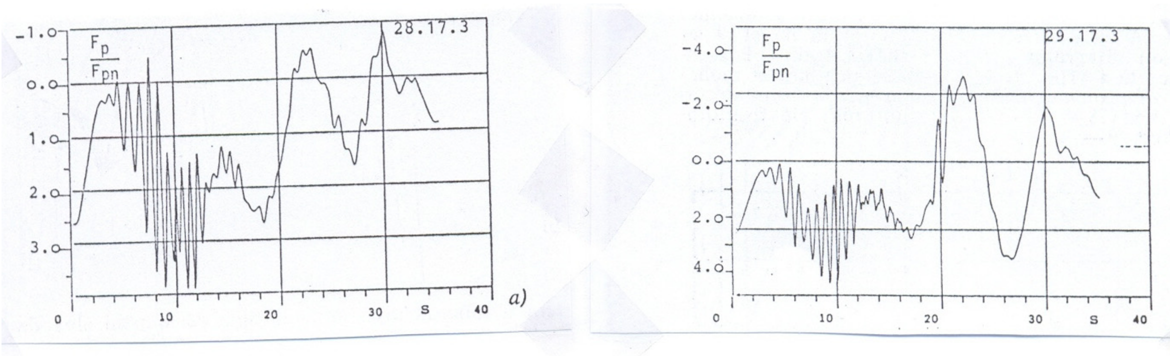


Figure 7. Transversal forces for upper boom joint diagram

Winding spindle coaxial forces diagrams both cases of changing reach drive set are presented in Figure 8. Static load at maximum reach in all diagrams is acquired for unit load.

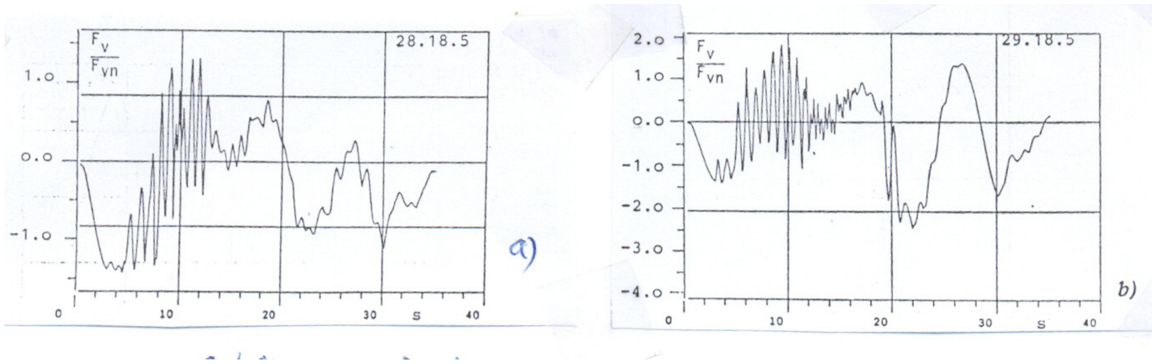


Figure 8. Winding spindle in drive set for changing the reach coaxial forces diagrams

When comparing forces extent, considerable impact of driving set kind could be concluded, not only to load swinging but over dynamic forces extent too.

In case of driving set programmed movement with more exact guidance during reach changes, Figure 9. present diagrams with load horizontal coordinates and boom spike difference, where, comparing to Figure 6., reduced load oscillation amplitudes could be concluded. Figure 9. present diagram for load horizontal acceleration.

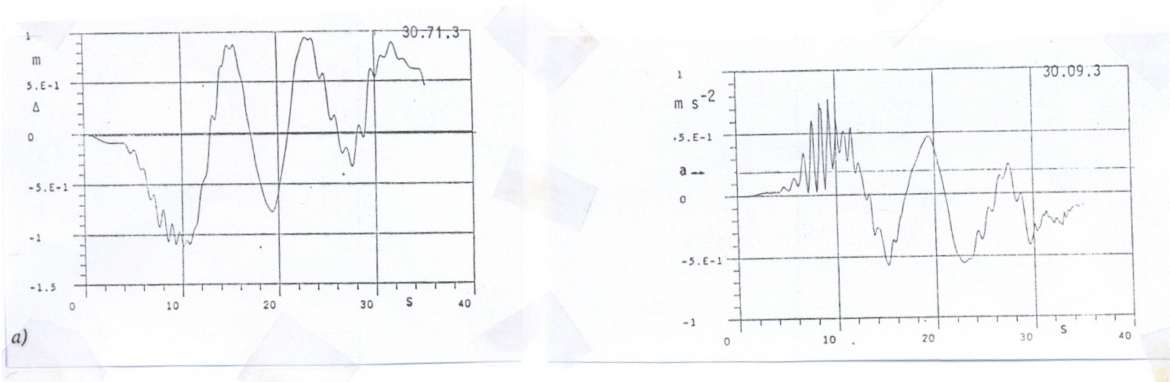


Figure 9. Diagrams of load coordinate and boom spike difference (a) and horizontal acceleration (b)

For crane metal construction, the mechanism present not so much impact comparable to drive set for changing the reach. Kind and regulation of driving set is significant for driving set parts and frequency analysis of whole system.

In one of simulations with elastic system of rope running over pulley, elapsed along the ideal curve that would be adequate to mild and smooth characteristic of driving electric motor. Diagrams of vertical coordinates and load lifting speed are displayed in Figure 10. Load landing in the moments prior to lifting, follows from elastic deflection of construction in a stage of load increase.

Diagrams of load vertical acceleration and boom spike are displayed in Figure 11. Analyzing this diagram it could be concluded that boom spike is oscillating according to oscillation law excited by mechanical system with large own mass.

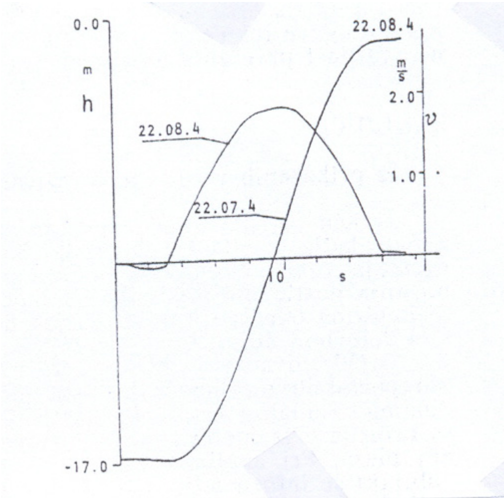


Figure 10. Diagram of load vertical coordinate and load speed

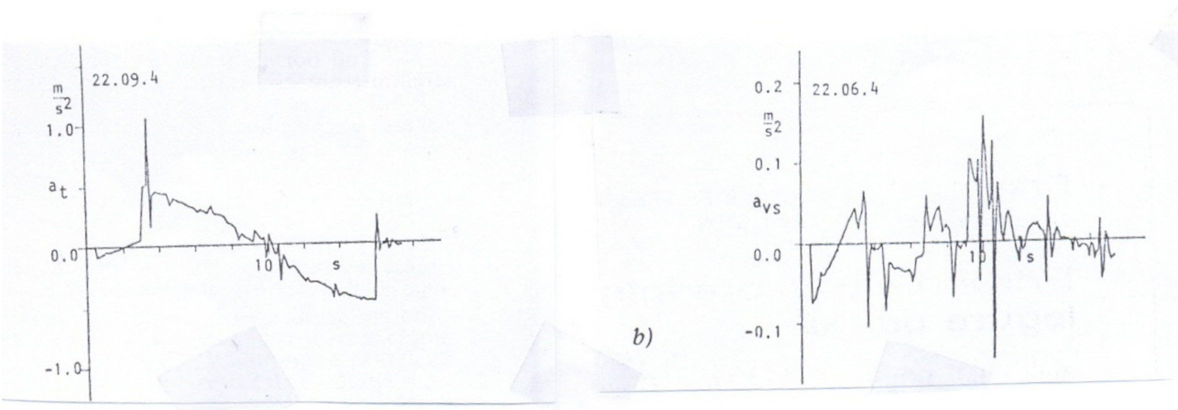


Figure 11. Diagram of load vertical acceleration (a) and boom spike (b)

Analysing presented diagrams, as far as other diagrams of forces in construction parts, it could be concluded that load charge of construction are almoust the same for regarded case of ideal drive set for lifting comparing to one with asinhronous electric drive.

In case of lifting drive set dynamic analysis, significant for crane, impact of drive set kind and its regulation is present especialy for intake shafts and firs gear pars in transmition.

4. Conclusion

Analysing the results it follows:

Analysis of drive sets and constructions in order to suppres load swinging, request to perform dynamic analysis too.

Swinging cranes transverse forces, could be only determined using dynamic analysis of rigid or elastic models. Elastic dynamic models analysis present us the informationes for mutual impacts of moving masses over increasing general dynamic status, as revealed by experimental researches.

Using computers it is possible to model complex mechanical systems. Dynamic analysis, besides critical evaluation of implyed aproximations, give us the loading data for all points of mechanical system.

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USEFUL INFORMATION THAT DESCRIBE CAD

N. Repčić

Abstract

A lot of people now have E-Mail which makes the sharing of drawings a lot easier. But, not everybody has got AutoCAD, so even if you E-Mail the drawing to them they still cannot open it. You could fax it, but that has it's own problems. Firstly, you must plot the drawing out to suit the size format of the fax machine, or cut the drawing up into strips and fax it that way. If you have a fax card and modem connected to your computer you can use a little bit of Visual Basic to send the drawing to your fax. Just remember to change the name of the Fax in the coding to the name of your fax. To demonstrate the use of VBA in AutoCAD, I've taken a few of the more common AutoLisp routines, and converted them to VBA Applications. This will hopefully help the AutoLisper who is trying to migrate from AutoLisp To VBA. These routines should be familiar to most AutoLispers and by having a good understanding of how the routine is written in AutoLisp, you should find it very easy to follow and understand the VBA logic and coding. (Sorry, AY2K Only.) When writing any sort of AutoLisp routine, one should supply some kind of Help. An Information box is also a handy thing to include as it allows you to inform the user of what version of the routine he is using, as well as giving you a chance to advertise yourself and your applications. You can access and integrate custom Help into the Windows Help Files, but this is quite an involved process and you need the brains of a rocket scientist to accomplish this. A much simpler way is to call an external Help or Info file from your AutoLisp routine. Whilst Lisp Help.Lsp, if you click on the Help button, your default browser will open, displaying an HTML Help file. Clicking on the Info button will open Notepad and display an Info Text file. Tested on R14 and RY2K. It is very important when writing AutoLISP routines to declare all your variables as Local. This prevents them from stepping on other variables of the same name defined from other routines. It often happens though, that on completion of your application, it can be quite difficult to remember and locate all the variables that you have used. This application will list all the un-declared variables and all functions used within your routine. Tested on R14 and RY2K I dare to say that 3D22D is that what you shall use for all your 2D-presentations of a 3D-Model This application enables the user - in a simple way - to establish 2D-presentations from a 3D-Model. These will be presented in predefined scales. Advantages: User friendly! There is just one dialog box including everything you need. No searching for icons on different toolbars. Everything is there! 3D22d just not handles Solids but even Solids - in blocks, in nested blocks and even in xrefs.

Keywords: CAD, design, state

1. Introduction

Designed to change dimension text from English units to metric units. The program utilizes the entity data base information to determine the distance of the dimension in English units and based on the user choices, changes the dimension text to millimeters, centimeters or meters. An engineering program designed to calculate all dimensions for keys and keyseats for any given shaft diameter, imperial or metric. It can even draw the appropriate views. I've tried to put everything that I do with dimensions on a day-to-day basis in one place - Dimension Control Panel.

It will change dimension variables and display format variables by changing entries in the dialog and picking the "OK" button. It will also update dimensions by changing entries in the dialog box, picking the "Update" button, and selecting the dimensions to be updated. If you pick the "Reset original Dimvars after update" toggle before the "Update" button, it will do dimension overrides and return to the original settings. If you pick the "Cancel" button at anytime it will return all dimension variables to their original settings. Adds Approximate, Delta, Diameter, Perpendicular, or Radius symbols to primary and alternate units of dimension. Also adds number of and size of spaces to primary units of dimensions. The selection of the spaces is interactive on the text screen. Dimension Leader function that is an enhancement over the AutoCAD's Leader command. The user picks the leader from and to points, and then fills in the Mtext information. The function adjusts the leader to align with the top line of the Mtext, using the user's selected points. AHatch Pro is a flexible and high performance tool for the design of Autodesk AutoCAD hatch patterns. The generated hatch patterns can be used with the AutoCAD "hatch" and "bhatch" commands. AHatch Pro is developed as a stand-alone program and may be used independently of (Autodesk) AutoCAD. WHAT BRICKPAT.LSP DOES: When run, Brickpat.lsp loads a menu file called rickpat.mnu, which displays 2 menu choices in the upper right hand of the autocad screen; Selecting MENUNDO will exit the user from the Brickpat menu and restore the original autocad menu in use at the time Brickpat.lsp was loaded. Selecting BRICKPAT in the upper right of the autocad screen will open an icon menu in the center of the screen, which displays the 12 brick patterns. Selecting any of the patterns will automatically load the pattern and start the usual autocad HATCH command. The user must input hatch scale and angle, and select the area to be hatched. To return to the original screen Menu the user must then select MENUNDO in the upper right corner of the Autocad screen. At last a program that creates brick hatches, dot hatches, line hatches with offsets. This is an evaluation copy (non commercial). It is fully functional however. You may purchase a full version from our website if you like to use it. [keywords: Hatch editor bricks blocks dots lines] Harvests Hatch Pattern data from drawing files. This paper is a description of application of the design process to solve an engineering problem, which includes interdisciplinary parameters such as human factors, engineering economy, safety, etc. A team structure is used to design a mechanical device or machine that performs the functions established by a project description. Each team produces detailed drawings, detailed specifications, a presentation, and a prototype of the proposed design. For today's technical firms, running effective and cost efficient CAD departments can be a real challenge. Outsourcing with AVF Design is the ideal way to meet that challenge. There are a complete CAD services company, staffed by experienced professionals with a strong background in engineering, architecture and CAD. To reduce your administrative burden, while increasing your control over drawing management. To have the manpower and expertise to meet your most demanding CAD challenges at a very affordable price. AVF Design is dedicated to providing projects/drawings accurately, efficiently and on time. The state of the art equipment includes some of the latest computers, plotters and scanners. To utilize AutoCAD and a large variety of CAD software, all available to meet your design and drafting needs. Converting paper drawings to structured CAD files yields many valuable benefits. However, when you consider the cost of dedicating your internal resources to this labor-intensive task, the benefits may seem out of reach. AVF Design solves this problem and allows hundreds of companies to enjoy the benefits of CAD conversion. Depending on quality and type of the original drawings we may use a singular or a combination of conversion methods, but the results are always the same.

2. There are no limits in producing different views

Just once you have to make a 2D-representation from your Model. From that 2D-represantation and the following you produce how many 2D-represantations you want and even on different layouts. Take a part of your drawing. With 3D22D you can - not only present a top view - but also a front-, left-, right- and back view. Be free to place your 2D-presentations on different layouts. There are no limits in producing different views. Beside the common views as front, back etc. and all the isometric views you now can make even anometric views. Not even that! You can with 3d22d make perspective views. Hey! You want to work in a view presented in paper space.

No problem, just click "Model" and you are in Model space at that view and you are free to make changes. So what! After your changes in Model space go back to your drawing - Paper space - and just update that single view or the entire drawing. With 3d22d it’s possible! You don’t want to make your Model public! Just click 2D-Drawing and in a few seconds you have make a unique 2D-drawing out of your Model. And much, much more. AutoProject is a plug-in for AutoCAD 2000/2000i/2002. This plug-in gives AutoCAD the ability to project 3D entities to 2D entities in the XY plane in the AutoCAD model space. A common but inefficient method of creating workshop ready drawings is to create the top view, the front view, a side view and sometimes an isometric view of a 3D model all in the 2D XY plane. Then these 3 or 4 views are placed relative to each other to give the end user a complete idea of what the 3D model is all about. Experienced drafters have confirmed that the isometric view is the one that takes most of the time, whereas the orthographic views only end up adding to the time spent in completing the drawing. A closer look at this method will show you that, in effect, you are drawing a single entity 4 times over, one for each view. With AutoProject you can drastically reduce the time spent in creating a workshop ready drawing, while making full use of the AutoCAD 3D functionality. All you have to do is create a 3D drawing of the model you wish to describe and AutoProject will take care of the rest. With AutoProject you can create 6 orthographic views and 8 isometric views within no time. This plug-in is very easy to use as it adds several commands to AutoCAD. You simply type a command at the AutoCAD command prompt, select the entities you wish to project and the job is done. Useful for recovering hatch pattern definitions when the original .pat file is unavailable. HACI is an AutoLISP application for AutoCAD 2000 or R14. It converts your drawing to hatch pattern, so you can easily convert your logos, symbols or patterns to hatches, which can be used in standard HATCH or BHATCH commands. You can create specific hatch patterns such as stone facing, wood grains, roof tiles and many other. Precision: The precision of calculus is affected by the snap value. The default value is 0.05. As the snap value is smaller, it is necessary more time for processing. The maximum precision allowed is 0.001. Limitations: Only LINE entities are processed. Any 2D entity can be converted to LINEs. You must do this conversion before using HACI.You have to use a 1x1 cell when draw the source. The source can also be smaller than 1x1 if the cells in the resulting hatch are independent. If you use a pattern name that exists in the acad.pat file, the new definition will be ignored. Quick_Mold - is a mold base assembly made by Hasco standards, and it's containing all standard elements that go with mold base assembly that is chouse (e.g. Guide pillars, locating guide pillars, screws etc.). Under advantage of this program is that you can edit all dimension of mold base assembly out of standards. Blank Development includes the following features: Bend Allowance - for calculating flat blank size. 2D Unfold - to calculate and unfold single bends in sheet metal parts. Flat Blank Report - to calculate strip width, progression, blanking tonnage, surface area, part weight, percent of scrap and other specifications to aid in the quoting process. Drawn Shell Calculator - for determining blank diameter, draw depth to achieve a desired cylinder diameter reduction. Acad Install features: All initialization happens from your setup executable before AutoCAD is launched. Setup your AutoLISP/Visual Lisp, ObjectARX/ADSARX, and VBA/VB applications. Set up any or all of the following:. Menus,Toolbars, Demand loading for ObjectARX applications. Add setup files to AutoCAD's Startup Suite with full path. Add or modify AutoCAD profile settings. Add install path to AutoCAD search paths with redundancy check so duplicates are not created. All registry keys created (i.e. that didn't exist prior to installation) can be deleted upon uninstall. Only two files need to be added to the installation, a copy of AcadInst.ini with your app's settings and AcadInst.exe. Easy to use INI file based install parameters. User specifies what AutoCAD profiles to which they wish to install your application. Alternately, a 'silent' install is available to registered users. A version with your product's name in the caption bar (instead of CADwerx). Look in the include help file (AcadInst.chm) for more information. Freeware C++ library for adding your own status bar button to the right edge of the AutoCAD status bar. You can download more than 70 pages of useful information that describe CAD terms, principles and applications. Many people have requested a listing of all of the available DCL tiles along with a working AutoLisp example of each tile. In this tutorial we will have a look at each tile, the DCL coding for it, as well as the AutoLisp coding required making the dialogue box tile functional.

When writing any sort of AutoLisp routine, one should supply some kind of Help. An Information box is also a handy thing to include as it allows you to inform the user of what version of the routine he is using, as well as giving you a chance to advertise yourself and your applications. You can access and integrate custom Help into the Windows Help Files, but this is quite an involved process and you need the brains of a rocket scientist to accomplish this.

3. Whether a beginner or experienced programmer?

Application of the design process to solve an engineering problem, which includes interdisciplinary parameters such as human factors, engineering economy, safety, etc. A team structure is used to design a mechanical device or machine that performs the functions established by a project description. Each team produces detailed drawings, detailed specifications, a presentation, and a prototype of the proposed design. For today's technical firms, running effective and cost efficient CAD departments can be a real challenge. Outsourcing with AVF Design is the ideal way to meet that challenge. There are a complete CAD services company, staffed by experienced professionals with a strong background in engineering, architecture and CAD. To reduce your administrative burden, while increasing your control over drawing management. To have the manpower and expertise to meet your most demanding CAD challenges at a very affordable price. AVF Design is dedicated to providing projects/drawings accurately, efficiently and on time. The state of the art equipment includes some of the latest computers, plotters and scanners. To utilize AutoCAD and a large variety of CAD software, all available to meet your design and drafting needs. Converting paper drawings to structured CAD files yields many valuable benefits. However, when you consider the cost of dedicating your internal resources to this labor-intensive task, the benefits may seem out of reach. AVF Design solves this problem and allows hundreds of companies to enjoy the benefits of CAD conversion. Depending on quality and type of the original drawings we may use a singular or a combination of conversion methods, but the results are always the same. The program scans all lisp files in a directory. In the lisp's after every Line that begins with defun the next lines witch are comments will be written in the help file. Example: (defun c: test); comment <- this will be written to help (setq ....) Whether a beginner or experienced programmer, DCG offers you an easy-to-learn graphical interface that makes development in DCL a simple and effortless task. With DCG you will no longer have to move back and forth between a text editor and AutoCAD. You will be able to code, preview, and debug your DCL dialogue boxes from within a simple graphical user interface. Developing dialogue boxes with DCG is as easy as point-and-click! Key Features: - Dramatically reduces DCL programming time with its easy to use graphical development environment. - Create, preview, and debug your DCL dialogue boxes from within a single application. - Automatically generates properly formatted DCL code. - Direct integration with AutoCADÆs Programmable Dialogue Box facility for easier DCL debugging. - Support for multiple dialogue box definitions per session. - Context sensitive help facility. - Platform independent. Using Drag and Drop technique to design dialog, Auto generate DCL code and Lisp code to load in AutoCad, Easy create even associate with a dialog tile,Syntax hightlight lisp and DCL editor. Works on Win98 and WinNT and Win2000 (win 95 and WinME not tested but should work) if your serious about AutoLISP programming or system customization, this program is a flexible and indispensable addition to your arsenal. Simply load the self-configuring VLX program file, and you will be running in minutes. Once loaded the program exports a single function to native AutoLISP which can be called from your AutoLISP program code. This program serves the frequent use of selecting single files, but unlike most file browsers or any available for AutoLISP programming, DFBrowser v2.15 (for ACAD 2000) has the added ability to select multiple files and single or multiple directories. You can select filenames across your entire network manually or automate filename collection using wildcards in seconds with the recently added file & directory search and collection features, all in one session. Instrumental for building data lists for your own batch-processing-utilities. This is a trial version of our AISC Steel Shapes Block Library. This library uses a pull down menu system to easily select the steel shape cross-section you need. The blocks can also be used in your 3D layouts. Just insert the shape you need, explode it, and then extrude it! Draw Beam - This routine can dramatically speed up 2D drawing process for architects, construction engineers and detailers.

The tool is very simple to use, its goal is to help you edit beam designation and drawing beams sections on a 2D drawing as fast as possible. The program uses a DCL program interface for easy user input. Actually it is a 2 in 1 routine and it have on its support a database file (BeamDB.dbs) with designation and section profile of almost all AISC and CISC wide flange beams. “Edit beam size” action (see command dialog window) insert in current layer a text (using current text size) representing beam designation and beam flange width, by picking two points on the beam line. The text object will be offset at a proper distance of the beam line. “Draw beam section” action creates in current layer a polyline object representing exact section of the selected beam, section axis (line object) and a text object with beam designation and beam flange. Both sub routines are for editing beams designations and draw beam sections on plans without checking your AISC manual. CAD is computer graphics software that is commonly used to make engineering drawings.

4. Works with all versions of DWG files

A much simpler way is to call an external Help or Info file from your AutoLisp routine. Whilst Lisp Help.Lsp, if you click on the Help button, your default browser will open, displaying an HTML Help file. Clicking on the Info button will open Notepad and display an Info Text file. Tested on R14 and RY2K. It is very important when writing AutoLISP routines to declare all your variables as Local. This prevents them from stepping on other variables of the same name defined from other routines. It often happens though, that on completion of your application, it can be quite difficult to remember and locate all the variables that you have used. This application will list all the un-declared variables and all functions used within your routine. Tested on R14 and RY2K. Able DXF manager - It is a program that enables you to view and print DXF files generated by most CAD programs. The program can also convert to one of the following formats: JPEG Bitmap (JPG), TIFF Bitmap (TIF), PaintBrush (PCX), Portable Network Graphics (PNG), Windows Bitmap (BMP), OS/2 Bitmap(BMP), Targa Bitmap (TGA), Portable PixMap (PXM), Portable PixMap (PPM), Portable GreyMap (PGM), Portable Bitmap (PBM). AEC-VIZ is the smart 3D viewer for the AEC market (Architecture, Engineering, Construction) it is based on a new and powerful technology, which allows manipulating huge models in real-time, on standard PCs. This compact technology allows sending file easily through the net. Features: DXF/DWG full support, fast cast shadows, intuitive cross-section, full editing possibilities, very large models and Real-time manipulation, secure file packaging, and more. In conclusion, AEC-VIZ is the 3D communication tool. AEC-VIZ Reader is the smart 3D viewer for the AEC market (Architecture, Engineering, Construction) it is based on a new and powerful technology, which allows manipulating huge models in real-time, on standard PCs. You can also create shortcuts to AFV on the Desktop, Startup, and Start Menu. AFV was written using VB6 Professional Edition. Source code is available upon request. Small and lean - the fastest and neatest CAD viewer ever! Amethyst CADwizz is a viewer for AutoCAD files, but it offers much more. CADwizz enables you to add redline annotations, convert files to any version of AutoCAD, open and save zipped files, create self-extracting encrypted archives. The Wizzle feature enables you to create hand-drawn effects directly from your drawings! View AutoCAD DWG and DXF files versions 2.5 to 2002. Directly download and view files from the Internet. Save files in any version of AutoCAD. Convert DWG files to DXF, and DXF to DWG. Save drawings in BMP, GIF, PNG, JPEG, PCX, TGA, TIFF, EMF and WMF file formats. Zoom, pan and print drawings. View 3D views. Rotate drawings. Modify color and visibility of layers. Supports external references. Open multiple documents. Includes drag and drop functionality. View up to 16 AutoCAD drawings on one sheet. View an unlimited amount of drawings in any directory. Large zoom view of selected drawing. Retrieve/display Drawing Properties information. Support for Windows Explorer SendTo Insert drawings as blocks or Xrefs. Open drawings directly from the viewer into AutoCAD r14 or 2000/i. What this application does: - Use OXREF to open XREFÆs blocks without using the new command REFEDIT. - Use RELOAD to pick an XREFÆs block to reload, without using the XREF dialog. - Use BSOURCE when you work in non multiple documents, when the system variable SDI = 1 thatÆs turns off multiple-drawing interface. xRepath - A Windows

95/98/Me/NT/2000 tool (no AutoCAD needed) for changing or listing external reference paths (XREFs and IMAGEs) in AutoCAD DWG files.

Works with all versions of DWG files containing XREF or IMAGE objects, R11 to Acad2002. Like other BLITZ! tools, xRepath doesn't need AutoCAD to access and modify drawing files. Another remarkable feature is its extreme processing speed of thousands of drawings per hour. It can be used to change paths of attached reference files (XREF or IMAGE) (up to 1 MILLION drawings per run) on all local and network drives and directories. Ideal tool when changing drive mapping, moving the project to another drive or returning project files to the client. There is also an option for creating the Excel spreadsheet of reference files attached to processed drawings.

5. Conclusions

ActiveX interface for use in VBA and Visual Lisp. The purpose of the control is to graphically display the standard AutoCAD colors 1 thru 8, and allow the user to choose one. Then, return its color value in your program for setting line color, point color, block color, etc. Its design is intuitive, and has a very small footprint. Color selection is hot track able to provide visual feedback to the user. Methods include GetColor, for returning the AutoCAD color value. SetColor, for setting the color on the button. This compact technology allows sending file easily through the net. Features: DXF/DWG full support, fast cast shadows, Very large models and Real-time manipulation, and more. In conclusion, AEC-VIZ Reader is the 3D breakthrough technology...for free! The AutoCAD File Viewer (or AFV) is a multi-purpose AutoCAD file viewer/editor/loader. AutoCAD R14 is req'd. With AFV you can view the bitmap image of DWGs, BAKs, etc. as well as insert them into AutoCAD R14. You can also view SLDs as well as create an entire directory of slides by selecting one drawing within the destination directory. AFV also has the ability to view LSPs, DCLs, MN*s, SCRs, PCPs and load them into a user-specified text editor. If a LSP is selected, you can load the file into AutoCAD. AFV will determine what the FIRST "defun c:xxxx" command is and auto-start the LSP program based on that command. The control exposes two events; Click event and Change event. User properties consist of GridColor, ToolTipText, and Enabled. To make this control available to your Visual Basic toolbox: download it to your windows system directory and register it. The control graphically displays AutoCAD point styles, and allow the user to choose one. It returns the point value so that the AutoCAD PDMODE system variable can be set. Its design is intuitive, and has a very small footprint. Icon selection is hot track able to provide visual feedback to the user. Methods include GetPointType, for returning the value needed by AutoCAD to set the PDMODE system variable. SetPointType, for setting the graphical icon on the button that represents a point type. The control exposes two events; click event and change event. User properties consist of GridColor, ToolTipText, and enabled. To make this control available to your Visual Basic toolbox: download it to your windows system directory and register it. Then add the component CTLacPointPicker to your project stoolbox. While Coding An AutoLISP function, it is very important to localize all the variables that are local. Sounds easy - It is if your function (or routine) is a short one. When writing functions that have dozens (or even more) variables - this is getting less fun. This is why I coded AVC. (AVC was coded in Visual Basic). AVC is very fast and it will help you in creating those lists. If you work in a methodical way and all your vars are prefixed with the same combination -you can use the apropos feature of VILL (or VLIDE) and then with the match prefix checked - copy the list to the log and then paste it to the function.[keywords: autolisp, development, utility]. Extracts Comments from Lispfiles and generates a acad-Helpfile (hlp,ahp) from these.

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ANALYTICAL AND EXPERIMENTAL CHARACTERIZATION OF BALL-GROOVE CONTACT PROBLEMS

S. Zelenika

Abstract

Ball-groove contact problems are often encountered in machine design. The analytical modeling of the resulting stress-strain behavior is however difficult, as it implies the necessity to deal with the non-linear Hertzian theory of point contacts. This work addresses the limits of applicability of the available analytical approaches for the calculation of ball-V groove couplings employed in ultra-high precision positioning. The analytical results are validated experimentally via high-precision measurements.

Keywords: Point Contacts, High-precision Positioning, Experimental Validation

1. Introduction

In the mechanical design of machine elements based on rolling members (e.g. ball bearings, ball screws, …) designers are confronted with the need to consider the behavior of ball-groove contacts, which is difficult to calculate both analytically and numerically. The analysis implies, in fact, the necessity to consider the non-linear Hertz theory of point contacts between elastically deforming solids [1]. In literature, various approaches can be traced which deal with such a problem. The exact model based on the theory of elasticity is complex since it involves an iterative evaluation of elliptic integrals [2]. Other approaches are based on approximated methods making use of diagrams [3, 4], polynomial approximations [5] or interpolating procedures [3, 6, 7] for the calculation of the stress-strain behavior of the bodies in contact as function of the mechanical characteristics and main dimensions of the ball-groove coupling. In high-precision positioning applications, because of the required accuracies in the micrometric and sub-micrometric range, the establishment of the limits of applicability of these approaches is essential.

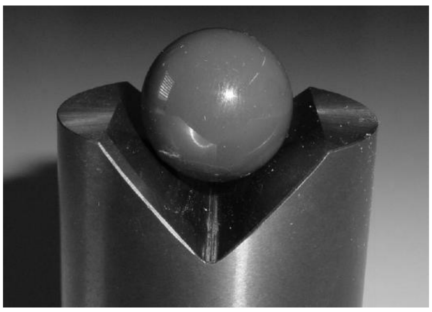


Fig. 1. Ball in a V groove

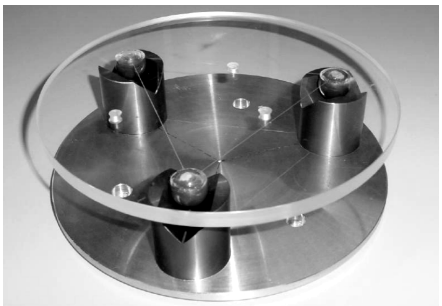


Fig. 2. Kinematic coupling

This work addresses the comparison of the available analytical approaches in the case of a ball-V groove coupling (Fig. 1). The studied configuration is often used in kinematic coupling systems (Fig. 2) employed in ultra-high precision positioning and relocation of opto-mechanical components, in metrology, in scientific apparatuses, by the assembly of micro-parts, in high-precision manufacturing systems and machine tools.

The analytical results obtained for the studied case are then validated experimentally by employing high-precision measurements. These allow the influence of the various mechanical parameters on the behavior of the ball-V groove contact pairs to be established.

2. Analytical Models

Hertz theory describes the non-linear stress-strain behavior of point contacts between elastically deforming isotropic solids loaded perpendicular to the surface (shear stress, i.e. friction, is neglected), in which the dimension of the contact area is small compared to the radii of curvature and the dimensions of the involved bodies [1-3, 5]. The corresponding exact analytical model entails a lengthy iterative evaluation of transcendental equations involving elliptic integrals (Fig. 3). In fact, by indicating with E_1, ν_1, E_2, and ν_2 the Young's moduli and the Poisson's ratios of the bodies in contact, with F the normal contact load, with R_b the ball radius (R_b=$R_{b\,\min}$=$R_{b\,\max}$) and with $R_{g\,\min}$ the groove radius ($R_{g\,\max}$=∞), the following notation can be introduced [2]:

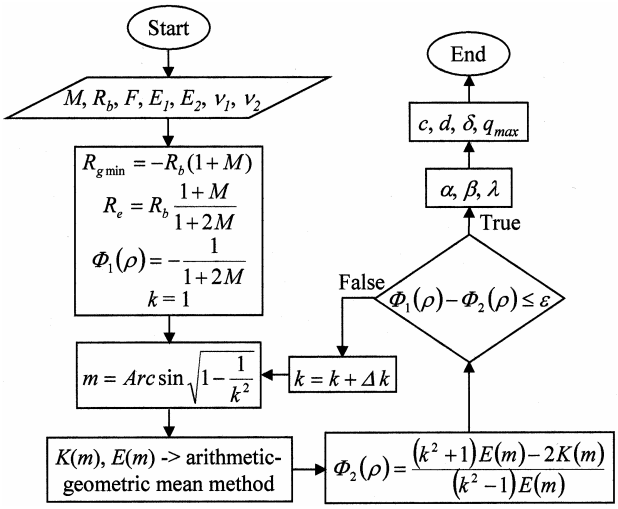


Fig. 3. Exact analytical model

– equivalent Young modulus:

$$E_e = \frac{1}{\frac{1-\nu_1^2}{E_1} + \frac{1-\nu_2^2}{E_2}} \tag{1}$$

– ratio of groove and ball radii of curvature and equivalent radius:

$$M = -\left(\frac{R_{g\min}}{R_b} + 1\right) \qquad R_e = R_b \frac{1+M}{1+2M} \tag{2}$$

– curvature difference:

$$\Phi(\rho) = -\frac{1}{1+2M} = \frac{(k^2+1)E(m) - 2K(m)}{(k^2-1)E(m)} \quad \text{(with } \rho = \frac{1}{R_e}\text{)} \tag{3}$$

– ratio of the major and minor semi-axes lengths of the elliptical contact area:

$$k = \frac{c}{d} \ge 1 \qquad m = Arc\sin\sqrt{1-\frac{1}{k^2}} \tag{4}$$

The resulting calculation algorithm is then arranged as shown on Fig. 3, where

$$\alpha = \sqrt[3]{\frac{2k^2E(m)}{\pi}} \qquad \beta = \sqrt[3]{\frac{2E(m)}{\pi\, k}} \qquad \lambda = \frac{2K(m)}{\pi}\sqrt[3]{\frac{\pi}{2k^2E(m)}} \tag{5}$$

are the characteristic parameters, while

$$K(m) = \int_0^{\pi/2} \frac{\mathrm{d}\varphi}{\sqrt{1-m\sin^2\varphi}} \qquad E(m) = \int_0^{\pi/2} \sqrt{1-m\sin^2\varphi}\,\mathrm{d}\varphi \tag{6}$$

are the complete elliptic integrals of the first and second kind calculated, as suggested in [8], by employing the arithmetic-geometric mean method.

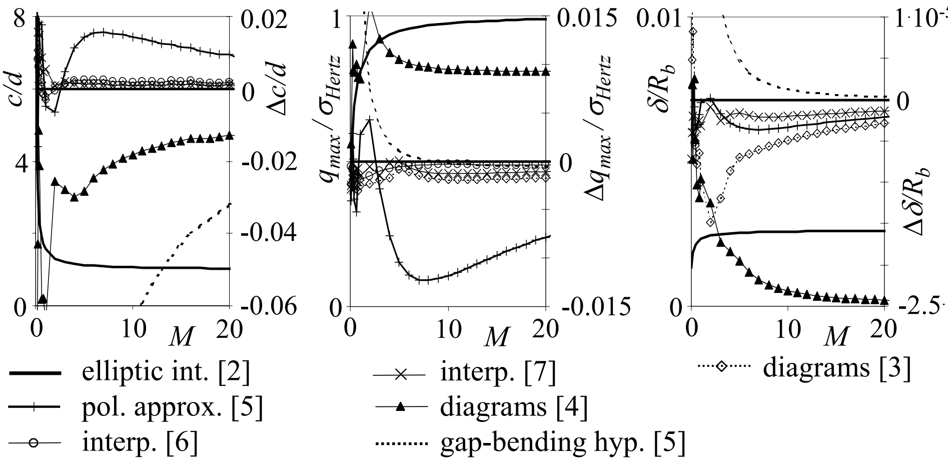
The results of the algorithm represent the major (c) and minor (d) semi-axes of the elliptical contact area, the interpenetration distance δ of the bodies and the maximum contact stress $q_{\max}$:

$$c = \alpha \sqrt[3]{\frac{3F\,R_e}{2E_e}} \qquad d = \beta \sqrt[3]{\frac{3F\,R_e}{2E_e}} \qquad \delta = \frac{\lambda}{2R_e}\sqrt[3]{\frac{3F\,R_e}{2E_e^2}} \qquad q_{\max} = \frac{3\,F}{2\,\pi\,c\,d} \tag{7}$$

The approximated methods given in literature in which the need to calculate the elliptic integrals is obviated by introducing polynomial [5], tabular [3, 6, 7] or graphical [3, 4] representations of the characteristic parameters are summarized in Table 1 (a is the radius of the circular contact area, α, β, γ, and λ are the characteristic parameters, $\cos\theta$ is dependent on the radii of curvature and ϕ - the angle between the planes of principal curvature; the other parameters are analogous to those given above).

Table 1. Approximated analytical methods

	pol. approx. [5]	interp. [6]	interp. [7]	diagrams [4]	diagrams [3]	gap-bending [5]
R_e	$R_e = R_b\dfrac{1+M}{1+2M}$	$R_e = 2R_b\dfrac{1+M}{1+2M}$	$R_e = 1.5R_b\dfrac{1+M}{1+2M}$	$R_e = R_b\dfrac{1+M}{1+2M}$	$R_e = 4R_b\dfrac{1+M}{1+2M}$	$R_e = R_b\dfrac{1+M}{1+2M}$
$\cos\theta$	$\cos\theta = \dfrac{R_e}{\lvert R_{g\,\min}\rvert}$	$\cos\theta = \dfrac{R_e}{2\lvert R_{g\,\min}\rvert}$	$\cos\theta = \dfrac{R_e}{1.5\lvert R_{g\,\min}\rvert}$	$\cos\theta = \dfrac{R_e}{\lvert R_{g\,\min}\rvert}$	$\cos\theta = \dfrac{R_e}{4\lvert R_{g\,\min}\rvert}$	/
c	$c = \alpha\sqrt[3]{\dfrac{3\,F\,R_e}{2\,E_e}}$	$c = \alpha\sqrt[3]{\dfrac{3\,F\,R_e}{4\,E_e}}$	$c = \alpha\sqrt[3]{\dfrac{F\,R_e}{E_e}}$	$c = \alpha\sqrt[3]{\dfrac{F\,R_e}{E_e}}$	$c = \alpha\sqrt[3]{\dfrac{3\,F\,R_e}{8\,E_e}}$	$c = a = \sqrt[3]{\dfrac{3\,F\,R_e}{2\,E_e}}$
d	$d = \beta\sqrt[3]{\dfrac{3\,F\,R_e}{2\,E_e}}$	$d = \beta\sqrt[3]{\dfrac{3\,F\,R_e}{4\,E_e}}$	$d = \beta\sqrt[3]{\dfrac{F\,R_e}{E_e}}$	$d = \beta\sqrt[3]{\dfrac{F\,R_e}{E_e}}$	$d = \beta\sqrt[3]{\dfrac{3\,F\,R_e}{8\,E_e}}$	$d = a = \sqrt[3]{\dfrac{3\,F\,R_e}{2\,E_e}}$
δ	$\delta = \lambda\sqrt[3]{\dfrac{2\,F^2}{3\,R_e E_e^2}}$	/	$\delta = \lambda\sqrt[3]{\dfrac{F^2}{R_e E_e^2}}$	$\delta = \lambda\sqrt[3]{\dfrac{F^2}{R_e E_e^2}}$	$\delta = \lambda\sqrt[3]{\dfrac{9\,F^2}{64\,R_e E_e^2}}$	$\delta = \dfrac{1}{2}\sqrt[3]{\dfrac{9\,F^2}{4\,R_e E_e^2}}$
$q_{\max}$	$q_{\max} = \dfrac{3\,F}{2\,\pi\,c\,d}$	$q_{\max} = \dfrac{3\,F}{2\,\pi\,c\,d}$	$q_{\max} = \dfrac{3\,F}{2\,\pi\,c\,d}$	$q_{\max} = \gamma\sqrt[3]{\dfrac{F\,E_e^2}{R_e^2}}$	$q_{\max} = \dfrac{3\,F}{2\,\pi\,c\,d}$	$q_{\max} = \dfrac{a\,E_e}{\pi\,R_e}$



(a) (b) (c)

Fig. 4. Ratio of the semi-axes lengths of the elliptical contact area (a), normalized contact stresses (b) and normalized interpenetration distances (c) versus the ratio of the radii of curvature *M*

The analytical results of the ball-V groove contact behavior obtained with the exact approach are compared in Fig. 4 with the approximated analytical methods. For clarity reasons, the results are given as differences of each of the considered method with respect to the exact solution. It can be observed that the gap-bending hypothesis [5], in which the contact between two curved surfaces is reduced to that of a plane and an equivalent sphere, introduces considerable errors. It is worth noticing, however, that this hypothesis yields conservative results, i.e. the calculated stresses and strains are higher than in reality.

The errors introduced by the approximated methods based on polynomial, tabular and graphical representations are always smaller than ±2% (or even, for the methods given in [6, 7], smaller than ±0.2% - Fig. 4). Given the small entity of the stresses and strains involved in most high-precision applications, in absolute terms these errors are negligible in all but those cases in which true nanometric accuracies are sought. Only in the case when the mentioned characteristic parameters approach their limit values (respectively 0 and ∞), which physically corresponds to the curvature of the groove approaching that of the ball, the errors involved in the approximated methods become appreciable. In this case, however, the basic assumptions of the Hertzian model do not hold any more, and the Hertz theory itself starts to break down [5].

3. Experimental Assessment

In high-precision applications the repeatability of the couplings has to be addressed [5]. The considered analytical approaches cannot, however, take into account the extent of non-repeatability caused by friction, as this effect can be evaluated only with elaborated numerical formulations based on incremental variational inequalities [9]. Even in that case, however, the extent of variation due to the stochastic nature of friction is not taken into account. Moreover, since the magnitude of the deflections is often in the sub-micron range, surface finish plays an important role. In fact, real solids make contact only where the asperities on the two surfaces come together, and Hertzian analysis is thus merely the limit case to which real contacts tend [10]. Other effects (e.g. load asymmetry) also affect repeatability.

In order to examine thus the repeatability and, as the most important feature in high-precision applications, the interpenetration distance of the ball-V groove contacts, an experimental set-up was built (Fig. 5). Gothic-arch shaped grooves ($R_{g\,\min}$=12mm÷∞) with polished contact surfaces (R_a=100nm) are built as modular inserts and epoxied onto the lower plate. In order to make the compliance of balls' fixation low compared to that of the coupling, the balls (R_b=5.5÷10 mm, R_a=20÷60nm) are inserted into conical seats in the upper plate, burnished until the surface is brinelled, and then epoxied [5]. The set-up is thermally isolated (a stability of ±0.1°C was reached). Stainless steel grooves and balls of various hardness (HRC 34÷67) are used. To minimize fretting corrosion, friction, as well as the footprint (i.e. to approach as much as possible true point contacts) [5], ceramic (tungsten carbide (WC) and silicon nitride (Si_3N_4)) grooves and balls are also employed. The loads are applied to the coupling via a pneumatic piston, and their magnitudes are measured with a precision (±0.25% ES) calibrated load cell. The interpenetration distance is measured with linear absolute encoders (HEIDENHAIN type CT 6002, resolution: 5nm, accuracy: ±100nm). Two encoders are used to have control of the symmetry of the behavior.

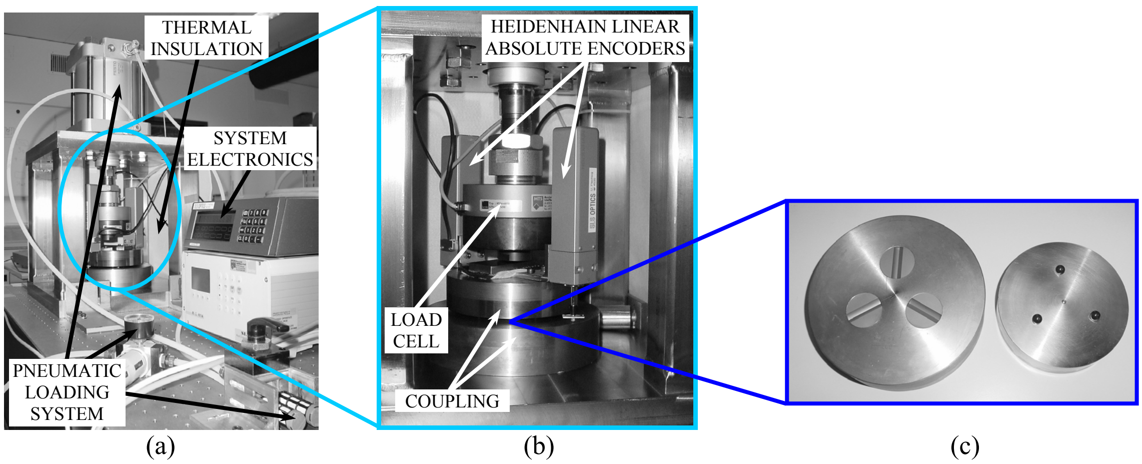


Fig. 5. Experimental set-up (a) with detail of the load and displacement measurement systems (b) and of the coupling elements (c)

The results of cyclic measurements (25 cycle averages with 100 points in each cycle) and the corresponding theoretical data calculated by using the exact analytical model are shown in Fig. 6. The interval of uncertainty (up to ±10% of the measured values) is mainly due to dimensional tolerances of the couplings' components, the residual compliance (e.g. epoxied connections) and the uncertainty in the mechanical properties of the used materials (cf. [6]). Despite the care devoted to the set-up of the experimental apparatus, this uncertainty is hence much larger than the errors introduced by adopting the considered approximated analytical methods. The obtained results can be summarized as:

- In all the considered cases, the theoretical values of the interpenetration distance are within the intervals of uncertainty of the measurements, regardless of the used materials.
- For small loads the measured values are smaller than the theoretical ones, which could be due to surface roughness and the resulting flattening of the contact points ("micro-approaching" [2]). This is supported also by the observed brinelling of contact surfaces (Fig. 7). Previous studies have allowed establishing that, because of surface roughness, for light loads the peak pressure can be up to 70% smaller and the contact area up to 10 times larger than in theory [10]. Moreover, the micro- and nano-hardness and Young's moduli differ from the macroscopic ones and depend on the state of the surface, which can have a significant impact on the results in this region, too.
- For higher loads the experimental results are closer to the theoretical ones, which could be due to the lower influence of the surface finish and the residual compliances in this region. By using ceramic coupling components, a tendency towards higher measured interpenetration distances than those calculated theoretically was observed. This could be due to the uncertainty of the mechanical properties of ceramic materials.
- Although lubrication generally has a small effect (Fig. 6), in some instances it induces a lowering of the measured values (≤ 10%). The explanation for this event was not found.
- After a wear-in period of less than 50 cycles, the repeatability of the couplings is typically in the $\sigma \leq 100$ nm range (comparable to the surface finish of the coupling interface). The residual non-repeatability could be due not only to surface finish, but also to non-linearities such as creeping or pre-sliding displacement.

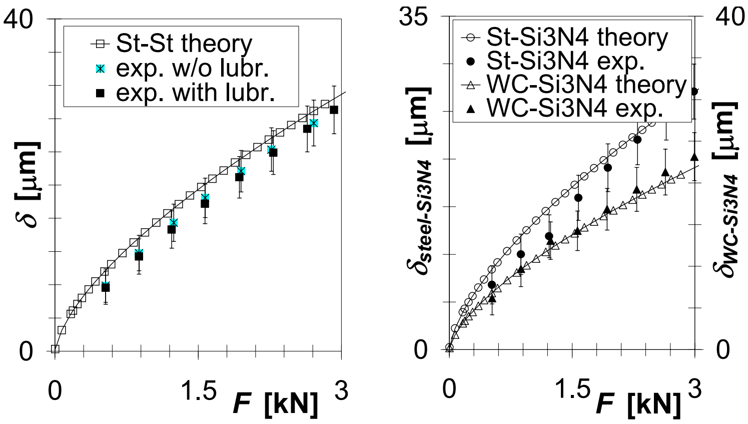


Fig. 6. Comparison of theoretical and experimental results for different materials

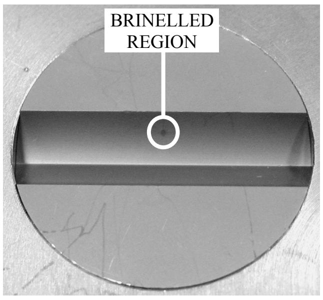


Fig. 7. Brinelling of the contact surface

A trial was also performed to measure the area of the contact region by optical means, i.e. by employing a 3D ZYGO type Newview 5010 scanning white-light interferometry-based surface profiler used to characterize the polishing accuracy of optical surfaces (vertical resolution: 0.1nm, RMS repeatability: 0.4nm, lateral resolution: 4.72µm). It was hence shown that:

- In the elastic domain the results are characterized by low accuracy (Fig. 8) and big dispersion.

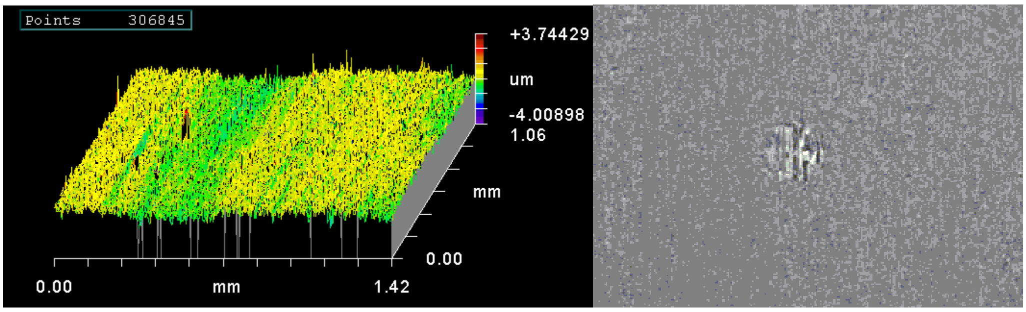


Fig. 8. Interferometric measurement of the contact area in the elastic domain

- In the plastic domain a good accuracy is obtained (Fig. 9) but the results are of little practical use (all the cited theoretical approaches are valid only in the elastic domain).

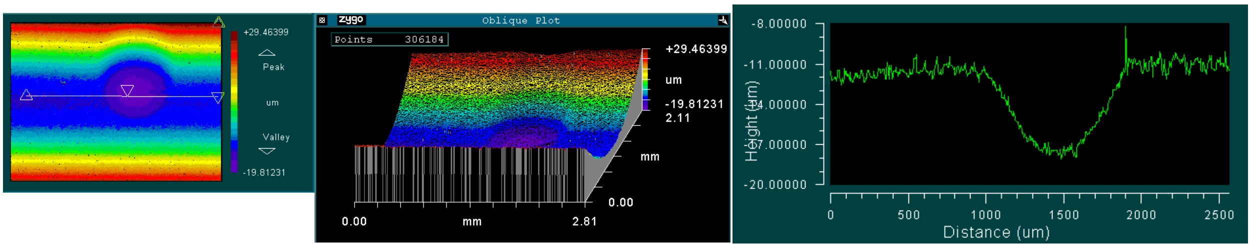


Fig. 9. Interferometric measurement of the contact area in the plastic domain

- Previous trials to measure the contact area by using contact resistance measurements or photo-elasticity have also given results characterized by low accuracy. Perhaps only the usage of newly developed pressure sensitive films (cf. www.sensorprod.com) could allow the situation in this regard to be improved.

4. Conclusions

Except for the gap–bending hypothesis method, the approximated analytical approaches available in literature for the evaluation of the stress-strain behavior of ball-V groove contact problems are giving results equivalent to those obtained with the exact analytical model in the micrometric and sub-micrometric domain, and are therefore of suitable accuracy for most of the practical cases encountered in dimensioning high-precision couplings.

In the whole range of elastic deformations, the correspondence of the theoretical values of the interpenetration distances with the experimental ones is within the intervals of uncertainty of the latter, regardless of the used materials and lubrication conditions. These effects seem, in fact, to influence the behavior only in the sub-micrometric range.

The repeatability of the couplings is comparable to the surface finish of the contact interface and thus it is in the 100 nm range.

Despite the high accuracy of the employed measurement technique, the measurements of the contact area are characterized by low accuracy and are left to eventual future studies.

Acknowledgement

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PHOTOVOLTAICS – A PROMISING ALTERNATIVE

T. Betti, B. Bonin, Lj. Bonković

Abstract

Energy problem due to fossil fuels eventual exhaustion and even more their negative environmental impact make renewable energy sources more and more desirable. Although it is still not currently competitive, photovoltaic industry is one of the fastest growing industries in the world with promising potential to become serious energetic alternative in the next few decades. In this work, a brief overview of photovoltaic industry and trends are given. Having excellent geographical and climate conditions, especially in coastal parts of the country, Croatia could have considerable amount of electrical energy generated by photovoltaics.

Keywords: photovoltaics, renewable energy, fossil fuels

1. Introduction

After the famous oil crisis in 1973 industrialized countries became aware of their oil dependence. This encouraged them to start investments in finding new energy sources and technology development. Since then, significant progresses have been made on both fields, but the energy situation is more or less unchanged. Energy consumption in EU is constantly rising (by 1 to 2% a year) [3] while production is insufficient to meet its requirements. Currently, around 50% of EU energy requirements are imported and if no action is taken it is assumed that in next 20 to 30 years this figure will rise to 70%, increasing overall share for fossil fuels [4]. If this was the case, Europe would be even more dependent on unreliable energy sources whose prices have proved to be unstable. But problem of ensuring energy supply is not the only one as global awareness of environmental impact (global warming) of energy use and distribution is growing as well. Energy production and use, including transport, accounts for 80% of greenhouse gases. Unless current patterns of energy consumption are changed, emissions of greenhouse gases will continue to rise. At present, EU still cannot fulfill its commitments from Kyoto protocol. Today, energy demand is covered by 41% oil, 22% gas, 16% coal, 15% nuclear and only 6% renewable energy (including hydro energy which accounts for 5% in that figure)[4], Figure 1.

The key to change current unfavourable position is further investigation and development of renewables. It is decided that until 2010 their share in total energy production will double from 6% to around 12%, while their share in electrical energy production will rise from today's 14% to 22% [4]. But more decisive actions by means of financial measures (aids, tax deductions, financial support) are necessary if that ambitious plan is to be realized.

Photovoltaics is one of the most promising technologies for electrical energy production converting it directly from solar energy. In last five years it is among fastest growing industries with an average yearly increase of solar cells production of around 40%.[1]. The advantages of solar cells are numerous: they produce electricity with no noise, pollution or moving parts, their maintenance costs are small and they are long lasting.

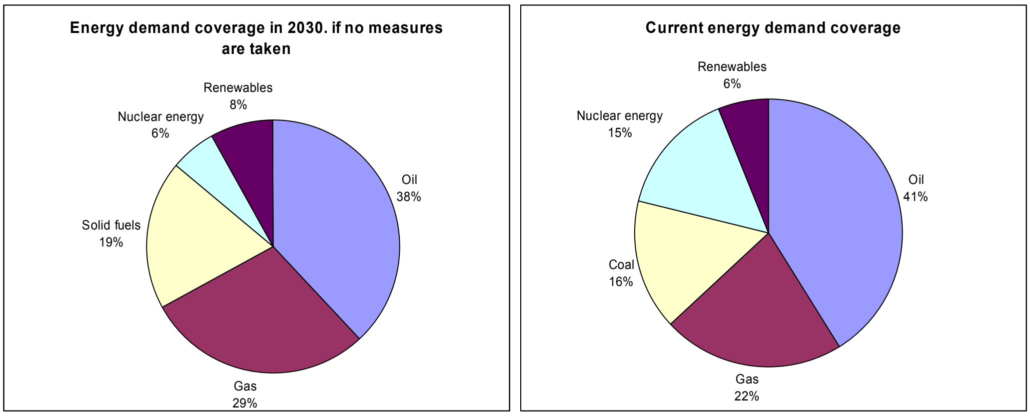

Figure 1. Energy demand coverage today and in 2030 if current trends continue [1]

2. Historical overview of photovoltaics

The first practical uses of solar cells were demonstrated in 1950s and in 1960s they received major boost from the space industry which needed reliable energy source for satellite applications. Oil crisis in 1970s focused world attention towards desirable renewable energy sources and comprehensive investigations of photovoltaics started. The research in silicon solar cells paid off in 1980s when solar cells began to increase its efficiency. In 1985 silicon solar cells reached the efficiency of 20% [2]. Over the next decade the photovoltaic industry grew steadily with rates of 15% to 20%. Today solar cells are recognized not only as a means of providing electrical energy but they are also a means of significantly diminishing the impact of environmental damage caused by conventional energy generation [2].

3. The world PV market

The development of photovoltaics is not only driven by progress in materials and processing technology but by market introduction programs in many countries. Within last few years Japan took over the leading position in solar cells production, Figure 2.

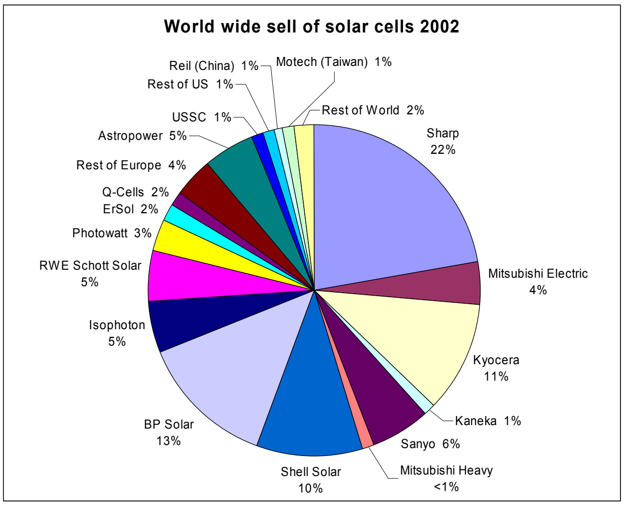

Figure 2. World wide sales of solar cells in 2002 (562 MW) [1]

The best example of Japanese production increase is Sharp which in 1997 had production capacity of 5 to 10 MW/year and held about 6 % of world market share. Fulfilling their ambitious plan, in year 2002 they reached the production capacity of 148 MW thus taking the leading place in the market with 22%. According to Sharp press release in July 2003 Sharp planned to increase their production to 248 MW in 2004 and in accordance with world market further growth can be expected [1]. The planned expansion of the production in Europe and USA is rather moderate. Currently, there is a fairly high uptake of solar technology in developing countries [6], Figure 3.

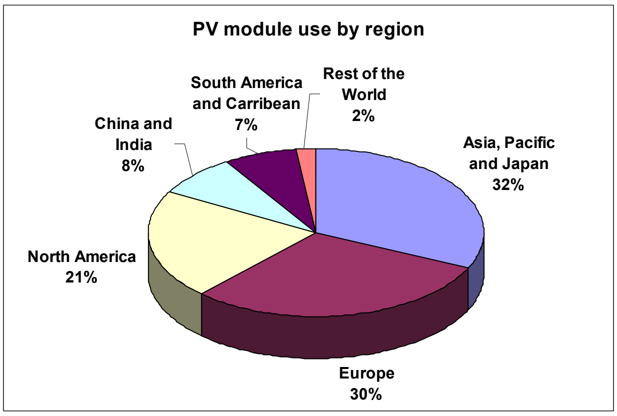

Figure 3. PV module use by region [6]

4. PV in Europe

European Union has set the targets that 12% of the total and 22% of the electrical energy in European Union has to be generated from renewable energies in order to meet the obligations towards the CO_2 reduction pledged in the Kyoto Protocol and to lower the dependence on energy imports. The member states were given freedom until 2005 to choose the kind of measures and incentives they want to use to reach the targets. The target for cumulative photovoltaic systems capacity installed in European Union by 2010 is 3000 MW [1]. Photovoltaic capacities in European Union in 2001 and 2002 are shown on Figure 3. Within the countries of European Union, current growth is currently driven by the German market which represented 77,5% of the newly installed capacities of the European Union in 2002. Led by its “100 000 Solar Roof Program” Germany installed 82 MWp in 2002, thus reaching a total capacity of 278 MWp [5].

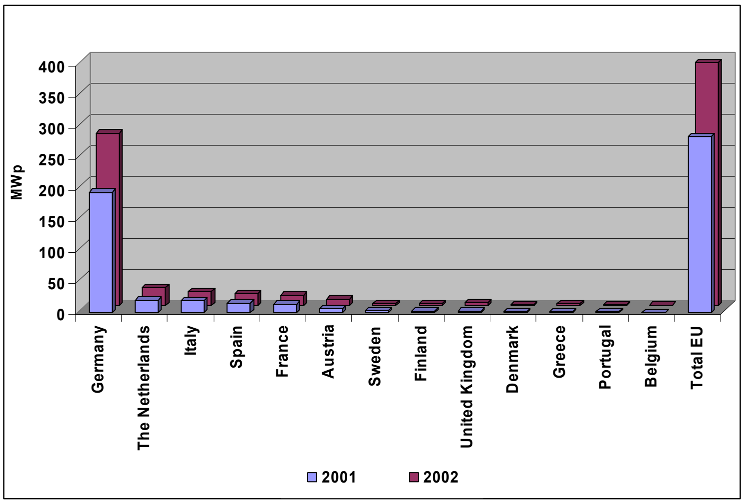

Figure 3. PV capacities in EU in 2001 and 2002 [5]

5. PV in Croatia

Croatia, especially its coastal region possesses excellent conditions for solar energy applications. That is obvious from comparison of solar irradiation on horizontal surface given in Table 1 [7].

From Table 1 it is clear that the sunniest parts of Croatia get 40% more solar energy than Central Europe and around 60% more than North Europe. The differences are biggest in January, when even the continental parts of Croatia receive twice as more solar radiation than North Europe.

The biggest potential for Solar energy applications have islands which have the most sunny hours in a year (2300-2800) [8]. Taking into account that economy of the islands is primarily oriented to tourism, the energy consumption is therefore the biggest exactly during summer months, while there is most solar energy available. That is one strong argument in favour of solar energy usage. The other one is fact that it is clean which is essential for regions oriented to tourism.

Table 1. Monthly mean daily solar irradiation of the horizontal surface in Europe and Croatia [7]

Location	**Annual average $kWh/m^2/day$**	**July average $kWh/m^2/day$**	**January average $kWh/m^2/day$**
Dubrovnik	4,4	7,0	1,8
Split	4,2	6,6	1,7
Istra	3,4	6,0	1,2
Slavonija	3,4	6,0	1,0
Zagreb region	3,2	5,7	0,9 - 1,0
Central Europe (largest part of Germany, France etc.)	3,0 - 3,2	5,2 - 5,5	0,7 - 0,9
North Europe (The Netherlands, Denmark, UK, southern Sweden)	2,6 – 3,0	5,2 – 5,5	0,4 – 0,6
South Europe (Greece, southern Spain)	4,4 – 4,8	7,2 – 7,6	1,8 – 2,6

For practical applications, measurements of solar irradiation of the horizontal surface and its components (total, direct and diffuse) are necessary. Systematic measurements of solar radiation in Croatia had begun in 1969 and since 1983 eight measurement stations were functional. Unfortunately, since 1989, total irradiation of horizontal surface is measured on none meteorological station of State Meteorological and Hydrological Service [9]. The only measurements kept in meteorological practice are measurements of insolation (sunshine duration in hours) which provides, using developed analytical models, to calculate irradiation of the horizontal surface. But much more precise and studious measurements have to be taken during longer period of time (several years) in order to be capable to precisely evaluate the real potential of solar energy. In that direction, modern system for solar radiation measurements is currently under installation on the Faculty of Electrical Engineering. It will ensure precious data about solar radiation in this area, allowing us to further investigate potential use of solar energy.

Today, the usage of solar energy in Croatia is negligible, represented mostly by locally installed systems for hot water heating, while photovoltaics are limited to very rare individual applications.

6. Conclusion

Energy demand and consumption in the world are constantly rising. In order to meet their energy needs, most countries have to import fossil fuels what makes them dependent on others. Complete economy of those countries depends on fossil fuels prices, which can vary significantly due to different reasons. On the other hand, fossil fuels are the major producers of greenhouse gases, which are responsible for climate changes. Therefore, the renewable energy sources are getting more attention. At the moment, photovoltaics are still not competitive comparing to fossil fuels. But solar cells prices are steadily decreasing with development of new production technologies and materials and that pattern is expected to continue. On the contrary, the price of electrical energy produced by fossil fuels can only rise. The most developed countries recognized the potential of photovoltaics and are making huge investments in its research and development. Photovoltaics could be the key for majority of the world's developing countries many of which have ample sources of solar insolation which can be economically harnessed throughout the year. Croatia possesses much better conditions for solar energy applications than most European countries but decisive measures for their stimulation are needed.

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ON THE DESCRIPTION OF CYCLIC BEHAVIOR OF ALUMINIUM AU4G. PARAMETERS' INFLUENCE IN THE HARDENING LAW

L. Blaj

Abstract

The aluminium AU4G samples, subjected to symmetric strain control cycles, presents a cyclic hardening, which is most remarkable in the first few cycles.

In order to fit this hardening in a constitutive model for material behavior, the Chaboche model was chosen, considering for this case a viscous behavior (through parameters K and n), a nonlinear isotropic hardening (parameters R, Q, b) and a kinematics nonlinear hardening (parameters C, D).

The simulations and the optimization of the parameters' values are done by means of the FEM code "Zebulon" [1].

The paper presents some aspects of the influence of parameters' values on the response of the material to the cyclic loading.

There are illustrations and analyses on the changes in the hysteresis loops caused by each parameter's variation.

Keywords: uniaxial constitutive model, isotropic and kinematics non-linear hardening law, viscoplasticity, strain control symmetrical cycling, simulations, optimisation

1. Introduction

In the last decades, a lot of constitutive models have emerged to describe the mechanical behaviour of materials. The model chosen here to describe the behaviour of Au4G aluminium is that of Chaboche [2], [3]. The experimental work was performed at INSA-Rouen (France), Laboratoire de Mecanique.

2. Presentation of the model

In uniaxial loading, the equations of this model are:

$$\sigma = X + sign(R + \sigma_v) \tag{1}$$

In this expression, sign has the value (+1) for traction and (-1) for compression, X is the kinematics hardening variable and R the isotropic one (the initial value of R is $R(0) = R_0$) and σ_v is the viscous component (which depends on the rate of plastic deformation).

In isothermal conditions, we have the next expressions:

$$dp/dt = \left| d\varepsilon^p/dt \right| \tag{2}$$

$$d\alpha/dt = d\varepsilon^p/dt - D\alpha\, dp/dt \tag{3}$$

and:

$$R = Q(1 - \exp(-bp)) \tag{4}$$

$$X = C\alpha \tag{5}$$

$$\sigma_v = K\left(\frac{dp}{dt}\right)^{1/n} \tag{6}$$

The phenomena of hardening are taken into account by means of two variables R (isotropic hardening) and X (kinematics hardening).

The isotropic hardening law is that in which the limit elastic surface in elasticity in stress space (loading surface) has an evolution governed by a single scalar variable (the dissipated plastic work or the accumulated plastic deformation, p), associated to thermodynamically force, R. The isotropic hardening corresponds to a simple dilatation of the initial loading surface.

The kinematics hardening corresponds to a translation of the loading surface in stress space. It is introduced using the variable X, which has a tensorial nature. It indicates the actual position of the loading surface (fixed as dimensions) in stress space. We have X = 0 in the initial state. There is another kinematics variable, α, in linear dependence with X, in order to be able to reproduce the cyclic experimental behavior.

In the case of monotonic loading, the combination of the isotropic linear and kinematics linear hardening laws is sufficient to describe the behavior; in cyclic loading the Bauschinger effect is qualitatively present and we must introduce nonlinear dependencies in the hardening laws.

The variable R is introduced to take into account the cyclic hardening or softening of the material, and changes from one cycle to another. In this way, the coefficient b is generally of order 10 and the accumulated plastic deformation p is given in mm/mm. The value of Q shows the difference between the maximal stress in the first cycle and in the stabilized cycle. It is positive for hardening and negative for softening.

On the contrary, the variable X has a rapid evolution during the cycling, to represent the Baushinger effect. The material coefficient D gives the saturation rate of the hardening, a value of 100 correspond to a slow saturation, and 1000 to a rapid one. The asymptotic value obtained in simple traction is given by C/D:

$$X = C/D(\ 1 - \exp(-D\,\varepsilon^{p}\ )\ ) \tag{7}$$

The viscous stress σ_v becomes greater when the effect of speed is important. When the deformation rate is not important, K must have a small value (zero for a model with instant plasticity). The exponent n diminishes with temperature. By simply taking n = 1 for a purely viscous material at high temperature, the values for intermediate temperatures can be 20 or 30, with a monotonous variation. The coefficient K varies in a non- monotonous way, “bell” shape, with the maximal values at intermediate temperatures.

The identification and optimization of the parameters’ values, after a procedure presented in [4], conducted to the following values (units MPa, mm, s): E = 65000, ν = 0.3, K= 20, n = 2, C = 60000, D = 750, R_0 = 60, Q = 75, b = 50. With these values are traced the simulated loops presented in Figure 1 (cyclsim5.test), together with the experimental ones (EXP/5sim.exp).

There is an asymmetry in the hysteresis loops, the maximal and minimal stress values not being equal, which produced some problems in founding the optimal values of the parameters. There were represented the first five loops for clarity, and also from the observation that the stabilization process is almost ended.

In order to see the influence of each parameter, the next figures present the simulated loops obtained by varying the value of one of these, the others being kept constant. The value was modified (smaller and bigger), keeping in attention the order of magnitude of each of them.

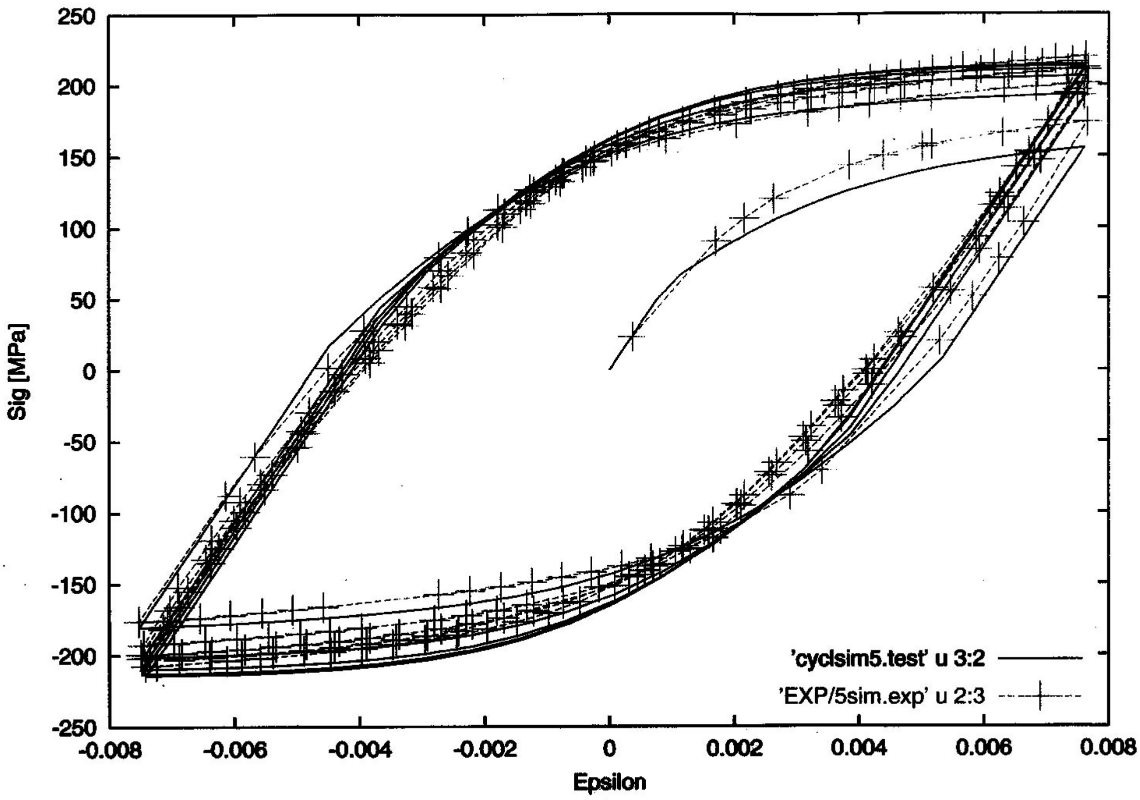

Figure1. The experimental and simulated curves

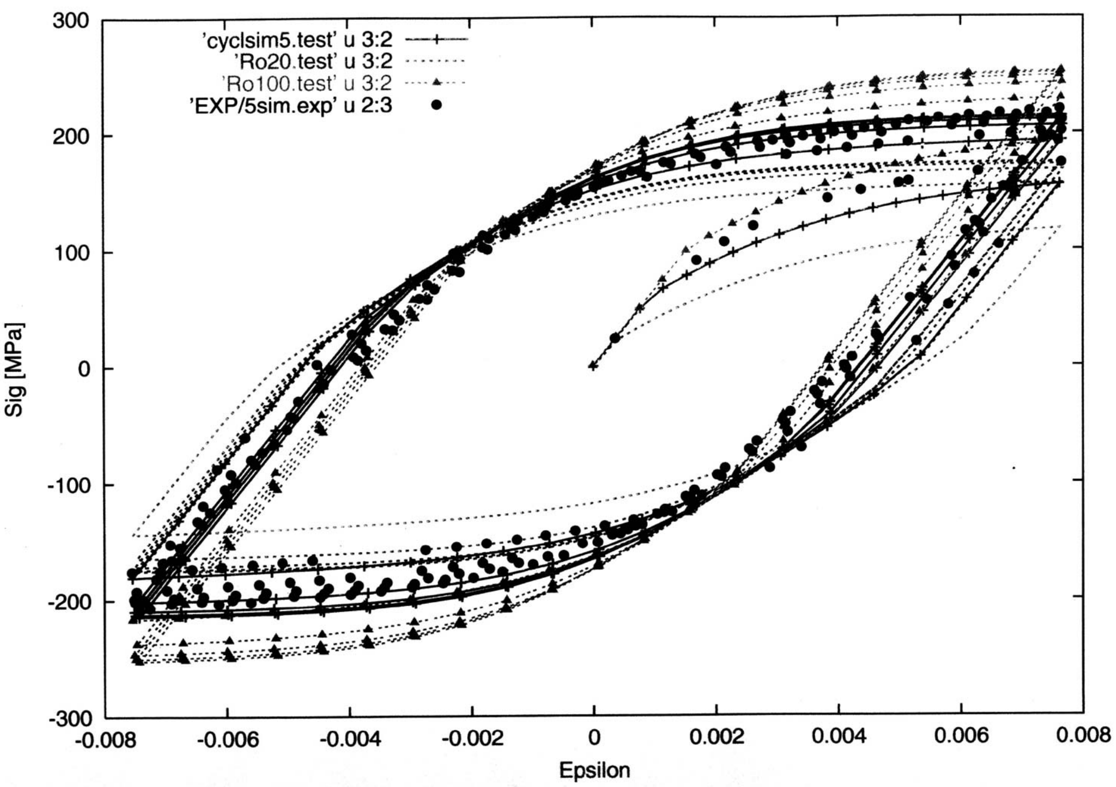

Figure 2. The influence of R_0

Figure 2 presents the influence of R_0. There can be seen the loops obtained for R_0 = 20 (Ro20.test curves) and for the value R_0 = 100 (Ro100.test curves). The value of R_0 strongly influences the elastic part of the curves, and in this way the value where the stabilization takes place (the bigger R_0, higher stabilized loop).

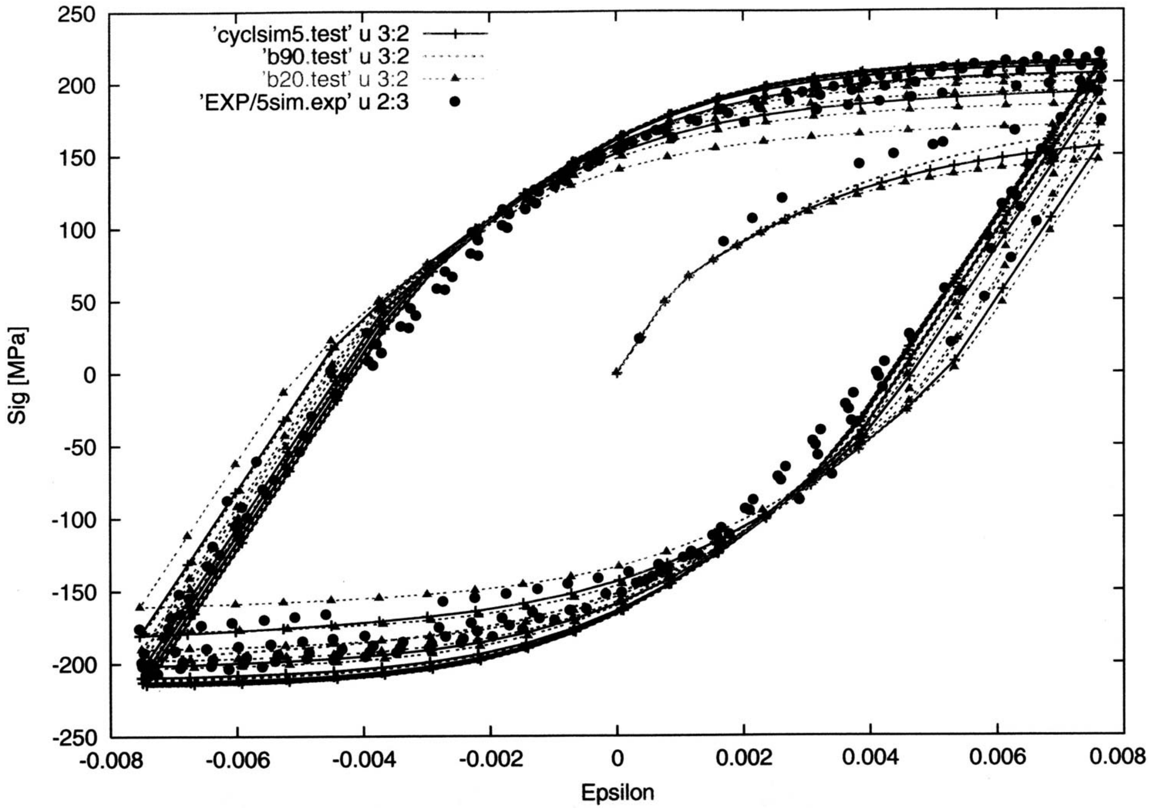

Figure 3. The influence of b

The influence of "b" can be seen in Figure 3. The curves are obtained for b = 20 (b20.test) and b = 90 (b 90.test). The influence of "b" is not so strong; a bigger "b" gives less flat loops, and approach better the experimental stabilized curve.

In Figure 4 we can follow the influence of Q. A value of Q = 15 (curves Q15.test) gives a difference of stress between the first and the last loop of 8 MPa, while Q = 105 (Q105.test), a difference of 90 MPa.

In order too see the influence of D, which influences the speed of saturation, we can compare the loops obtained for D = 550 (D550.test) and for D = 950 (D950.test), when the saturation rate is bigger.

As we have here experiments made at room temperature and with the same strain rate, we cannot put into value the influence of n and K in the viscous stress. The curves for K = 2 and K = 20 are almost identical. In order to see (anyhow) the influence of K, it was taken an unrealistic value of K = 800, which conducted to a stabilized loop much higher tat the experimental one (Figure 6).

In order to put into value the viscous stress we need also other experiments like simple traction with different strain rates, cyclic loading with different strain amplitudes, fatigue – relaxation tests.

A method to use these experimental tests will be presented in another article [5].

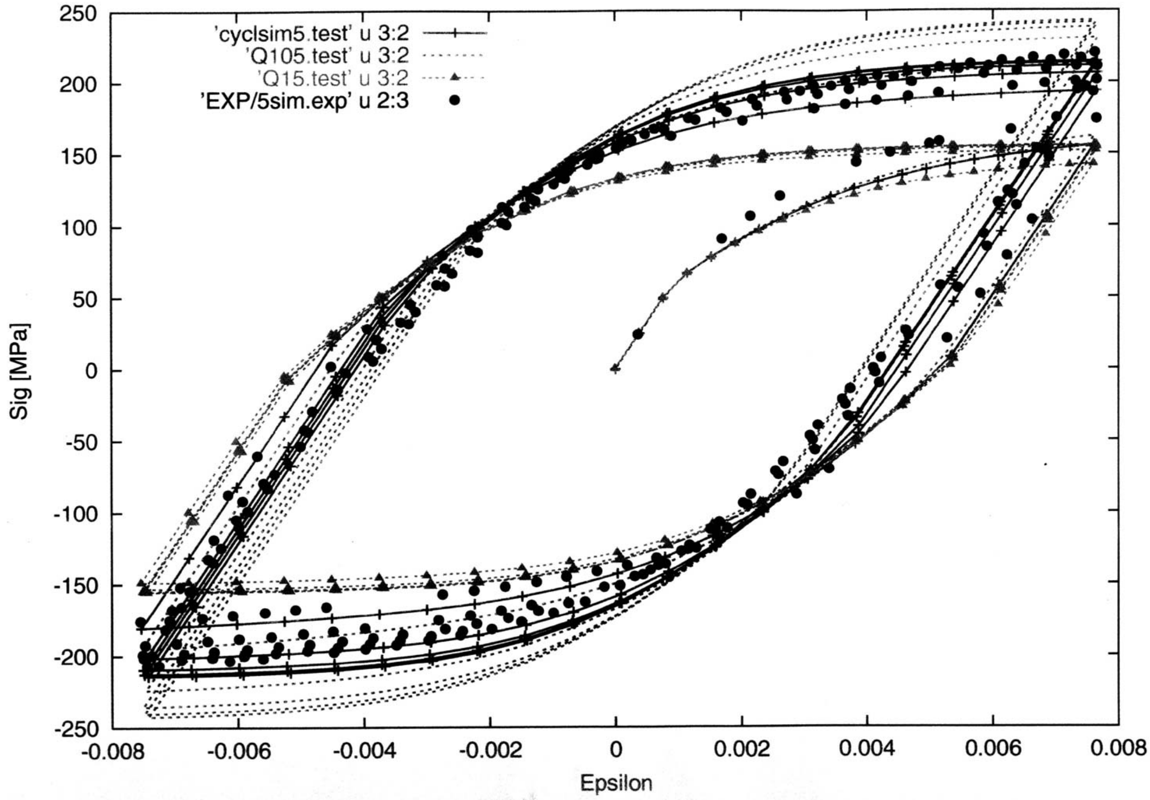

Figure 4. The influence of Q

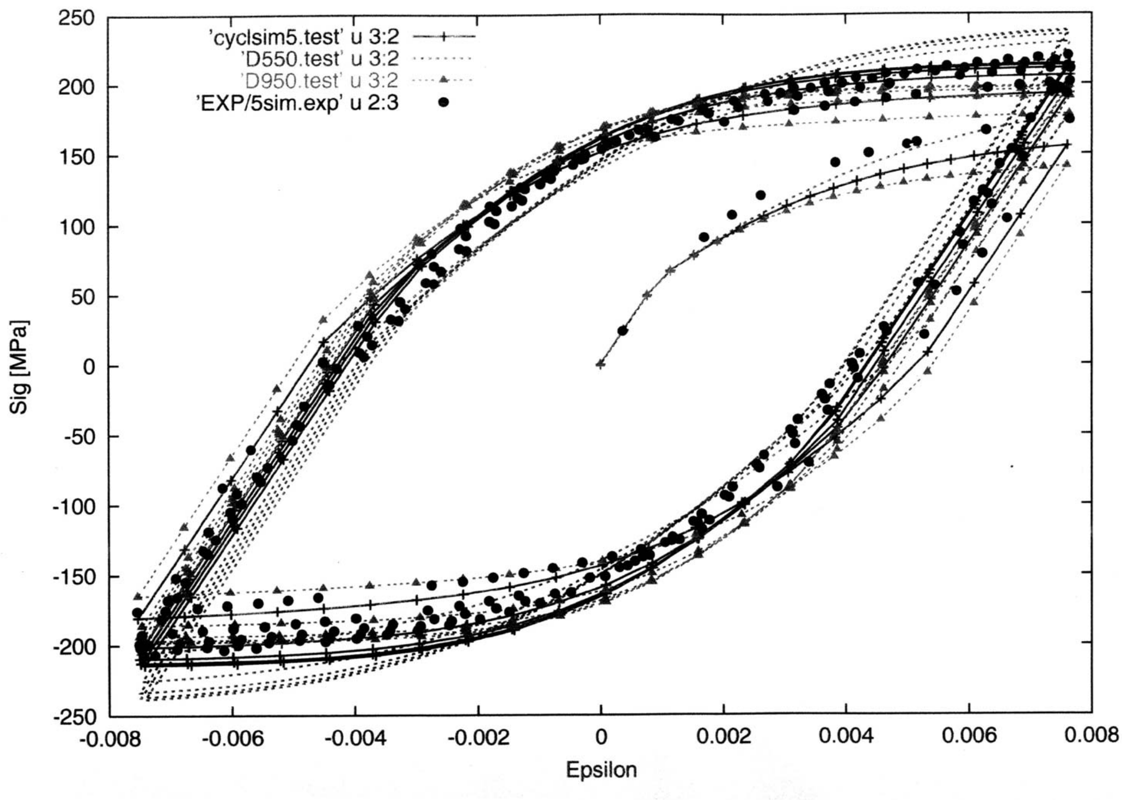

Figure 5. The influence of D

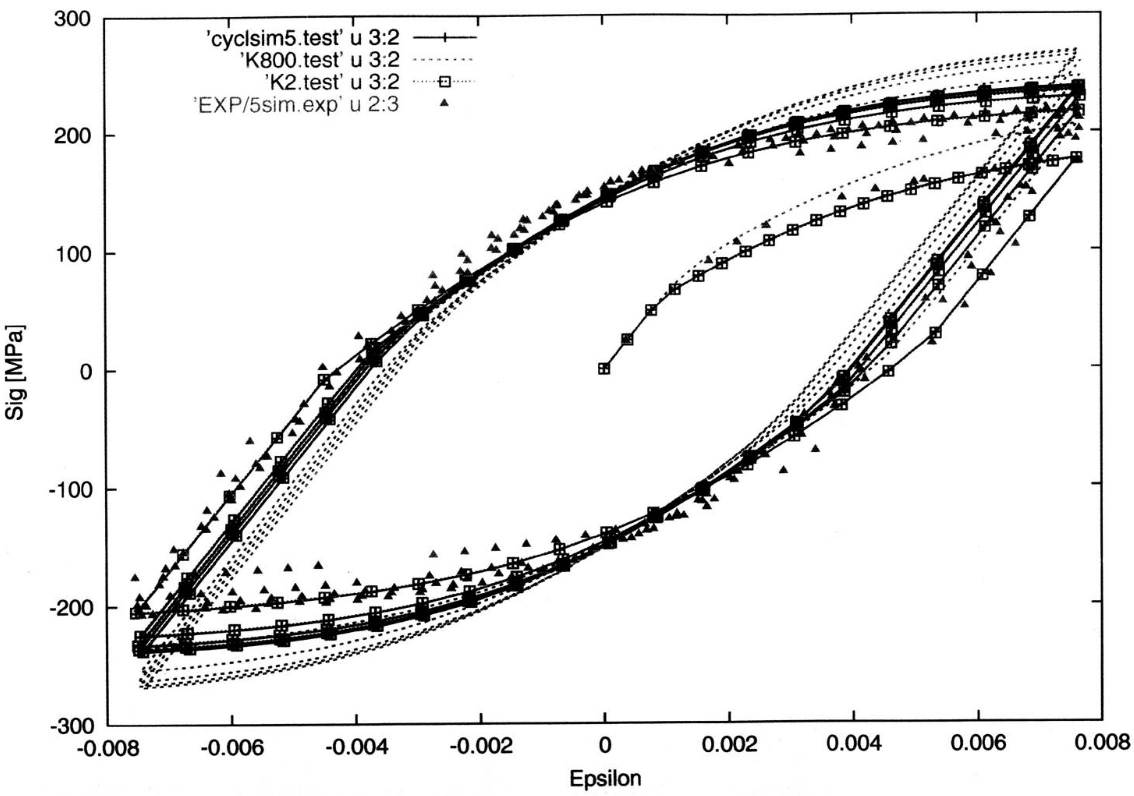

Figure 6. The influence of K

3. Conclusions

The constitutive model presented here contains 9 parameters. Each of them has its importance in the equations, which will describe the mechanical behavior of the material. For this material in particular, the most important are the parameters incorporated in the nonlinear isotropic and kinematics hardening law. As the test was performed at only one temperature, using one strain rate, the parameters in the viscosity law are less important

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THE INFLUENCE OF THE RENDERING METHODS ON THE PROPERTIES AND DIFFERENTIATION OF THE GAMUT SIZE OF THE IMPRINTS

S. Bolanča, M. Milković, N. Mrvac and N. Knešaurek

Abstract

The focus of this investigation is the explanation of the influences of different combinations of the rendering methods and starting colour spaces of the originals on the size and characteristics of the reproduction gamut. In accordance with this the identical test samples were created for the investigation, which were recorded into three different colour spaces: RGB, CMYK and CIE L*a*b*. Each sample was rendered by perceptual, saturation, relative and absolute colorimetric method and printed on two different types of the digital printing machines (with the liquid and powder toner) on identical printing substrate under standardised conditions.

Based on the information obtained by spectrophotometric measurements for each of 24 samples, particular and comparative presentations of gamut were constructed in CIE L*a*b* colour space, and their volume was calculated. On the basis of the obtained results the situations were defined, enabling the conclusion which of the rendering methods in the combination with the starting colour space, depending on the digital printing machine would give the preferred properties and the gamut size.

Key words: gamut, method of colour rendering, colour space, print

1. Introduction

Gamut of the original (scanner input media or the scene of the digital camera) as a rule, is always greater than the gamut of the four-colour printing. However the non-linearity of the human visual system enables the interpretation of the four-colour print (CMYK) as the substitution acceptable conception of the original, due to the psychophysiology of our perception. In different gamuts (original and print) which represent identical image or scene, the human brain will not perceive (at least not considerably) the difference among these gamuts in many cases, if the process of gamut transforming and mapping from bigger into the smaller was performed in one of the correct ways. It refers to the case of so called memory visual evaluation of the print (the possibility of perception of two different gamuts) in relation to the original (the case when the originals and reproduction cannot be compared simultaneously), The difference between gamuts (original and print) exists and it is possible to measure it by an instrument and to present it. In some cases it can be visually noticed by the determined methods of visual evaluation. In the mentioned context, this work is directed primarily to the explanation of the role of particular methods of gamut mapping, i.e. particular phases of the transformation of the colour presentation.

The aim of this work is to find out how much the method of rendering influences the size of gamut reproduction with regard to the technique of digital printing and the starting colour space, in order to contribute to the problems solving which appear during the process of graphic reproduction by digital printing technique.

2. The reproduction of the image information in digital printing

The reproduction of colour images, according to the present-day CIE interpretations is the process which, among others, includes four basic separable elements: medium characterization, modelling of the colour appearance, improvement of image and gamut mapping.

During the colour reproduction, the description of the original image which was originally at disposal depends on a medium in which it is present. In the prepress, they are different forms of electronic media which generate colours according to the propositions of the additive synthesis (scanners, digital cameras, computer monitors) In printing process the colours are generated on the basis of the subtractive synthesis on the defined printing substrate (most often on paper). In order to enable the information about colour being transformed from one medium into another (which is the case in the process of graphic reproduction), it is necessary first to describe (to characterize) the colour in particular medium in an independent way. Except that, one should take into consideration the perceptual attributes of colour: brightness, hue, saturation, because they are more important in communication than some characteristics of stimuli, which depend only on the receptors in the eye, and not on the subsequent processing by the visual system [1]. The two previously mentioned elements of the reproduction process (characterization of media and modelling of the colour appearance) should be enough for the reproduction of the colour image if the media always reproduced the same set and range of colours and if the process of graphic reprodcution would not include the category called image improvement (authenticity, accuracy, feeling of comfort, designers'demands and similar). As it is not a very often case, there is the need for overcoming all the differences which could exist among the colour sets obtained in different media, i.e. it is necessary to have a procedure (algorythm) of transforming and mapping among their sizes and characteristics, i.e. gamuts [1] (CIE commision had defined four basic methods of colour rendering in 2001, which contain, among other things, the defined mapping procedures).

2.1 The idea of gamut

Different media used in everyday life for the distribution of information have limits referring to the set of information which can be comprised and presented. Visual media are limited in the quantity of information about colour (and their characteristics) which they can present. The same is valid for the media used in the process of the graphic reproduction (scanners, digital cameras, computer monitors, different printers, digital and classic printing machines). This mentioned limited group of information about colour for the determined medium is defined as the term gamut. Mathematical description of the term gamut in graphic reproduction (on the print) is given in the following relations:

If Ω_{CIE} is the volume of the numerical values in the determined selected area of CIE colour space and if Ω_{print} is the numerical volume of the controlled colour values of medium, then the set:

$$G = \{t \in \Omega_{CIE} \mid \exists c \in \Omega_{printing} \text{ where } F_{device}(c)=t\} \qquad [3]$$

determines the gamut of the mentioned device (medium). It is similar with the complementary set:

$$G^c=\{t \in \Omega_{CIE} \mid \nexists c \in \Omega_{printing} \text{ gdje } F_{device}(c)=t\} \qquad [3]$$

where the colours, which are outside the gamut G^c of the mentioned device (medium) are defined.

The term F_{device} represents the function, which performs transformation from the dependent colour space of the device/medium in CIE colour space, the letter t represents information about colour in CIE colour space, and the letter c, represents its transformed value in the dependent colour space of the device/medium. Colours which are inside G^c (colours outside the gamut), which cannot be reproduced on the medium/device, must be placed inside the gamut, which can present the given device/medium. This process of placing the colours from one gamut into antoher gamut of different size (volume and characteristics) is called gamut mapping. For colours which are inside the gamut, the mapping is done among the control values of the device/medium and CIE colour space.

2.1 Rendering methods

In 2001 ICC defined and standardized four basic ways of gamut mapping in regard to the intention (accuracy) of the information presentation about the colour and it called them with the following names: perceptual rendering, relative colorimetric one, saturated and absolute colorimetrice colour renedring. The term color rendering intent refers to the process of the transforming and mapping of the gamut of the original into the gamut of reproduction, in dependence on the intention in which way (which accuracy and which characteristics) one wants to reproduce the colours in the reproduction gamut.

In perceptual rendering all the colours of the original gamut are transferred so that they became a part of the gamut reproduction, i.e. they are compressed so that they are completey put or almost completely put into the gamut reproductions. With this transforming, all the colour of the original gamut, even those which could be identically transformed into the reproduction gamut have been changed at the output, however the lightness axis (the range from the lightest to the darkest area) as well as the mutual relations among the tones are preserved, i.e. the relative relations are retained. In perceptual rendering the accuracy of the colorimetric colour characteristics has been changed to the benefit of the total perceptual experience which is based on the retaining the relative relation among the colours. From the aspect of the reproduction accuracy, the perceptional method satisfies the criteria of the equivalent or corresponding reproduction.

In saturation rendering, all the colours which are not a part of the reproduction gamut are usually transformed into the nearest corresponding colours of the same saturation, while the lightness and hue can be changed. Colours inside the limits of the reproduction gamut shift towards the gamut limits in order to additionally increase the saturation. Colorimetric accuracy between the original and the reproduction in saturation rendering can in certain cases be kept, but it is not the priority. In regard to the accuracy, the saturation method has the qualities which are demanded up to the certain point in the preferred (wanted) reproduction.

In relative colorimetric rendering, all the colours belonging to gamuts of the original and of the reproduction remain unchanged. Colours which are not a part of a reproduction gamut, have been mapped into the nearest colours of the same lightness (depending on the black and white dot), but with different saturation which is on the limits of the reproduction gamut. Mapping of several different colours of different lightness into one lightness value, which is performed in the area outside the reproduction gamut, causes disturbances (loss of value) on the lightness axis, and it is characteristic for the relative colorimetric rendering that the reproductions seem to be darker. However, the method of relative colorimetric rendering tries to decrease the mentioned problems by the tone, by the reproduction of black and white dot. In regard to the accuracy, the closest method to the relative colorimetric method of colour rendering is the colorimetric reproduction.

In absolute colorimetric rendering all the colours belonging to the gamuts of the original and the reproduction stay unchanged. Colours which are not a part of the gamut have been mapped into the nearest colours of different saturation which are in the limits of the reproduction gamut. Except the loss of hues and lightness in the area outside the reproduction gamut, in absolute colorimetric rendering, another problem appears which is combined to the achromatic axis of lightness and which refers to different values of black and white dots on the gamut of the original and the gamut of the reproduction. In the reproduction of cross-media, which happens in the process of the graphic production, where there are additive (prepress) and subtractive media (printing), the problem combined to the black and white dot appears [[2]. The additive media, i.e. their primaries cannot influence the predefined values of the black dot (phosphorus without stimulus) and the subtractive media cannot influence the value of the white dot (colour of the printing substrate). The mentioned facts cause that all the relations among the hue and lightness on the image do not change in dependence on the whiteness of the substrate, which results in an inaccurate presentation of the lighter tones.

3. Experimental

The measuring samples are created by printing of ECI measuring form composed of 210 patches of different combinations of colour value of the subtractive synthesis, generated by the vector graphic in steps of 5%, from the three starting colour spaces (RGB, CMYK i L*a*b*), where the printing substrate for both kinds of machines for digital printing (Xerox, DocuColor 2060 and Canon W2200) was the identical material – on both sides multi-coated glossy fine art paper of high whiteness (expressed in CIE L*a*b* values: L*= 95.8, a* = 0.2 i b* = 0.3), and the grammage 135 g/m^2, with the size of 350 x 480 mm. The paper was in the same room before the printing process, air-conditioned for the period of 48 hours with the standard conditions (temperature 23^{0}C, relative humidity of 55%).

During the printing, each test form was rendered with each of the defined standard methods: perceptual method, saturation one, relative colorimetric one and absolute colorimetric method. 12 different samples were printed by the mentioned process on each of the digital printing processes (3 colour spaces x 4 rendering methods), i.e. total 24 different samples which were marked with the numbers from 1 to 24 because of the identifications in further investigation phases. The run for each sample was 10 prints (for statistical accuracy during the measuring process).

Measurements of the samples were performed on X-Rite DTP 41 by the reflex spectrophotometer in the range of the wavelengths from 390 to 710 nm, in steps of =10nm and the illumination geometry of 45^0/0^0. The accuracy of the device, i.e. approximate aberration in the sense of the reflexion is mostly up to 0,5% per step of the wavelength. The reference standard for calibration was the input in MSCL laboratory on RIT, on 12.05.2003 with the validity term of 18 months. The accuracy of measurements after that standard input is by CIE Lab E* = 0.25, for the light source D50 and observation angle of 2^0.

4. Investigation results

After the performed spectrophotometric measurements the volume of the gamut was calculated from the medium three-stimulus values which were converted in CIE L*a*b* values, which were expressed in cubic units (CCU) for CIE L*a*b* system of the colour presentation.

Table 4.1.1. Presentation of the gamut volume of the individual samples

Mark of the sample	Starting colour space	Rendering method	Kind of toner	Volume of gamut (CIE L*a*b* CCU)
1	RGB	SATURATION	DRY	792887
2	CMYK	SATURATION	DRY	756073
3	Lab	SATURATION	DRY	728200
4	RGB	SATURATION	LIQUID	467058
5	CMYK	SATURATION	LIQUID	401812
6	Lab	SATURATION	LIQUID	297116
7	RGB	RELATIVE COLORIMETRIC	DRY	965570
8	CMYK	RELATIVE COLORIMETRIC	DRY	838543
9	Lab	RELATIVNE COLORIMETRC	DRY	830160
10	RGB	RELATIVE COLORIMETRIC	LIQUID	593611
11	CMYK	RELATIVE COLORIMETRIC	LIQUID	553525
12	Lab	RELATIVE COLORIMETRIC	LIQUID	419210
13	RGB	PERCEPTUAL	DRY	791049
14	CMYK	PERCEPTUAL	DRY	751777
15	Lab	PERCEPTUAL	DRY	738192
16	RGB	PERCEPTUAL	LIQUID	465158
17	CMYK	PERCEPTUAL	LIQUID	396992
18	Lab	PERCEPTUAL	LIQUID	293928
19	RGB	ABSOLUTE COLORIMETRIC	DRY	1038538
20	CMYK	ABSOLUTE COLORIMETRIC	DRY	859160
21	Lab	ABSOLUTE COLORIMETRIC	DRY	849975
22	RGB	ABSOLUTE COLORIMETRIC	LIQUID	682203
23	CMYK	ABSOLUTE COLORIMETRIC	LIQUID	578016
24	Lab	ABSOLUTE COLORIMETRIC	LIQUID	587851

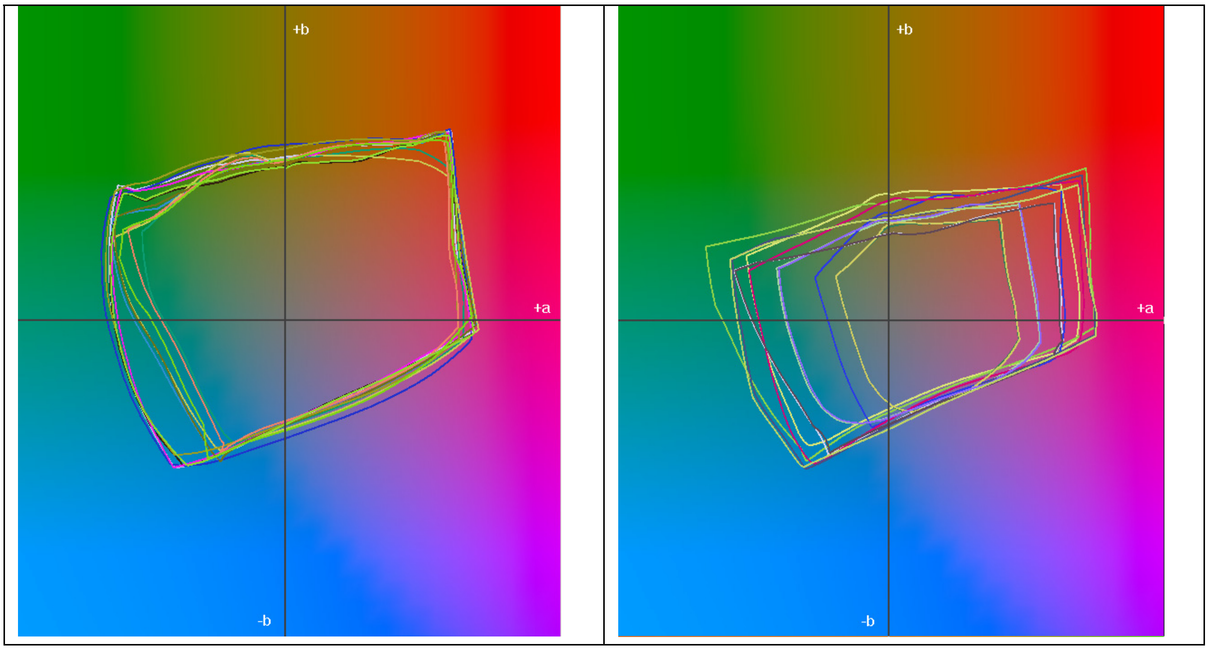

Figure 1. Presentation of the gamut of prints made by the dry toner (left) and the liquid toner (right) for L*=50

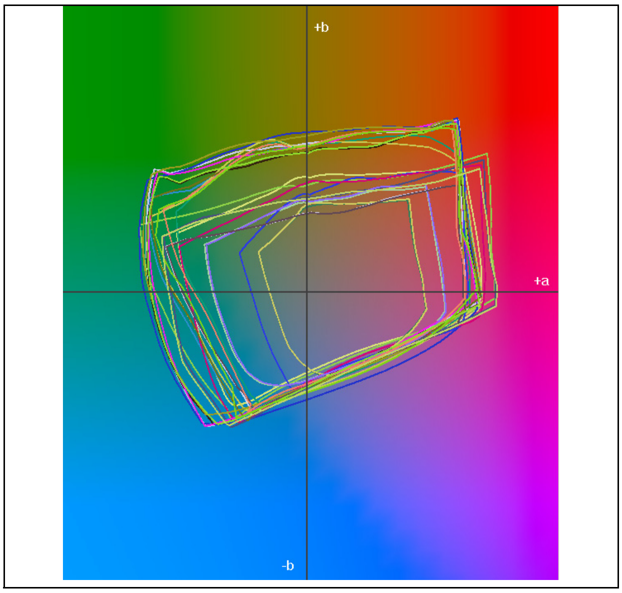

Figure 2. Comparative presentations of gamuts of all the prints for L*=50

5. Discussion and conclusions

In the result analysis, it was found out that when the type of the digital printing machine was taken as the observation criterion, i.e. the principle of the liquid and dry toner, the gamut volume in digital prints on the principle of the dry toner was always greater than the gamut of prints obtained by the liquid toner in all the cases (on all the samples).

The difference in gamut volume calculated with the instrument, for CIEL*a*b* CCU between the two mentioned techniques is such that the smallest gamut measured on the sample produced with the dry toner – sample 3 (V=728200 CIE L*a*b* CCU), is greater than the greatest gamut obtained by the liquid toner – sample 22 (V=682203 CIE L*a*b* CCU). The further visible differences in the gamut size between the two techniques of the digital printing show that the volume of the greatest gamut calculated for the print obtained by dry toner – sample 19 (V=1038538 CIE L*a*b* CCU) is 3 times greater than the smallest gamut volume for the print obtained by liquid toner – sample 18 (V=293928 CIE L*a*b* CCU).

When analysing the results of the instrumental sources, the starting colour space of the original has been taken as the observation criterion, which in the process of the graphic production can be RGB, CMYK ili L*a*b*, the following regularities combined with the relations gamut volume are visible:

The greatest gamut volume in both types of digital printing machines was obtained when the starting colour space of the original was RGB colour space (samples 19 and 7 with dry toner, and the samples 22 and 10 with liquid toner). The smallest gamut volume was obtained with both types of the digital printing machines for identical colour space, which was in this case L*a*b* (samples 13 and 14 with dry toner, and the samples 6 and 18 with liquid toner). The samples (prints) with the starting colour space CMYK are in the middle part (between RGB and L*a*b* colour space) in regard to the gamut size for particular type of the digital printing machine. However, when observing the gamut sizes of all 24 samples on both digital printing machines, it was not possible to determine exactly, which colour space would always give the greatest gamut on the print. There is no exact repetability for all 24 samples except for the smallest and the greatest gamut volume.

If the rendering method has been determined as the selection parameter together with the observation priority, more accurate indicators with exactly defined influence of the starting colour space on the gamut volume are obtained.

During the result observation which describes the mutual relations of the starting colour space and particular rendering methods it is visible that there is the regular arrangement of influences of the starting colour space of the original on the gamut volume of the reproduction for each rendering method in digital printing, performed by dry toner and by liquid toner.

In each particular rendering method, the greatest gamut volume on the reproduction (print) is obtained by the usage of the RGB starting colour space with the original. The smallest gamut on the print was obtained by the usage of L*a*b* starting colour space of the original. CMYK colour space of the original for a particular rendering method on both digital printing machines, in regard to the gamut size, is always between the gamut sizes obtained by RGB and L*a*b* starting colour spaces.

The dependence of the gamut size on the applied rendering method and the starting colour space of the original have been found out.

It was found out that for each starting colour space, the greatest calculated gamut volume on the print, on both digital printing machines was obtained by means of the colorimetric rendering method, after that relative rendering colorimetric method, then saturation rendering method and finally perceptual rendering method. (The obtained aberrations from the mentioned L*a*b* starting colour space on the machine for digital printing based on the dry toner point out the need to perform further investigations for the given case).

It was found out that the influence of the combination of a particular rendering method with the particular starting colour space on the gamut size is much more expressed on the sampes printed with liquid toner than on the samples printed with the dry toner.

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OPTIMIZATION OF THE SUPERFINISHING PROCESS

R. Cebalo, D. Bajić and B. Bilić

Abstract

By superfinishing process, ultra precision machining process of cylindrical, conical, spherical and even flat surface machine parts is performed. These parts must have high wear resistance and low coefficient of friction.

In this paper impact factors on surface roughness are determined. According to the factors test plan and regression analysis, extend equation for mean arithmetical roughness is given. In other to get minimum values of the surface roughness, optimization of the mathematical model is done and optimal values of the examined factors are determined. The obtained results are, according to the experiment plan, valid for the testing of material 34 CrNiMo6. The test results are to be probably applied to other materials, however, has to be proved for each separate case.

Keywords: surface roughness, superfinishing, mathematical modelling, optimisation

1. Introduction

Surface finish quality influence to the exploitation characteristics of machine parts (sliding clearances, noise, lubrication etc.). Ideal straight and smooth surface cannot be obtained, but there are several processes that improve finish quality. Smooth surface provide a very close fit between two parts in contact and for parts exposed to the dynamic load. Supefinishing, figure 1., is a surface–improving process that removes undesirable effects in exploitation. Due to the high costs of the process the shape and dimensions of the workpiece are to be obtained by a procedure of fine machining (e.g. fine turning, milling, grinding), leaving a machining supplement which depending on the surface quality obtained by the previous machining, does not go over 0.005 to 0.01 mm. Roughness *Ra* from 0.012 μm to 0.0025 μm can be obtained by superfinishing. The basic features of the process are the following:

- slow tangential circumferential speed of the workpiece,
- medium pressure,
- little heat,
- large area of workpiece and tools contact,
- short machining time,
- silent machining.

During the procedure the workpiece surface roughness falls very quickly. Simultaneously, the workpiece surface effects the stone surface causing the wear of the stone. Full automatisation of machines for superfinishing process is obtained by building in the elements for acceptance, supply and further transport of workpieces and by building in devices for their automatic control. Besides great advantages obtained by such a process it is chiefly applied in mass production since it is difficult to decide on optimal conditions for a particular process without long lasting experiments. In piecemeal machining in which the process was not optimalised machining costs would be too high.

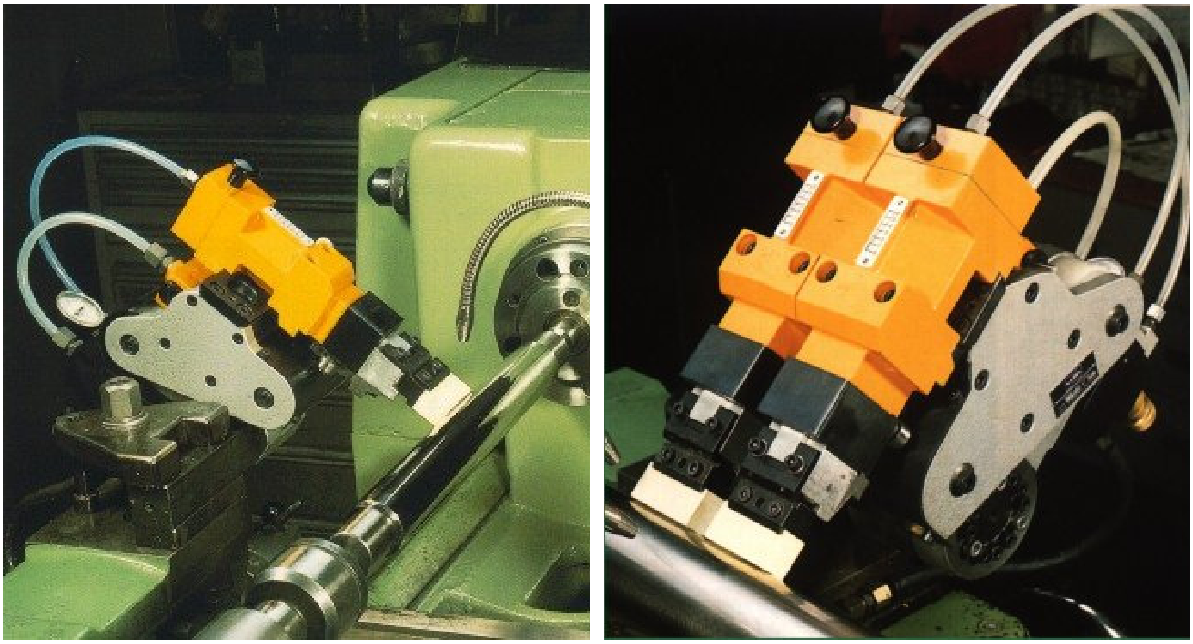

Figure1. Illustration of superfinishing process

During machining there is practically no warming up of the workpiece and consequently the workpiece surface does not alter characteristics obtained by previous heat machining. This is why the possibility of heat exertions of surface in the course of machining is excluded.

2. Influencing factors on the surface roughness

During machining, figure 2., main motion is a complex motion from workpiece rotation with tangential circumferential speed v_o and stone vibration parallel to the workpiece axis with speed v_v. Feed speed v_f is also parallel to the workpiece axis. Stone presses upon workpiece with the force F_n and the pressure between the workpiece and stone appears, the high of which enables the chip formation process. The result of such motion is a sinusoidal curve, which appears at the surface of the workpiece in the form of a coil. Because of such motions an abrasive grain seldom covers the same way, thus taking off roughness without new scratches. Relative motion of tools (stone) in relation to the workpiece can be decomposed into three orthogonal speed components, figure 2:

- speed components parallel with workpiece surface:
  1. axial speed v_a (feed velocity v_f and oscillation velocity v_v),
  2. tangential circumferential speed v_o,
- speed component vertical to workpiece surface:
  1. supply speed v_n.

The result of superfinishing is influenced by two sets of units, figure 3:

- Machining system
- Operating parameters

So-called "*statical units*" which do not change in the course of processing define machining system:

- Machine (work effect, power, dynamic properties),
- Workpiece (geometry, material, quality of roughing out),
- Tools (geometry, type of abrasive, grain size, hardness, porosity, bond, finish quality, accuracy),
- Cooling (type, viscosity, concentration, quantity, mode of supply, pressure).

Operating parameters are variable units, which alter according to the needs and within the limits of the construction capabilities of the operating system:

- Pressure,
- Amplitude of axial sinusoidal oscillation,
- Workpiece rotational speed,
- Axial oscillation frequency.

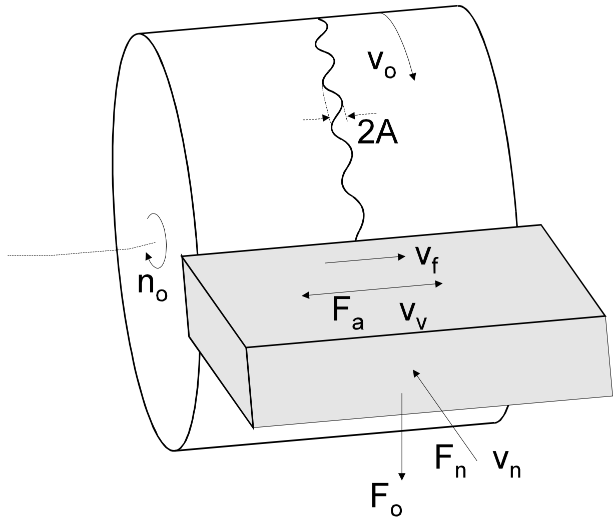

Figure 2. Superfinishing stone in contact with the workpiece

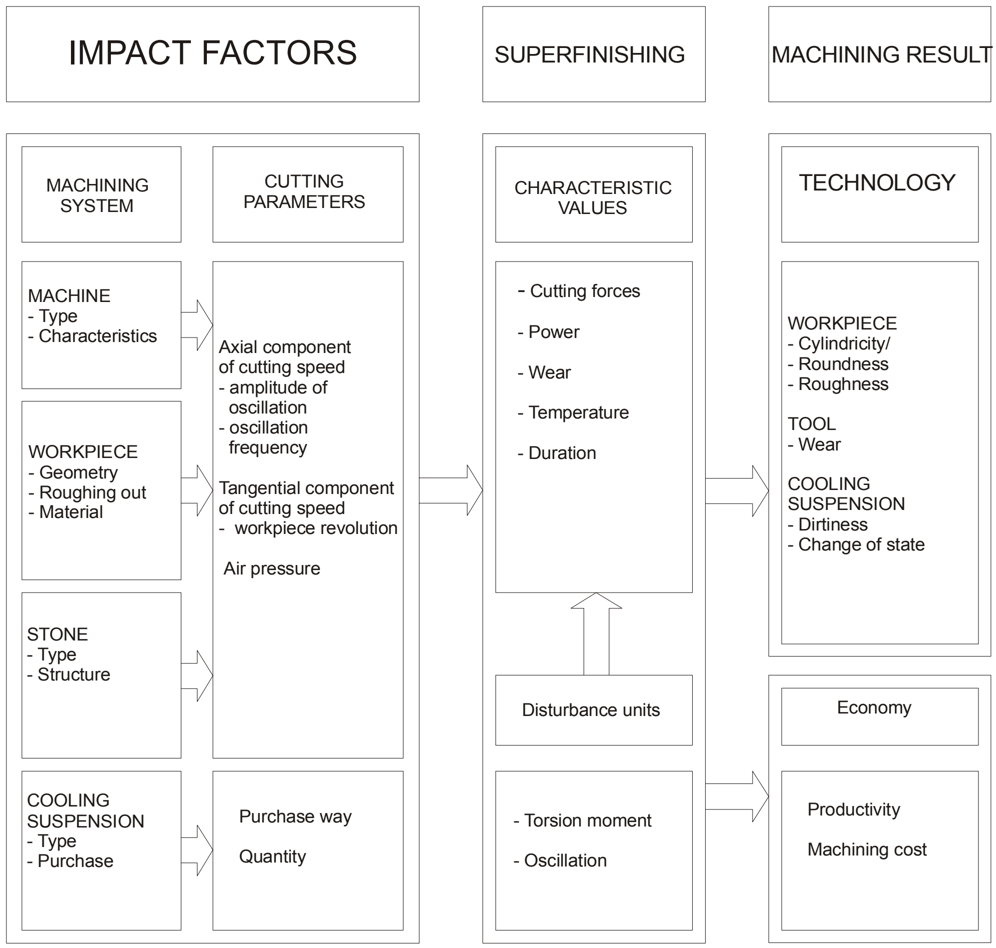

Figure 3. Impact factors and superfinishing result

3. Testing conditions

Testing were executed using universal lathe “Prvomajska”, type D420/1500. Preparation of the specimen were done to remove influence layer, rust, grooves, damage in material, admixtures in surface and to get specimen with defined dimensions and initial roughness. Superfinish device “Supfina SE-40” was fixed in tool holder on lathe, so the lathe was used for superfinish process also. Sandvik Coromant tools and inserts were used for specimen preparation (inserts *TNMG 16 04 08 – PR* and *TNMG 16 04 08 – PF* as well as tool *PTGNR 20 20 K 16)*.

Superfinishing stones for this investigation contained 400 grit silicon carbide abrasive. Each stone had a rectangular cross section 60 mm wide (axial direction) and 28 mm thick (circumferential direction). Each workpiece was a cylinder of 34 CrNiMo6, 70 mm outer diameter and 420 mm length, subdivided into 5 test specimens 58 mm wide. Device “Surtronic 3+” was used for measurement of surface roughness. Beside device, Data Processing Module was used. Data processing Module connected directly to the “Surtronic 3+” via the RS232 port, has an integral thermal printer for hard copy output of measured profiles and results lists. During superfinishing a mixture of mineral oil and kerosene in ration 60/40% was applied.

4. Results of experiments and optimisation

As it was mentioned before, surface roughness during superfinishing is influenced by lots of impact factors. Due to limited number of factors that could be examined in the same time, in this paper are chosen:

- tangential circumferential speed v_o,
- air pressure *p,*
- machining time *t,*
- initial roughness R_{a0}.

According to the design of experiment, in table 1. experimental results of measured surface roughness are given. Statistical analysis of data, using software *Design Experiment 6.0*, was done. Using obtained response functions models, singular values for certain conditions were calculated and set in table 1. High value of coefficient of determination shows high parity of calculated values with the measured values. The response function is well modeled by a non-linear function of the independent variables, and the approximating functions for *Ra* is the second order model:

$$\begin{aligned} R_a = {} & 0.105714 - 0.01 \cdot X_1 - 0.084167 \cdot X_2 - 0.066667 \cdot X_3 + 0.043333 \cdot X_4 - \\ & - 0.03125 \cdot X_1 \cdot X_2 + 0.01625 \cdot X_1 \cdot X_3 + 0.01875 \cdot X_2 \cdot X_3 - 0.02375 \cdot X_2 \cdot X_4 + \\ & + 0.030238 \cdot X_1^2 + 0.051488 \cdot X_2^2 + 0.035238 \cdot X_3^2 + 0.017738 \cdot X_4^2 \end{aligned} \tag{1}$$

with coefficient of determination $R^2=0.9749$.

Applying the partial derivation as an optimization method on the function (1), optimal value of influencing parameter can be determined:

$$\frac{\partial R_a}{\partial X_1} = 0, \quad \frac{\partial R_a}{\partial X_2} = 0, \quad \frac{\partial R_a}{\partial X_3} = 0, \quad \frac{\partial R_a}{\partial X_4} = 0 \tag{2}$$

Thus, following equations has to be solved:

$$\begin{aligned} & 6.0476 \cdot X_1 - 3.125 \cdot X_2 + 1.625 \cdot X_3 - 1 = 0 \\ & -3.125 \cdot X_1 + 10.2976 \cdot X_2 + 1.875 \cdot X_3 - 2.375 \cdot X_4 - 8.4167 = 0 \\ & 1.875 \cdot X_2 + 7.0476 \cdot X_3 - 6.6667 = 0 \\ & -2.375 \cdot X_2 + 3.5476 \cdot X_4 + 4.3333 = 0 \end{aligned} \tag{3}$$

Optimal parameters obtained applying this procedure are:

$$v_o = 1.672 \text{ m/s} \qquad p = 0.178 \text{ MPa} \qquad t = 18.67 \text{ s} \qquad R_{a0} = 0.95\ \mu\text{m}$$

Table 1. Measured values of machined surface roughness

FACTOR		v_o/m/s/	p/MPa/	t/s/	R_{a0}/μm/
FACTOR CODE		X_1	X_2	X_3	X_4
BASIC LEVEL	(0)	1.5375	0.15	15	1.21
UPPER LEVEL	(+1)	2.050	0.2	20	1.52
LOWER LEVEL	(-1)	1.025	0.1	10	0.89
LOWER LEVEL OF MIDDLE AXIS	(-2)	0.513	0.05	5	0.58
UPPER LEVEL OF MIDDLE AXIS	(+2)	2.560	0.25	25	1.84

R.B.	X_1	X_2	X_3	X_4	R_a/μm/	R_{max}/μm/	R_z/μm/
1	-1	-1	-1	-1	0.35	3.05	2.71
2	+1	-1	-1	-1	0.37	3.04	2.73
3	-1	+1	-1	-1	0.24	2.46	1.92
4	+1	+	-1	-1	0.14	1.60	1.11
5	-1	-1	+1	-1	0.16	1.94	1.31
6	+1	-1	+1	-1	0.20	2.25	1.65
7	-1	+1	+1	-1	0.11	1.42	1.03
8	+1	+1	+1	-1	0.08	1.01	0.67
9	-1	-1	-1	+1	0.47	3.35	2.78
10	+1	-1	-1	+1	0.50	3.40	2.85
11	-1	+1	-1	+1	0.29	2.76	1.98
12	+1	+1	-1	+1	0.17	2.03	1.47
13	-1	-1	+1	+1	0.26	2.67	2.11
14	+1	-1	+1	+1	0.38	3.13	2.76
15	-1	+1	+1	+1	0.15	1.80	1.32
16	+1	+1	+1	+1	0.11	1.43	1.06
17	-2	0	0	0	0.25	2.53	1.90
18	+2	0	0	0	0.17	2.01	1.42
19	0	-2	0	0	0.45	3.13	2.77
20	0	+2	0	0	0.14	1.63	1.15
21	0	0	-2	0	0.36	3.09	2.71
22	0	0	+2	0	0.10	1.34	0.95
23	0	0	0	-2	0.07	0.98	0.63
24	0	0	0	+2	0.25	2.54	2.08
25	0	0	0	0	0.11	1.41	1.05
26	0	0	0	0	0.10	1.34	0.91
27	0	0	0	0	0.11	1.39	1.03
28	0	0	0	0	0.10	1.30	0.88
29	0	0	0	0	0.10	1.32	0.89
30	0	0	0	0	0.11	1.40	1.05
31	0	0	0	0	0.11	1.40	1.07

Figure 4 shows dependence of surface roughness upon stone pressure and tangential component of cutting speed for optimal values of machining time and initial roughness.

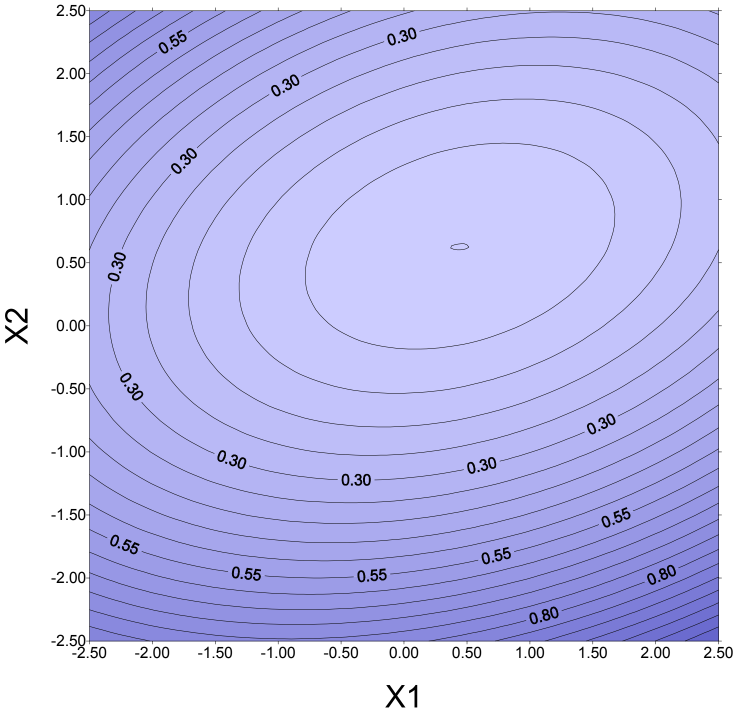

Figure 4. Dependence of surface roughness upon stone pressure and tangential component of cutting speed for optimal values of machining time and initial roughness

4. Conclusion

In this paper effect of tangential circumferential speed v_o, air pressure p, machining time t, initial roughness R_{a0} on surface roughness during superfinishing process has been examined. The strongest effect on roughness has air pressure, and than follows machining time, initial roughness and tangential circumferential speed. Model that includes only impact factors was not satisfied because of low coefficient of determination. Because of that, interaction between factors should be included. The strongest effect has interaction between air pressure and initial roughness, as well as interaction between air pressure and machining time. However, interaction between tangential circumferential speed and initial roughness, as well as interaction between machining time and initial roughness has not significant effect on surface roughness. Applying the partial derivation as an optimization method on the function (1), optimal value of influencing parameter is also determined. The obtained results are, according to the experiment plan, valid for the testing of material 34 CrNiMo6. The test results are to be probably applied to other materials, however, has to be proved for each separate case.

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OPTIMIZATION OF PARAMETERS OF GRINDING PROCESS

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Abstract

Machining of complex form surfaces is nowadays possible in several procedures, e.g. with deep grinding process with high porosity grinding wheels. To maintenance form accuracy there is necessity for tool dressing. Applying the certain grinding procedure and in certain condition of tool dressing, it is possible to influence on roughness of grinding wheel as well as on ground surface roughness. The influence of tool dressing strategy and grinding parameters on final ground surface roughness will be shown in this paper. During the wheel dressing, two different strategies were applied: diamond roller and pressing roller dressing.

Keywords: grinding, tool dressing, optimization and roughness

1. Introduction

Roughness of the grinding surface is important characteristic of the grinding process that is influential on the performances of machine elements in use, especially if they are exposed to the dynamic stresses. It is also very important quality of the obtained surface layers in the meaning of functionality of the machine elements in use.

Because of permanent modification of the grinding wheel roughness during the grinding process, initial grind wheel roughness is the one that is taken for the testing its influence on the grinding process. It has to be mentioned that at very early stage of use of new tool, maximum grind wheel roughness as well as maximum roughness of grinding surface appears. Also, grinding wheel roughness, obtained by certain wheel, as well as procedure and conditions of dressing reflects on ground surface. Higher grinding wheel roughness and higher capacity for chip emplacement and removal allow higher removal rate, but also the worse surface finish. Because of that it is important to search the as higher as possible removal rate for the given roughness of the ground surface. There are several factors that influence roughness of ground surface. With increasing of grinding wheel speed, ground roughness decrease until certain value, and after that follows increasing because of loosing of sharpness of the cutting edges and reduction of capacity for chip emplacement into grinding wheel body. Actually, the highest roughness obtained after tool dressing has decrease because of wear of the edges on the tool. After wearing away of the edges, what depends on grinding wheel speed, removed chips are compressed into reduced space for chips and therefore is grinding process mainly included with friction what makes ground surface worse. This fact is valid for deep grinding, and will be tested in this paper. In the literature is noted reduction of ground surface with increasing of grinding wheel speed.

2. Diamond or pressing roller dilemma

Process of grinding wheel cutting surface dressing with pressing roller is mostly performed by complex form surface grinding, when dressing with diamond roller is not economic acceptably in the small batch or in the severally production. This wheel dressing process is applied mostly for rough and semifinal grinding, when high productivity is demanded. Penetration of the pressing roller into wheel body results with grinding grain cracking and grain release. Pressing roller is rotating with certain speed around 3,33 s^{-1}, and during the contact with grinding wheel cutting surface force the wheel to rotate free driven. During roller penetration into wheel body, demanded profile of wheel cutting surface is forming either while is profiling initially or either standing profile corrects, thus sharpening the wheel cutting surface. In consideration of fact that cutting edges on wheel cutting surface during dressing with pressing roller doesn't cut at all, oppositely to the dressing with diamond roller, sharp grinding grain edges were obtained after penetration, as well as larger chips space

The main characteristics of the diamond roll are high durability and high influence on grindability of the tool, that is pronounced with:

- number of static edges per unit area of the grinding surface,
- roughness of the grinding wheel and
- capacity for emplacement and removal of the chip.

Tool dressing with diamond roll results with lowering of the static edge number as well as reduces the wheel roughness. Nevertheless, duration of the diamond roll is considerably longer in comparison with pressing roll, but is also very expensive and difficult for reconditioning. High price is reasonable because of the dressing accuracy, longstanding profile maintenance and because of the possibility of permanent and cyclic tool dressing.

2.1 Dressing results

Number of static edges (N_s) is relevant for wheel cutting surface influence on ground surface roughness. Certain static number of edges and grinding wheel roughness ($R_{b\text{-max}}$) are obtained during tool dressing. For accurate prediction those two values during the dressing, it were planed and performed the experiments and afterward-statistical analysis of data to describe the results of experiments. There are two influencing factors during dressing: holding up time (t_z) and speed ratio (q_d). Equations 1 and 2 were obtained for dressing with diamond roller.

1. Number of static edges:

$$N_s = 17{,}91 * t_z^{0{,}05} * q_d^{-0{,}2} \tag{1}$$

with the coefficient of determination r^2=0,95

2. Grind wheel roughness

$$R_{b\text{-max}} = 7.66 * t_z^{-0{,}08} * q_d^{0{,}26} \tag{2}$$

with the coefficient of determination r^2=0,99.

Equation 3 was obtained for dressing with pressing roller.

$$R_{b\max}=7{,}704914-0{,}01944*t_z+3{,}971278*N_s-0{,}155191*t_z*N_s-2{,}34353*N_s^2+0{,}009910*t_z \tag{3}$$

In accordance with equations (1) and (2), it were drawn diagrams on figure 1 and figure 2. Diagrams shows influences of hold up time of diamond roll penetration into grinding wheel body, as well as of ratio of the diamond roll and grinding wheel speeds on number of static edges and grinding wheel roughness. With increasing of hold up time (figure 1), number of static edges significantly increase over the all speed ratios. With increasing of speed ratios, number of static edges decrease.

Number of static edges and cutting wheel roughness depends on hold up time of the pressing roller at the end of penetration, figure 2. As one can on diagram see, number of static edges increase with increasing of hold up time, whereas cutting wheel depth of roughness decrease with hold up time decrease.

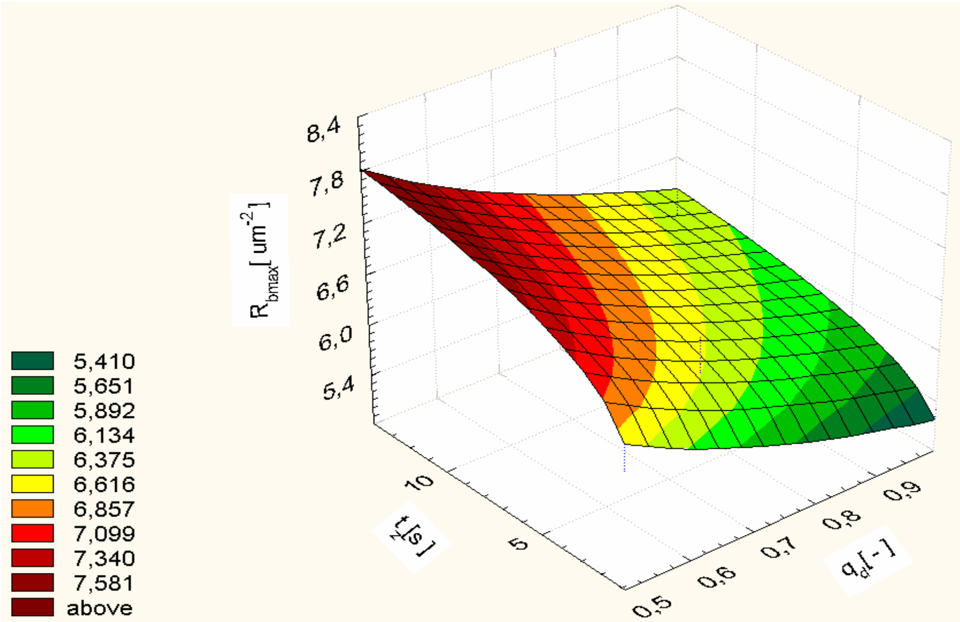

Figure 1. Maximum grind wheel roughness in dependence on hold up time and speed ratios Conditions: grinding wheel 81A-60-3-G12-V18 + diamond roller

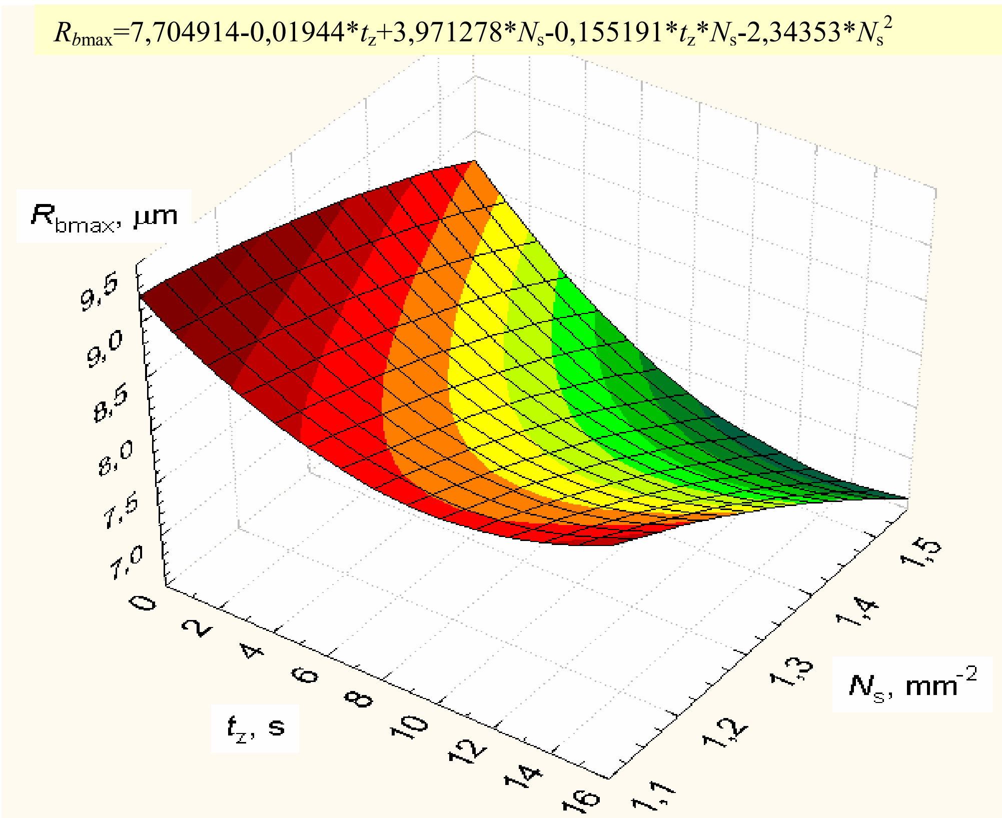

Figure 2 Maximum wheel roughness in dependence on hold up time and number of static edges: Conditions: grinding wheel 81A-60-3-G12-V18 + pressing roller

3. Design of grinding experiment

Influence of grinding condition and number of static edges on surface roughness has been investigated in this paper. It was assumed mathematical model of surface roughness as follows:

$$f(x,y,z \text{ and } w) = const + p1 * x + p2 * y + p3 * z + p4 * w + p11 * x2 + p22 * y2 + p33 * z2 * w2 + p44 * w2 + p12 * x*y + p13 * x * z + p14 * x * w + p23 * y * z + p24 * y * w + p34 * z * w \quad (4)$$

where : $x=v_c$ – grind wheel speed in m/s
$y=v_d$ – feeding speed in m/s
$z=a_p$ – depth of grinding in mm
$w=N_s$ – number of static edges on mm2

Input data of the experiment are shown in table 1. Experiments were performed in conditions as follows:

- machine tool: grinding machine for flat and profile grinding, mark FPA-10-S4.2
- grind wheel: high porosity 81-60-3-G12-V18 (Elbe)
- Work: NIMONIC 80A
- tool dressing conditions (pressing roller K10) and diamond roller
- roller diameter D_t=0,0925 mm
- peripheral speed of the roller v_t=0,967 ms^{-1}
- penetration speed of the roll f_{pt}=0,234 μm rad^{-1}
- hold up time : t_z=1,03 –7 s
- grind wheel dressing depth a_r=0,15 mm
- grinding conditions :
- peripheral speed of grinding wheel cutting surface v_b=24 - 34 ms^{-1}
- feeding speed v_b=1,03 to 2,3 mms^{-1}
- grinding depth a_p=0,17 to 0,63 mm
- number of the static edges N_s=0,96 to 2,11 mm^{-2}
- cooling : CASTROL CLEAREDGE EP 284 – 2% emulsion
- coolant flow – for grinding Q_b=3,33dm^3s^{-1}, pressure p_b=3 10^5Pa
- for dressing Q_b=1,33dm^3s^{-1}, pressure p_b=8 10^5Pa.

4. Roughness measurement results and optimization

Roughness was measured with roughness measurement device Perthometar C3A, with nose radii 3μm. Measurements were performed on the surfaces that were ground with grinding wheel in the very short time after dressing to lead the grinding wheel sharp and to provide influence of wear of the grinding wheel. Analysis of the influencing parameters is performed in accordance with design of experiment and results of measurements are given in table 1.

In accordance with table 1, statistical analysis of data, using software statistic, was done. Using obtained response functions models, singular values for certain conditions were calculated and set in table 1. High value of coefficient of determination shows high parity of calculated values with the measured values. Applying the partial derivation as an optimization method on the response function, optimal value of influencing parameter can be determined.

The response function is modelled by a non-linear function of the independent variables. The second order model function is chosen as an approximation functions for R_a and $R_{\max}$ after diamond roller dressing:

$$R_a=10,48-v_b*0,195+v_f*0,188-a_p*1,22-N_s*3,05+v_b^2*0,0038-v_b*a_p*0,011-v_b*N_s*0,015-v_f*a_p*0,017+v_f*N_s*0,15+a_p*N_s*0,418 \quad (5)$$

$$R_{\max}=141,4-v_b*4,66+v_f*3,468-a_p*9,65-N_s*38,73+v_b^2*0,063-v_b*v_f*0,002+v_b*a_p*0,06+v_b*N_s*0,442-v_f*N_s*0,908+a_p*N_s*1,67 \quad (6)$$

The response function is well modeled by a non-linear function of the independent variables, and the approximating functions for R_a and $R_{\max}$ after pressing roller dressing is the second order model:

$$R_a=6{,}78-v_b*0{,}259+v_f*0{,}436-a_p*0{,}904-N_s*1{,}59+v_b^2*0{,}0042-v_b*a_p*0{,}0006- \\ - v_b*a_p*0{,}09+v_b*N_s*0{,}0083-v_f*a_p*0{,}167-v_f*N_s*0{,}216+a_p*N_s*0{,}75 \quad (7)$$

$$R_{\max}=120{,}8-v_b*5{,}13+v_f*2{,}51-a_p*23{,}4-N_s*32{,}86+v_b^2*0{,}077+v_b*v_f*0{,}0256- \\ -v_b*a_p*0{,}016+v_b*N_s*0{,}393+ v_f*a_p*0{,}3-v_f*N_s*1{,}59+a_p*N_s*13{,}72 \quad (8)$$

Table 1. Experimental results

Exp. no.	v_b [m/s]	v_f [mm/s]	a_p [mm]	N_s [mm^{-2}]	R_a [µm] diamond	$R_{\max}$ [µm] roller	R_a [µm] pressing	$R_{\max}$ [µm] roller
1	24,0	1,03	0,17	1,98	1,22	11,7	1,40	13,8
2	34,0	1,03	0,17	1,98	1,16	10,6	1,35	12,5
3	24,0	2,30	0,17	1,98	1,35	13,5	1,68	15,5
4	34,0	2,30	0,17	1,98	1,29	12,3	1,60	14,0
5	24,0	1,03	0,63	1,98	1,08	10,1	1,30	11,0
6	34,0	1,03	0,63	1,98	1,02	9,4	1,15	9,0
7	24,0	2,30	0,63	1,98	1,15	11,0	1,32	12,0
8	34,0	2,30	0,63	1,98	1,05	10,0	1,25	11,0
9	24,0	1,03	0,17	2,11	0,85	7,8	1,15	9,0
10	34,0	1,03	0,17	2,11	0,75	7,0	1,10	8,5
11	24,0	2,30	0,17	2,11	0,94	8,5	1,25	10,5
12	34,0	2,30	0,17	2,11	0,83	7,5	1,20	9,5
13	24,0	1,03	0,63	2,11	0,65	5,2	0,98	7,5
14	34,0	1,03	0,63	2,11	0,58	5,0	0,90	6,5
15	24,0	2,30	0,63	2,11	0,80	7,1	1,10	8,0
16	34,0	2,30	0,63	2,11	0,72	6,3	1,00	8,0
17	28,6	1,54	0,33	2,04	0,87	7,2	1,18	8,9
18	28,6	1,54	0,33	2,04	0,90	7,9	1,14	8,5
19	28,6	1,54	0,33	2,04	0,92	7,8	1,10	9,0
20	28,6	1,54	0,33	2,04	0,93	8,1	1,21	9,1

4.1 Optimization results after GA

Goal of the grinding process is the achievement of surface layers in the acceptable quality, especially ground roughness concurrently with the higher productivity. Passive grinding force could be an indirect indicator of the ground surface quality in terms higher force as a consequence of higher productivity rate during grinding results with lower quality. Therefore, the acceptable roughness obtained with the higher productivity is the economical goal of the fine grinding process. Therefore is the goal function of the optimization process given with the equation:

$$\Phi_c = C * Q_{br} / R_a = C * a_p * v_f / R_a \quad (9)$$

Value of the roughness in the equation (9) can be calculate from equations (5) and (7) and thus obtain the grinding parameters which results with maximum value of goal function.

If we apply numerical calculation of surface roughness in accordance with equation (9) with the parameters values between the parameter value boundaries given in table 1, very wide roughness results will be obtained. If we, additionally, find the optimal parameters using floating-point genetic algorithm method that results with minimal roughness, optimization has been done. GA procedure does not require any knowledge of how to get a solution for the problem to be solved; we only need to know dependence between parameters and goal function, to evaluate possible solutions (generations). The two major problems with creating genetic algorithms are in converting a problem domain into parametric domain and creating an effective evaluation function (object function).

Optimal parameters obtained applying this procedure are:

a) for diamond roller dressing

R_{aopt}=0,75 µm ; v_{bopt}=30,728 m/s; v_{fopt}=1,03 m/s; a_{popt}=0,63 mm; N_{sopt}=2,11.

b) for pressing roller dressing

R_{aopt}=0,1441 µm ; v_{bopt}=33,825157 m/s; v_{fopt}=1,03 m/s; a_{popt}=0,53 mm; N_{sopt}=2,11.

4. Conclusion

Optimisation of the grinding parameters was done in two levels. Former experiments for determination number of static edges in dependence of grinding parameters, were done firstly. Next task was to determine surface response approximation of the roughness *Ra* and *Rmax*, in accordance with second order function. Those responses of the roughness are suitable for determination of the smallest achievable roughness value. Foregoing the estimation of the goal function (economic) and its optimisation. The results obtained after optimisation of goal function set the grinding parameters with highest ratio of productivity and ground roughness.

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PREDICTION OF STRESSES AND STRAINS WITHIN WELD POCKET DIES DURING EXTRUSION OF RECTANGULAR SOLID SECTIONS

I. Duplancic, Ž. Lozina and D. Vučina

Abstract

This paper shows the results of numerical simulation of behavior of weld pocket dies during extrusion of rectangular solid sections having various a/b ratios. The shape of the weld pocket was taken as an influence variable. Based on this simulation the stress as well as strain distribution within the die was obtained. This analysis shows the critical area of the die regarding the simulated parameters. Results obtained by such simulations could be useful for the die designer.

Keywords: stress, strains, extrusion, weld pocket die

1. Introduction

The extrusion of aluminum is a complex metal forming process that is very convenient for production of sections with complex cross sectional areas. It consists of several mutually dependent processes that each represent production based on specific technology. One of them is die design.

The die design is a discipline developed through experience accumulated during several decades. The development of new computer facilitates and software packages have improved the methods of extrusion process analysis. Many processes have been made in automatic die design with the help of CAD technology. Experience shows that no CAD system can deal with every shape of the section and extruding conditions, that is every form of die design. This situation leads that different die designs, even for the same section, can be obtained depending on each designer's experience and concepts. This means that the die designer alone makes the decisions about some important items of the die, such as die layout, number of cavities, its dimensions, etc. Therefore, the die design procedure continues to depend more on the skill and experience of the designers, toolmakers, and other professionals involved in the process than on scientific principles.

2. Numerical simulation of the weld pocket die

Currently, pre-chamber dies are use for the production of solid sections. The use of pre-chambers (weld plate or weld pocket) originates from many requirements. They are used to achieve billet to billet welding in continuous extrusion when using a puller [1,2]. Another advantage of the weld pocket die is that it gives better stability to the shape and size of the extruded section [3,4]. Pockets have the additional advantage of protecting bearings from damage [5].

Generally speaking, extrusion dies undergo deformation during their exploitation that result in sections out of tolerances. To reduce the cost of scrapped sections that are out of tolerances and a tooling replacement, various numerical studies on extrusion dies have been perform. These studies take into account a very precise geometric description to analyze extrusion dies. They allow understanding how the die is deformed during extrusion process.

In this paper, stress and strains in weld plate die was studied. Numerical simulations were performed for industrial weld pocketed dies that were used for extrusion of rectangular solid sections. These type of sections were chosen in order to be able to validate numerical results with industrial data.

Rectangular solid sections have a cross sectional area A_1 = 1200 mm^2 and different **a/b** ratio. The ratio a/b varies between 1 for square section to 36.75 for thin walled section. For extrusion of these sections, weld pocket dies were used, figure 1. These dies have pockets that follow the section's contour at the distance of 5 mm and have the same depth of 20 mm. This simulation was performed with an equal bearing length of 8 mm for all dies.

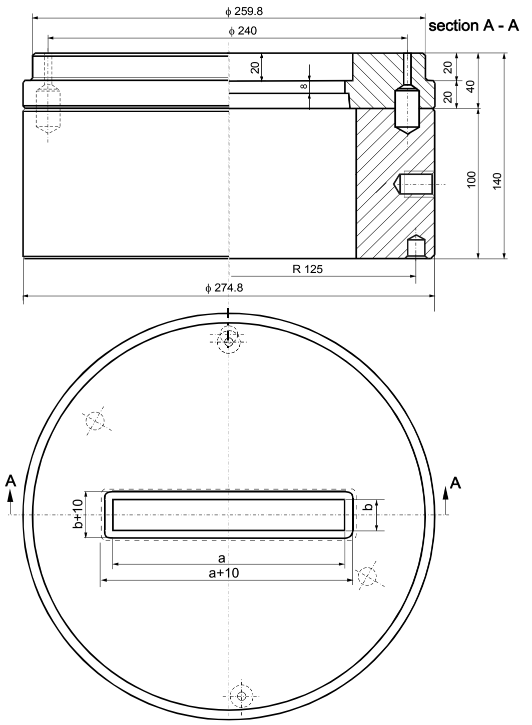

Figure 1. Weld pocket die for extrusion of rectangular sections

Steel, referenced as X38CrMoV51 (DIN¸1.2343, or H11), was taken for all dies. It was assumed to be isothermal at a constant temperature of 470 ^oC. Properties of the steel at 470 ^oC are:

Density	ρ = 7.85 kg/dm^3
Young modulus	E = 175 GPa
Modulus	G= 81 · GPa
Poisson coefficient	ν = 0.29
Yield strength	Rp = 1050 MPa
Thermal coefficient	$\alpha \approx 13{,}2 \cdot 10^{-6}$ $^oC^{-1}$

Aluminum alloy EN AW 6063 was used for the extrusion of these sections.

This type of die have been normally used on the extrusion press having the nominal force of 25 MN. The container's diameter of the press was D_o = 225 mm, and its temperature was 470 ^oC. The extrusion ratio R was A_o/A_1 = 33.11. All billets had dimensions of ϕ 217x500 mm, and they were homogenized. Before extrusion, billets were heated to 440 ^oC. Simulation was performed by ram velocity of v_R = 10 m/min.

The equations that were used in this simulation are:

The total extrusion pressure can be expressed referencing Sheppard and Wood [(8)], by the equation:

$$p = \overline{\sigma}\left[A + B\ln R + C\left(\frac{L_B}{D_B}\right)\right] + \Delta p \qquad (1)$$

Flow stress of material used is expressed by the equation:

$$\bar{\sigma} = \left(\frac{1}{\alpha}\right) \ln \left\{ \left(\frac{Z}{A}\right)^{\frac{1}{n}} + \sqrt{\left[\left(\frac{Z}{A}\right)^{\frac{2}{n}} + 1\right]} \right\} = \left(\frac{\ln 2}{\alpha n}\right) + \frac{1}{n} \ln\left(\frac{Z}{A}\right) \tag{2}$$

Finally, extrusion pressure is defined by:

$$p = \frac{1}{\alpha n} \left\{ A + B \ln \lambda^2 R + C \left[\ln \lambda^2 \left(\frac{Z}{A\alpha}\right)\right] + D\left(\frac{L_B}{D_B}\right)\left[\ln \lambda^2 \left(\frac{Z}{A\alpha}\right)\right]\right\} \tag{3}$$

Modeling procedure

The analysis of stresses and deformation of these dies during extrusion was performed using the commercial FEM software package that was designed for metal forming calculations. Results of such analyses are used for determining the loads of the dies. Under the condition that the meshes of both aluminum and die correspond at the contact surface, the reaction forces on that surface can be directly applied to the die. Since the deformations of the dies are expected to be very small, a Lagrangian approach seems to be the best for this simulation. For this simulation, approximately 6000 different three- dimensional elements were used for each weld plate die. For the simulation of the die used for extrusion of rectangular sections, symmetry conditions were applied. A standard elastoplastic material model was used to model the steel die.

Several boundary displacement conditions were assumed. First, it was assumed that the tool is supported by rigid solid at the exit. This means that the displacement in the extrusion direction at the back of the die is suppressed (*assumed to be zero*). Boundary conditions were given by symmetrical conditions and contact conditions.

3. Results of simulations

Using this method, the calculation both of stress σ and displacement at the point **A**, **B** and **C** was performed. Point **A** lies at the center of the wider side **a** of the die opening. Point **B** lies in the corner of the die opening while point **C** lies at the center of the shorter side of the pocket, figure 2.

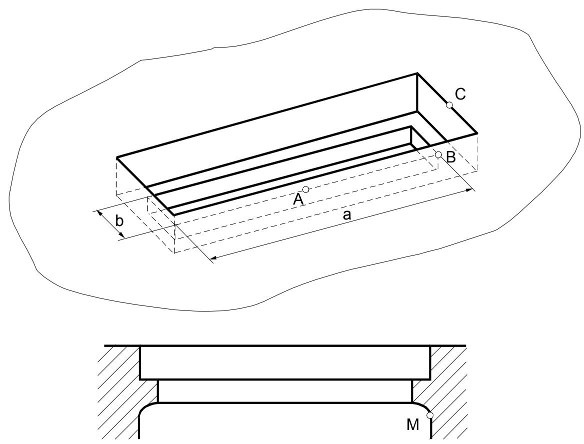

Figure 2. Position of the points for stress and strain analysis

Besides stresses and displacements at these points, the position of maximal value of stress was investigated. Simulation that was performed showed that this point is located below the bearing on the shorter side of the die opening. This position was defined as point **M**. Calculated stresses at these points as a function of ratio **a/b** are given in figure 3.

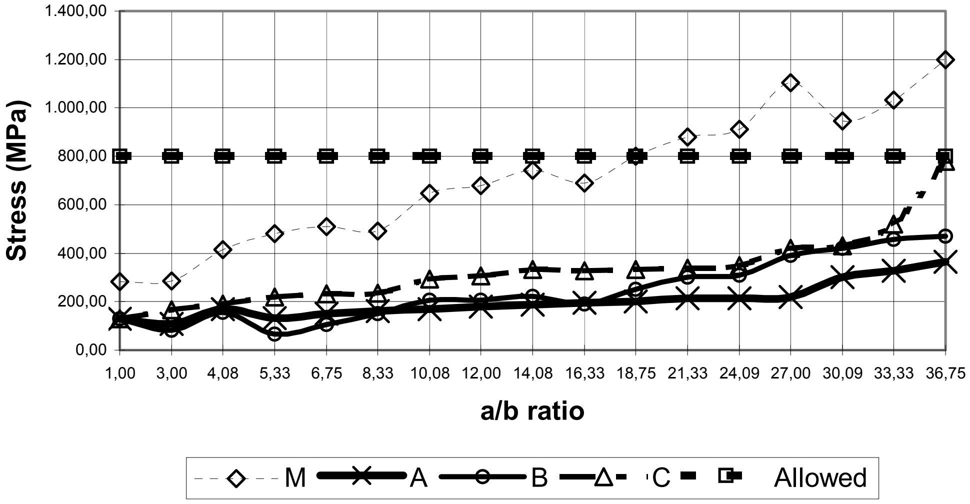

Figure 3. Results of stress analysis in the weld plate die used for extrusion of rectangular section

Figure 3 clearly shows that values of all stresses increase by the increase of ratio a/b. Stresses in all considered points are below the allowed stress of the die that, for these working conditions is σ_{all} = 800 MPa. For extreme value of ratio a/b = 36.75, the stress at the point **C** reaches the value of allowed stress. On the other hand, maximal value of the stress in the position **M** reaches the value of allowed stress at the ratio a/b = 18.75.

The stress distributions within whole weld plate die used for extrusion of rectangular sections for the case of ratio a/b = 16.33 is shown in the figure 4.

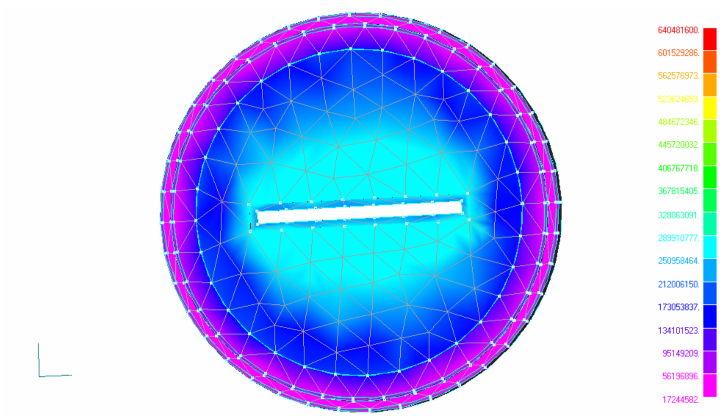

Figure 4. Stress distribution within the weld plate die for extrusion of rectangular sections (*a/b=16.33*)

Results in figure 4 confirm that all stresses within the die are lower than allowed values of stress for used steel and extrusion conditions.

During one extrusion stroke the die should be loaded within the elastic deformations. This means that all displacements of the die should result in strains that are lower than the strain at the yield point of material under working conditions. Results of calculation of total displacements $\mathbf{u_i}$ at considered point **A**, **B** and **C** of the die is shown in figure 5. The calculated value of allowed displacement $\mathbf{u_{all}}$ is 0.25 mm.

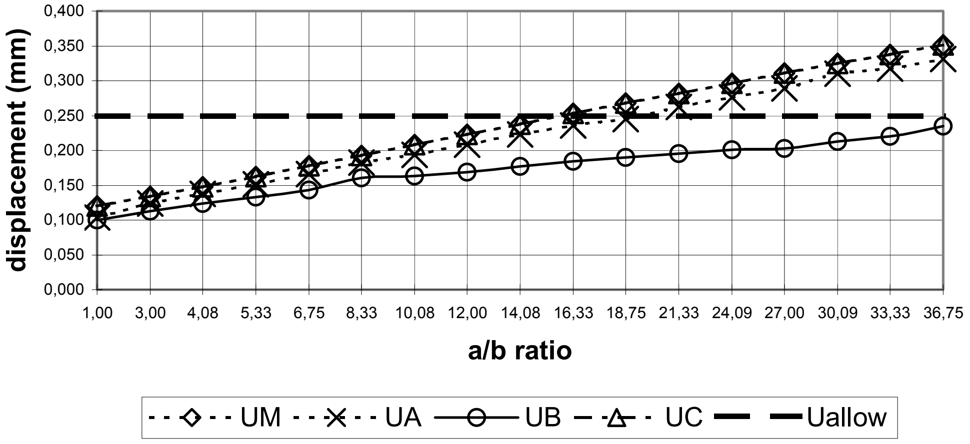

Figure 5. Results of displacement analysis in the weld plate die used for extrusion of rectangular section

Figure 5 shows that values of displacements also increase by an increase of ratio a/b. Only displacements in the corner of die opening (*point B*) are below the allowed value for all dies. Displacement at point **A** reaches the allowed value at the ratio **a/b** = 19, and at the point **C** at the ratio a/b = 16.33, respectively. This simulation also shows that the position of maximal value of displacement corresponds to the displacement at the point **C**.

Figure 6 shows how the die deforms due to extrusion pressure. The deflection may cause significant changes in sectional wall thickness and bearing angle. These changes will affect the flow resistance in the die.

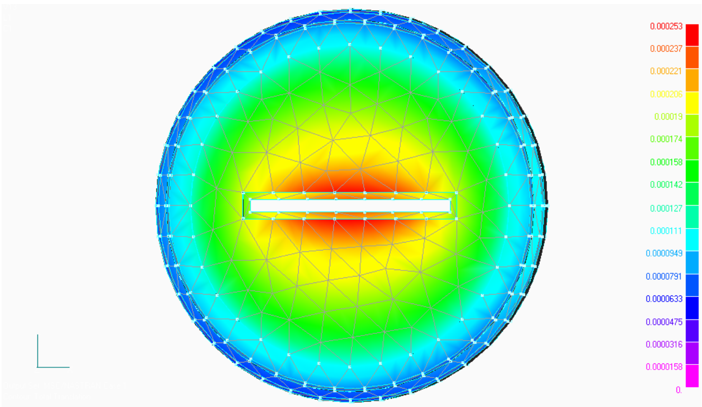

Figure 6. Strain distribution within the weld plate die under extrusion pressure (*a/b = 16.33*)

This figure shows that the strains have maximal values in the center of the die. Therefore, under the load die has a tendency to close, not only in the die orifice but also at the entrance to the weld pocket. These results match the results of stress analysis.

4. Conclusion

In this work, the simulation of the weld pocket die for extrusion of rectangular sections with different the die opening ratio **a/b** was performed. This simulation shows that values of stresses and displacement in a particular point of the dies increase by the increase of the a/b ratio. At some ratios a/b these values can overcome the allowed values of stresses as well as displacements. The critical position of the die, regarding to stress, is area below the bearing on the shorter side of the die opening. On the other hand, the critical position of the die regarding to displacements is at the center of the wider side *a* of the die opening. Because of this, the die under the load has a tendency to close, not only in the die orifice but also at the entrance to the weld pocket. Such deformation of the die orifice causes deformation of the cross sectional area of the section that leaves the die. Therefore, at critical values of ratio **a/b** some changes of die design are required.

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CROATIAN WEB PORTAL FOR THE MATERIALS – MATNET®

T. Filetin, I. Kramer and G. Papić

Abstract

Concept of the virtual network, that connects the institutions and experts on material science and engineering field in Croatia, has been developed under the technological project "SUMAT-Development and application of advanced materials". Web portal for the materials and accompanying technologies represents the base of communication network whose main task is the transfer of knowledge between research community and users from the industry. Information service takes care of collecting, storing, processing and disseminating of the information, but also about communication with the outside institutions. The information stored is about: researchers, other experts, details about research institutions (laboratories, equipment, methods, procedures), materials, producers and merchants, software, commercial and other material databases and production processes, testing methods in Croatia and foreign countries. The research results and other texts that are interesting for users from the industry – Ph.D. and Masters thesis, journal articles, new books, analyses and studies are also available. Portal gives plenty of information about seminars, conferences and other actual events in Croatia and foreign countries, and also a lot of links to the foreign and home institutions and other information resources.

Keywords: engineering materials, virtual network, web portal

1. Introduction

The improvements of existing materials and the development and application of new materials and technologies are the basis of innovation of industrial products.

The initial analyses show that about 90% of scientists and experts in Croatia, in the field of materials, work at universities or in independent scientific institutes. A need for tighter linking of scientists and experts from the industry and collaboration on aimed technological projects is necessary. Furthermore it is of great necessity to create conditions for a thought out, faster and more efficient transfer of knowledge on new materials, processes and equipment into our industrial companies. Experiences of other countries, of similar development stage, show that the establishment of contemporary equipped centres for the transfer of knowledge into small and medium size companies is an essential prerequisite to raising the technological and manufacturing level of those companies.

The existing Technological centres in Croatia are mostly focused on new incubation idea's approach (Business Incubation Centres) and less on the transfer of advanced technological knowledge into the industry. Therefore one needs to approach to organising of a technological centre (Concept of Contract Research Centres) for advanced materials and production process. Highly educated researchers would be operating in this centre working on up-to-date, carefully selected equipment, researching and using new materials, technologies and testing methods.

One of more advanced and more rational ways of organising and working on the field of research and material development and accompanying technologies are virtual networks of institutions and experts. We can find examples of such organisational forms in Materials Valley in the province of Rhein Main where they have 750 companies and 120 high educational institutions [1]. In Virtual Tribology Institute in the European Union [2] (initially institutions, laboratories and experts from 22 countries were involved) or in CORONET network of 18 institutions from 9 European Union countries on the filed of polymer matrix composites [3].

The organisation of the network in Croatia would start by connecting the existing prominent centres, which work on researching and developing of certain groups of materials and/or technologies. In a second stage, after establishing priority directions of technological development, it would be essential to strengthen the work of individual cores in the network with needed equipment and people. Within such a concept we long for the organisation of chains and clusters of technological projects in which various scientists from natural sciences, especially physics and chemistry, and even biology could be involved. The reason for this is the fact that a whole range of technological problems cannot be solved without this knowledge and experiments when developing new materials and introducing advanced material production processes – such as nanocomposites, laser forming and surface modification technologies, sintering, PVD, CVD, plasma assisted technologies and others.

The aim of the technological project “SUMAT – Development and application of advanced materials,” that is being financed by Ministry of Science, Education and Sport Republic of Croatia (MZOS) from 2002-2005 (program TEST), is the creation of a base for future more effective operation that has the aim of a faster and high quality transfer of scientific research results from around the world and from our community into the Croatian industry. The establishing of a network of material and technology centres MATNET® is one of the first steps taken to in order to achieve the objective [4]. Web portal **mat-net.hr** makes a communication infrastructure in establishing future network centres. Here available stored information are only the initial collection of data and are the basis for future network growth, and the results are the survey, the analysis and research within the SUMAT project.

2. The objectives of the material network

Establishing a network of centres for materials, production technologies and testing laboratories would enable the joining of knowledge, experts and equipment from independent institutes, universities and other high educational institutions. The objectives are: encouraging, directing and solving developmental and expert industry needs – especially for small and middle size companies that do not have the power to develop on their own.

The content and methods of work of individual centres in the network mainly based on the experiences of existing institutes for materials in the world.

Main objectives are:

1. The establishment of a network of institutions – laboratories, equipment, scientists and experts in the field of materials and production technologies, test methods, software etc., in order to get greater work efficiency and synergy;
2. Development of a system for faster and higher quality overview and transfer of knowledge from scientific and technological research into industrial usage – seminars, courses, workshops, conferences, publishing;
3. Expertise's and counselling for industry needs;
4. Encouragement and support for innovation and commercialisation of ideas;
5. Organisation and realisation of complex development projects for industry needs – better usage of human and other potentials and possibilities;
6. Thought out and co-ordinated purchasing, introduction, usage (service laboratories and workshops) and maintenance of most current equipment – for research and testing, manufacturing and improving the properties of materials;
7. Co-ordinated competition for European and other international projects;
8. Joint application of projects for financing from the different sources;
9. Technical support for development of existing and encouragement for establishing new small and middle size knowledge based companies.

Benefit for the industry would be seen through three types of effects:

a) A faster approach to existing knowledge, equipment and procedures in centres of excellence in the field of materials and accompanying technologies, for orienting personal activity and solving manufacturing problems;
b) More rational, joint usage of available resources – highly educated people, advanced equipment and technology;
c) Creation of new ideas with the aim of developing advanced materials, technologies and marketable products.

3. Institutions and network links

Institutions and other members and partners in the functioning of the network have joint resources that are available to all interested users. The elements that link the members and users of the network are:

- Laboratories – equipment and testing methods, accreditation, authority…;
- Researchers and experts for different fields;
- Information, knowledge and understanding – literature, surveys, contacts;
- Materials testing;
- Users – industry and education,
- Finances – ones own or from other sources.

Institutions in the network

The core of the network would be made out of all interested universities, independent institutes from all around Croatia, which work on research and development of materials and production processes:

From the field of natural sciences: Rudjer Bošković Institute, Zagreb; Institute of Physics, Zagreb; Faculty of Natural Sciences and Mathematics, Zagreb and others.

From the field of **technical and biotechnical sciences and engineering** are: Faculty of Chemical Engineering and Technology, Zagreb; Chemical-Technological Faculty, Split; Faculty of Metallurgy, Sisak; Faculty of Mining, Geology and Petroleum Engineering, Zagreb; Faculty of Mechanical Engineering and Naval Architecture, Zagreb; Faculty of Mechanical Engineering, Slavonski Brod; Technical Faculty, Rijeka; Faculty of Electrical Engineering and Computing, Zagreb; Faculty of Electrical Engineering, Osijek; Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, Split; Faculty of Civil Engineering – Zagreb, Osijek, Rijeka, Split; Croatian Civil Engineering Institute; KONČAR- Institute for Electrical Engineering; Faculty of Architecture, Zagreb; Faculty of Forestry, Zagreb; Faculty of Textile Technology, Zagreb and others.

Outside collaborating institutions are:

- **Technological centres –** Zagreb, Rijeka, Split, Osijek and CTT- Zagreb.
- **Users and partners from the industry**

Active co-operation between industrial partners and the using of results made by work through the network would be realised with long term contracts or membership subscription.

From small and medium sized companies one anticipates a wide co-operation with companies, which deal with the manufacturing of metal and non-metal materials, making of tools, construction parts and usable products.

4. Organisation of network centres

Within the network there would be several mutually linked relatively independent centres based on a consortium way of working.

Every one of the centres would gather the existing resources (experts, equipment and processes), that would work with related group of materials or technologies. The functioning of individual centres and network would follow a concept of **project organisation** with a high level of horizontal integration.

In further forming of the network we would aspire towards the organisation of logical **clusters** of institutions and projects.

Motivation of researchers and experts from the industry for working in the network, would be achieved through:

- possibility of an easier achievement of scientific and developmental results and other ideas through a more free teamwork (without institutional barriers);
- possibility of a different and favourable financing and funds disposal, acquiring and using usually inaccessible equipment, and easier getting of needed information;
- possibility of easier protection and the commercialisation of the research results;
- participation in the work on new organisational forms of scientific and technological projects and other activities;

According to an adopted concept of network MATNET® [4] beginning of work and the connection of the following existing and new centres are expected:

1. Co-ordination centre of the network
2. Centre for polymeric – "SVECIPOL" (University Centre for Polymeric)
3. Centre for production processes – "CPP"
4. Centre for tribology and surface engineering
5. Centre for recycling of materials
6. Centre for development of casting technologies
7. Centre for inorganic materials
8. Centre for metallic materials
9. Centre for renewable materials.

5. Description of the web portal mat-net.hr

The structure of the portal is made up of several elements:

1. **ABOUT US**: Description of the activity. Members. Description of the SUMAT project;
2. **TEXTS**: Articles from journals, collections of different professional papers and similar. Translations of books, articles and other publications. One′s own books: listing, review. Graduate, Masters and Ph.D. thesis; others;
3. **SUBJECT CATALOGUES** (Resources):
   - 3.1. Institutions in the Republic of Croatia: Research institutions: laboratories, equipment, procedures, researchers and projects…; Material producers; Users – companies: type of products; Material traders.
   - 3.2. Institutions abroad: Research institutions; Material producers. National institutions and professional associations. Manufacturers of equipment and processes. Material traders.
   - 3.3. Croatian projects: description, links at http://bib.irb.hr.
   - 3.4. Researchers and experts in the Republic of Croatia.
   - 3.5. Web sites. Software. Data base and information systems (description and links).
   - 3.6. National journals (index and links).
   - 3.7. Trade associations for materials in Croatia and abroad (index and links).
   - 3.8. Norms: Link to the State Office for Standardisation and Metrology;
4. **INFO-SERVICE**: News and advertisements. Calendar of conferences and seminars: description, links. Useful links;
5. **COMMUNICATION**: Contacts. Forum. Chat. Mailing list.

All the facts and information are saved into the data bases, so that alterations, amendments, search, analysis and archive are possible.

Basic functions of the web portal are:

- Gathering and depositing of information from domestic and international sources, through on line forms or electronic mailing of news and other ways (visits to symposiums, conferences, fairs, exhibitions, etc.);
- Gathering of information through data base searches. For this type of search a special own search engine has been designed for key words;
- Connecting with outside sources in Croatia and abroad.

Figure 1. shows the first page of the web portal mat-net.hr. Figure 2. shows a page about the new texts on the portal.

Using of the portal is for the time being free for all users.

6. Conclusion

Basic concept of the organisation and the functioning of the network of institutions, which work on research, development and application of materials and technologies has been worked out.

The network should enable a more efficient action on this field - linking of scientists and experts from the academic community and from the industry, transfer of knowledge, a more rational purchasing of equipment and its usage, realisation of complex projects etc.

Web portal mat-net.hr, a communication platform of the network, has been established. Future development of the portal comprises the following activities:

- Complementing the bases about domestic institutions and experts.
- Gathering of information about capital equipment financed from state funds – making of a catalogue for research and pre-industrial equipment.
- Complementing of information regarding the manufacturing possibilities of domestic companies.
- Making of an English version of the portal.
- Informing about the possibilities of the network for users in the industry.
- Commercialisation and protection of certain information needs to be worked out.

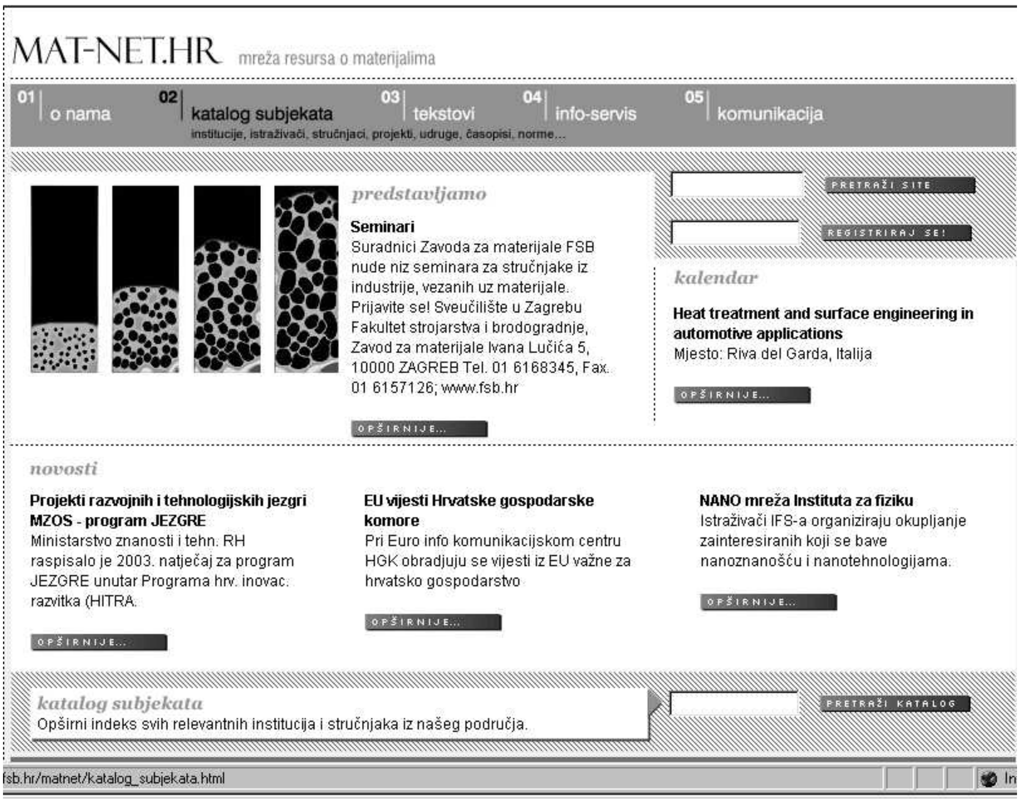

Figure 1. First page of the web portal mat-net.hr

Figure 2. First page of the new texts on the portal mat-net.hr

Acknowledgement

This work is the result of a technological project “SUMAT – Development and application of advanced materials,” which has been financed by MZOS since 2002.
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All suggestions, comments and new information from all users would be valuable to us in the correction of this first draft and it would surely help us in the future development and expansion of the content of this web portal.

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APPLICATION FEM IN BENDING

B. Grizelj

Abstract

The paper is concerned with the numeric procedure in axial-symmetrical plate bending. For numeric procedure the finite element method is used. Calibration force is determined when bending force and calibration coefficient are known. The calibration coefficient is determined by experiment. The axial-symmetrical plate bending analysis is restricted to the data used so far in the manufacture of spherical tanks i.e. to deform. up to 1%.

To obtain equations for the calculation of force for axial-symmetrical plate bending and displacements during loading procedure and after its removal, data obtained by finite element method were used. The method of least squares was used to interpolate results. Mathematical procedures were used to obtain equations for the calculation of force and displacements, the equations being of use for solving practical problems.

Keywords: Axial-symmetrical bending, Finite element method, Calibration of plate

1. Introduction

The work elaborates numerical procedure for plate bending. Equations for bending force optimisation are also given. The analysis of bending plate is limited to the facts and figures used so far in the fabrication of spherical tanks, i.e. for deformations up to 1 %.

The existing increasing necessity for spherical tanks is easy understandable because it exists the possibility to store medium with the minimal thickness of tank, small needed volume and minimum cost price. Spherical tanks are becoming far more interesting with increasing of their radius. The shell of spherical tank consists of steel sheet, while the segments are assembled by welding in whole at the actual place. The bending of separate parts is achieved in several indentations on hydraulic press as can be seen from Fig. 1.

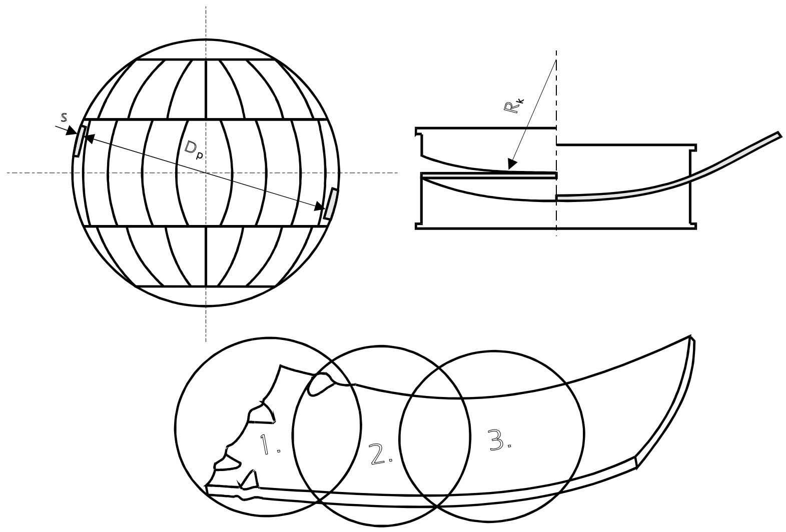


Figure 1. The bending of segment in tool Kt. 5-081 R_k =4925 and Kt 5-136 R_k =4500

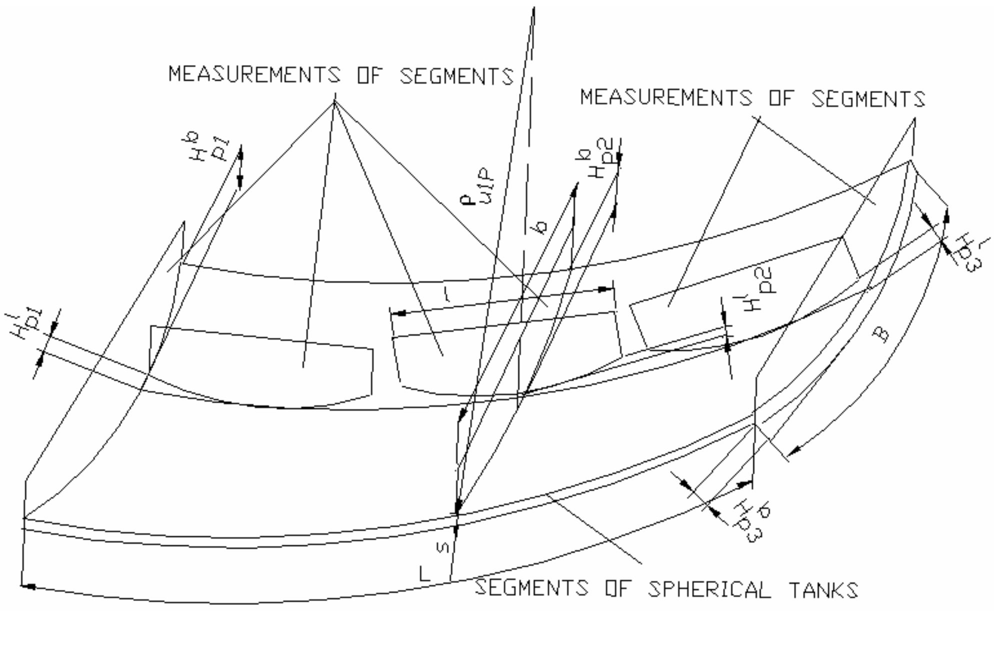
Analysing the data obtained by analytical method, finite element method and checking of individual cases experiments were conducted to find the factors that influence stresses, displacements and force during application of load to circular plate and after its removal.

These factors are:

1. material of the circular plate
2. bending radius the of circular plate
3. diameter of the circular plate
4. thickness of the circular plate and
5. way of loading of the circular plate.

2. Experiment results

MATERIAL			Nioval 47 ($\approx$ StE 500)		
SHEET DIMENSION *s L B*			29x6000x1800(2000), and16x6000x1800(2000)		
DIE NUMBER			Kt. 5-081(R_k =4925) AND Kt 5-136(R_k =4500)		
UPPER DIE RADIUS			R_k =4925 AND R_k =4500		
MEASUREO VALUE *H* FOR *b* = 1800			MEASUREO VALUE *H* FOR *l* = 1800		
H^b_{p1}	H^b_{p2}	H^b_{p3}	H^l_{p1}	H^l_{p2}	H^l_{p3}
ARTIMETIC MEAN VALUE H^b_{p1}, H^b_{p2}, H^b_{p3} $\Rightarrow H^b_p$			ARTIMETIC MEAN VALUE H^l_{p1}, H^l_{p2}, H^l_{p3} $\Rightarrow H^l_p$		
CALCULATEO VALUE FOR RADIUS OF PLATE RELATED TO H^b_p AND $b \Rightarrow \rho^b_p$			CALCULATEO VALUE FOR RADIUS OF PLATE RELATED TO H^l_p i $l \Rightarrow \rho^l_p$		
ARTIMETIC MEAN VALUE H^b_p i H^l_p $\Rightarrow H_p$					
ARTIMETIC MEAN VALUE ρ^b_p i ρ^l_p $\Rightarrow \rho_p$					
FORMING FORCE [MN]					
CALIBRATION FORCE [MN]					
FORMING TIME 10 s					
CALIBRATION TIME 3 s					



DATA	EXPERIMENTAL RESULTS Kt 5-136 and Kt.5-081															
	II 16x1800 Kt5-136	III Kt5136	IV 29x1800 Kt5-136	V Kt5136	VI 16x1800 Kt5-136	VII Kt5136	VIII 29x2000 Kt5-136	IX Kt5136	X 16x1800 Kt5-081	XI Kt5081	XII 29x1800 Kt5-081	XIII Kt5081	XIV 16x2000 Kt5-081	XV Kt5081	XVI 29x2000 Kt5-081	XVII Kt5081
H_{p1}^{b}	66,2	67	66,4	67,7	75	76	76,9	76,6	50,5	51	52	51,6	58,2	57,1	58,9	58,1
H_{p2}^{b}	64,5	64	66,7	66,3	72	74	75,3	75,1	50,6	49,3	51,8	51,8	56	55	58,2	59,8
H_{p3}^{b}	66,7	65,5	66,4	67,9	75,3	75	76,4	78,4	52,2	51,5	51,6	52	57,2	56,1	57,2	58,2
H_{p1}^{l}	65	66,6	67,5	68,8	69,3	67,8	69,3	69,3	56,2	55,5	58,2	59,3	56,1	56,1	59,9	60,5
H_{p2}^{l}	67,5	68,5	69,5	70	68,5	69	70,5	70,4	58,1	58	60,1	59,7	59,8	59	61	61
H_{p3}^{l}	66,7	66,5	67,3	68,5	65,6	67,8	69,9	71,5	56,1	56	58,7	60,4	57,2	56,2	60	60,6
H_{p}^{b}	65,8	65,9	66,5	67,3	74,1	75,5	76,2	76,7	51,1	50,6	51,3	51,8	57,2	56,6	58,1	58,7
H_{p}^{l}	66,4	67,2	68,1	69,1	67,8	68,2	69,9	70,4	56,8	56,5	59	59,8	57,2	57,1	60,3	60,7
ρ_{p}^{b}	6188	6179	6123	6051	5503	5402	5353	5319	7951	8029	7920	7844	7109	7184	7000	6929
ρ_{p}^{l}	6133	6060	5981	5896	6007	5972	5829	5788	7159	7196	6894	6802	7048	7121	6746	6702
H_p	66,1	66,55	67,3	68,2	70,95	71,85	73,05	73,55	53,95	53,55	55,15	55,8	57,45	56,85	59,2	59,7
ρ_p	6160,5	6119	6052	5973,5	5755	5687	5591	5553,5	7555	7612,5	7407	7323	7078,5	7152,5	6873	6815,5

Figure 2. Experiment results (M 1:1)

3. Numerical method

The finite element approach consists of three parts: pre-processor, main program and machine related information and post-processor. Pre-processor for solving the main program MATCVO contains [1]: material data (modulus of elasticity, Poison's ratio, true stress or characteristic of plastic flow), the generating of structure, data according loading, connectivity and boundary conditions. The material that takes place is Nioval 47, produced according to DIN 17102/83. The dimensions of specimens were B6x50 according to DIN 50125. From the same table were taken sheet blanks ϕ 2000x16 mm for evaluation of the results obtained by FEM. The machine used for material data establishing used lately in pre-processing is from firm "Siempelkamp". On the same machine were performed the experiments with the tool for bending of circular plate for evaluation the results achieved with FEM. By examination of the specimens the obtained results are. True stress or characteristic of material flow $k_f = 588 + 700\varphi_v^{0.4}$. Modulus of elasticity E=206112-206795 [N/mm^2]. Poison's ratio ν=0.31 - 0.33

The main program is used for computing the displacements as well as the stresses.

Using the auxiliary program RESULT one can establish the data about the demanded form of output results as well as the numerical presentation of all computed values.

The tools used for experimentation are presented on the Fig. 1. Comparison of numerical and experimental results of the force that depends of displacements is presented on the Fig. 3.

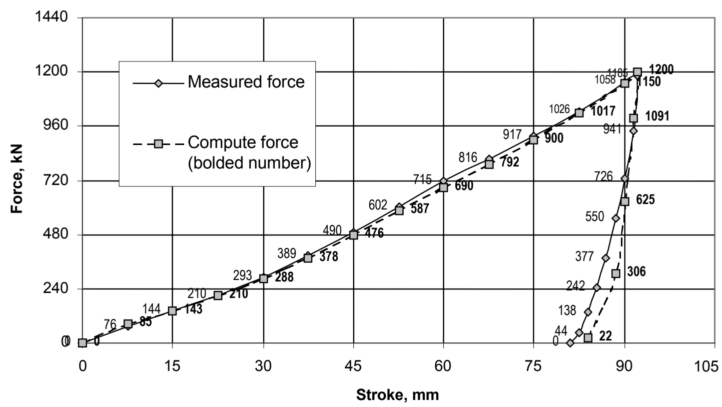


Figure 3. Numerical and experimental comparison the force depending of displacement

4. Mathematical interpretation of results obtained by FEM

4.1 Mathematical interpretation for computation of the force

In attempt to obtain expression for calculate the force in dependency of displacement it has to be observed tables 9.10 till 9.14 that represent the results of FEM [1]. The interpolation of these results is performed by the least square technique. Using tables 9.10 till 9.14 for the cases of loading the circular plates across the whole cross-section-trapezoidal distribution with applying the tool presented on the figure 2. follow expressions has been obtained (Table 1.). Analysing the expressions given in table 1 for the diameters between ϕ1800 and ϕ2200 mm with thickness of 29 mm it can be written the general expression for bending force in the form

$$F_{q0} = \left(a_1 u_{z1} + 0{,}5\right)10^5 \tag{1}$$

where the factor a_1 depends of the diameter of the circular plate and has the value

Table 1. Computation of the bending force

Plate diameter [mm]	Plate thickness [mm]	Bending force [N]
460	13	$F_q = (0{,}180\ u_{z1} + 0{,}21) \cdot 10^5$
460	16	$F_q = (0{,}300\ u_{z1} + 0{,}80) \cdot 10^5$
1800	29	$F_q = (0{,}188\ u_{z1} + 0{,}48) \cdot 10^5$
2000	29	$F_q = (0{,}150\ u_{z1} + 0{,}53) \cdot 10^5$
2200	29	$F_q = (0{,}128\ u_{z1} + 0{,}55) \cdot 10^5$

a_1 = 0.188 for the plate with the diameter 1800 mm; a_1 = 0.150 for the plate with the diameter 2000 mm; a_1 = 0.128 for the plate with the diameter 2200 mm. u_{z1} (u_{z1}=h) in mm presents the displacement (punch motion) in the middle of the plate during indent. The expression (1) is valid for material StE 500 and the thickness of 29 mm. If another material has to be taken into account than in the expression (1) ought to be included additionally the ultimate strength. On that way the expression containing also the ultimate strength of material has the following form

$$F_{q00} = \left[\left(a_1 u_{z1} + 0{,}5\right) / 750\right] 10^5 R_m \ \ [\mathrm{N}] \tag{2}$$

where R_m is the ultimate stress of material. The expression (2) is valid for calculating the force in dependency of punch motion for materials StE 355, StE420, StE 500 and materials similar to them. These materials are in common use for assembling the spherical tanks.

In attempt to include in above presented expression the thickness of the plate, it will be used from [1] the expression (10.3). In that case the expression for axial-symmetrical bending that include the influence of plate diameter, plate material and plate thickness has the form

$$F_{q00s} = \left[\left(s_1^2 / 6{,}75\right)\left(a_1 u_{z1} + 0{,}5\right)\right] R_m \ \ [\mathrm{N}] \tag{3}$$

The mathematical interpretation in the form (3) obtained with the results of FEM can be accepted only for the tested area and examined materials as well as considered thickness among 15 and 40 mm. As in assembling the spherical tanks these are the commonly used parameters of thickness and materials it can be concluded that this expression can be used in projecting or planning the spherical tanks.

4.2 Mathematical interpretation of expression for computing mechanical spring-back

In attempt to find out the expression for predicting mechanical spring-back it was from [1] used tables 9.10 till 9.14 obtained with FEM. The interpolation of these results is performed by the least square technique. Using these tables for the cases of continuously loaded circular plate - trapezoidal distribution follow the expressions for computing the displacements after release, Table 2. If from displacement u_{z1} is subtracted u_{z2} then follows the expression for determination of mechanical spring-back

$$u_{el} = u_{z1} - u_{z2} \tag{4}$$

Table 2. Computation of displacement (dislocation) after release

Plate diameter [mm]	Plate thickness [mm]	Dislocation of the middle of the plate [mm]
460	13	$u_{z2} = 0{,}63\,u_{z1} - 6{,}34$
460	16	$u_{z2} = 0{,}70\,u_{z1} - 5{,}85$
1800	29	$u_{z2} = 0{,}52\,u_{z1} - 31{,}45$
2000	29	$u_{z2} = 0{,}55\,u_{z1} - 39{,}75$
2200	29	$u_{z2} = 0{,}60\,u_{z1} - 52{,}41$

In the area of material thickness between 15 and 40 mm as it was found there is no considerable influence of the thickness on the amount of mechanical spring-back. In such way the tables 9.10 and 9.11 [1] as well as the results obtained in [2] are valid for the mentioned values of the thickness too. The expressions given in table 2. are valid for StE 500 and thickness between 15 and 40 mm. If some other material is taken into account then in relevant expressions must be included ultimate strength of considered material. In that case follow the next expressions that comprehend the ultimate strength too, Table 3.

Table 3. Computation of mechanical spring-back after release

Plate diameter [mm]	Plate thickness [mm]	Dislocation of the middle of the plate after release [mm]
460	13	$u_{z2} = (0{,}63\,u_{z1} - 6{,}34)R_m / 750$
460	16	$u_{z2} = (0{,}70\,u_{z1} - 5{,}85)R_m / 750$
1800	29	$u_{z2} = (0{,}52\,u_{z1} - 31{,}45)R_m / 750$
2000	29	$u_{z2} = (0{,}55\,u_{z1} - 39{,}75)R_m / 750$
2200	29	$u_{z2} = (0{,}60\,u_{z1} - 52{,}41)R_m / 750$

General expression for mechanical spring-back follows by subtraction of displacements u_{z1} and u_{z2}

5. Plate calibration

5.1 Experimentally obtaining the calibration force

The experiments were conducted using the plates ϕ2000x16 mm of material NIOVAL 47. Using the expression (3) it can be find necessary bending force as F_{q00s} =1.185 MN. The plate bended with 1.185 MN has had wrinkles at the edge of height up to 2 mm. Owing to that reason the plate has to be calibrated. The calibration force can be calculated using the expression

$$F_k = k \cdot F_{q00s} \tag{5}$$

In order to compute the calibrating force it is necessary to obtain experimentally the amount of coefficient of calibration *k* for relevant dimensions. For the plate with dimensions ϕ2000x29 mm coefficient of calibration *k* is *k*=2, and for the plate with dimensions ϕ2000x16 this value is *k*=2.5. Comparing the values of coefficient of calibration *k* it can be seen that its value is greater when the plate thickness is smaller. It is because during the bending process the wrinkles tend to form themselves more if the thickness is smaller. In such way for the plate with dimensions ϕ2000x20 it can be supposed using the above obtained experiments that *k*=2.34.

5.2 Determination of the mechanical springback after calibration

The factors that on the basis of production experience have the most significant influence on the amount of mechanical spring-back are: calibration force, plate material, punch radius and respectively punch motion, plate thickness and plate diameter. In order to research the influence of punch radius R_k, plate thickness and plate diameter, according to technological and productivity conditions it was used experiment′s factor plan. It was carried out the industrial experiments with scale dimension 1:1. Experiments were conducted using randomised distribution in attempt to avoid systematic errors. The considered factors were: punch radius 4500 and 4925 mm, plate thickness 16 and 29 mm, plate diameter 1800 and 2000 mm.

Using all above mentioned considerations, it can be on the basis of experimental and industrial researching determined the law for coefficient of mechanical spring-back of calibrated plate with constant plate diameter K^{II}. It can be determined using expression [2-3]:

$$K^{II} = \frac{1}{0{,}768304 + 0{,}0906276\,R_p} \qquad R_k = K_{II}\frac{D_p}{2} \tag{6}$$

For technological praxis it is recommended the calculation by using the expression (6). For instance, in the case of the plate with 2000 mm diameter, bending plate radius 7m (shell diameter of spherical tank 14 m) and plate material NIOVAL 47 this coefficient of mechanical spring is

6. Conclusion

In metal forming processes, the cold axial-symmetrical bending process has a considerable great role. The production of axial-symmetrical bended plates with larger dimensions is industrial interesting for producers of steel tanks and similar products.

FEM enables using program MATCVO and corresponding pre and post-processor the determination of displacements, stresses and mechanical spring-back of plates of various dimensions and related materials.

In order to eliminate the wrinkles at plate edges that are formed during the process, the plates have to be calibrated after the bending.

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POSSIBILITY OF APPLICATION OF ANALYTICAL METHODS AT DETERMINATION OF LOADS OF ROLLING STAND ROLLS

M. Imamović, S. Brdarević and S. Olević

Abstract

During dimensioning of basic parts in construction procedure as well as checking dimensions of parts of rolling stands in operation the problem of loads determination arises. In spite of, different methods are existing of carrying out of this procedure and these are: analytical and experimental. From analytical methods in basic process of rolling the most used methods are Ekelund, Hill and Golovin-Tjugan. All of these methods give quite different results. The differences that appear are up to 50% of the value one to another. Their source is because different authors solved Karman equation on different ways, the Karman equation defines specific pressure at rolling and because different influental factors are taken into consideration on different ways during rolling process.

In this paper is performed critical analysis of these methods application at simple process of hot steel rolling on two rolls stand. The analysis is based on results of experimental research in operation during different working conditions in real industrial production. In spite of recommendations are given for further application of some analytical methods during this type of rolling.

Keywords: loads, analytical methods, rolling process, rolling stand.

1. Introduction

Rolling is one of the processes of plastic metal deformation where the cast shaped or semifinished product is passed between rolling rolls and its cross section is reduced giving wanted shape with contemporary improvement of mechanical characteristics. Considering rolling temperature there are hot steel rolling and cold steel rolling. At hot steel rolling the material for rolling has been previously warmed up to certain temperature depending of material type. At cold rolling the material is not warmed up, i.e. it is rolled on the environmental temperature.

During calculation of safety and reliability of the main parts of rolling stands it is necessary to determine loads (forces and moments) which depend of many variable effecting sizes and conditions of work. Because of that the loads during rolling have stochastic variable character during time.

Forces and moments during rolling can be determined in two ways: analytical and experimental. Analytical proceeding exists on many hypotheses and it is insufficiently reliable, while the experimental is exact and gives much more exact results. However carrying out of experimental method is very complex proceeding, requires appropriate equipment adapted to given conditions and also it is very expensive. In this paper is given method how can be carried out analytical and experimental methods of loads determination of the rolling stands rolls during basic process of billet rolling in final profile shape. With this process can be established which of the analytical methods give the most exact results and which of them can be used for establishing of loads for concrete conditions and type of rolling.

2. Forces of metal pressure on rolling stand rolls during rolling process

The forces that rolled material act on rolling stand rolls are consisted of vertical and tangential components, figure 1. Those are loads that together with moments (static and dynamic) make operational loads. The line of resultant force depends of type and rolling conditions. In every concrete case the line of resultant force can be determined from conditions of the vector sum of components at deformation of rolled material. At basic rolling process the resultant force is directed vertically, parallel with line, which connect center of belonging rolls, figure 2.

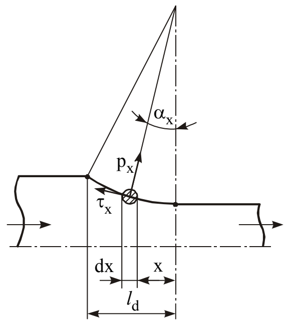

Figure 1. Vertical and tangential pressure on the roll

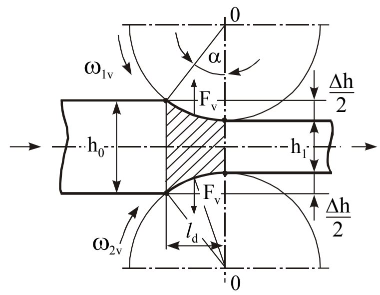

Figure 2.Basic rolling process

Analytical definition of the force which rolled material act on rolling stand rolls Fv (rolling force) can be defined regarding on type of rolling as well as conditions under plastic deformation of material is performed. General expression, which takes into consideration all relevant factors, defines rolling force as [1]:

$$F_v = b_{sr}\left[\int_0^{\alpha} p_x \frac{dx}{\cos\alpha_x}\sin\alpha_x + \int_{v_H}^{\alpha}\tau_x \frac{dx}{\cos\alpha_x}\sin\alpha_x - \int_0^{v_A}\tau_x \frac{dx}{\cos\alpha_x}\sin\alpha_x\right] \tag{1}$$

At practical calculation of the rolling force the middle pressure is taken Psr, so the rolling force can be defined as:

$$F_v = p_{sr}\cdot A \tag{2}$$

Where are: p_{sr} - middle specific pressure; A - projection of the contact surface of metal with rolls

Differential equation that defines specific pressure with same simplifications of conditions in zone of metal deformation is known as Karman equation and it has form:

$$\frac{dp_x}{dx} - \frac{k}{y}\frac{dy}{dx} \pm \frac{t_x}{y} = 0 \tag{3}$$

Where are: t_x - specific friction force,

p_x - specific pressure in arbitrary section *dx,*

x - distance of section from output part from rolls

Many authors solved the differential Karman equation (3), so expressions for definition of the force the rolled material act with on rolling stand rolls are established F_v [2]:

- Rolling force according Celikov has final form:

$$F_v = \frac{b_0+b_1}{2}\cdot\frac{2l_d\cdot h_n}{\Delta h\cdot(\delta-1)}\; k\left[\left(\frac{h_v}{h_1}\right)^{\delta} - 1\right] \tag{4}$$

- Rolling force according Ekelund has form:

$$F_v = \frac{b_0+b_1}{2}\sqrt{R\cdot(h_0-h_1)}\; p_{sr} \tag{5}$$

- Rolling force according Korolev has form:

$$\frac{p_{sr}}{k}=\frac{1-2f}{2f^2}\frac{h_{sr}}{l_d}+\frac{1}{2f}+\frac{1}{4}\frac{l_d}{h_{sr}}-\psi_{pr}\left[1+\frac{h_{sr}}{l_d}\left(\frac{1}{2f}-\psi_p f\right)\right] \tag{6}$$

- A.F. Golovin I V.A. Tjugunov calculate specific pressure as:

$$p=p_0\left[1+f\cdot\left(\frac{2\sqrt{R_k\cdot\Delta h}}{h_0+h_1}+1\right)\right] \tag{7}$$

- Rolling force according Hill has final form:

$$\frac{p_{sr}}{k}=\left[1{,}08+1{,}79\left(1-\frac{h_1}{h_0}\right)f\sqrt{\frac{R}{h_1}}-1{,}02\left(1-\frac{h_1}{h_0}\right)\right] \tag{8}$$

Therefore, it is obvious that in expressions for defining of the specific pressure and rolling force exists many influential factors that are taken in different ways. In results are given very different values of forces with rolled material act on rolling stand rolls during rolling process.

3. Experimental definition of pressure force on rolls during rolling process

Aiming to check accurate efficiency of definition material pressure force on rolls according to exact authors and their analytical expressions, the proceedings of parallel, analytical and experimental methods are carried out. The proceedings were carried out for existing conditions during rolling process on two rolls rolling srtand at continuous rolling process [3].

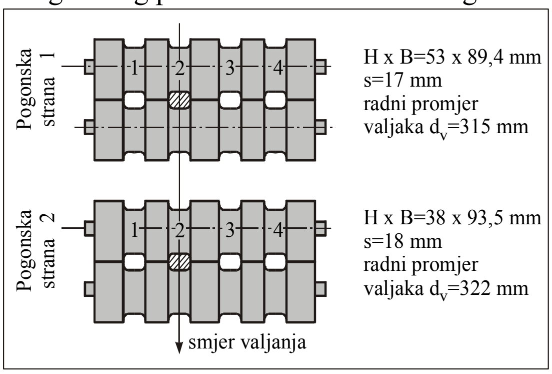

Figure 3. Rolling scheme

Table 1. The results of analytical methods of definition of the rolling force

Load	Method of checking of operational load		
	Ekelund	Hill	Golov.-Tjug.
Rolling force kN	425,45	277,51	549,53
Roling moment, kNm	27,25	17,78	35,30

Experimental research is carried out according scheme given on figure 3. Semifinished block which had been rolled was the billet □ 80x80x6000 mm from steel 37 NT/č.0300 with chemical composition of main elements: C= 0,17% and Mn=0,48%. The billet temperature was 1100°C and other characteristic factors were experimentally get and are given in literature [3]. As this research was part of wide experiment it is for these conditions load check made for 20 billets. For every billet were registered characteristic values.

After this the analytical methods are carried out and made comparison between analytical and experimental results. The analytical method of definition of the rolling force had been carried out on the base of three authors whose methods are usually carried out for calculation of this rolling process. Those are methods according: Ekelund, Hill and Golovin-Tjuganov (5,7,10). The results of rolling forces according these authors are given in table 1. As it is obvious at analytical methods there are considerable dispersion of calculation results. The highest values are get according Golovin-Tjuganov, and the lowest values according Hill. The results according Ekelund are located between values of these two authors.

For carrying out of the experimental method of rolling force establishing as well as other important parameters for operational loads during rolling, the preparation works were carried out. The most important of them are: production and preparation of instruments for measure of temperature of rolled material and devices which enable measuring of rolling velocity and electrical sizes. All measure locations, and there were 11 are connected by one amplifier Spider 8 (HBM) with computer and its software package for data processing.

Therefore during passing it is recorded flow of loads for 11 characteristic values in time intervals of 0,1 sec. It enabled registration of all changes happened in rolling process, table 2.

Table 2. The results of process of operational loads and rolling parameters

Item no	Time t	Force F_{1L}	Force F_{1D}	Force F_{2D}	Force F_{2L}	Temp. T	Veloaity v_1	Tension U_1	Elektric I_1	Veloaity v_2	Tension U_2	Elektric I_2
	s	kN	kN	kN	kN	^oC	1/min	V	A	1/min	V	A
1	20,6	189,481	221,467	0,878	5,389	1001,2	132,92	249,65	130,56	186,52	358,84	36,48
2	20,7	193,036	224,922	12,157	30,875	1069,6	132,66	248,93	133,44	186,52	358,84	39,84
3	20,8	192,672	224,878	33,049	100,573	1083,9	132,79	249,07	133,44	186,25	356,64	127,68

Besides results given in table 2. in the figures 4 and 5 are given graphics of flow changes rolling parameters during rolling of one billet.

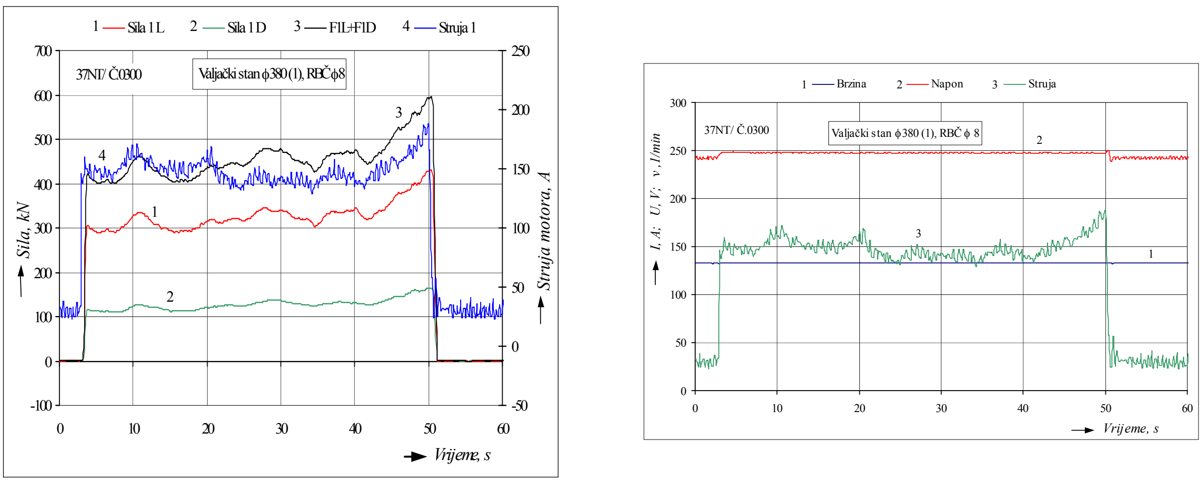

Figure 4. Time flow of operational loads during the pass

4. Conclusions

On the base of researches carried out in this paper the next conclusions can be drawn:

- During the rolling influencing parameters on operational loads are stochastic changeable values. It limits that operational loads during the pass are changeable as well.
- Changes of rolling forces are present because of change of the rolling conditions (different quality of material, diameters of rolls, velocity of rolls, assortment etc.)
- Calculation of the force as well as moments of rolling by analytical method according different authors results in wide diapason of the result disperse.
- In this work it is confirmed by experiment that for basic process of rolling the best results are get by Ekelund analytical method. However these results should be raised in cca 25% as real results will be get which can be used further for calculation of safety and reliability of the rolling stand main part.
- For other types of rolling the results should be checked experimentally.

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SELF – ORGANIZING ASSEMBLY SYSTEM

B. Katalinic and V. Kordić

Abstract

Scope of this paper is to present current state of development of biologically inspired self-organizing complex flexible assembly system. The self-organizing systems have very strong tendency to act autonomously, this characteristic is positive one from the point of robustness of functionality and efficiency of system. From other side the bionic assembly system is part of larger computer integrated production structure (factory, concern) and has to follow the aims which are coming out from this subordination. This conflict is through functional integration of vertical and horizontal communication resolved.

Keywords: bionic assembly system, self-organization, communication, autonomous assembly unit

1. Introduction

Scope of this paper is to present current development of the Bionic Assembly System and its components. The concept of Bionic Assembly System was developed as an answer on a real industrial demand to significantly reduce the production costs of electrical motors in mass production with open range of variants of types of electrical motors, which is in permanent change. Such kind of production demands high level of flexibility, adaptivity and intelligence of assembly system [4, 7]. Rash development of new forms of production/machining/assembly systems makes used equipment obsolete in a short time. Hence assembly systems have to be autonomous and modular. Modularity simplified introduction of new technology and processes as they become available.

The main advantage of autonomous systems is self-organising phenomena [4, 6]. Self-organization simplifies control structure of an assembly system and minimises downtime in reconfiguring of assembly system and preplanning, and rescheduling of assembly operations. The analysis of self-organisation processes of biological systems such are social insects colonies showed that physical systems are able to self organise only if all of following prerequisites are fulfil: lack of forced centralized control, autonomous nature and extreme networking of the units involved, natural parallel distribution of the processes. These requirements are frame of development of Bionic Assembly System [1, 2, 3]. Bionic Assembly System is a flat architecture based on concepts of autonomy, co- operation and intelligence of assembly units and self-organisation of assembly system. The former forms are successfully realised and verified in the industry on three systems: flexible machining system for rotational components, flexible assemble system for electrical motors and flexible complex logistical - transport system. The assembly system is suitable for complex assembly tasks in low batches.

2. Bionic Assembly System Layout

The layout of Bionic Assembly System is shown on the Figure 1. The system is composed out of two subsystems: Core subsystem and supplementary subsystem of BAS, these subsystems are divided by system border. The core subsystem is central part of assembly system. It includes:

all assembly stations, mobile robots, and assembly pallets, repair station, quality control station. The dominating activity in the core subsystem is assembly, quality control, and repair. The supplementary subsystem is surrounding the core subsystem. The main activity this subsystem is the storage of parts and components. The main activity on the system border between the core and supplementary subsystems is the supply of the assembly stations with the parts and components, which have to be assembled. The material flow crossing system border includes additionally the set-ups for the stations. The pool of pallets is buffer storage of assembly pallets in the case that the pallet is not designed to be universal assembly pallet for all type of products. The main material output from core subsystem is in the form of finalised products with good quality. These products are leaving system at loading/unloading station and after packing they are ready to delivering to the customer. Over the same station is organised the output of bad products and half products did not complete the assembly and and/or cannot be repaired.

3. Assembly unit classes

Assembly process of Bionic Assembly System consists of series of matching between changing assembly requirements of product assembled and capabilities of assembly units. Successful design of assembly system depends on proper estimation of relations between capabilities of assembly units and correlated minimal number of assembly units required. Lowering assembly unit’s capabilities increase specialization leading to higher optimization of these. Side effect of specialization is need for more different assembly unit types involved in assembly. By each introduction of a new product to be assembled or by unit break starts automatic reconfiguration. Thus increased different assembly units types involved in the assembly process increase frequency and required time of reconfigurations of assembly system. Distribution of assembly unit’s capability (or specialization grade) is roughly a trade off of these factors. To realize Bionic Assembly System six assembly unit types are introduced. Assembly units of the same type create one assembly class. Table 1 summarises classes their function and realisation description.

Table 1. Decomposition and function of classes

CLASS	FUNCTION	REALISATION
Transport	Place of assembly, carrier of assembling product, assembly related information carrier.	Autonomous mobile robot with exchangeable palette.
Assembly	Assembling of assembly steps in charge, storage for corresponding assembly parts.	Mobile robots with manipulator and part storage for three different assembly parts.
Supply	Delivering of assembly parts to assembly stations.	Autonomous mobile robots adapt to transport assembly parts in quantities.
Energy	Changing batteries of an assembly station at the actual assembly station position and transporting of these to the charging station.	Autonomous mobile robots adapt to transport and exchange batteries.
Repair	Repairing or removing of non repairable motors from assembly process.	Fix box. Shop floor operator driven.
Unload	Taking over of finalised products with good quality.	Fix mounted industrial robot.

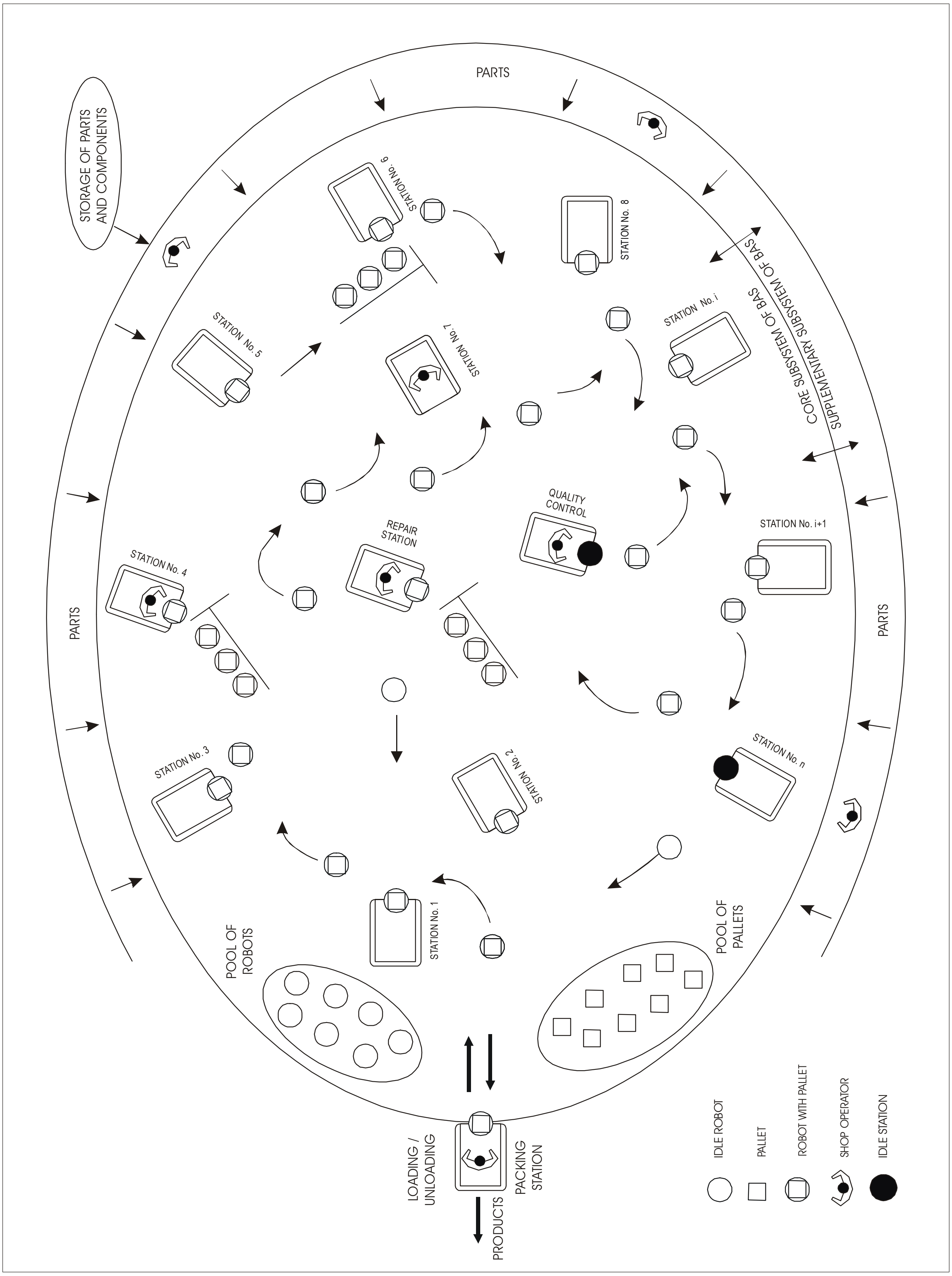

Figure 1. Basic Structure of Self-organising Assembly System

Transport and assembly class builds a basis of Bionic Assembly System. They have to deal with following sources of uncertainty and dynamic events:

- Incoming parts variation: Variable availability and arrival rates and poses of incoming parts

- Variable quality of incoming parts: Faulty parts must be removed before they either cause errors in system, or become assembled into products.
- Mixed batch of parts to by assembled: The assembly station assembling a range of variants of electrical motors types.
- Variable availability of resources: Resources are tools and machines with which the assembly station needs to directly coordinate.
- Response to dynamical events in self – organising assembly system: For example opening alternative assembly ways to bypass machines break ups or allowing more assembly stations and transport agents in core subsystem to increase production capacity. Supply class provides assembly class units with needed parts, energy class exchanges empty batteries. Booth actions take place at actual position of assembly unit supporting self - organised assembly structure.

4. Communication

Data exchange between the subordinate computer integrated environment and the self organising assembly system as well as between assembly units within assembly system has crucial influence on the functionality of the self-organising assembly system. The influence of subordination on self-organising assembly system must be as low as possible. Thus interface between them must be loosely coupled. According to the task distribution there is no assembly unit or assembly unit class which can complete the assembly task alone. Each class is able to do the task of the class independently. The assembly task is accomplished by the cooperation of the different classes. Cooperation is understood as a process at which the assembly units coordinate their activities with each other. Coordination of activities is realised by exchange of information between assembly units. In accordance with this outline two global communication channels are required, further denoted as vertical and horizontal communication. The two way vertical communication between central control system and assembly units realizes at the shop floor the functions and aims which are defined at higher level. Vertical communication denotes functional interface between subordinate computers integrated production structure and self-organising assembly system. A vertical communication is carried out between factory scheduler and assembly units. Through it each assembly unit become task oriented information. Factory scheduler becomes information about actual unit's status. Table 2 summarise possible statuses. Due to the assembly unit statuses factory scheduler can calculate actual assembly capacity as well as make meaningful plans for next assembly batch. Vertical information exchange is on Figure 2 in detail represented. Integration of self– organizing assembly system in computer integrated production structure solved three open questions of self- organising systems; (1) compatibility with existing manufacturing control system, (2) to be lined up with down automation outside self-organising assembly system and (3) motivation of self–organizing assembly system by vertical communication.

Table 2. Assembly unit status

STATUS	DESCRIPTION
Active	Assembly unit is active.
Queue overload	The waiting Queue in front of the assembly unit is full. Assembly unit is idle.
Malfunction	Assembly unit is idle but it cannot proceed with given tasks. It must be exchanged.
Spear	Assembly unit is not idle and waits activating signal from factory scheduler.

The horizontal communication between all assembly units realizes self-organizing functions at level of sequence of assembly operations of one single product. Horizontal communication is a synergetic element, which forms an intelligent behaviour of the self-organising assembly system. Assembly units alone have no intelligence per se. However if one summarizes the activities of whole assembly system an intelligent behaviour can be notified. Figure 3 shows horizontal communication in detail.

Vertical and horizontal communication structure is a backbone of integration of task orientation and self-organization of the assembly system. In that way functionality and efficiency from one side and high flexibility, re-configurability and robustness of the assembly system from the other side can be reached.

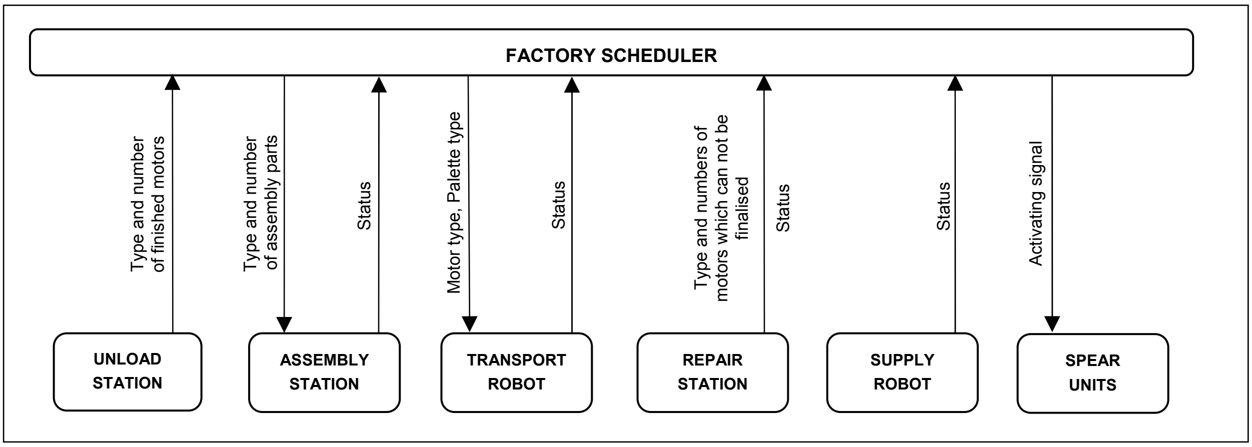

Figure 2. Vertical communication

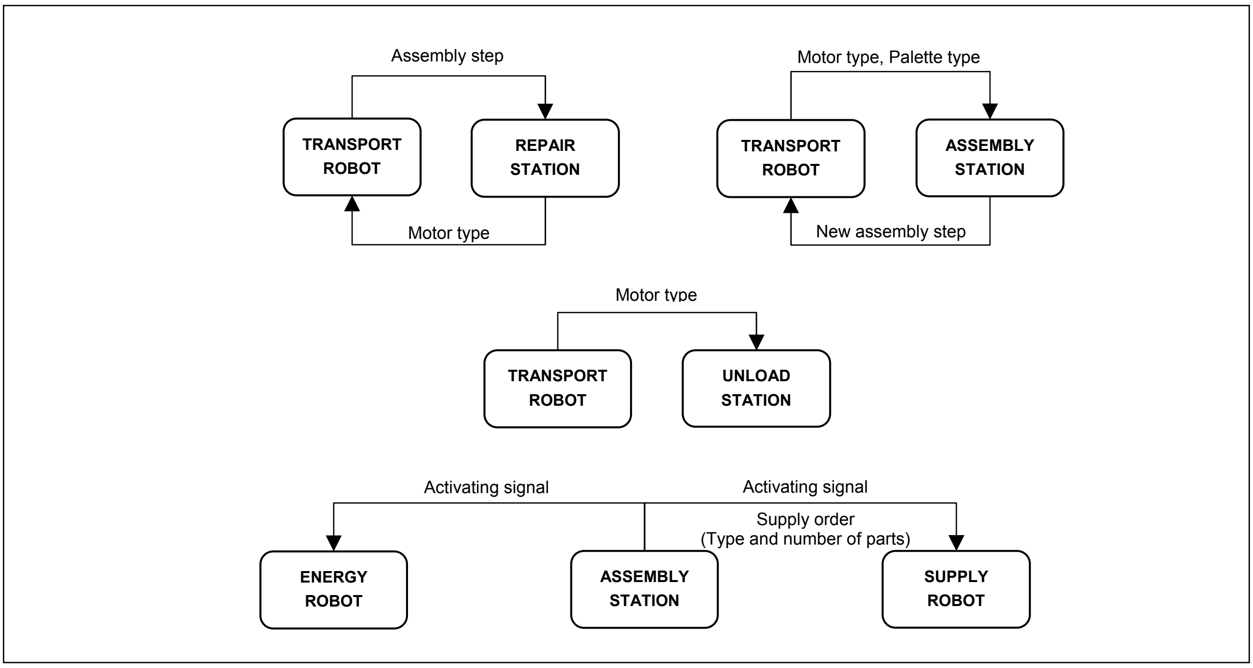

Figure 3. Horizontal communication

5. Case Study

Technical realisation of proposed communication structure is in following case study presented. Case study is focused on typical scheduling situations in assembly system. Horizontal and vertical communications are carried out by means of infrared and high frequency radio system. Infrared communication is used as a short distance interface for exchanging location bounded information. Radio communication system is used for localisation of assembly, repair, quality and load station and transport robot pool. Radio communication system also built up information exchange between all classes and factory scheduler. For a radio communication Industrial, Scientific and Medical band (ISM) at 2.45 GHz is used. This band does not have to be licensed and can be used for free. Assembly, quality, repair, loading station and transport robot pool are equipped with one transmitter each. Every transport, supply and energy robot is equipped with two receivers. Due to the radio trigonometry and magnet field strength of the received signal transport, supply and energy robots can find relative position of the assembly station and steer to him. Transport robot receivers can receive all predefined frequencies but only one at the time. Which one is currently received depends on actual assembly step as well as capacity utilization rate and availability of the assembly station. Loading and supply robots however scan whole frequency range and wait for the activating signal from assembly stations. As each assembly unit has its own control the information valid for longer period of time can be transferred to this unit and saved in its memory. Table 3 shows this information for a case of transport robots and one motor type. The information shift from factory scheduler to the individual assembly units is one elegant way to make hierarchical/autonomous coupling loosely. Hierarchical system decided what will be assembled, but not how. The information shift relieves the vertical communication channel considerably simultaneously supporting self-organisation and thus real time optimization of the assembly process. When a new motor type will be assembled, factory scheduler make updates assembly units memory. For each group of similar motor types there is a corresponding assembly palette. The assembly palette is the basic carrier for product during the assembly cycles. Palettes are used to support the assembly process. Each motor type has its own assembly procedure. Assembly procedure consists of assembly steps represented through a string of all transmitter frequencies of assembly stations capable for a given assembly step. In the table 3 column "Assembly step" and "Assembly unit" are presented to help following the example on Figure 4 and do not exist in a transport robot memory. Assembly cycle begins in the transport robot pool by transferring motor type code from factory scheduler to one transport agent. This transfer is carried out through infrared interface mounted at the output of transport robot pool. In that way a starting point for each assembly cycle is determined helping to stabilise a whole assembly structure. Transport robot TR_2 puts his own receivers on first transmitter frequency that is 2452 MHz. If receivers detect the frequency transport robot steers to transmitted point. When transport robot reaches assembly station he sends motor and pallet type code to the assembly agent. Due to the transferred information assembly station can check if this assembly station is responsible for this transport robot, and if it is, can choose proper assembly part from the part storage within assembly station and put it on the right place on the transport robot palette. This assembly process and quality control of assembly is controlled through vision system mounted on the end-effectors of the assembly station manipulator.

Table 3. Assembly procedure for one motor type

<table>
<tr><td rowspan="6">Motor Type Code</td><td rowspan="6">Palette Type Code</td><td>Assembly step</td><td>Assembly unit</td><td>Transmitter Frequency</td></tr>
<tr><td>1</td><td>2;5;7</td><td>2452; 2455; 2457 MHz</td></tr>
<tr><td>2</td><td>1;4</td><td>2451;2454 MHz</td></tr>
<tr><td>3</td><td>3;6</td><td>2453;2456 MHz</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Finish</td><td>Unload</td><td>2500 MHz</td></tr>
<tr><td colspan="2">Transport robot pool</td><td>-</td><td></td><td>2501 MHz</td></tr>
<tr><td colspan="2">Repair</td><td>-</td><td>Repair station</td><td>2400 MHz</td></tr>
<tr><td colspan="2">Energy maintenance</td><td>-</td><td>Energy robot</td><td>2405 MHz</td></tr>
</table>

If searched frequency cannot be found, the transport robot automatically switches to alternative transmitter frequency for a corresponding assembly step. In presented example there are three suitable frequencies for first assembly step. That means within self-organising assembly system physical border there are all together three assembly stations capable to execute this assembly step. Transport robot switches own receivers therefore, first on 2457 MHz and if this frequency cannot be found on 2455 MHz. For each assembly step there must be at least one active assembly station. There are three reasons why an assembly station transmitter does not transmit.

These are:

- Assembly station status active/overload: When assembly station queue is completely occupied assembly station turns own transmitter off and forward new status to factory scheduler. Factory scheduler will switch a certain number of alternative assembly stations of the same type. On the figure 4 this is case with the assembly station AS_3.

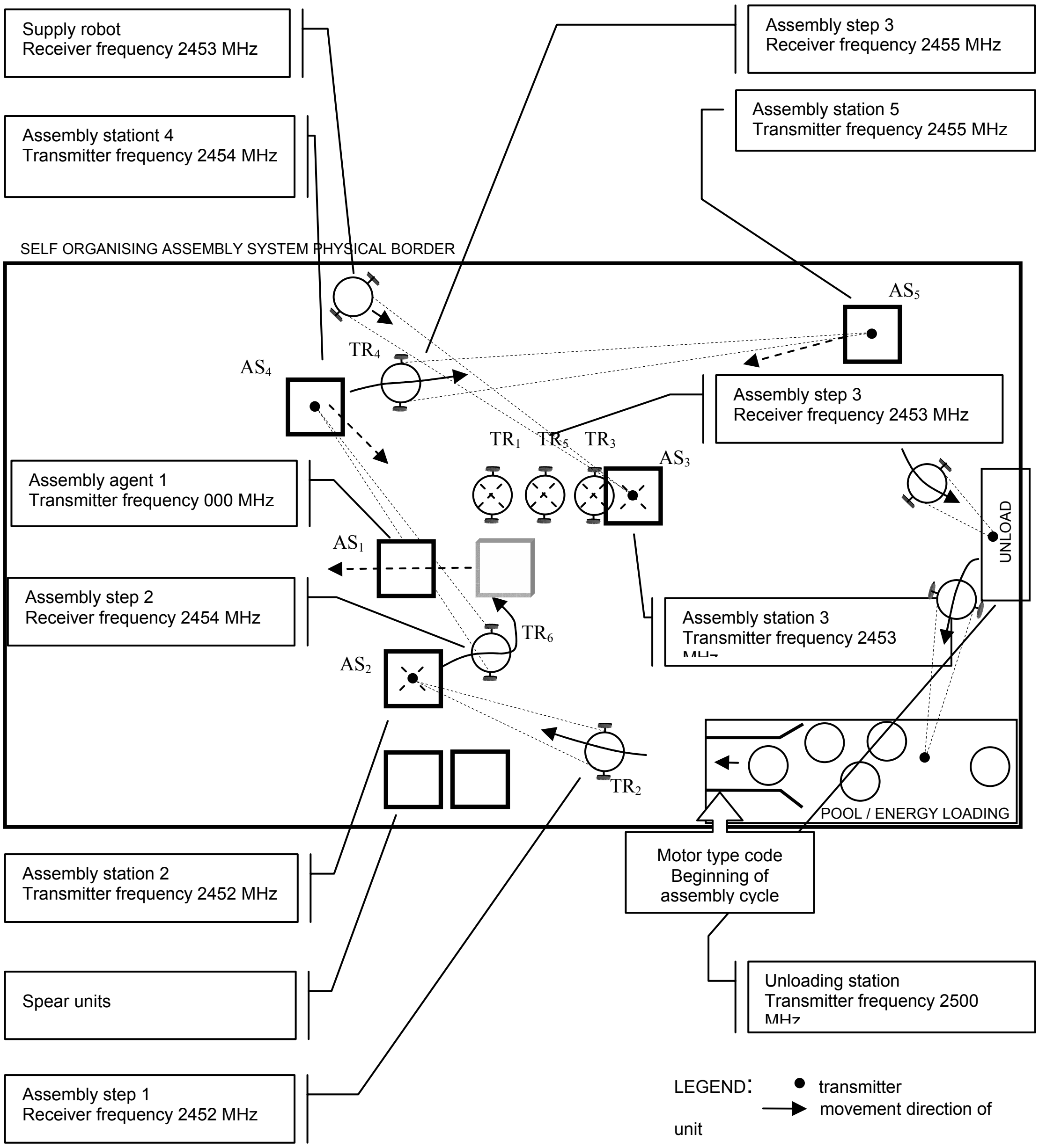

Figure 4. Example of the Bionic self-organising assembly system after table 1.

- Assembly station status active/brake off: Assembly unit brake off. On figure 4 that is the case of assembly station AS_1.
- Assembly station is turned off deliberately: If production capacity has been decreased some of active assembly stations may not be required any more and can be withdrawn from the assembly structure.

After the successful completion of the first assembly step assembly station AS_2 changes status of the transport robot TR_2 on the next assembly step. Transport robot receivers jumps on 2451 MHz. However if assembly step was not successful, assembly robot switches the transport agent receiver to the repair station frequency, thus on 2400 MHz. The transport robot steers to repair agent. Second assembly step can be managed by two assembly stations AS_1 and AS_4. Assembly station AS_1 does not send any signal because this one broke down and will be automatically redrawn from the assembly structure. Assembly station AS1 status changes from active/ok to the active/brake off. Factory scheduler will according to changed status activate a new assembly station. To be adequately exchanged new assembly station must be functionally equivalent to the first one and must transmit either on 2451 MHz or 2454 MHz. New assembly station M4 transmits on 2454 MHz. This signal will be captured by transport robot TR2. On the way to the assembly station AS4 transport robot avoids assembly station AS1. He treats it as an obstacle. Transport robot considers all detectable objects within physical border of self-organising assembly system as obstacles except the actual steered object. At a moment both, assembly station AS4 and transport robot TR2 are in moving. Assembly station AS4 search for an optimal position in the assembly structure. Criterion for optimal placement of assembly station is minimal interruption time between two assemblies. Each assembly station measures the interruption time and tries to minimize it. Minimal time depends on transport robot speed and minimal allowable distance between assembly stations. Minimal allowable distance must be greater as working field of the manipulator of the assembly station. In presented example it is 2.5 m. Maximal speed of the transport robots is limited through mechanical construction and is 6 m/s. When he is within working field of the unloading station, unloading station takes manufactured motor, stores it and switches transport robot receivers on the transport robot pool frequency, therefore on 2501 MHz. In transport robot pool transport robot waits new assembly task and loads own batteries in between. However, assembly cycle can be ended in the repair station. Fault motors which are not repaired will be taken by repair station. Empty transport robot is free and steers for transport robot pool. Repair station sends type and number of not repairable motors to the factory scheduler. Factory scheduler corrects the number of motors which must be assembled.

6. Conclusion

Flexibility is the one of the essential issues to overcome in future manufacturing systems. Presented self-organising assembly system shows flexibility which can not be reached with operating manufacturing systems concepts. Flexibility in respect to:

- Changing system configuration: the number of assembly units can vary from minimal one of each type to unlimited. According to the results of the search transport robot decides which assembly station will be used. Therefore, even in cases where some new assembly stations are added or some are taken out of service for maintenance or other reasons, transport robots can select a suitable assembly robot adapting to changes in the system configuration. Transport robots need not to know which and how many assembly robots are running; they can decide which assembly station to use by relying on transmitted frequency from the assembly station.
- Product mix and size of run can vary in extremely wide range. Each transport robot has assembly procedures on how to finish the target product. Assembly stations have assembly part storage capable to store up to three different assembly parts in sufficient number. So, it is possible to produce mixed types of products concurrently with batch size 1. Production capacity is with number of assembly units and physical space limited.
- Variable structure of system: At a beginning of assembly of different motor types there will be one assembly structure. As production capacity increase new bottlenecks arise. To manage it factory scheduler activates corresponding number and type of assembly stations. As each assembly station tries to minimise the interruption time between two assemblies, assembly structure will be substantially reorganised. New assembly structure consists of two assembly sub systems for each motor type with join assembly stations. If capacity demands increase further it can reach the point where for each assembly step and motor type one or more active assembly stations are needed. In that case assembly structure splits on two independently assembly structure. Two parallel assembly structures co-exist within physical border of self-organising assembly system.
- Changing production order of products: The self–organizing assembly system can very quickly respond on the demands of master scheduling system. Each target product is mapped on

transport robot. This can help complete urgent work or urgently needed products (with imminent delivery dates) quickly by changing the production order. Production order has an external priority as a measure of order urgency. The priority scale has 10 points, from 0 to 9. Priority 0 is given to the orders which are not to be processed yet. The normal urgency is priority 5, a very urgent order is priority 9, and a not urgent order is priority 1. The volume of the order of priorities is established on a linear scale of interpolated order urgency. Scheduling strategies are designed to fulfil the key aim: Justin- Time Delivery of products according to the specification of customer order. The scheduling strategies are task oriented to fulfil the order for one particular customer in predefined time. That means one customer has ordered different quantities of different types of products, and all products have to be assembled and prepared for the delivery and transportation at predefined day and time (yyyy-mm-dd hh:mm).

- Workers friendly system: Possibility to integrate workers for the normal assembly tasks and special tasks (repair, inspection, supply of parts, set up, etc).

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CASE STUDY OF A SMALL STATE PREPARING FOR THE WEEE DIRECTIVES

M. Kljajin, D. Kozak and Z. Vnučec

Abstract

Croatia is a small state with intention to be EU state with a significant electrical and electronic equipment (EEE) manufacturing industry. It has a relatively underdeveloped recycling infrastructure and a lack of markets and outlets for recycled materials. This poses significant difficulties for the government in preparing for the proposed WEEE directives. The current situation regarding WEEE management has been assessed. WEEE arisings in Croatia have been predicted, using the Market Supply method [1,5], at between 10,2 and 17,6 kg/inhabitant/year for 2002. A survey of local authorities has found a lack of facilities for public WEEE recycling. Those that are in operation are exporting WEEE to Europe for recycling or, in some cases, processing it inappropriately. A survey of the Croatian EEE manufacturing industry reveals a lack of awareness regarding the proposed WEEE legislation. Environmental information on products was found to be poor, despite the potential to provide such information. There is poor awareness of the ecodesign concept in Croatia. A WEEE collection trials project has recently been started that aims to help Croatia to overcome some of its deficiencies and begin to prepare for the WEEE directives.

Keywords: EEE, WEEE, WEEE directives, recycling, ecodesign

1. Introduction

The Republic of Croatia, with a population of just 4.437.460 (census from 2001), is one of the smaller European states. The EEE manufacturing industry is not too much important to the Croatian economy, but with import of EEE it has an annual turnover of 5,5 billion EUR [2]. A strong, growing import of EEE in the last 5 years has resulted in an increase in the consumption of electronic and electrical equipment. In contrast with this, Croatia has an underdeveloped waste management and recycling infrastructure, and little is currently done to remove WEEE from the household waste stream. Croatia therefore faces a challenge to meet the requirements of the forthcoming European legislation. The first step in meeting this challenge has been to assess the current situation regarding WEEE management. Prior to this investigation very little information regarding this waste stream was available in Croatia. The next step has been to establish trials for the collection of WEEE in order to develop an appropriate methodology for Croatia.

2. How to estimate WEEE arisings?

Initial research was undertaken in order to estimate WEEE arisings using similar methods to those of previous European and world studies. Sales data was acquired from a range of sources including the state Statistics Office of Croatia (using production, import and export data), market research companies and industry associations. Figure 1, shows the example of PC sales in Croatia. Our investigation found flaws in the method used to gather import and export data. This Market Supply method are common to European statistics offices and raise questions over the suitability of state data for use in waste predictions, and over the reliability of previous waste predictions using such data. Due to the problems identified, WEEE arisings were calculated using sales data from market research sources. Croatian data was applied to this method but the use of this method resulted in a range of waste predictions. WEEE arisings for Croatia have therefore been presented as a range, as shown in Figure 2. The true level of WEEE arising is likely to sit somewhere between the upper and lower estimate. For the year 2002 it is predicted that between 45.260 and 78.099 tonnes of WEEE will arise, equating to between 10,2 and 17,6 kg/person/year.

3. Current WEEE management

At present Croatia has a relatively underdeveloped WEEE recycling infrastructure. This is most likely due to the small size of the country, which limits the economic base available for profitable recycling. The difficulties are exacerbated by the island nature of the country.

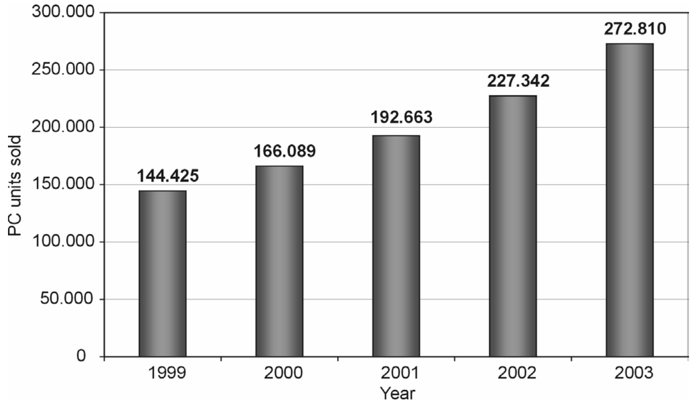

Figure 1. Sales of PCs in Croatia calculated from our own collecting data

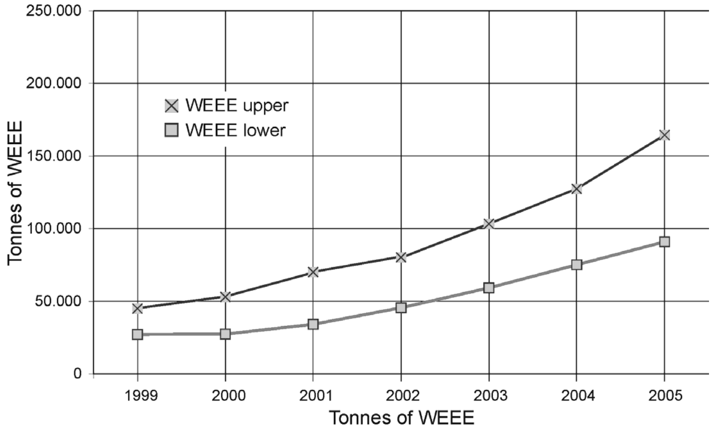

Figure 2. Estimated WEEE arisings for Croatia (upper and lower)

A 2002 survey of all 20 local authorities in Croatia has found that only 9 local authorities provide facilities for the public to recycle all items of WEEE. A further 11 provide facilities for the recycling of white-goods only. In total there are 27 sites for the collection of WEEE in Croatia, with a further 45 planned for the next 2-3 years. Half of all existing facilities impose a fee on the public when they drop off items of WEEE. Almost all WEEE collection systems operated by local authorities are permanent collection points at civic amenity sites (municipal depots). Several authorities operated bulky waste collection systems, which included WEEE, but these have ceased since the beginning of 2002 due to the restrictions on refrigerator recycling caused by the Croatian low and EU regulation on substances that deplete the ozone layer. Data is rarely collected on the quantities of WEEE being disposed of. When monitoring does take place, it is often by number of items only, and there is variation in the definitions of equipment categories. This makes comparison of systems very difficult and highlights the need for a standardised monitoring methodology.

3.1 Collection rate at existing public WEEE facilities

Estimating the WEEE collection rate (kg/inhabitant/year) at existing facilities is difficult. An assumption must be made regarding the catchments of the facility, and this has a great bearing on the resulting rate. Collection rate has been calculated based on information from local authorities.

3.2 Existing Markets and Outlets

At present WEEE recycling in Croatia is dominated by basic shredding of metal-rich white-goods. This does not provide for the separation of any hazardous components. The cost of metal recycling has also risen recently with the 2001 closure of the only outlet available for scrap metal in Croatia. This means that all scrap metal must now be exported for recycling. Approximately 5 specialist EEE recyclers exist in Croatia, but these are predominantly IT equipment recyclers. There is currently no facility for the recycling of cathode ray tubes (CRTs). Televisions and monitors are therefore exported for recycling.

The average collection rate of 1,23 kg/inhabitant/year is significantly lower than the target set in the draft WEEE directive (4 or 6 kg/inhabitant/year), and this demonstrates the difficulties Croatia faces in meeting the requirements of the directive. Since the EU regulation on substances that deplete the ozone layer came into force there is also no facility for the appropriate recycling of refrigerators. IT recyclers in Croatia primarily act as refurbishes and dismantlers, reselling useable components and exporting others for recycling. Such recyclers focus on commercial sources of IT equipment. Bypassing indigenous recycling companies, several local authorities currently ship all collected WEEE directly to Austria, Slovenia, Germany or the Netherlands for recycling.

4. WEEE collection trials

The Croatian Environmental Protection Agency (CEPA) has to fund a new project to establish trials for the collection of WEEE in Croatia. These collection trials will be run over two years from 2004, in a variety of different locations throughout Croatia. The CEPA has to recognise the need to conduct WEEE collection trials in order to develop a coordinated national approach to meeting the requirements of the WEEE directives. A range of locations has been selected for collection trials. These locations represent different population densities in both urban and rural locations allowing for a comparative analysis.

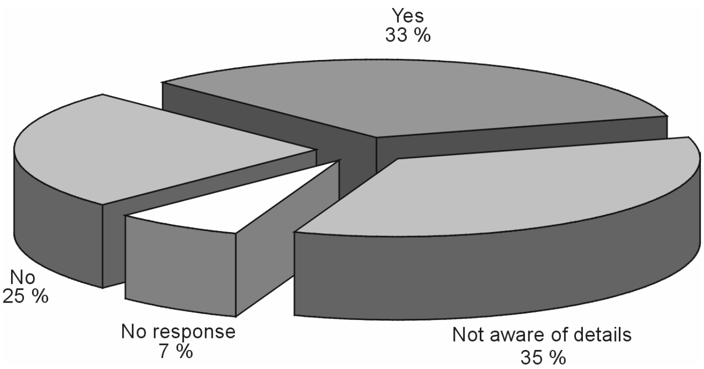

Figure 3. Production and trading company responses to the question: Are you aware there is draft European legislation regarding waste electronic and electrical equipment (WEEE)?

All facilities will be extensively promoted using a range of media, and the success of different promotional avenues is to be assessed by way of customer surveys. A standardised methodology has been developed to ensure comprehensive monitoring of quantity and weight of equipment collected. Data will be gathered according to the categories used in the WEEE directives. Preliminary collection results from the project will be available towards the end of 2004.

5. Environmental performance of the EEE industry in Croatia

The electrical and electronics manufacturing and trading industry are one sector of the Croatian economy, which will be growing in the near future. A survey of the EEE industry in

Croatia was conducted in 2003 in order to provide baseline data on the attitudes, views, knowledge and awareness of companies with regards to environmentally-related management, legislation, information flow and product design.

5.1 Environmental management systems

Over 35 % of companies responding to the survey have an environmental management system (EMS) in place. 25 % of all companies had installed ISO14001. This is a 5 % lower uptake of the standard than was found in a similar survey of the industry in the Nordic Countries [3]. Significantly, however, it was found that just 7,5 % of indigenous companies have an EMS in place, compared with 45 % of the multinational companies. Similarly, smaller companies have a much lower uptake of EMS.

5.2 Preparedness for European legislation

Almost a quarter of companies responding to the survey (33 %) were unaware that there is major legislation pending in their industry, as illustrated in Figure 3. A further 35 % know that there is proposed legislation but are unaware of the details of this legislation. This means that almost 68 % of companies in the Croatian EEE industry are unaware of among Croatian companies and smaller companies. It was also found that 67 % of companies have taken no action to prepare for the requirements of the WEEE directives. One reason for this is that 35 % of companies in the sector feel that the directives will not be relevant to them. Given the extensive measures proposed by the legislation, this appears to be a worrying misconception. Small and indigenous companies were found to have a particular disregard for the directives.

5.3 Information flow

Product or supply chains for items of electronic and electrical equipment are complex in nature, involving a multi-tiered network of supplier companies. The flow of environmental information in the product chain has been recognised as a crucial issue in environmental policy. However, a lot of information is lost as a product passes through its life cycle and along the product chain.

The survey found that companies in the Croatian EEE industry have relatively poor communication of environmental information through the product chain, particularly when compared with the industry in the Nordic countries [3].

Obtaining information on the material contents of electronic components and products has been identified as a major difficulty and a barrier to improving environmental dialogue through the product chain [4]. A lack of environmental information on a product prevents customers from making informed decisions and acts as a barrier to efficient end-of-life management of the product.

The Croatian survey found that their customers ask 25 % of companies for information on the contents of their products. In addition to this, 37 % of companies stated that they are able to document close to 100 % of the material contents of their products (Figure 4). A further 29 % stated that they could at least provide some information about product contents.

But, are companies actually making this information readily available?

Despite the ability of 66 % of companies to document at least some of the material contents of their products, Figure 5 shows that only 18 % actually provide environmental information on products. This indicates the potential for an improvement in providing information to customers about the contents of products.

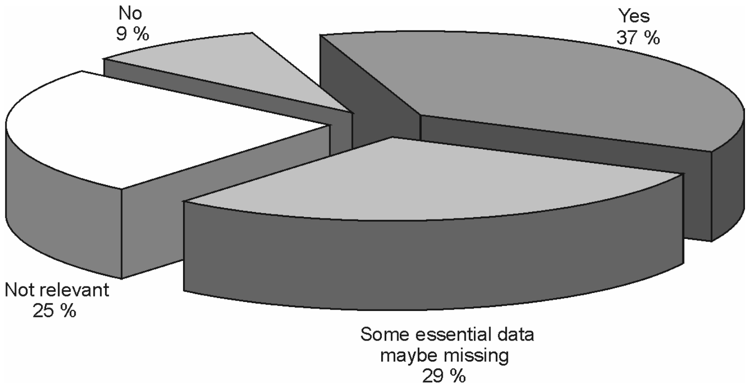

Figure 4. Responses to the question: Can the material contents of your products be documented?

5.4 Ecodesign

To date the only significant ecodesign activity in Croatia has to be included into an "Environmentally Superior Products" scheme. We suppose that this scheme has to be coordinated by Enterprise Croatia between 2004 and 2006. This scheme has also to involve a small number of Croatian SME's including some from the EEE industry.

The survey found that the majority of EEE companies in Croatia (82 %) have little or no knowledge of the concept of Ecodesign. It was also found that awareness of the concept is particularly poor among indigenous Croatian companies.

It was found, however, that many companies have made environmental improvements in products, but that these are as a by-product of other design efforts rather than an ecodesign strategy.

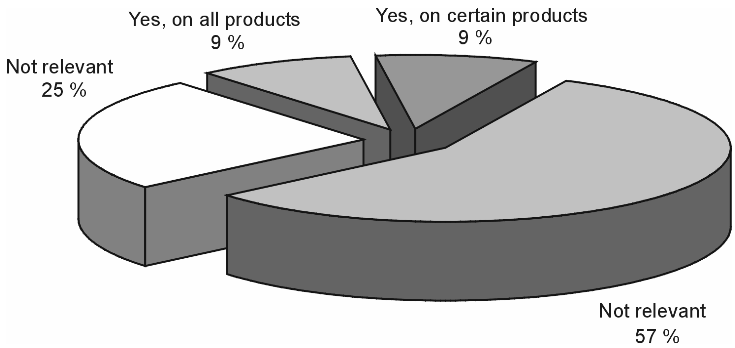

Figure 5. Responses to the questions: Does your company present any kind of environmental information about your products?

6. Conclusions

An attempt to predict WEEE arisings using international models has produced a range of results. Such results have limitations due to poor data reliability and variations in calculation models. It is of concern that previous attempts to predict WEEE arisings for the purposes of waste management planning are likely to have the same limitations. The EEE manufacturing and trading industry in Croatia is found to be unaware and unprepared for the WEEE directives. Lack of knowledge is particularly apparent among small and indigenous companies.

This indicates that the industry in Croatia will have a reactionary response to the requirements of the directives. There is a strong need for awareness rising in the industry.

An assessment of current WEEE management in Croatia has revealed a lack of coordinated public WEEE recycling facilities. The ad hoc nature of present facilities means that data gathering has been limited and is difficult to analyse. This highlights the need for a standardised collection and monitoring method for the whole country.

There is a clear need for a national methodology to be developed in order to help prepare Croatia for the requirements of the WEEE directives. A recently started project to trial WEEE collection systems will go some way to addressing this.

Acknowledgement

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METHODS AND WAYS FOR ENSURING INCREASED HOLE QUALITY IN COMPOSITE MATERIAL DRILLING

N. Koboević, A. Mišković and M. Prčan

Abstract

Composite materials are intensively used in manufacture of new products due to many advantages, when compared to metals. However their inhomogeneous and highly abrasive reinforcements create machining difficulties. The most frequently used machining in drilling, because it is necessary to fabricate a large number of holes in order to connect composite material parts with other parts. During drilling intensive tool wear, dust generation and specific hole damage (hole fabrication deviations) occur. Drilling damage and errors are to be reduced to minimum or completely removed, thus achieving high hole fabrication quality.

In this paper, elements for forming useful value matrix, hole fabrication method and means decision-making with elements for hole fabrication optimization by drilling in composite materials, are given.

Keywords: composite materials, fabricated hole quality

1. Introduction

In composite material drilling following occurs: increased tool wear, machined hole surface damage, hole dimension deviation, cracking, peripherals hole zone damage and dust generation. These occurrences are undesirable so they must be removed, or minimized. Fabricated hole damage requires additional fabrication or machining, induces crack formation and causes earlier failure.

If increased quality hole is to be made, correct method, work means and machining regimes must be chosen in order to avoid damage. It is important to notice that hole damage has a considerable impact onto part elements features in exploitation. Existing quality criteria needs to be expanded and drilled hole quality measurement methods improved.

In this paper value analysis elements give a practical machining method, means and regime selection algorithm that ensures increased hole fabrication quality, [1].

2. Implementation of research results in production

Considering requirements for composite material application (they are used when their properties exceed conventional material ones), such as: no conductivity, no magnetic properties, low density, high corrosion resistance, high specific strength, specific rigidity, etc. It is practically impossible to achieve complete optimization. Optimization by useful value matrix systematically formed in following steps, [2]:

- system goal forming,
- factors determination,
- goal magnitude matrix forming,
- goal value matrix forming.

The first step in useful value analysis of systematic grading criteria composition by determining adequate goal system, that must be envelope all relevant graded property variants.

Which criteria will be taken into goal system can be decided on orders demand, constructive-technological documentation or general demand list (other criteria that can be determined in solution searching process or goal system realisation). When forming goal system following differences must be taken into consideration:

- solid demands,
- minimal demands
- wishes.

Solid demands are not be evaluated, and therefore cannot be introduced into optimization process, because not fulfilling a solid demands results in absolutely unfit construction. Similar occurs when minimal demands are reduced; they can be subdued to grading only if given minimal values are exceeded. As a solid demand, error elimination is placed.

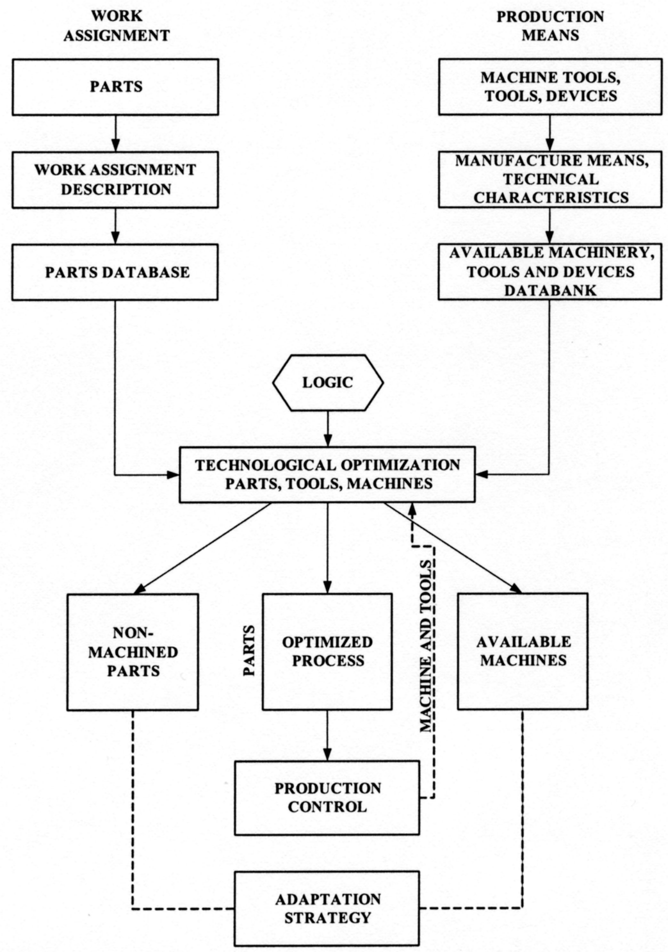


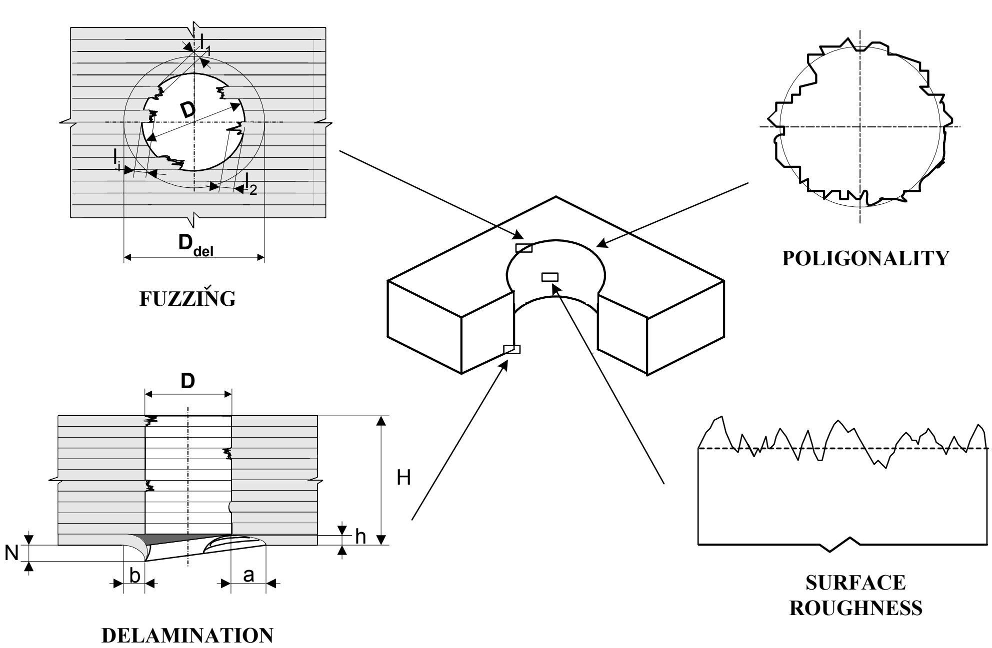
Figure 1. Technological process optimization schematics for composite material part fabrication using work means and regime choice by use adaptation strategy

System is more or less complex, in correlation to the number of solid demands given by constructive-technological documentation taken for fabricated composite material part or hole quality grading. It is desirable that solid demands are ensured in all machining process phases, that will not, in production conditions increase damage products.

For hole fabrication by conventional machining processes, activity sequence is given in table 1. Wit hole number for fabrication increases and work means automation degree, optimal cutting tool parameters and manufacture regime data accuracy requirements are increased. Hole fabrication means and method depend onto composite material structure, dimensions, exploitation conditions, etc. Satisfaction degree (i.e. optimisation possibility) depends on: manufacturer's technological level, available technical database, experience, technical equipment and inventively of technical-technological personnel.

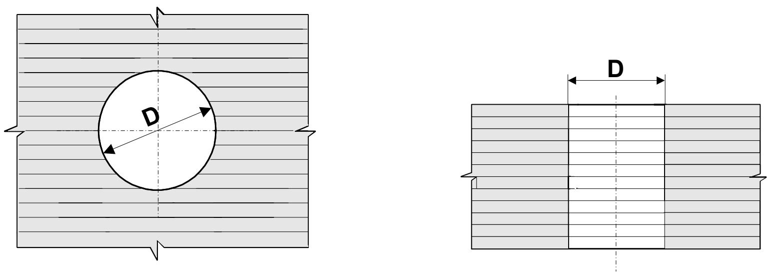
Table 1. Elements for forming useful value matrix, method and mean decision making for ensuring fabrication with expected effects

ELEMENT LOAD AND CONSTRUCTION FORM	COMPOSITE MATERIAL COMPOSITION, SHAPE AND DIMENSION	AVAILABLE WORKING MEANS	TECHNICAL-TECHNOLOGICAL KNOWLEDGE AND PERSONNEL CREATIVITY	PRODUCTION TYPE AND MANUFACTURING PROCESS COMPLEXITY	PROBABILITY OF ACHIEVING GOAL WITH EXPECTED EFFECTS
STATIC LOAD	MATRIX TYPE	HAND TOOLS	TRAINED WORKER	SINGLE PRODUCTION simple parts complex parts very complex parts	1,0
DYNAMIC LOAD (one or several directions)	REINFORCEMENT TYPE	PNEUMATIC HAND TOOLS	EDUCATED WORKER		
HEAT LOAD	REINFORCEMENT/MATRIX CONTENT	CLASSIC MACHINE TOOLS	ADDITIONALLY EDUCATED WORKER	SERIAL PRODUCTION simple parts complex parts very complex parts	
COMBINED LOAD	UNIDIRECTIONAL	ABRASIVE WATER JET	NON INVENTIVE PERSONAL		
OTHER SPECIAL LOAD	MULTIDIRECTIONAL	LASER MACHINE	INVENTIVE PERSONAL	MASS PRODUCTION simple parts complex parts very complex parts	0,5
FREE ELEMENT	ONE LAYER	ULTRASONIC MACHINE	VERY INVENTIVE PERSONAL		
MULTILAYERED COMPLEX CONSTRUCTION	SEVERAL LAYERS	AUTOMATED MEANS	HIGHLY INVENTIVE PERSONAL		
	SEMIFINISHED MATERIAL minimal machining considerable machining single operation processed several operations processed	NC or CNC MACHINE	EXTREMELY INVENTIVE PERSONAL		
			TIM WORK		0



$$k_d = \frac{D_{del}}{D} \text{ (delamination parameter)}, \qquad k_f = \frac{\sum_{i=1}^{n} l_i}{\pi D} \text{ (fuzzing parameter)}$$

a)



$k_f \le \varepsilon_1$, $k_d \le \varepsilon_2$, ε_1 and ε_2 - previously defined conditions

b)

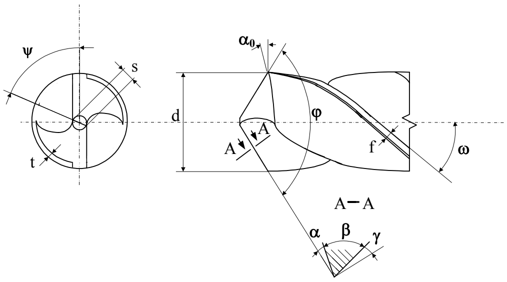
Figure 2. Hole in composite material
a) Expected errors overview, elimination of which (reduction to an acceptable value) is set as a solid demand
b) Hole appearance when solid demands are satisfied

3. Selection of hole fabrication method and ways

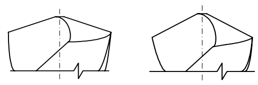
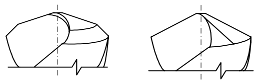
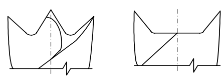
Possibility of whole fabrication without failure can be written as a following equation:

$$P(t) = 1 - \int_0^t \left[a_1 f_1(t) + a_2 f_2(t) + a_3 f_3(t) + a_4 f_4(t)\right] dt$$

where:
a_1, a_2, a_3, a_4 - represent coefficients for machined part quality reduction, process flow deviation (material errors, delamination, fuzzing, hole shape quality deviations),
$f_1(t)$, $f_2(t)$, $f_3(t)$, $f_4(t)$ - material errors distribution function, delamination, quality deviation, fuzzing.

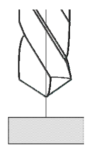
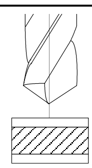


Tool material		
High speed steel	Carbide	Polycrystalline diamond (PCD)

Drill point geometry		
 Cutting edges formed by conical sharpening (CS)	 Cutting edges formed by CS and re-modelled main edges	 Modified cutting edges - improved cutting geometry

Tool material	Fabrication regimes for drilling	
	Cutting speed (m/min)	Feed rate (mm/rev)
HSS	12 - 18	0,02 -0,05
Carbide	40 - 120	0,03 - 0,1
PCD	30 - 150	0,02 - 0,25

Cutting tool geometry				
φ	ψ	α_0	ω	s/d
90° - 95° 116° - 118° 140° - 142°	50° - 55°	10° - 12°	20°, 30°, 45°	0,14 – 0,16

Drilling method	
 Drilling without backplate	 Drilling with backplate

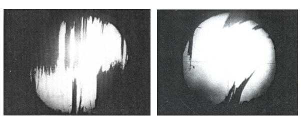
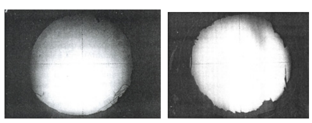
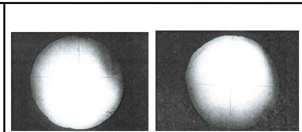
Holes overview		
 Holes – low quality manufacture	 Holes – average quality manufacture	 Holes – high quality manufacture

Table 2. Elements for hole fabrication technological procedure optimization in composite materials and holes overview

5. Conclusion

Based on the above stated, following conclusions can be made:

- modern economy development direction and market conditions impose a need for increased composite material parts application, and by that new machining process research and perfecting existing , implemented technology,
- hole fabrication in composite materials should be optimised by useful value analysis as a solid demand by elimination of fabrication errors,
- error elimination and achieving satisfactory manufacture results should be based on hole method and fabrication ways, having in mind available technological means.

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FACTORS INFLUENCING EXPLOITATION PROPERTIES OF BRAKE SHOES ON ROLLING STOCK

V. Marušić, D. Krumes and S. Aračić

Abstract

This paper presents test results of examining friction and wear properties of brake shoes made of phosphorus gray castings. Brake shoes with different content of phosphorus and hardness levels have been analyzed, and their wear in laboratory conditions of dry rub down in contact with rotating discs of various hardness has been tested. If has been established that brake shoe wear resistance depends much more on chemical compositions and distribution of structural constituent parts then on hardness values of the wheel – disc..

Keywords: brake shoes, phosphorus content, hardness, wear

1. Introduction

Long time production and accompanying quality controls of brake shoes on rolling stock established that set quality demands were mainly kept within given norms [1] and [2], specifically regarding chemical composition and hardness. Sometimes measured values approached close to boundary limits, and rarely were lower/ higher of those allowed (min 0,8 up to max. 1,10 %P and min. 197 up to max. 255 $HB_{10/3000/30}$).

During train operation there are ongoing changes in tribology system comprising components such as: rails – wheels – brake shoes. Materials are dilapidated, especially components having lower price and requiring simple substitutions. There are changes in structure due to high contact pressure and heat input, which leads to alternation of mechanical properties and hardness values of the surface layer. Friction and the related material wear of braking system of the trains has always been relevant traffic safety issue. With increase of train speed it attracted additional attention. The common wisdom of the railway men says that "the train does not have to start, but it must stop".

Taking into account development of high temperatures at train braking, dissipation of phosphorus content and measured hardness values (brake shoe and the wheel), test experiments of material wear were conducted on laboratory device SMT1-2070 [3]. The goal was to establish amount of material wear of brake shoes, in relation to their hardness and chemical composition, but also on train wheel hardness values, under conditions of simulated interaction of samples of train wheel and the brake shoe.

2. Experimental results

Laboratory wear testing was conducted on samples manufactured out of three charges of brake shoes, having different chemical composition and hardness values (Table 1). Charges were selected so as to represent brake shoes on the lower level P, middle and the upper boundary level of set and allowed phosphorus content.

6 samples for wear control were manufactured out of each of the brake shoe charge: three for "softer" disc, and three for the "harder" ones.

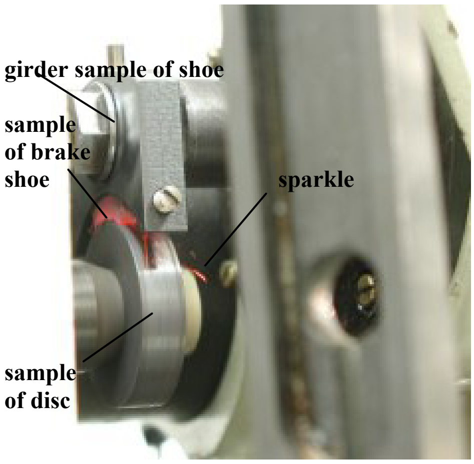
Hardness control of braking surfaces, bandages and the mono-block wheels showed differences between the new wheels (≈300 HB) and the wheels in operation for several years (≈380 HB). Therefore, for the needs of laboratory wear testing total number of 6 disc samples were manufactured. Out of that number, three discs were heat treated on hardness level of ≈300 HB ("softer disc") and three on ≈380 HB hardness level ("harder disc"). Discs have been machined by lathing (Ra_{max}=12 μm) and made out of steel which by its chemical composition corresponds to designation R9 [4], used for production of mono-block wheels for locomotives out of series 441 and 442 (the most frequent type on domestic tracks).

Table 1. Chemical composition and hardness value of train brake shoes of selected charges

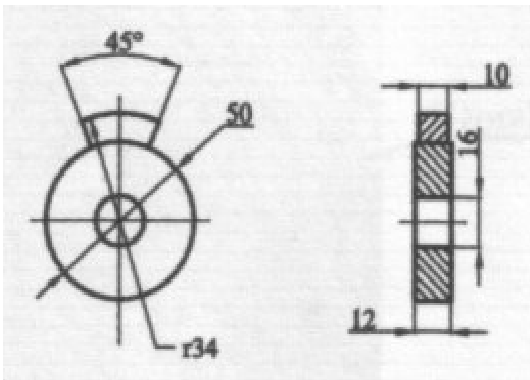
Brake shoe charge	Chemical composition, %						Hardness $HB_{10/3000/30}$
	Cg	C_{uk}	Si	Mn	P	S	
I	1,75	3,18	1,89	0,89	0,82	0,124	205
II	1,86	3,28	1,67	0,84	1,01	0,130	240
III	1,98	3,35	1,74	0,91	1,11	0,115	260

2.1 Sample wear under laboratory conditions

Size of shoes and test disc samples taken for testing on laboratory device SMT1-2070 are shown with sketch given in Fig. 1.a.



a)



b)

Figure 1. Samples and their position during testing on laboratory device SMT1-2070
a) Size of show/disc samples
b) Position of samples in device and appearance of sparkling during wear test

Recommendations [5] are to limit specific braking pressure on shoes to $p_{max} \leq 120$ N/cm^2 so as to reduce negative influence of heat input. Therefore pressure on brake shoes selected for the purpose of laboratory tests amounted to ≈220 N (which was controlled by dynamometer DOSM3-02). As friction surface of the brake shoe samples amounts to ≈2 cm^2, the calculated pressure on brake/ disc sample was ≈110 N/cm^2.

Taking into account heating which occurs during braking, temperature control by thermocouple NiCr-Ni linked on thermometer DT02 of brake shoe samples throughout test was foreseen.

Wear resistance testing of the samples was divided into cycles: 1st cycle = 7.500 disc revolutions. Disc revolution number within unit of time was maintained constant, and it amounted to 1.000 min $^{-1}$. After each cycle dimensional control (precision 10^{-1}mm) and mass loss control of the sample (weighing precision 10^{-2} g) was carried out. Total number of cycles per sample was limited by dimensional wear of the brake shoe samples, due to danger of reaching of "critical" value of wear, after which bolts fixing brake shoe position come into contact with rotating disc.

Table 2 gives presentation of average mass loss of the brake shoe samples of all three charges in contact with discs having hardness value of ≈ 300 HB (in numerator) and the discs with hardness of ≈ 380 HB (in denominator).

Table 2. Average mass loss of the brake shoe sample in contact with rotating disc

Disc revolution number	Average mass loss, g		
	Brake shoe charge		
	I	II	III
7.500	0,59/0,91	0,39/0,58	0,39/0,53
15.000	0,94/1,27	0,76/0,91	0,69/0,85
22.500	1,29/1,58	1,04/1,22	0,88/1,26
30.000	1,51/1,85	1,48/1,53	1,55/1,49
37.500	2,05/2,18	2,05/1,98	2,11/1,94
45.000	2,64/2,70	2,54/2,59	2,71/2,53

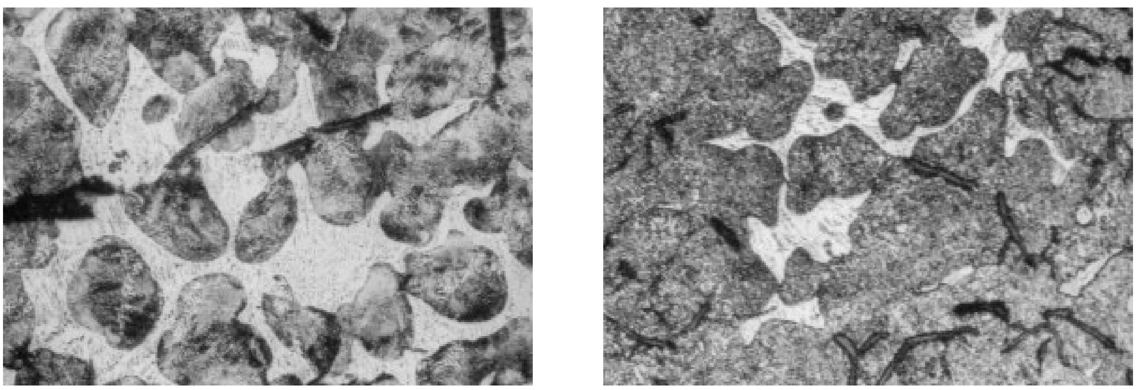
Disc mass loss control after each cycle was also carried out. Only after completion of final testing of all three brake shoe samples very slight differences were observed – manifested only on the third decimal.

2.2 Testing of the brake shoe structure

Characteristic structures of brake shoe samples were analyzed on cross sections from surface towards the core. All the charges displayed predominantly perlitic composition, with presence of less than 5% of ferrite (more expressed towards the surface). It was observed that in relation to charge I (content of 0, 82 % P), brake shoe taken from charge II (1,01 %P content), and especially charge III (1,10 %P content), presence of phoshphide eutectic nests can be observed – somewhat more expressed towards the middle. The measured hardness values of perlite with all three charges are approximately equal and ranged from 300 to ≈ 350 HV0,1, while phosphide eutectic had from ≈ 770 to 830 HV0,1. Hardness control according to Brinell ($HB_{10/3000/30}$) on three cross sections each 10 measurements established that increase of P content results in increase of dissipation of measured hardness values, so that measured ranges were:

- With brake shoes taken from charge 1 from 195 to 216 HB,
- With brake shoes from charge 2 from 207 to 253 HB,
- With brake shoes from charge 3 from 223 to 271 HB

This is probably consequence of presence of differences in distribution of eutectic, i.e. its increased presence in the form of nests in brake shoes having higher P content, Fig. 2.



a) b)

Figure 2. Characteristic microstructure of the brake shoes taken from different charges
Nital etched. Enlargement 200 x
a) Brake shoes with 1,10% P content
b) Brake shoes with 0,82% P content

3. Evaluation of experimental test results

It is characteristic to observe that with samples as well as with real brake shoes, size wear (due to effect of momentum) was larger on the surface – part of the shoe which comes first in touch – contact in disc or wheel rotation direction, and that the outgoing surfaces are less worn, Fig. 3.

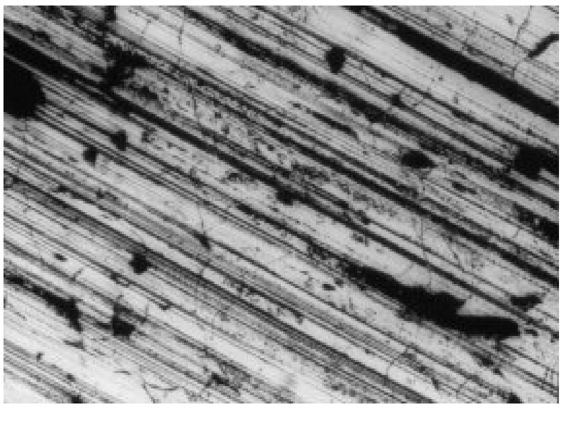
a)

b)

Figure 3. Size wears of brake shoes in wheel or disc rotation direction
a) Brake shoe worn in exploitation
b) Brake shoe sample after laboratory testing

The evaluation of friction surface wear, both with samples and the brake shoes taken from exploitation indicate presence of almost parallel grooves in direction of disc – wheel rotation. These grooves are wider on places where there was transition of brake shoe material on disc (Fig. 4.a). This confirm also traces of material wear recorded on the friction side of discs, Fig. 4.b.

a)



b)

Figure 4. Characteristics of friction surfaces after wear test. Enlargement 250 x.
a) Discs
b) Brake shoe samples

Temperature measurements of brake shoe samples used in laboratory wear testing established that temperatures in the contact zone reached values of $\approx 900^0$ C, which is confirmed also by glowing red color of the sample, visually observable after $\approx$3.500 to 4.000 disc revolutions in each cycle. The appearance of sparkling is also characteristic phenomenon – sparks with numerous exploding little stars can be observed which is distinctive for SL [6], as shown on Fig. 1.b.

Dependence of brake sample mass loss on chemical composition (P content) was analyzed through comparison of shoe structure and hardness value. Data on material wear (Table 2) shows that shoes with greater P content and larger hardness value wear slower at the beginning. Later on, after 15.000 to 20.000 disc revolutions this difference reduces and almost disappears. After the test conducted by brake shoe sample structure control, hardness HB measurement and micro hardness HV0,1 measurements perlitic and phosphoid eutectic it was established that measured values for hardness HB and phosphoid eutectic dropped when compared with values measured at the beginning of the test, while perlitic hardness remained essentially unchanged. In heat treatment laboratory tests with annealing of samples cut out of the brake shoes were conducted. Structure analyses of brake shoe samples after laboratory wear test and in those of the same charge annealed for short time period in furnace at 900^0 C did not show that heating had any influence on shape and distribution of graphite flakes, and distribution of perlit i.e. phosphoid eutectic. But, hardness measurements HB showed that "annealing" caused drop of values for $\approx 10\%$. Reason for this drop lies in the fact that hardness of phosphoid eutectic sank to value of 700 -744 HV0,1, while perlit remained approximately equally hard.

Comparison of mass loss test results shown in Table 2 generally shows somewhat more intensive wear of shoe samples under condition of contact with hard (380 HB) disc, when compared with contact with less hard disc (300 HB). This difference appears later on at the beginning of the test – at approximately ten thousand disc revolutions, while differences between single charges almost disappear. Reason for that is the influence of "annealing", which leads to reduction of differences between charges i.e. mitigate the influence of the increased P content on hardness of phosphoid eutectic. The established material wear traces having shoe friction surfaces grooved with harder structural constituents (released martensite) contained in disc material (mono-bloc wheel – bandages) which is approved in Fig. 4.a.

4. Conclusion

Testing of brake shoe samples produced from charges having different chemical composition indicate that the influence of P content is more expressly demonstrated at the beginning of the experiment – braking. This is manifested in lesser material loss with shoes having bigger P content. With the increase of braking cycle these differences decrease and almost vanish. This is consequence of heating of shoes during braking ("glow"). High temperatures (even up to $\approx 900\ ^oC$), followed by slow cooling (till the next "braking cycle") results in decrease of general shoe hardness (HB), mainly as consequence of reduced hardness of phosphoid eutectic, from ≈ 800 to ≈ 700 HV0,1. More intensive wear of shoe samples in contact with rotating disc of higher hardness (≈ 380 HB) can be observed. This is consequence of more intensive "grooving" by micro cutting due to presence of martensite having somewhat higher micro hardness then discs normalized at higher temperature (hardness ≈ 300 HB).

Analysis of shoes made from different charges showed that shoes with 1,01 %P content, on average showed greater hardness values for 20%, and those with 1,10 %P even 30% then those containing 0,82 %P. With increase of P content there is a phenomenon of increase of micro hardness of phosphoid eutectic, but also its more significant dissolution in the form of nests. "Annealing" tests in laboratory showed that heating to high temperature and slow cooling leads to decrease of general shoe hardness, but also to reduction of micro hardness (HV0,1) of phosphoid eutectic. Taking into account that from general tribological standpoint main wear resistance components should be as evenly distributed as possible, and the fact that brake shoes having higher hardness value show greater wear resistance only at the beginning, it can be concluded that preference should be given to those shoes having phosphoid eutectic more evenly distributed in perlitic matrix with presence of smaller graphite flakes. More suitable properties of such brake shoes are shown in more even wear in single braking cycles.

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SOME ASPECTS ON THE USE OF IDEAL CUTTING DATA

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Abstract

The paper investigates the possibility of using ideal cutting data in optimizing the cutting process. Mathematical formulae for determining tool straight line, tool machine straight line and ideal cutting data were derived. In one example of cutting for different tool lives, tool straight line and machine tool straight line as well as ideal cutting data to be optimized, were determined. The obtained results and conclusions with recommendations for practice were analyzed.

Keywords: ideal cutting data, tool straight line, tool machine straight line

1. Introduction

With modern machining conditions on expensive machine tools and systems the aim is to choose such cutting data which will give the best effects. At fine machining the required criterion is quality of the machined surface, while at semifinishing and roughing it is the productivity and cost efficiency. The relevant cutting data will be the one which is the most suitable for concrete machining conditions.

The cutting tool has a resource of tool life, while machine tool has the installed power of electric motor which it gives to the main spindle as machine tool gross power (P_{bs}). The aim is to maximally use these resources, i.e. to perform the machining with higher power in order to achieve better machining productivity and higher utilization grade of electric engine.

In determining of relevant cutting data there are two limiting cases [3]: (a) cutting data at full use of tool life, and (b) cutting data at full use of machine tool power. In case of simultaneous full use of tool life and full use of machine tool power, the ideal cutting data will be achieved (ideal cutting speed v_{ci} and ideal feed f_i) which can be additionally optimised.

2. Determining the ideal cutting data

First the cutting speed as a function of chip cross area $v_c = \varphi(A)$ at T = const is determined, and so the tool straight line is achieved. Then the same function is determined at P_{bs} = const and so the machine tool straight line is achieved. The simultaneous use of full tool life and full machine tool power, i.e. ideal cutting data, determines the intersection of these straight lines.

2.1 Determining the tool straight line

The expanded Taylor's equation for cutting speed which additionaly includes the feed f (mm/r.p.m.) and depth of cut a_p (mm), can be expressed as [4]:

$$v_C = C\, f^{E} a_P^{F}\, T^{G} \quad \text{(m/min)} \tag{1}$$

By using chip slenderness ratio $g = a_p/f$ and chip cross area $A = a_p f$ there follows:

$$A = g \cdot f^2 ;\quad a_p = \sqrt{gA} ;\quad f = \sqrt{\frac{A}{g}} \tag{2}$$

By elimination of the feed f and depth of cut a_p from (1) the formula for tool straight line is:

$$v_c = C_1 A^{\frac{E+F}{2}} \tag{3}$$

where constant C_1 is: $C_1 = C\, g^{\frac{F-E}{2}}\, T^G$

By taking the logarithm of (3) yields:

$$\log v_c = \frac{E+F}{2} \cdot \log A + \log C_1 \tag{4}$$

Equation (4) in a log v_c – log A diagram represents the tool life efficiency straight line reffered to as tool straight line, because the tool life is a constant.

2.2 Determining the machine tool straight line

The formula for machine tool net power (cutting power in the cutting zone) is well known:

$$P_c = \frac{F_c v_c}{60} \quad \Rightarrow \quad P_c = \frac{A k_c v_c}{60} \ \text{(W)} \tag{5}$$

where: $F_c = Ak_c = a_p f k_c$ (N) - main cutting force; $k_c = k_{c1.1} h^{m_c}$ (N/mm^2) – specific cutting force; where: $k_{c1.1}$ - specific cutting force (N/mm^2) and m_c - exponent which depends on cutting conditions; $h = f \sin\kappa_r$ chip thickness (mm) and κ_r - tool setting angle (entering angle) (°).

Machine tool gross power (which main spindle receives from the electric motor) is:

$$P_{bs} = \frac{P_c}{\eta_s} \quad \Rightarrow \quad P_{bs} = \frac{A k_c v_c}{60 \eta_s} \quad \Rightarrow \quad P_{bs} = \frac{A k_{c1.1} h^{m_c} v_c}{60 \eta_s} \ \text{(W)} \tag{6}$$

where: η_s - machine tool utilisation coefficient ($\eta_s \cong 0{,}7$ do 0,9).

By elimination of the values k_c and h from formula (6) the formula for tool straight line is:

$$v_c = C_2\, A^{\frac{m_c}{2} - 1} \tag{7}$$

where constante C_2 is: $C_2 = \dfrac{60\, P_{bs}\, \eta_s\, (\sin \kappa_r)^{m_c}}{g^{\frac{m_c}{2}}\, k_{c1.1}}$

By taking the logarithm of formula (7) the following is achieved:

$$\log v_c = \left(\frac{m_c}{2} - 1\right) \cdot \log A + \log C_2 \tag{8}$$

Formula (8) in the log v_c – log A diagram represents the straight line for machine tool full power use reffered to as machine tool straight line, because the machine tool power is a constant.

2.3 Tool straight line and optimal cutting data

When economical tool life T_e is inserted in formula (3) i.e. in formula for constant C_1, the economical tool straight line is achieved. In this case the full economical tool life is used, and machining costs are minimal. The formula is:

$$v_{ce} = C_1 A^{\frac{E+F}{2}}, \text{ where the constant } C_1 \text{ is: } C_1 = C\, g^{\frac{F-E}{2}}\, T_e^G \tag{9}$$

By analogy to previous analysis, when T_{pmax} (tool life under conditions of maximal productivity) is inserted, the above formula turns to formula for tool straight line at maximal productivity.

Economical tool life T_e and tool life T_{pmax} are computed by known formulae [5]:

$$T_e = \frac{1-m}{m} \cdot \left(t_{iz} + \frac{K_{WT}}{K_{ML}} \right) \text{ (min);} \qquad T_{pmax} = \frac{1-m}{m} \cdot t_{iz} \text{ (min)} \tag{10}$$

where: m - tool life exponent, K_{WT} – tool costs for one tool life (or one cutting edge), K_{ML} – workplace costs, t_{iz} – tool changing time. The machining costs are computed also by known formulae [5]:

$$K_O = K_{PM} + K_A \qquad \Rightarrow \qquad K_O = K_{ML} t_k + K_{WT} \cdot \frac{t_t}{T} \text{ ((€/piece)} \tag{11}$$

Tool costs for one tool life for tools with changeable cutting inserts - which do not require sharpening are (the meaning of each particular value in formulae (10) and (11) is given in heading 3.):

$$K_{WT} = \frac{K_{WP} n_P}{n_{TP}} (1 + \frac{z_b}{2}) + \frac{K_{WH}}{n_{TH}} + \frac{K_{WE}}{n_{TE}} + K_{WV1} + K_{WV2} \text{ (€/tool life)} \tag{12}$$

2.4 Graphical display of tool and machine tool straight lines in log-log diagram

Figure 1 shows tool straight line PA, machine tool straight line PS and economical tool straight
line PA_e.

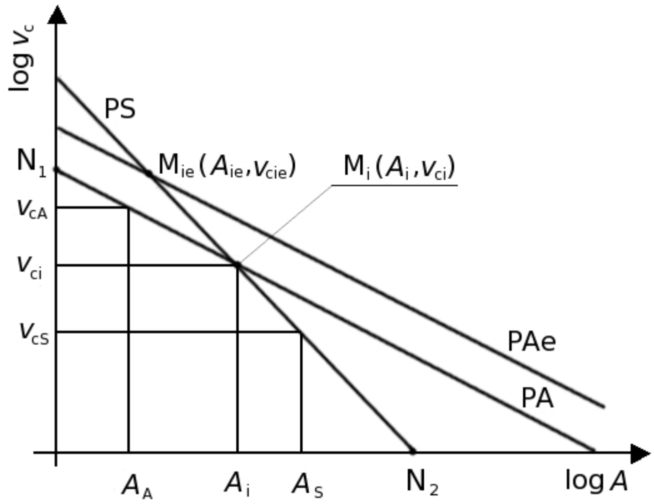

Figure 1. Tool straight line and machine tool straight line

Point M_i (intersection of straight lines PA and PS) represents simultaneous use of full tool life and full machine tool power. The values v_{ci} and A_i (i.e. feed f_i) are the ideal cutting data. On the left from point A_i (abscissa) the tool straight line PA is competent (the ordinates v_c are smaller), because determining of cutting speed by straight line PS would imply exceeding of tool life. In the same way, on the right from point A_i the machine tool straight line is relevant.

The diagram area between line $N_1 - M_i - N_2$ and abscissa represents allowed cutting data which should not be exceeded. By equating of the right sides of the formulae (3) i (7) the ideal chip cross area A_i is obtained:

$$A_i = \left(\frac{C_2}{C_1} \right)^{\frac{1}{z}} \qquad \text{where:} \qquad z = \frac{E+F}{2} - \frac{m_c}{2} + 1 \tag{13}$$

Based on the formula (2) the ideal feed is: $f_i = \sqrt{\frac{A_i}{g}}$ (mm/r.p.m.) (14)

By inserting of formula (13) for A_i in formula (3) or (7) the ideal cutting speed is given:

$$v_{ci} = C_1 \left(\frac{C_2}{C_1} \right)^{\frac{E+F}{2z}} \tag{15}$$

The relevant cutting speed v_c beetween v_{cA} (based on the use of full tool life) or v_{cS} (based on the use of full machine tool power) is the one which has lower value: $v_c = \min(v_{cA}, v_{cS})$, i.e. it is not necessary to determine v_c by comparison with the ideal cutting speed v_{ci}.

Intersection point $M_{ie}(A_{ie}, v_{cei})$ between economical tool straight line PAe and machine tool straight line PS is the ideal economical point which deternines the full use of economical tool life (T_e = const), the full use of machine tool power (P = const) and minimal machining costs (K_{Omin}). The values of A_{ie} and v_{cei} are computed by using the formulae (11) to (13), with previous calculation of constant C_1 as a function of economical tool life Te.

3. Practical example and results

At semifinishing turning of shaft ∅100x200 it is necessery to determine tool straight line, machine tool straight line, ideal cutting data and ideal optimal cutting data.

Known and accepted data: Workpiece material: Steel Č 4732 (DIN 42CrMo4), R_m = 950 N/mm^2, 280 HB, $k_{c1.1}$= 2500 N/mm^2, m_c = 0,26. Cutting tool: Turning holder PSBNR 2525-M12 purchase price K_{HP} = 65 €, cutting insert SNMG120408-PM (GC4025) purchase price K_{WP} = 8 €, setting angle κ_r = 75°. Number of the edges which operate simultaneously n_P = 1, number of available cutting edges on an insert n_{TP} = 8, break factor for cutting insert z_b = 0,2, holder resource n_{TH} = 250 tool lives, service parts resource n_{TE} = 200 tool lives, service parts purchase price K_{WE} = 0,25·K_{WH} = 0,25· 65 = 16,25 €.

Machine tool: Turning lathe, workplace price per hour K_{ML} = 50 €/h, tool changing time t_{iz} = 1,5 min, auxiliary time t_p = 1 min, additional time coefficient k_d = 0,2, machine tool gross power P_{bs} = 12 kW, machine tool gear utilization factor η_s = 0,8. Tool set costs: K_{WV1} = K_{WV2} = 0.

Solution: Under given cutting conditions for semifinishing, first the depth of cut (a_p = 1 to 6 mm) and feed (f = 0,2 to 0,6 mm) are selected [2]. Chip slenderness ratio g = 8 is accepted. By using the formulae (1) to (15) and the known formulae for calculating cutting time, the basic values are determined (table 1). After this, based on the selected tool life (five values), the tool and tool machine straight lines are determined, as well as the ideal cutting data, optimal ideal cutting data and machining costs (figure 2).

Table 1. Basic values

Data	Values, data	Note
Taylor's equation	C = 392; E = - 0,27; F = - 0,11; G = - 0,22	Accepted [5]
Feed	f_1= 0,2; f_2 = 0,6 (mm/rpm)	Accepted [2]
Chip cross area	A_1= 0,32; A_2 = 2,88 (mm^2)	Calculated (2)
Tool costs for one tool life (edge)	K_{WT} = 1,44 (€/ tool life)	Calculated (12)
Economical tool life	T_e = 11,5 (min)	Calculated (10)
Tool life at max. productivity	T_{pmax} = 5,3 (min)	Calculated (11)

Table 2. Calculation results

Values	Tool straight lines					Mach. tool str. line
	Tool life T (min)					
	5,3	11,5	15	30	60	
Constants C_1 and C_2	321	270,5	255,2	219,1	188,1	$C_2 = 174$
Cutting speed v_{c1} (m/min)	399	336	317	272	234	469
Cutting speed v_{c2} (m/min)	263	221	209	179	154	69
Ideal chip cross area A_i (mm^2)	0,406	0,523	0,570	0,713	0,892	-
Ideal feed f_i (mm/okr)	0,225	0,255	0,266	0,298	0,330	-
Ideal cutting speed v_{ci} (m/min)	381	306	284	234	192	-
Cutting time t_t (min)	0,743	0,818	0,844	0,915	1,007	-
Piece time t_k (min)	2,090	2,181	2,213	2,298	2,408	-
Work place costs K_{PM} (€/piece)	1,735	1,810	1,837	1,907	1,998	-
Cuting tool costs K_A (€/piece)	0,202	0,102	0,081	0,044	0,024	-
Machining costs K_O (€/kom)	1,937	1,912	1,920	1,951	2,022	-

Figure 2 shows the straight lines: tool straight line PAp (at max. productivity), PAe (at min. mach. costs), then PA_{15}, PA_{30}, PA_{60} at tool lives of 15, 30 and 60 min and PS machine tool straight line.

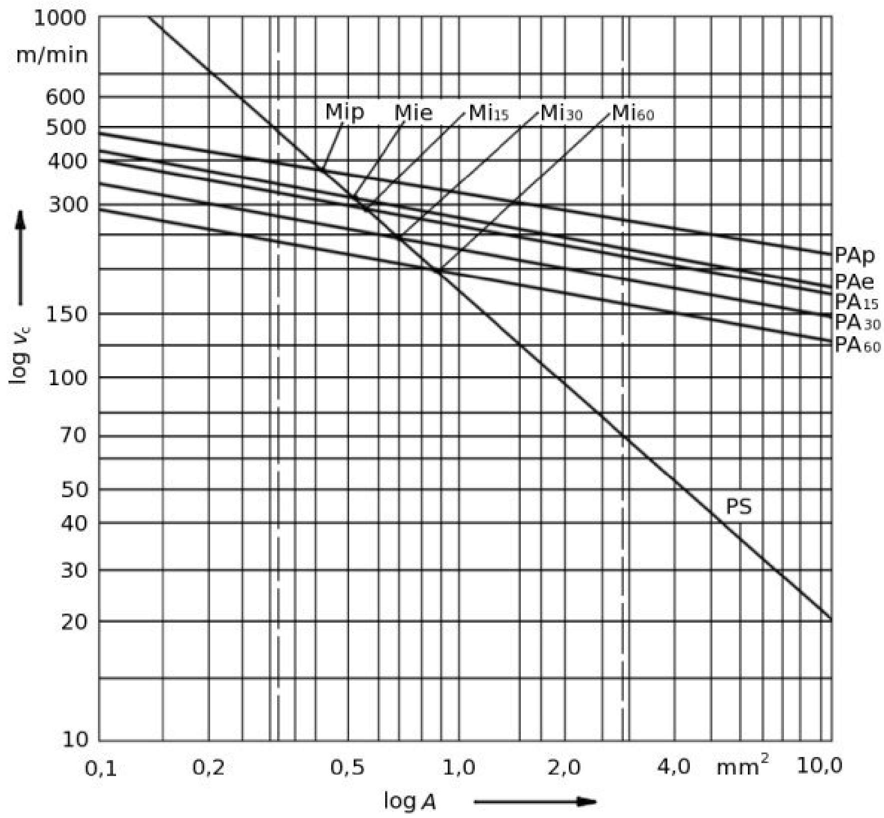

Figure 2. The given tool straight lines and tool machine straight line

The machine tool straight line PS is valid for one machine tool with concrete cutting case. Point M_{ie} (0,523; 306) defines appropriate ideal economical cutting data (at T_e = 11,5 min = const), namely: ideal feed f_i = 0,255 mm/r.p.m. and ideal cutting speed v_{ci} = 306 m/min. Here the tool life and machine tool power are fully used, and also the machining costs are minimal with amount K_O = 1,912 €/piece. Cutting data at maximal productivity is determined by point M_{ip} (0,406; 381) on diagram (at T_{pmax} = 5,3 min = const), where the ideal feed is f_i = 0,255 mm/r.p.m. and ideal cutting speed v_{ci} = 381 m/min. At this point the maximal productivity i.e. minimal piece time t_k = 2,09 min is achieved.

Other tool straight lines PA_{15}, PA_{30} and PA_{60} refer to tool lives T of 15, 30 and 60 min. Intersection points M_{i15}, M_{i30} i M_{i60} represent ideal cutting data at given values of tool life.

By analysing the positions of straight lines on diagram and numerical values of the given results, it is evident that the tool straight lines are very near to each other, although the tool life was varied in wide range from T = 5,3 to 60 min. The range of the given ideal cutting data is smaller and goes from v_{ci} = 381 to 192 m/min, f_i = 0,225 to 0,33 mm/r.p.m.. The machining costs range is K_O = 1,937 to 2,022 €/piece.

By machining on NC machine tool the tool life amount is from T = 15 to 30 min, and in this case the appropriate ideal cutting speed was in range from v_{ci} = 284 do 234 m/min, ideal feed f_i = 0,266 to 0,298 mm/r.p.m. and machining costs K_O = 1,920 to 1,951 €/piece. Consequently, while the tool life is increased by 100 %, the ideal cutting speed is 21 % lower, ideal feed is 12 % higher and the machining costs is 4,3 % higher. There are similar relations at machining on the classic machine tools, where the tool life is about T = 30 to 60 min. Consequently, changes of the cutting speed, feed and machining costs are considerably lower than the changes of the tool life. It is significant in practice.

Economical tool straight line PAe (at T_e = 11,5 min) and tool straight line PA_{15} (at T = 15 min) are very near to each other. This is to say that the tool life of 15 min (which is recommended by cutting tool producers) is within the field of economical tool life.

The tool straight lines with higher tool life values are located lower in the diagram (this is suitable for machining on the classical machine tools), but the tool straight lines with lower tool life values are located higher in the diagram (this is suitable for machining on the more expensive NC machine tools and systems.

4. Conclusions

On the basis of the achieved results, it is possible to conclude the following:

(a) In determining the range of relevant cutting data for appropriate case of the productive machining (especially when the machining is performed on expensive machining systems), it is possible by using of tool straight line and machine tool straight line to determine border values i.e. ideal cutting data which result in the best effects of the machining process.

(b) When deciding on cutting data, it is necessary (if possible), to accept the values, which are close to ideal, in order to reduce machining costs i.e., increase machining productivity.

(c) Modern cutting tools will operate in economical range if tool life of T = 15 do 20 (30) min is accepted, which is also recommended by cutting tool producers.

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NUMERICAL ANALYSIS OF STRESSES IN ADHEREND OF SINGLE - LAP ADHESIVE JOINTS

P. Raos, F. Matejiček and M. Lucić

Abstract

This paper deals with modelling of single lap adhesive bonded joints, at which true physical characteristics of adhesive have been considered and lap length has been changed. The experimental specimens have been made of two types of adherend material: stainless steel X5CrNi18-10 and aluminium Al99.5. Dimensions of prepared adherend plates are $a \times b \times s$ = 30 $\times$ 90 $\times$ 1,95 mm. All bonded joints have been realized using an engineering two-component epoxy adhesive. Such prepared joints have been stretched up to the break in the jaws of the tensile testing machine.

The true diagram of stresses of adherend (metals) has been considered and comparison of data (applied force vs. end displacement) obtained with numerical analysis and experimental investigation. The results of both of them are in a good correlation.
This investigation is a part of continuously testing of adhesive bonded joints.

Keywords: adhesive bonding, single-lap joints, finite element method, numerical analysis

1. Introduction

Adhesive bonded joints have wider and wider application in home and world industry. Adhesive joints are the most using for bonding of automotive and airplane parts, but also in everyday life (industry of shoes, bookbinder, household…).

Therefore, the investigations of influence of different factors on adhesive joint strength are incontrovertible. Beside of all influencing factors on adhesive joint strength (properties of adhesive, properties of adherend material, bonding procedures, joint design and loading conditions), of special importance is predicting the stresses which an adhesive joint should hold out, with purpose to satisfied their implementation requests.

Thereby, the minimal amount of adhesive should be defined, which will in joint with mechanical properties of adherend product the maximal values of joint strength. Thereby, the geometry of joint (lap length, width, adhesive thickness) is optimal.

As already referred in authors previous papers, it was experimentally researched the influence of lap length on strength of a single lap joint considering the joints made of three types of adherend (aluminium, stainless steel and brass) [1,2]. It was also investigated the influence of adhesive thickness on joint strength [3].

This paper goes one step beyond dealing with a numerical simulation of those joints and special attention on investigating of stresses in adherend.

2. FEA modelling

Geometry of joints used for modelling is the same as already has been discussed in [1,2,3] with lap length of 30 mm (l/a = 1). Thickness of adhesives in numerical model was 0,15 mm. Numerical simulation of static load was carried out using the ANSYS software [4].

The geometry and the FE mesh of total joint and a part of joint are shown in Figure 1. The structure is modelled with 845 two-dimensional 8-node isoparametric finite elements (Ansys PLANE82). Whereas the simulation of only one type of testing requires complicated pre-processing; therefore the simulation is based only with one lap length. Geometry of joints is the same as in experiment [1,2] without a part of joint between the clamps of the machine; total length of the joint was 78 mm.

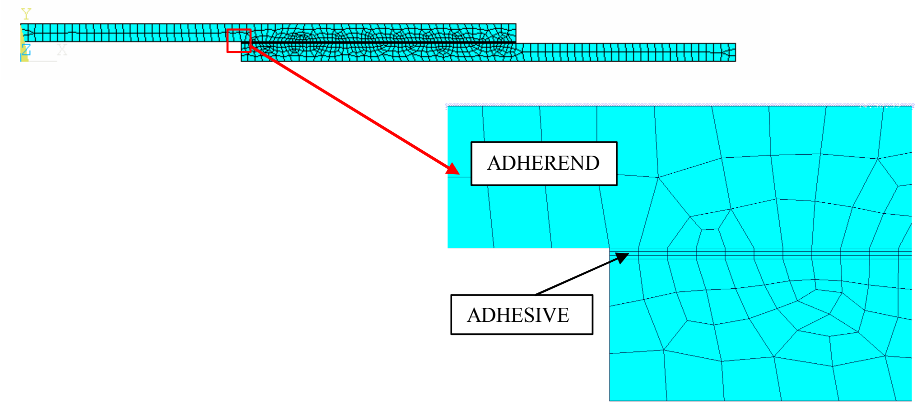

Figure 1. FE model of a single-lap bonded specimen (no crack)

Characteristics of the materials (table 1) of adherend and adhesive are given in input file. Thereby a data of adherend (stress-strain diagram) are taken from tensile test (Fig. 2), and data of adhesives (figure 3) are used with back way method described in [5]. During the analysis the structure is unidirectional stretched from the initial displacement 0,005 mm up to 0,3 mm in 50 increments. Two simulations performed assuming the multiple linear elastic material models for both the adherend and the adhesive by using the experimentally calculated parameters [1, 2], firstly with no crack initiation and secondly involving an initial crack.

Table 1. Mechanical properties of the materials used for simulation

Input data		
ADHESIVE	ADHERENDS	
	Al99.5	X5CrNi18-10
E=4 000 N/mm^2 ν = 0,35 σ_m≅17 N/mm^2	E= 70 000 N/mm^2 ν = 0,3 $R_{p0,2}$=100 N/mm^2 σ_m≅120 N/mm^2	E=200000N/mm^2 ν = 0,3 $R_{p0,2}$=190 N/mm^2 σ_m≅430 N/mm^2

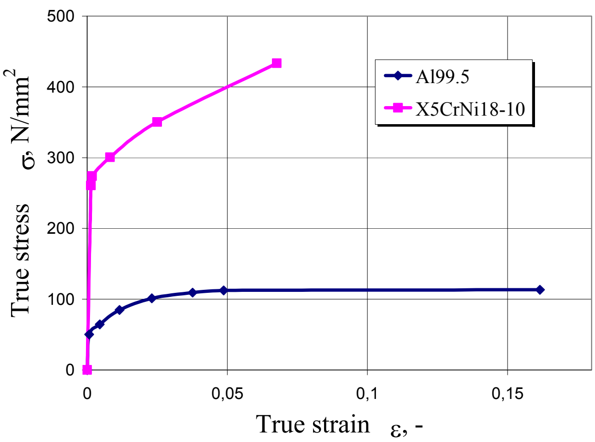

Figure 2. True stress-strain diagram for adherends

Involving an initial crack in the adhesive layer, spreading from lap ends to the inside in the FEA calculation in the next step it was achieved very good correlation with experimental data [1,2].

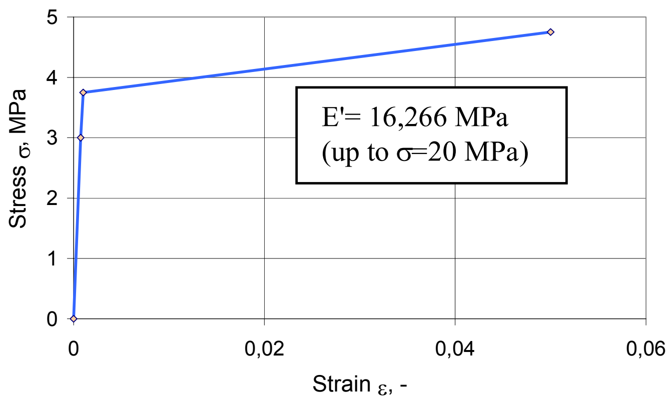

Figure 3. Stress-strain diagram for adhesive

This phenomena caused by attempting the applied tensile force to be linear through the joint specimen, which leads to bending at the lap ends, has been experimentally recorded (Fig. 4) [1,2].

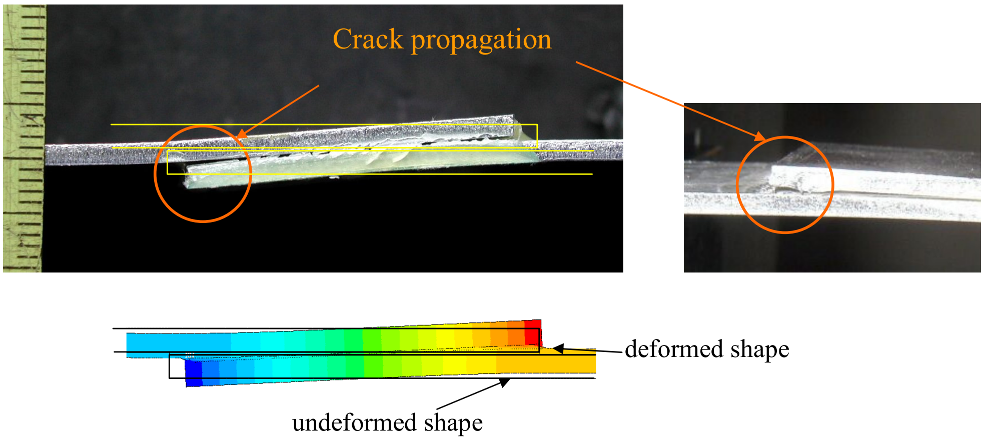

Figure 4. Deformed structure of the joint (left: above - experiment, under - FEA after loading); (right: during the testing)

3. Results and discussion

The results of testing of two adherend materials are given on figure 5 with 30 mm lap length.

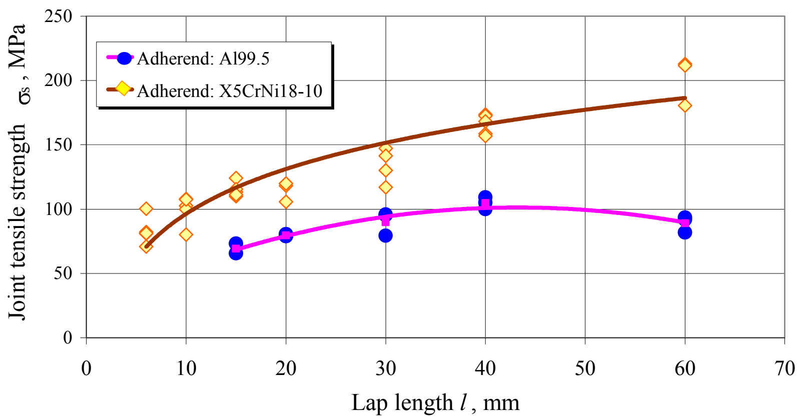

Figure 5. Joint tensile strength vs. lap length

All results have been compared with experimental ones done in [1,2,3]. Analysis of results of testing gives a following note: adhesive joint strength depends strongly of adherend materials. Maximum tensile force (F_{max}) increases continuously by increasing bonding area i.e. lap length. However, increase of the maximum tensile force is possible only up to the point of reaching yield point of adherend. At this point equilibrium between stress in adherends and strength of the adhesive layer is achieved. Beyond this point an excessive deformation of the adherends is occurred that cannot be compensated by relatively rigid layer of adhesive. This leads to crack failure inside the adhesive layer, spreading from lap ends to the inside. Therefore, maximum tensile force F_{max} decreases. Experimental observations confirm such theoretical model of the crack propagation at the lap ends (Fig. 4). Also, it is noted that experimentally recorded tensile strengths of the joints at optimum lap lengths match with values of yield stresses of the adherends ($R_{p0,2}$), which also confirm theoretical considerations presented in authors earlier papers.

The following figure shows the results obtained with numerical and with experimental testing.

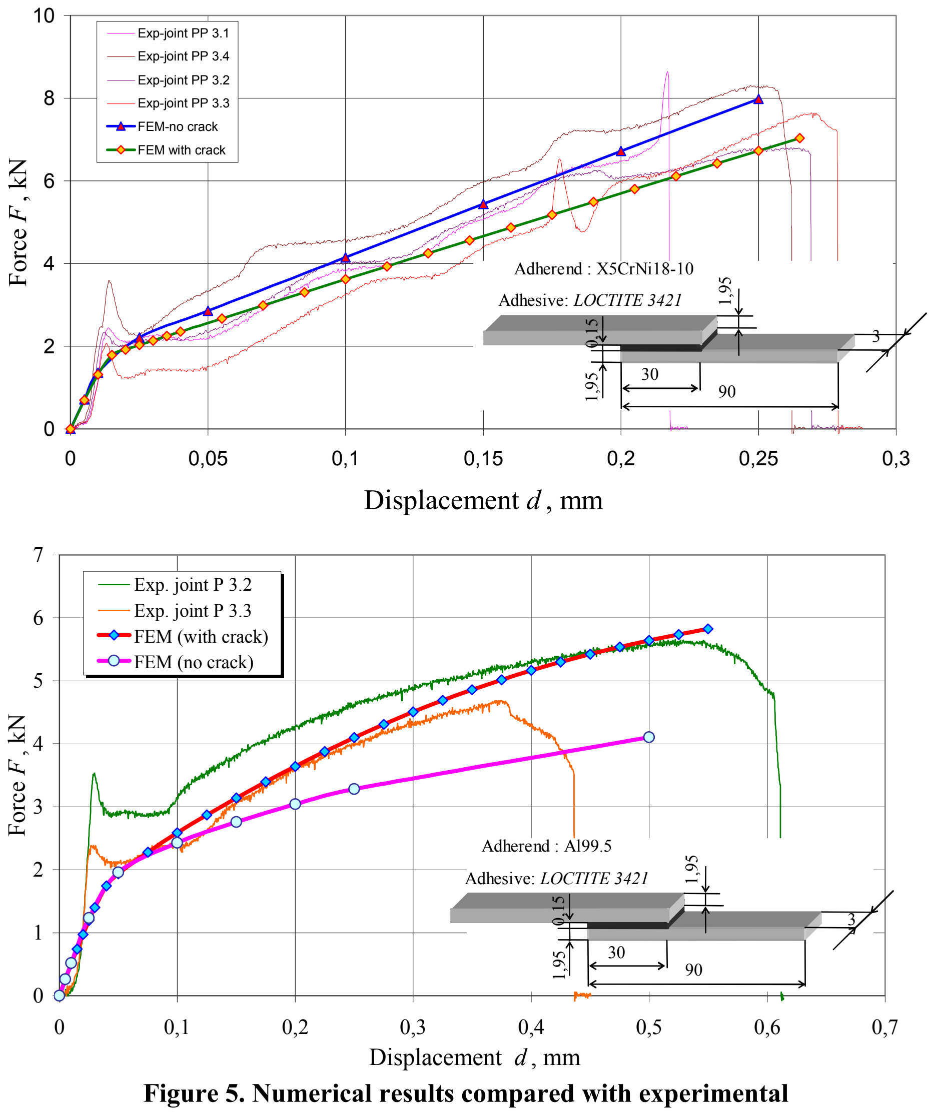

Figure 5. Numerical results compared with experimental

Results and conclusions obtained in experimental part of the paper can also be applied for numerical research. Like were said before, mechanical (deformational) characteristics of adherends having an important influence on load-bearing properties of bonded joint. The less deformable adherend affect the higher joint strength. Figure 6 shows the same geometry of both of adherends in joint, and their behaviour under load (von Misses equivalent stress). Red colour is used to show the yielding zone of adherends. It is obviously to note that soft material like aluminium is considerably more deformed than stainless steel and transform into the plastic zone.

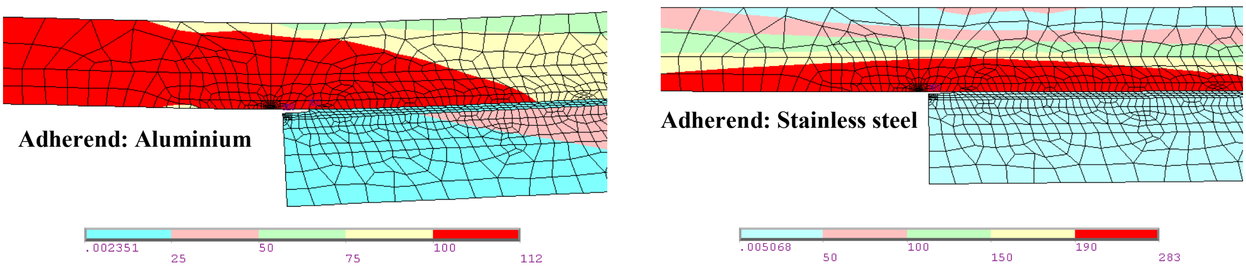

Figure 6. Yielding zone of both of adherends (stresses are in N/mm^2)

Increasing of tensile force more over the force which cause reaching of yield point of adherend, the material local suffer higher and higher stresses, and a parts of adherends which are not in joint are plastic deformed which is caused by bending. Obviously, it is not necessary to design such joint in with the lapping area, which cause such high stresses. The following figure shows the stresses (von Misses) in both of adherend, and the shear stresses inside of adhesive. The stresses are plotted along the path in adherends for y = 2, 1 mm for upper adherend, and y = 1,95 for under adherend. Stresses in adhesive are plotted along the path in the middle of adhesive layer.

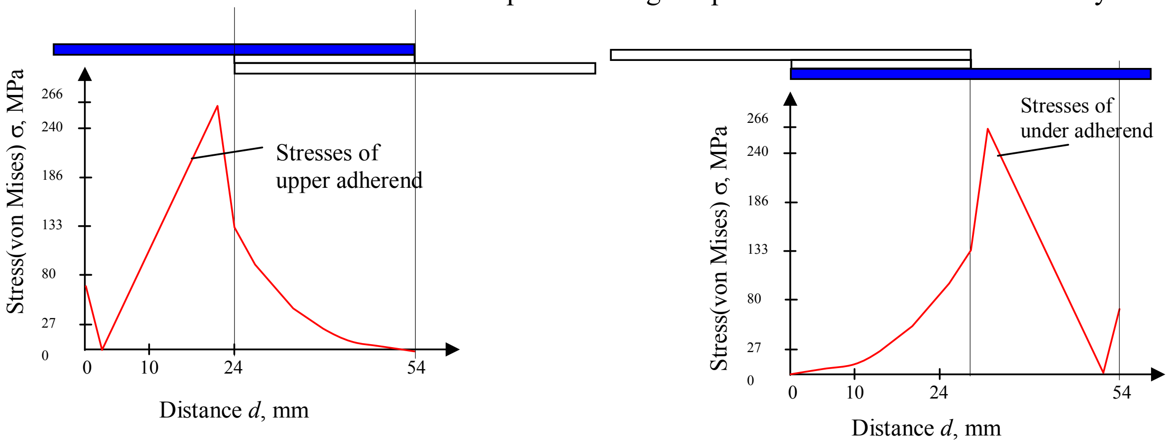

Figure 7. Stresses in adherends (obtained by FEM) – stainless steel

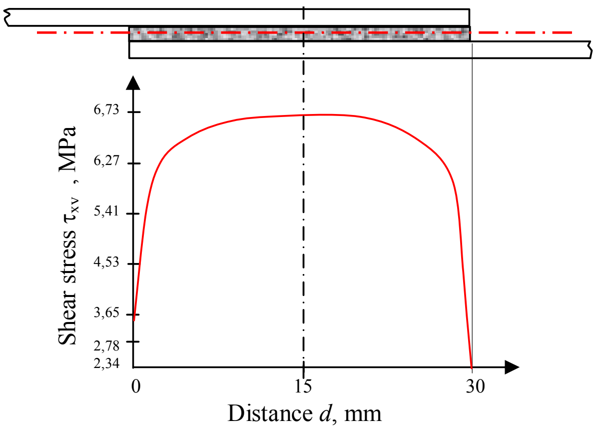

Figure 8. Shear stresses in adhesive

According to figure 7, stresses are growing more over the yield stresses in the part of adherend, which are not in joint, and those parts are in plastic zone. Crossing into the lapping zone, stresses are obviously under because of its loading function. Shear stresses in adhesive grow up to the ~ 7 MPa. It is in correlation with the shear strength defined for adhesive used and is equal 9-12 MPa.

4. Conclusion

In experimental part it was researched the influence of lapping area on stresses in adherend. Large lapping areas cause increasing of load bearing capacity. But also and increasing the stresses in materials which participate in joint, which could cause plastic deformation of parts. Thereby, the influence of the adherend deformational characteristics on joint strength is very significant, what was also confirmed in numerical investigation.

In the numerical part of the paper, the aim was to create appropriate model of adhesive joint. This is realised with good results. Two FE model are presented: with crack on lap ends, and with no crack. The models were used for both of aluminium and stainless steel as adherend. In joints with stainless steel as adherend, results of experimental and numerical investigation are in good correlation. In joints with aluminium as adherend, there are some differences in experimental and numerical results. Special attention was on investigating the stresses in adherends and adhesive layer. Investigation of bonded joints will continue for obtaining the answers on following questions: when crack occurs, and which is its length? Is it growing up continuously after existing, or is it continuous for some specific time under loading?

Finally, by designing an adhesive bonded joint, all of those investigated factors should be considered. This is the way to avoid undesirable stress concentration, and also too high stresses, and with minimal amount of adhesive obtain the joint with optimal mechanical properties.

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POLYMER COMPOSITE PROPERTIES MODIFICATION BY PARTICLES ADDING

Đ. Španiček and J. Indof

Abstract

The increasing use of polymer composites continues to fuel demand for more specific properties of materials. Therefore, influence of added mineral, micro-cellular particles on polymer composite properties were investigated. For this purpose the glass-reinforced polyester based composite with two different amounts of added particles were tested. Those added particles are inert, super lightweight, ecologically friendly, natural occurring substances of volcanic origin.

By adding the third component into the usual polyester based composite, structural changes as well as properties changes occur. Mechanical properties (flexural strength, flexural modulus, interlaminar shear strength) related to density of tested composites, were tested.

Keywords: polymer composite, mineral particles, mechanical properties

1. Introduction

It is already well known that polymer composites reinforced with continuous fibers possess some very attractive physical and mechanical properties, such as high modulus and strength per unit weight, relative to traditional materials. This is reflected in the increase of their use in areas where light, strong structures are required such as automobile and small crafts production. But, there is an eternal need for better materials or products. In order to improve some properties per unit weight, new polymer composite composition by adding mineral particles, was designed and investigated.

2. Experimental

2.1 Materials

Polymer composites were prepared with polyester thermoset matrix reinforced with nominal 45,5 % by weight of commercial E-glass fibers. For each composite the same matrix formulations based on orthpftalic acid polyester cured under identical conditions (curing time 24 hours at ambient temperature, conditioning time 2 hours at 80^0 C), were used. For properties modification different amount of mineral particles with different average size were added to basic composite (denoted as composite 1). Table 1 shows composite denotations, glass-fibers content and mineral particles content. By adding mineral particles, glass content seemed to be higher due to lower mass of composites.

Table 1. Data on tested composites

Composite	Particles content %	Glass content %	Density, ρ g cm^{-3}
Basic composite 1	0	45,5	1,5179
Composite A1	5% 300H	46,87	1,3810
Composite A2	10 % 300H	47,10	1,1522
Composite B	8 % 150 H	44,7	1,1361

* Denotation 150 and 300: average particle size range µm

Added mineral particles are inert, natural occurring substances of volcanic origin, and ecologically acceptable. The average data concerning chemical composition and some technical value for micro-cellular spherical particles added to basic composite are given in table 2 [1].

Table 2. Data on added H particles

Chemical analysis:	
SiO_2	73 %
Al_2O_3	17 %
CaO	1 %
K_2O	5 %
Na_2O	3 %
Other elements	Traces
Moisture	< 0,4%
pH value	7,0
Melting point ^{0} C	1260

Denotation H is for standard-type particles suitable for polyester resin, but very hydrophobic due to their coating. Hydrophobic properties of particles are desirable because of potential use of those composites in wet atmosphere (small craft building). Furthermore, suitable coating, i.e. initial impregnation increases the adhesion of inorganic particles to organic matrix by influencing the wetting by the resin system, but does not essentially decrease the mechanical adhesion due to surface roughness.

Both types of added particles can be used up to about 300^o C.

2.2 Results

To characterize the obtained polymer composites following mechanical properties were tested:

- flexural strength and flexural modulus (EN ISO 178:2003)
- interlaminar shear strength (BS 2 782)

Because of their heterogeneity due to chemical diversity of components, interfacial region between matrix, fibers and mineral particles plays important role in defining the composite properties [2]. Therefore, interlaminar shear strength is one of the most important properties for composite materials.

A minimum of five specimens for each property was tested. Average values are given in table 3.

Table 3. Mechanical properties of tested composites

Composite	**Flexural strength R_{ms} N mm^{-2}**	**Flexural modulus E_s N mm $^{-2}$**	**Interlaminar shear strength τ N mm^{-2}**
1	263	7362	18,6
A1	186	5061	15,7
A2	193	4244	13,8
B	166	4540	15,7

The obtained results show that added particles lead to decreasing of tested mechanical properties. But, regarding their specific values, i.e. per unit weight, the differences became smaller (table 4).

Table 4. Specific values of tested mechanical properties

Composite	Specific flexural strength R_{ms}/ρ N mm^{-2} g^{-1} cm^3	Specific flexural modulus E/ρ N mm^{-2} g^{-1} cm$^3{}_s$	Specific interlaminar shear strength τ/ρ N mm^{-2} g^{-1} cm^3
1	4850	173	12,3
A 1	3665	134	11,4
A 2	3385	132	11,0
B	3940	167	13,6

The composite B due to added particles has a smaller mass then the basic composite 1 with lower specific strength, but higher specific interlaminar shear strength (figure 1).

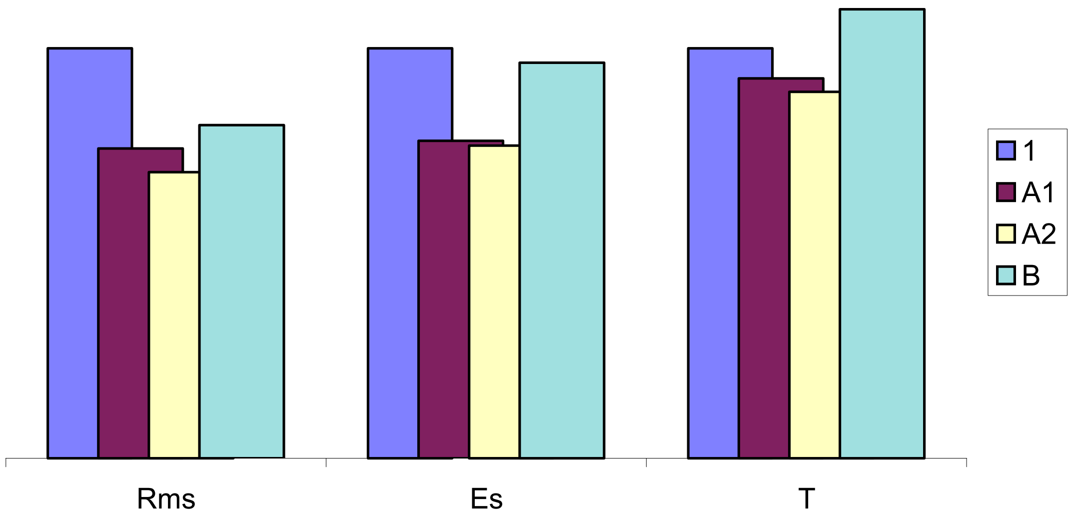

Figure 1. Changes of relative properties of tested composites

The results obtained for specific values suggest the application possibilities of modifying composite B in small crafts building. For better prediction of the composite B behavior in use, the void content has to be determined. The composites, even advanced one, have voids as processing consequence that can be reduced only to minimum. Interlaminar shear strength depends strongly on void content [4]. By comparing the obtained results for the tested composites no significant differences were determined [3]. This can be explained by the fact that mineral particles have good physical adhesion due to free energy of system, and, consequently, proper wetting by polymer matrix, especially in the composite B because of a smaller average size of added particle

3. Conclusions

In order to produce lighter material, suitable for small craft production, some new formulation of polymer composites by adding mineral particles, were prepared and investigated. It has been shown that density, but also mechanical properties of tested materials, decrease comparing the basic composite. However, specific values i.e. per unit weight, for strength and modulus decrease for all modified composite but interlaminar shear strength for composite B increases. This fact suggests the application possibilities of modifying composite B in small craft building.

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THE ANALYSIS OF CORROSION DAMAGE IN A 45MW STEAM TURBINE

B. Staniša and L. Pomenić

Abstract

This paper describes a problem of severe corrosion damage occurred in whole turbine flow section of a 45MW condensing steam turbine that was detected during turbine opening and repair. This is a combined turbine with controlled steam extraction for production of electrical energy and heat for district heating as well as for industrial use. The great loss of steam flows and considerably decrease in steam turbine efficiency was observed during turbine operation. A visual inspection performed during turbine regular opening and repair found that the most corroded were turbine stationary and moving blades. Because of corrosion damage the great change in the aerodynamic shape of the turbine stationary and moving blades occurred. Also, because of corrosion damage the cross section of the blades profile was decreased which caused a decrease of their strength and reliability. These unexpected corrosion damage of turbine blades required their replacement with the new blades which considerably increased the cost of turbine repair. This paper presents the results of the steam turbine corrosion damage analysis and measures for damage repair and corrosion protection.

Keywords: steam turbine, flow section, corrosion.

1. Introduction

Corrosion is a leading cause of loss of steam turbine availability. The financial effect of corrosion that occurs within the turbine flow section in power plants is on the order of millions of dollars per year [2,4]. Because of corrosion damage the degree of turbine efficiency and turbine operation reliability as a projected durability of corroded turbine parts decreases. Also, for numerous turbines because of corrosion damage the time for their repair was much longer than it was planned. Salt deposits on blades make the blade surfaces rough, distort blade channel profiles and redistribute heat-drop among turbine stages [2,3,6]. The loss up to 15% of MW generating capacity can be caused by buildup of blade deposits and several percent of turbine efficiency can be lost due to deterioration of blade surface finish and the deposits. Turbine component failures and loss of efficiency and megawatts due to deposits are very costly; the cost of lost production being ten times higher than the cost of repairs [2]. During the planned opening and repair of a 45MW condensing steam turbine, which was build in Osijek Heat and Thermal Power Plant with controlled steam extraction for production of electrical energy and heat for district heating as well as for industrial use, the severe corrosion and salting of the whole turbine flow section was detected. An inspection of diaphragms with stationary blades and discs with turbine moving blades was detected the severe corrosion damage. The severe corrosion occurred particularly on the stationary and moving blades. This unexpected severe corrosion of the turbine flow section that was found occurred during turbine operation between the two turbine regular openings and repairs. Also, because of these corrosion damages and deposits the efficiency and reliability of this steam turbine was decreased.

The objective of the investigation was to identify the cause of unexpected severe corrosion and salting, which has occurred on whole steam turbine flow section between the two turbine regular openings and repairs, to ascertain if this was due to changes in operational parameters as a boiler water chemistry, condenser tube leakage etc. This paper presents some technical data and description of 45MW condensing steam turbine with controlled steam extraction. Results of visual inspection of the considerable corroded parts of steam turbine are presented too. Cause of this unexpected severe corrosion of turbine flow section was investigated and analyzed. Also, methods for damage repair and corrosion protection of the steam turbine are proposed.

2. The basic technical data and steam turbine description

The condensing turbine consists of one controlled steam extraction and three uncontrolled steam extractions. This turbine was made in the former Jugoturbina Karlovac in 1979. The purpose of this turbine is production of electrical energy and heat for district heating as well as for industrial use. The electrical turbine power is 45 MW and entire boiled water and steam power for the heating with thermal output of 139 MW. On the turbine inlet the steam pressure is 8.6 MPa with steam temperature of 510 ^{o}C. The amount of steam on the turbine inlet is 250 th^{-1}. The pressure of the first uncontrolled steam extraction is 3.1 MPa with the steam amount of 31 th^{-1}. The pressure of the second uncontrolled steam extraction is 1.9 MPa with the steam amount of 27 th^{-1} and for third steam extraction it is 0.7 MPa and 64 th^{-1}. The controlled steam extraction is performed at pressure of 0.15 MPa. The steam amount of controlled steam extraction is 136 th^{-1}. The rotation speed of the turbine rotor is 3000 min^{-1}.

Figure 1 shows the longitudinal turbine cross-section. The turbine consists of 22 action stages. The first turbine stage is regulation Curtis stage with two rim of moving blades with average diameter of 1000 mm. Turbine stages from 2nd to 7th have stationary blades build directly in inner turbine casing while moving blades are directly build on the turbine shaft. The other turbine stages have the stationary blades build in the diaphragms and moving blades in discs. After the 7th, 10th and 15th turbine stages the uncontrolled steam extractions are performed. The controlled steam extraction is performed after the 18th turbine stage. For the pressure control of steam extraction the turning diaphragm is in use. The turbine rotor is supported on the two journal bearings where the front bearing is the thrust bearing which is used to prevent axial shift of the turbine rotor.

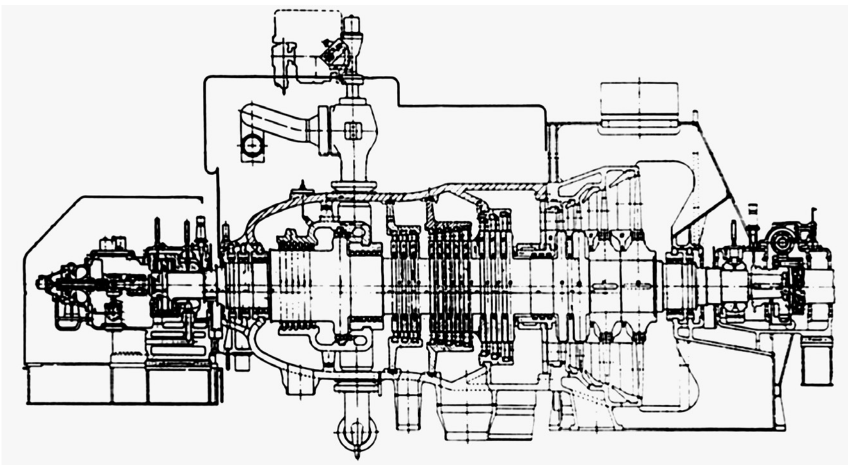

Figure 1. Cross section of a 45MW condensing steam turbine

The superheated fresh steam produced in the steam boiler enters the steam turbine and expands to the particular steam extractions were part of steam is extracted and the other part goes to the condenser. In condenser the spent steam from steam turbine is converted back in water. This resultant condensate is pumped and goes to the aerator, with added chemically treated feed water, and by feed pump is returned to the steam boiler to be reheated back in steam. The steam condenser cooling water comes from the river Drava. It is an open cycle (once through) cooling system.

3. Results

After the opening of the 45MW condensing steam turbine casing performed during the regular opening and turbine repair the unexpected severe corrosion and salting of whole turbine flow section were found. The whole turbine flow section was revealed the presence of adherent deposits of varying thickness. Corrosion and salting were so severe, that during turbine disassembly the additional efforts were needed to disassembly the upper turbine casing from the lower casing. The same case was with the replacement of the rotor from the lower turbine casing. Because of this severe corrosion it was difficult to take out the diaphragms with stationary blades from the inner turbine casings.

3.1 Visual inspection

After the turbine disassembly the detailed visual examination of corroded and salted steam turbine parts was performed. This examination showed corrosion and salting of the whole turbine flow section. The severe corrosion on the diaphragms with stationary blades and discs with moving blades was detected. Considerably severe corroded were the stationary and moving blades.

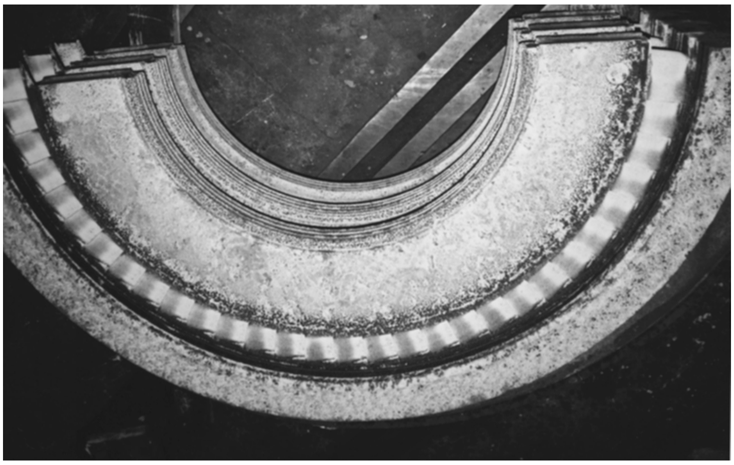

Figure 2. Corroded distribution walls with stationary blades

Corrosion and salting of the whole surface of distribution wall and particularly severe corrosion of stationary blades is shown on Figure 2. This corrosion damaged peaks of inter-stage labyrinth gaskets in the distribution walls.

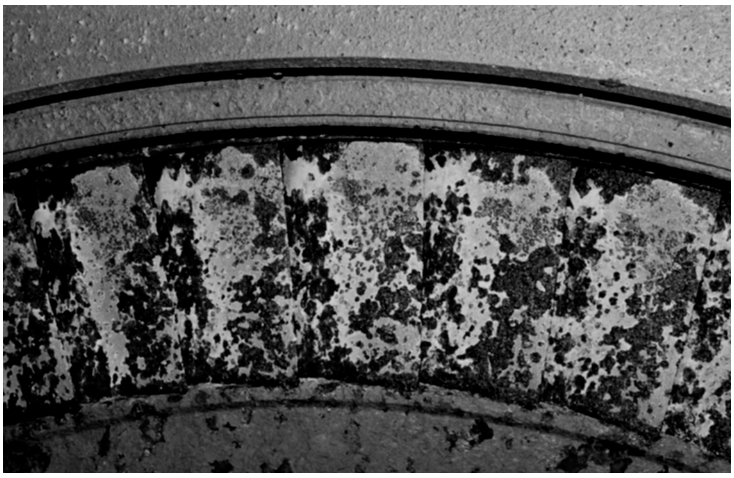

Figure 3. Severe corrosion of stationary turbine blades

Stationary blades were severe corroded and damaged on the whole their surface which is shown on Figure 3. This corrosion caused increase of roughness on blade surface with a change in the profile shape of stationary blades. Some portions of the blade surface appeared orange and some red-brown in color and it is a corrosion product hydrous ferric oxide, $Fe_2O_3 \cdot nH_2O$, which is the ordinary rust [1,5].

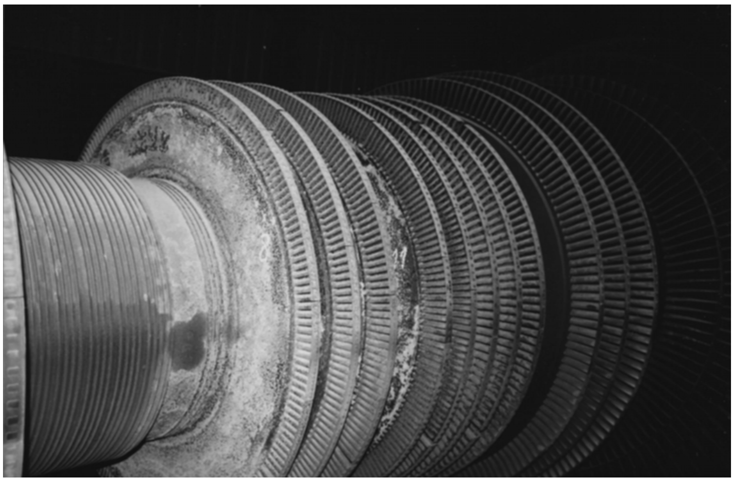

Figure 4. Corrosion and deposits of turbine rotor

The whole discs surface with moving blades and bandages that were corrosion damaged are shown in Figure 4. Moreover, corrosion damaged turbine shaft it is visible too. Surface of all blades appeared red-brown in color like as in Figure 3.

Figure 5. Severe corrosion of turbine moving blades profile

The most severe corrosion damages were detected on the moving blades. The surfaces of moving blades profile that were severe corroded on whole their length is shown in Figure 5. The formed deep corrosion holes were decreased surface of moving blades profile cross section. All of the moving blade surface and lacing rods appeared red-brown with numerous pits black in color, which is indicative to presume presence of a magnetic hydrous ferrous ferrite, $Fe_3O_4 \cdot nH_2O$ [5,6]. The consequence of this corrosion was in decrease of blades strength and their operational reliability. Also, corrosion was increased surface roughness on projected polished moving blades surface that caused a decrease of turbine efficiency.

3. 2 Chemical analysis

To establish the causes of this severe corrosion and salting that occurred in turbine flow section the chemical analysis of corrosion products is done. Deposit samples were scraped off from the damaged turbine part surface for the laboratory investigation and analysis. The chemical analysis of the deposits was carried out by a standard wet method. Following chemical analysis of deposit samples was showed: 80.14% Fe_2O_3, 11.85% SO_4^{2-}, 2.56% SiO_2, 2.35% CaO, 0.96% Al_2O_3. This chemical analysis showed that besides corrosion products of iron also the sulfates, calcium and silica as a salt were found. These results indicate that severe electrochemical corrosion and salting in turbine flow section occurred because of Ca and SO_4^{2-} presence. Silica and calcium present in steam were formed deposits of insoluble calcium silicates. The pH value that was measured in 2% water solution of corrosion products and salts was 6. This is area of very low acidity but in presence of oxygen this solution can cause considerable corrosion. Acidity of this environment promotes this electrochemical corrosion process. The loss of Fe from blade iron based alloy produces pits that weaken the blade structure. The following reaction usually takes place at anodic areas:

$$Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^{-} \tag{1}$$

When iron corrodes, the rate is usually controlled by the cathodic reaction, which in general is much slower (cathodic control). The cathodic reaction can be accelerated by reduction of dissolved oxygen in accordance with the following reactions, in acidic solution:

$$4H^{+}_{(aq)} + O_{2\,(g)} + 4e^{-} \rightarrow 2H_2O_{(l)} \tag{2}$$

Dissolved oxygen reacts with hydrogen atoms adsorbed at random on the iron surface, independent of the presence or absence of impurities in the metal. The oxidation reaction proceeds as rapidly as oxygen reaches the metal surface.
Adding (1) and (2), making use of reaction $H_2O \leftrightarrow 2H^{+} + OH^{-}$, leads to reaction (3),

$$2Fe_{(s)} + 2H_2O_{(l)} + O_{2\,(g)} \rightarrow 2Fe(OH)_{2\,(s)} \tag{3}$$

Hydrous ferrous oxide, $FeO \cdot nH_2O$ or ferrous hydroxide, $Fe(OH)_2$ composes the diffusion barrier layer next to the iron surface through which O2 must diffuse. At the outer surface of the oxide film, access to dissolved oxygen converts ferrous oxide to hydrous ferric oxide or ferric hydroxide, in accordance with

$$4Fe(OH)_{2\,(s)} + 2H_2O_{(l)} + O_{2\,(g)} \rightarrow 4Fe(OH)_{3\,(s)} \tag{4}$$

Hydrous ferric oxide is orange to red-brown in color and makes up most ordinary rust. It exists as nonmagnetic αFe_2O_3 (hematite) or as magnetic αFe_2O_3. A magnetic hydrous ferrous ferrite, $Fe_3O_4 \cdot nH_2O$ that often forms a black intermediate layer between hydrous Fe_2O_3 and FeO. Hence rust films normally consist of three layers of iron oxides in different states of oxidation [1,5].

This electrochemical corrosion process that occurred on whole steam turbine flow section is the real cause of corrosion damages. The pitting corrosion that occurred in steam turbine flow section is the most dangerous form of corrosion damage, which causes the blades replacement.

Investigations and chemical analyses of deposits showed that during turbine operation the leakage of some steam condenser tubes occurred because of Ca and SO_4^{2-} presence. From some of damaged condenser tubes the leakage of the cooling water occurred into the steam part of condenser. The cooling water that has penetrated into steam part of condenser together with steam condensate entered into the steam boiler for evaporation. In the steam boiler produced superheated steam entered into steam turbine where their present aggressive ingredients (salts) caused the severe corrosion and salting of the whole turbine flow section. These condenser tubes, on which the leakage of cooling water was detected, were excluded from the condenser operation by the plugging.

The visual examination of condensers tubes, which was also performed during turbine repair showed the localized corrosion products and salt deposits on the inner wall of the condenser tubes – on the side of cooling water. During turbine operation this localized pitting corrosion was propagated and perforated some condenser tubes. Because of these leakages the cooling water has entered into steam space of condenser. With the regular treatment of cooling water this corrosion and salt deposits on the inner wall of condenser tubes should not occur and it can be prevented.

4. Repair of steam turbine parts and measures for corrosion protection

Removing of corrosion products and salt deposits from turbine flow section was performed by sandblasting process of diaphragms with stationary blades, turbine rotors and inner turbine casings. Because of decrease in turbine reliability and usefulness the severe corroded moving blades from 1^{st} to the 18^{th} turbine stages were removed with the new blades. Stronger corrosion damaged stationary blades were aerodynamically reshaped by grinding. This treatment decreases costs of damage repair to the following regular turbine repair when they will be removed.

For corrosion prevention of turbine flow section it is necessary to perform the repair of the damaged steam condensers tubes. Besides it is necessary to protect the condenser tubes from corrosion and prevent the salt deposition with adequate treatment of cooling water.

5. Conclusion

During opening and repair of a 45 MW condensing steam turbine with steam extractions the unexpected severe corrosion and salting was detected on the whole turbine flow section surface that occurred during turbine operation between two planned repairs. The most corroded and salted were stationary and moving blades. These corrosion damages considerably decreased reliability and usefulness of steam turbine. Severe corrosion damage of moving blades profile decreased their projected strength that particularly decreased operational reliability of turbine. Because of decreased turbine reliability and usefulness the severe corroded damaged moving blades were replaced with new blades.

Investigations and chemical analysis of corrosion products and salt deposits showed that severe corrosion of turbine flow section has occurred because of steam condenser tubes leakage and the cooling water penetration into steam part of condenser. The cooling water with the condensate of the spent steam has come in the steam boiler and with produced steam into turbine. Corrosion aggressive ingredients present in inadequate steam have caused the severe corrosion and salting in turbine flow section. An adequate monitoring of steam chemistry can prevent these corrosion damages and salting in whole steam turbine flow section. The cation conductivity should be minimum and should be the routine way to prevent deposition of salts and hydroxides, which can lead to corrosion and turbine efficiency and MW loss.

In addition for the corrosion prevention it is necessary to replace damaged tubes from the steam condenser. Also, the adequate treatment of cooling water is needed to prevent corrosion and deposit formation on the cooling water condenser tubes.

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TURBINE BLADE MATERIALS AND PROCESS DEVELOPEMENT REVIEW

J. Šundrica, N. Jurjević and M. Prčan

Abstract

In this paper, superalloy development, starting from 1940s to the middle of 1990s is given, observed through changes in chemical composition on one side, and technology on the other, in correlation to the increase in temperature – strength capability. Conventional casting, directional solidification and single crystal growing processes for turbine blades manufacture are shown. A conclusion was made that material development, followed by technological advances keep setting new goals.

Keywords: turbine blades, superalloys, directional solidification, single crystal growing

1. Introduction

Turbine blades are special machine components. Application conditions require corrosion and heat resistance, along with increased mechanical properties. For this, and other, similar applications nickel or cobalt based materials, called superalloys, are used. Superalloys are a group of alloyed steels, created in the whirlwind of World War II. The first, nickel based superalloy – Nimonic was created in 1940.

From their appearance in 1940s to the 1970s, achieving better properties was based on altering chemical composition. In the period from 1970s, focus was turned towards development & application of new manufacture technologies for forming more favorable structures.

2. Development of superalloy composition

From the start of the 20th century, about the time that Nichrome and Stellite products became available, it was a scant 15 to 20 years until the stainless steels were in production during the 1920s.

By the end of another 20 years, approaching the start of World War II, the basis for current superalloys was laid with the development of a broad range of austenitic stainless steels, introduction of the cobalt-base alloy Vitallium, and the adaptation of the various strains of stronger Nichrome materials introduced to commercial use as Nimonic and Inconel products.

Carbide hardening was used to create the cobalt-base alloys, and, although the fundamentals of precipitation hardening were still being discovered, precipitation hardening nickel-base alloys were developed.

The cobalt-base alloy Vitallium was relatively strong, but the nickel-base and iron-nickel-base products were wrought and relatively weak in creep rupture by today's standards. Nevertheless, many of the alloys of the 1940s time frame (Vitallium, Inconel X) still have use today.

Major advances occurred from the 1940s to the 1960s. The need for high-strength, high-temperature-resistant superalloys increased due to the introduction of the gas turbine engine for aircraft applications. Iron-nickel-base superalloys were developed further as wrought materials, new cobalt-base superalloys were invented, while both wrought and cast nickel-base superalloys became the predominant alloys of choice for the most strength-critical applications. Historical overview of superalloy development of temperature – strength correlation to chemical composition and casting technology is given in figure 1 [1].

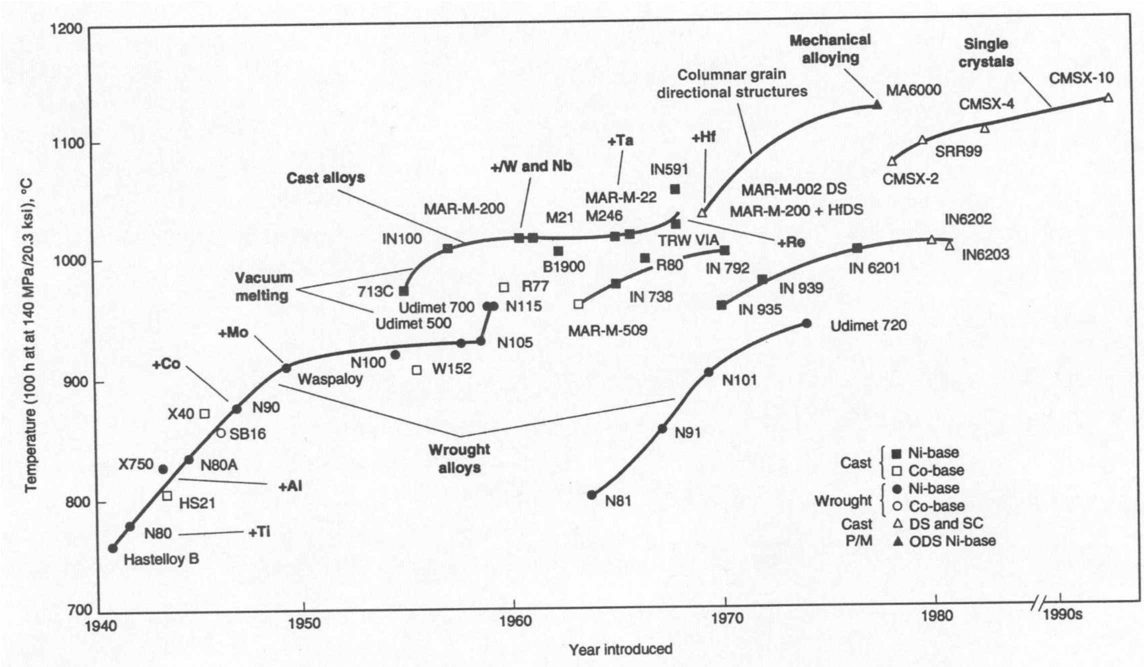


Figure 1. Increase in temperature – strength capability of superalloys in a developement span

Typical chemical composition of turbine blade superalloys is shown in table 1., while mechanical properties are given in table 2 [2].

Table 1. Turbine blade superalloys basic chemical composition

Superalloy name		Chemical composition (mass %)									
Commercial	DIN No.	Ni	Cr	Fe	Mo	C	Si	Ti	Al	Co	Nb
Incoloy 825	2.4858	38-42	21	31	2,5-3	<0,002	-	0,6-1	-	-	-
Hastelloy B2	2.4617	70-72	<1	<2	27-30	<0,01	<0,06	-	-	<1	-
Nimonic 75	2.4951	72-76	19-21	<5	-	0,08-0,13	0,3-0,7	0,2-0,6	-	-	-
Inconel 617	2.4663	53-57	20-23	<2	8-10	0,05-0,1	-	0,2-0,6	0,6-0,15	10-13	-
Inconel 718	2.4668	52-54	17-20		2,5-3,5	0,03-0,08	-	0,7-1,2	0,4-0,7	-	4,8-5,5

Table 2. Mechanical properties of nickel-base superalloys

Superalloy name		Mechanical properties										
		A_5 %	R_m, N/mm^2	$R_{p0,2}$, N/mm^2 at ºC								
Commercial	DIN No.			20	100	200	300	400	500	600	700	800
Incoloy 825	2.4858	>30	550	220	205	180	170	160	155	-	-	-
Hastelloy B2	2.4617	40	755	340	315	285	270	255	-	-	-	-
Nimonic 75	2.4951	25	650	>240	450	445	435	425	400	350	250	-
Inconel 617	2.4663	35	700	300	-	-	-	-	200	190	185	-
Inconel 718	2.4668	12	1240	1035	-	-	-	-	950	900	810	630

3. Development of turbine blade casting technology

The development of vacuum melting technology for superalloys provided for a quantum leap in capability. Oxygen (and nitrogen) reduction enhanced strength and improved the efficiency of hardener additions, such as titanium and aluminum.

Consequently, existing superalloys, for example, Waspaloy, gained significant amounts of strength by application of the vacuum melting process. Concurrently, the availability of vacuum melting made a new generation of cast, agehardenable nickel-base superalloys, such as IN-713, more feasible. At the same time, particularly in the mid – 1950s, research on the nickel-base superalloys became very intense.

By the end of the 20 year period from about 1960 into the early 1980s, not only were columnar grain directionally solidified materials available and operating in gas turbines, but also single-crystal directionally solidified (SCDS) casting alloys had been produced.

3.1 Conventional casting

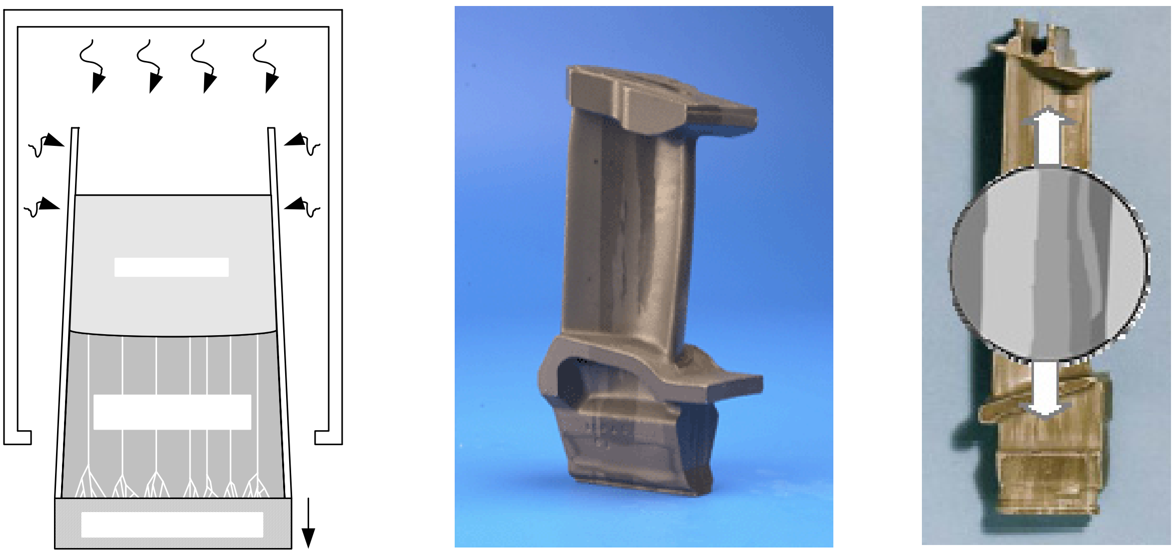
Conventional casting is a term commonly used for investment casting, utilizing ceramic molds, as shown in figure 2. Molten metal is casted in a ceramic mold where it hardens. Thus achieved structure is polycrystalline with grain boundaries making it subjectable to creep & cracking under increased stresses due to centrifugal forces at high temperatures [5]?

a) b) c)

Figure 2. Conventional cast process and product
a - ceramical mold for turbine blades; b – conventionally casted turbine blade; c – conventionally casted turbine blade with structure schematics

3.2 Directional solidification

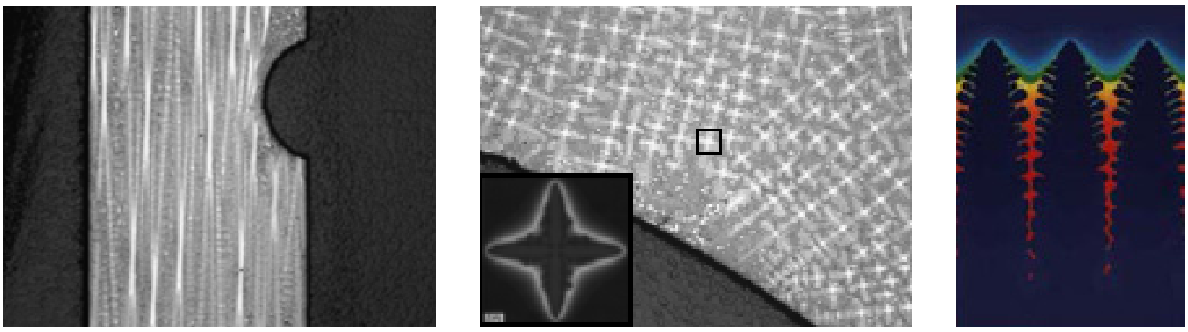
Directional solidification is an improved conventional casting process. Molten metal is casted into a chemical mold, placed into a heated tank, where it is slowly cooled by extraction downwards. Crystals begin to shape in the direction of extraction, thus forming boundaries as shown in figure 3.



a) b) c)

Figure 3. Directional solidification process and product
a –directional solidification process schematics; b –directionally solified turbine blade; c – directionally solified turbine blade with structure schematics

Directionally solidified structure is, due to slow extraction treelike dendrite, shown in longitudinal and transversal cross section in figure 4. Dendrite is formed through the cooling process from a seaweed-like structure, and by growing adjacent crystals bond. Produced blade is stronger in the direction of centrifugal forces developed in turbine.

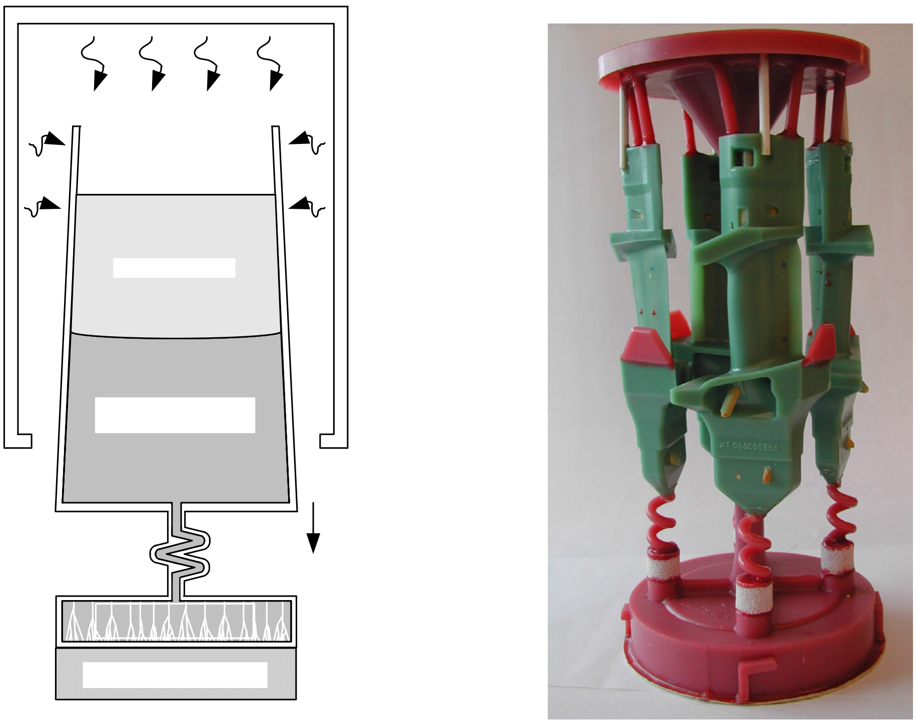


a) b) c)

Figure 4. Directionally solidified turbine blade microstructure
a – longitudinal cross section; b – transverse cross section with dendrite nanostructure; c – dendrite crystals formation simulation

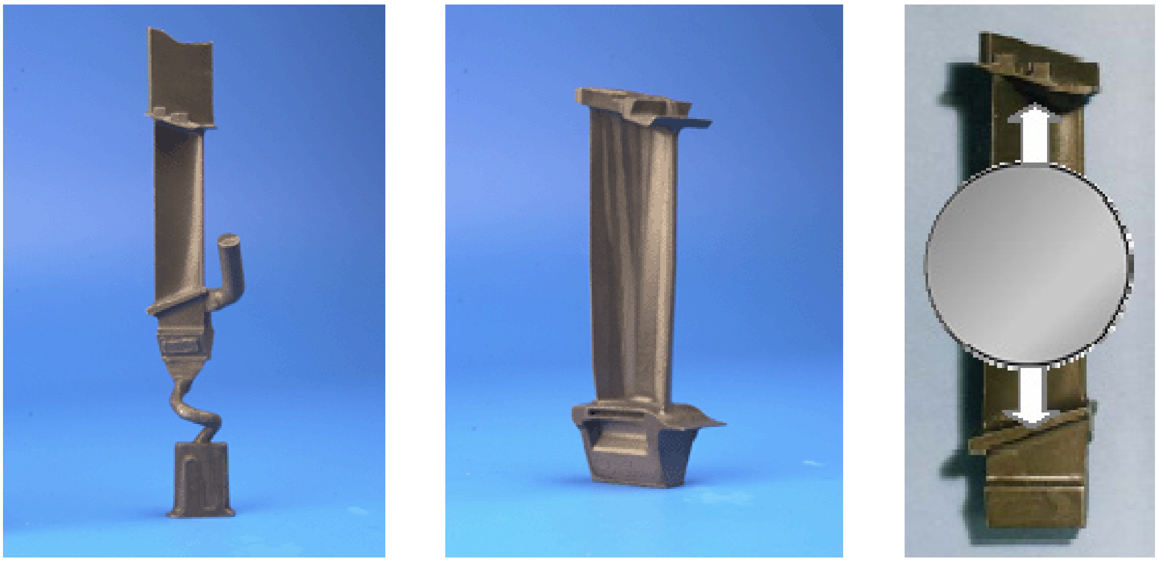
3.3. Single crystal growing

Single crystal growing is an improved directional solidification process. Molten metal is casted into a ceramic mold, placed into a heated tank. Mold is divided into two sections, connected via a spiral channel. As it is extracted downwards, crystals form in the lower section in the direction of extraction. Only one of those crystals manages to pass through the spiral channel. Controlled extraction rate results in single crystal growing at the upper section of the mold, as shown in figure 5. The lack of grain boundaries makes these blades resistant to creep and prolong service life [3].



a) b)

Figure 5. Single crystal growing process and wax model assembly
a –single crystal growing schematics; b – assembly of four wax models for turbine blade casting;



a) b) c)

Figure 6. Single crystal turbine blade
a –single crystal turbine blade with the “pigtail”; b – finalized single crystal turbine blade; c – single crystal turbine blade with structure schematics

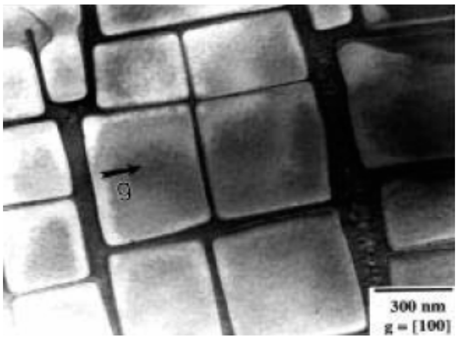
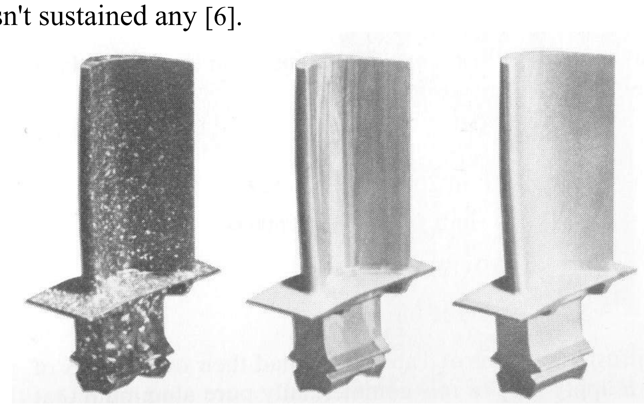


Figure 7. Single crystal nanostructure [4]

3.4. Turbine blade exploitation test comparison overview

Figure 8. shows turbine blades made by conventional casting (a), directional solidification (b) and single crystal growing (c) after exploitation tests. Severest, eye visible damage was sustained on a conventionally casted blade; directionally solilfied blade suffered barely visible damage, while single crystal grown blade hasn't sustained any [6].



a) b) c)

Figure 8. Turbine blades after exploitation test
a –conventional blade; b –directional solidification blade; c – single crystal blade

4. Superalloy evolution

Improving turbine blade behavior in exploitation remains a constant, despite major advances in material development. Constant exposure to harsh, corrosive environment and high temperatures requires, in addition to special superalloy properties, devising means of maintaining, or even prolonging turbine blade life span. Several technologies are used for achieving this goal: heat treatment, blade cooling, antioxidant and thermal barrier coatings, hot isostatic pressing and liquid metal cooling.

Long term advances will follow nanotechnology development and implementation of thus developed technologies. Primary goal of such an advance would be the complete uniformization and homogenization of material structure, elimination of all boundaries that are now present, even in single crystal structures.

5. Conclusion

By observing superalloy development, two trends can be defined. The first was chiefly based pioneer work made from 1940s to 1970s, when alterations in chemical composition for application characteristics improvement were made. In 1970s it became evident that improving material properties needed more than fine balancing in material ratios. Application of directional solidification made a quantum leap in technology, followed by single crystal growing in the 1980s, when superalloy temperature–strength capability was almost doubled. Use of other improvements in turbine blade structure, implementation of surface coating technologies, hot isostatic pressing, liquid metal pressing, etc., will make new standards for turbine blades, and lay new guidelines for further development.

Advances in turbine blade production technology immensely increased already outstanding mechanical properties of superalloys. It is only reasonable that by using new technologies, superalloys will become the prime example of what can be achieved by combining material science and engineering.

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INFLUENCE OF PROCESS PARAMETERS ON ROUGHNESS AND TEXTURE OF LATERAL FLAT SURFACES OF PARTS PRODUCED BY SELECTIVE LASER SINTERING PROCESS

A. Topčić, Dž. Tufekčić and R. Šelo

Abstract

Selective Laser Sintering – SLS process on the basis of its very good characteristics, is broadly used in many areas of direct and prototype production, but insufficient knowledge about essence of the process itself and influence of process parameters on properties of produced parts constraints widely usage of SLS process in production systems.

Keywords: Time-to-market, SLS process, process parameters, roughness and texture

1. Introduction

Rapid Prototyping - RP processes, since it's appeared, fifteen years ago, on commercial market take over more and more important role in manufacturing of prototypes and the ready-made parts. These processes with their characteristics enable to modern manufacturer achieving and keeping its competition ability on the global market through short response on market impulse and as a result of above mentioned is shorter time to market.

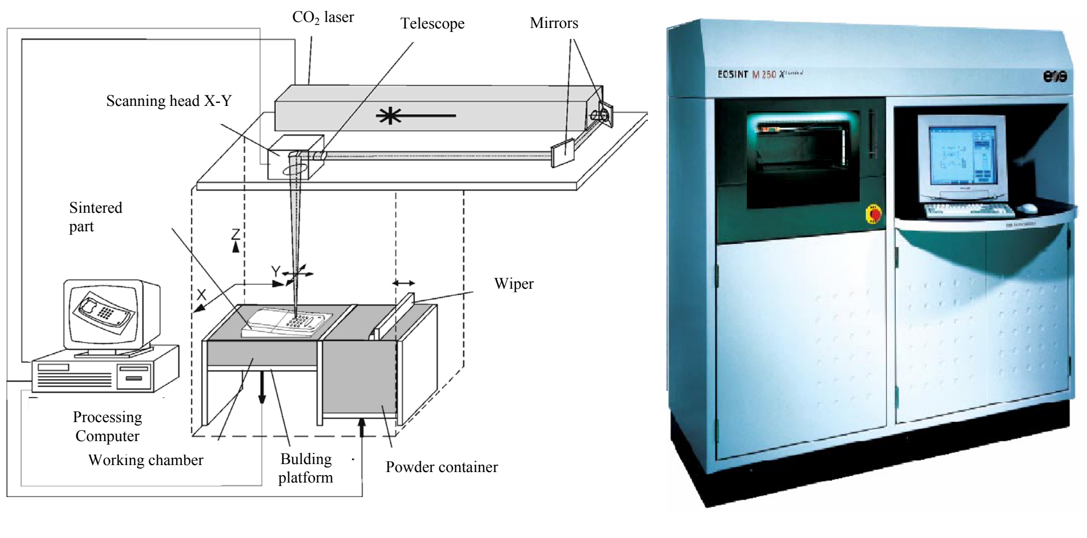
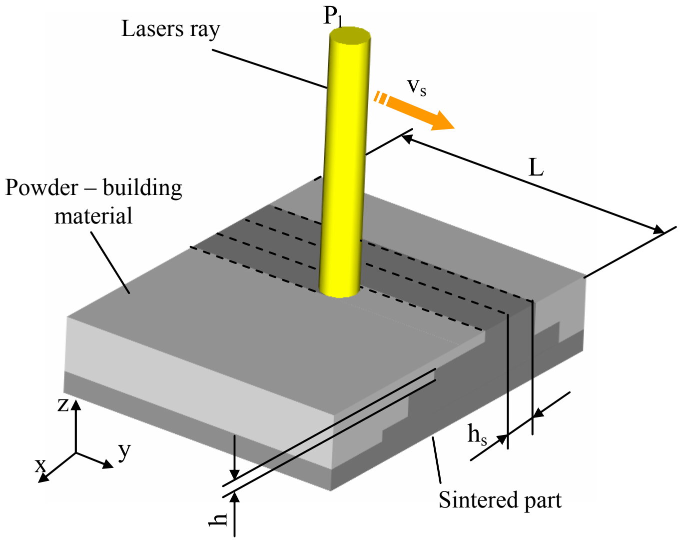


Figure 1. Schematic review of SLS process and SLS machine EOSINT M250

Selective Laser Sintering – SLS is a RP technology that have place in many production systems. SLS systems with their characteristics are successful used for indirect and direct production of the parts-prototypes. However, process features, especially used materials, enable production of ready-made parts directly without post processing and it is big progress in Rapid Prototyping field.

Despite to the obvious precedence of SLS processes insufficient familiarity with process essence and influences of process parameters on features of produced parts enable many researches on this domain. Those researches will enable finding of efficient ways for productions and increasing of produced SLS parts quality.

On the field of quality of machined surfaces are done many process analysis in consider to so called staircase effect (machined surfaces are under some angle on manufacturing direction-layer manufacturing) and on this field was achieved significant progress. Moreover, there are some researches of building materials particle size influences on quality of machined surfaces. However, analysis of SLS process parameters influences (scan velocity v_s and laser power P_l) on quality of the machined flat surfaces is dedicated relative low interest although considering to the process characteristics it is possible to expect significant influence on total quality of the produced part, on its price and finally on the time necessary for its production.



P_l- Laser power [W]
h – Layer thickness [mm]
h_s – Step [mm]
v_s – Scan velocity [mm/s]
L – length of sintered line [mm]

$$v_s=(0\div500)\ [\frac{mm}{s}]$$

$$P_l=(0\div200)\ [W]$$

$$E_l=(0{,}4\div1{,}72)$$

$$E_l=f\ (P_l,\ v_s),\quad E_l=\frac{P_l}{v_s}$$

Figure 2. Review of basic SLS processes variable

2. Basic Considerations

The aim of the experiment was to indicate on influence of SLS process parameters (scan velocity v_s [m/s] and laser power P [W, %]) on roughness and texture of flat lateral surfaces for parts produced by SLS process, using material DM50-V2, on machine EOSINT M250 (figure 1.). With measurement of texture dependencies from SLS process parameters was tried to get average shape of sintered lines-layers and average shape of sintered grain.

Roughness parameters followed during experiment are: R_t - DIN 4771; R_a - DIN 4762, DIN 4768, ISO 4287/1; R_q - DIN 4762, DIN 4768, ISO 4287/1; S_m –DIN4762, ISO4287-1; Rz (ISO) – ISO 468, ISO 4287-1; R_p and R_{pm} – DIN 4762.

For analysis of mentioned dependencies are produced parts with cube shape (10×10×10 mm, height of the support 10 mm). Respecting the fact that SLS process is relatively expensive process and used materials are very expensive too, for research needs dimension of the cubes are as minimal as possible, which however give opportunity to accomplish satisfactory roughness measurement according to corresponding standards.

Working area adopted for experiment, is illustrate on the figure 3, and it is limited with working characteristics of machine EOSINT M250 as well as with material characteristics. As it mention above observed working parameters are scan velocity v_s and laser power P_l and on the function of them energy line E_l was defined. Although it is possible to provide value of energy line less then 0,4 (E_l<0,4), due to properties of used material, which disable adequate stitching among layers, difficulties may occur during manufacturing process with possible break up of the part at the end. Due to that adopted minimal value of energy line is E_l=0,4. Since laser power and scan velocity is limited within interval P_l=0÷200 [W] and v_s=0÷500 [mm/s] on the basis of available domain, working area of machine divided according to rule, value of each following energy line is higher for 20% then previous value of energy line.

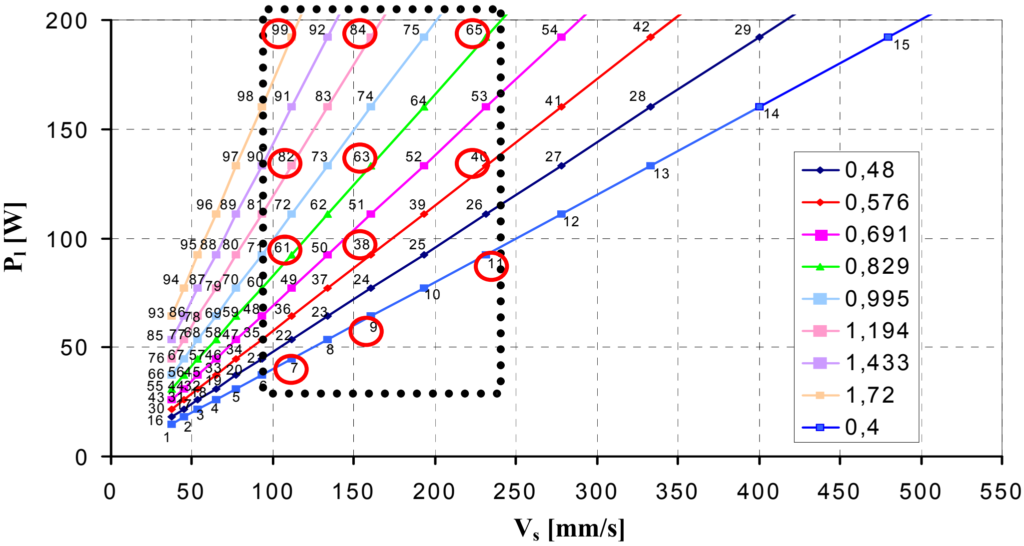


Figure 3. Working area and working points adopted for II faze of experiment

Marked points on the figure 3 represent working points with process parameters, which were, subserve for part productions. These points were taken because it was reasonable to expect most influence of process parameters on roughness and texture of lateral surfaces of parts along the margins of working area. Furthermore disposition of those points provide simple comparison of followed values on three directions P_l=*const*, v_s=*const* and E_l=*const* which enables satisfactory access to the influence of processes parameters on roughness and texture of lateral flat surfaces of parts produced by SLS process. In order to get satisfactory accurate of the results at the same time was produced three pieces for each part with the same contour parameters and measurement of following values are done two times on each flat lateral area of the parts.

3. Experimental equipment

For manufacturing of the parts (pre-processing, processing and post-processing), for measurements and data processing were the following equipment and software used:

- Machine for SLS process EOSINT M250 producer EOS Munich, Germany;
- Material for direct laser sintering processes -DMLS DM50-V2, producer EOS Munich, Germany;
- Machine for measurement of surface roughness and texture of produced parts MAHR PERTHOMETER, Göttingen, Germany;
- High speed camera Polaroid DMC Ie, Light microscope Olympus;
- Pro Engineer (UNIX Work Station, Silicon Graphics);
- EOSINT M Proceβ-Steuerrung Version 2.10.;
- WinSAM 2.6;

4. Measurement of observed values and processing of results

After production, post processing and measurement of roughness and texture on lateral flat surfaces of produced parts it was possible to see following dependencies presented on figures 4 - 6.

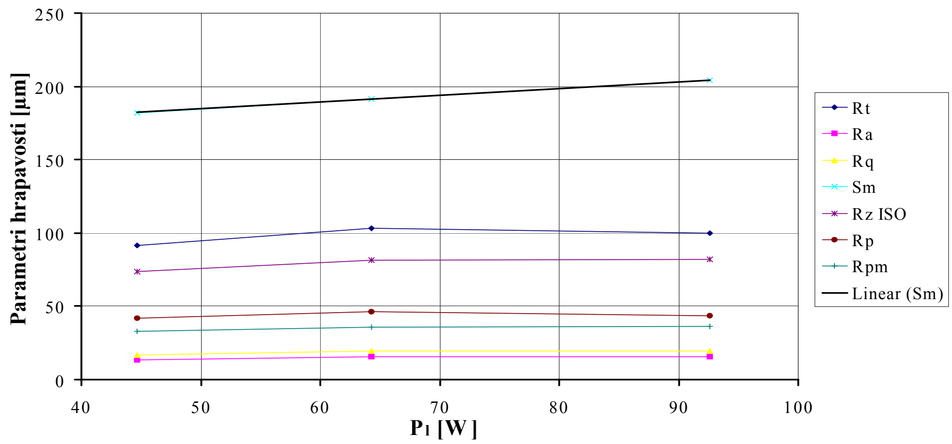


Figure 4. Changing of profile roughness parameters R_t, R_a, R_q, S_m, R_z(ISO), R_p, R_{pm} flat lateral surface (parts 7-9-11) on direction E_l=0,4=const

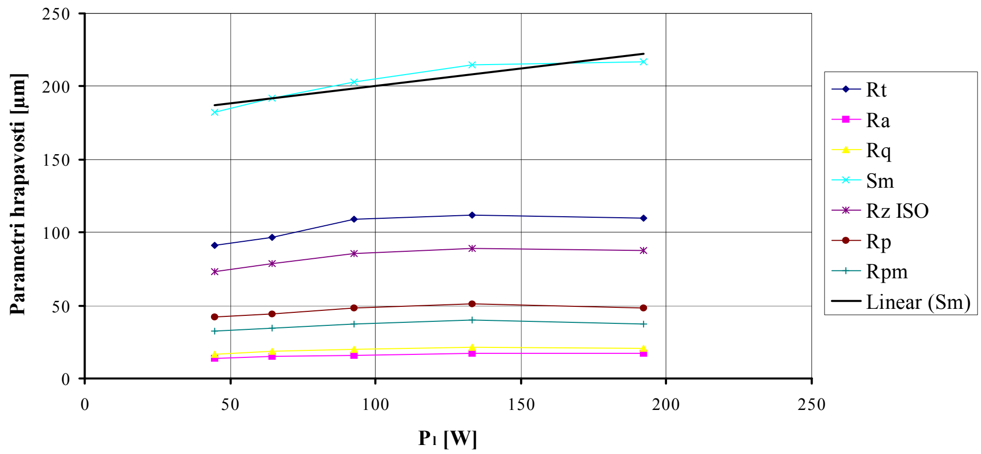


Figure 5. Changing of profile roughness parameters R_t, R_a, R_q, S_m, R_z(ISO), R_p, R_{pm} flat lateral surface (parts 7-36-61-82-99) on direction v_s=111,63[mm/s]=const

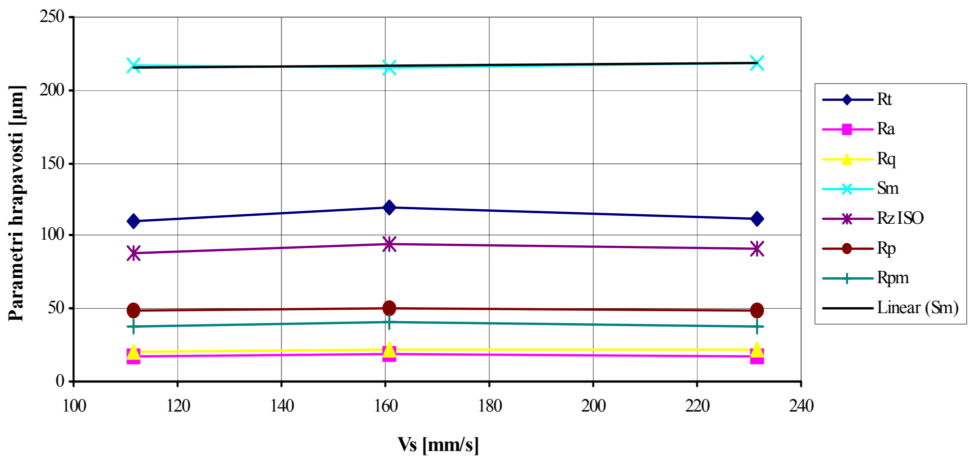


Figure 6. Changing of profile roughness parameters R_t, R_a, R_q, S_m, R_z(ISO), R_p, R_{pm} flat lateral surface (parts 99-84-65) on direction P_l=191,94[W]=const

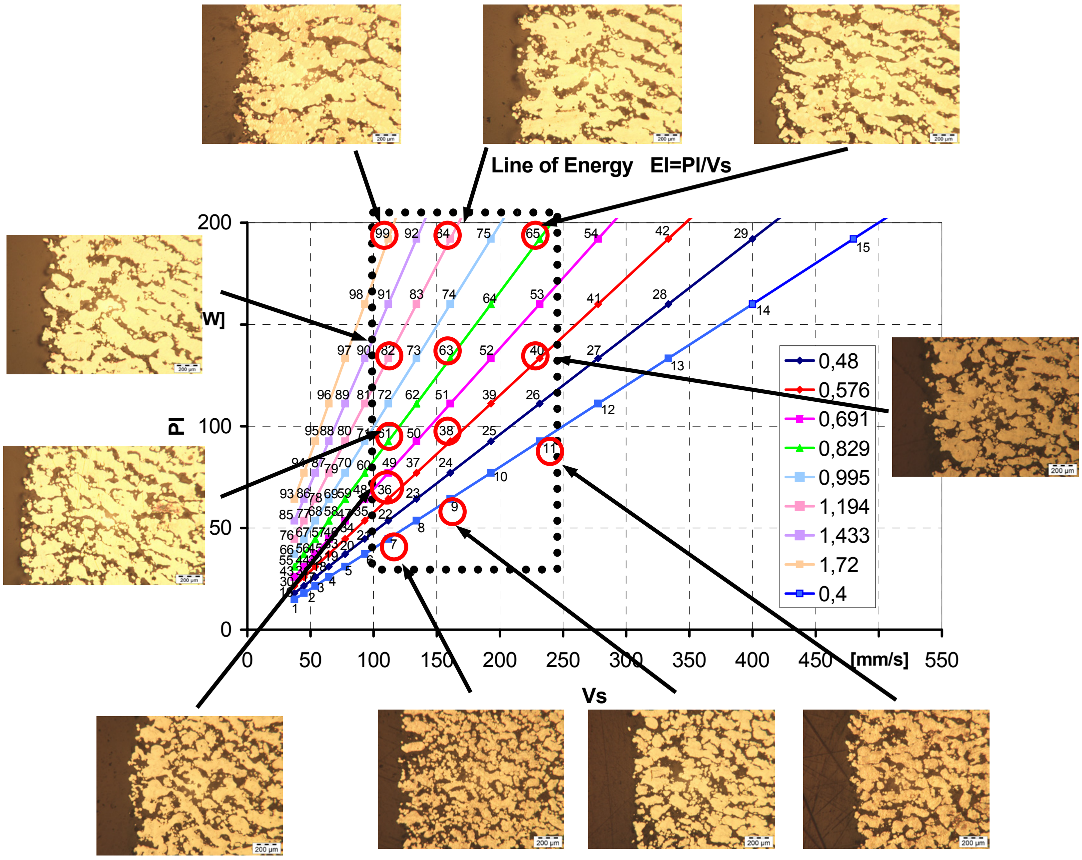
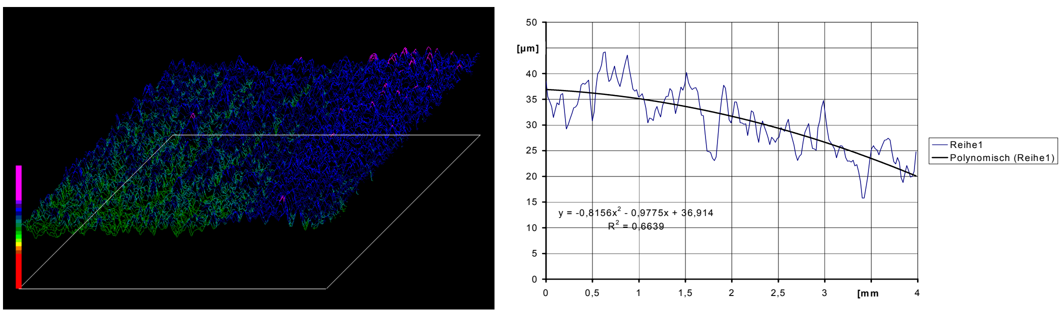


Figure 7. Influence of process parameters on grain's size of the sintering powder

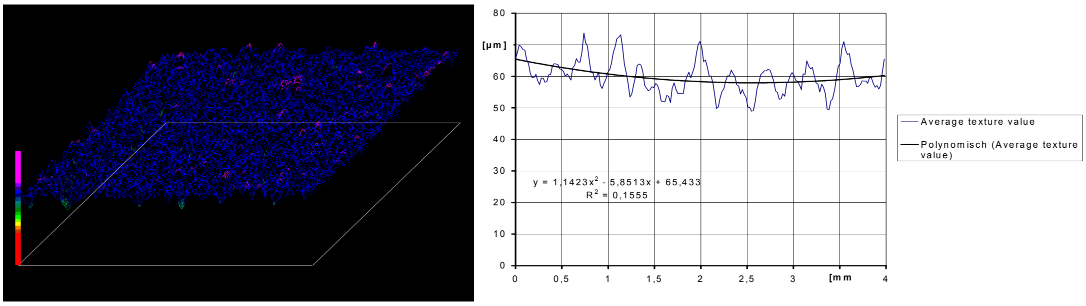
5. Conclusion

With respect to presented diagrams it is possible to make following conclusions. It is obvious that there is influence of processes parameters on roughness of flat lateral areas of produced parts particularly along lines El=const and v_s=const, but along lines Pl=const influence of processes parameters on observed characteristic is a little bit lower. At the same time there is linear dependency of roughness parameters of flat lateral surfaces from process parameters and with higher energy value carried in the sintered powder roughness parameters was higher. Explanation for that is possible to find in fact that there is a bigger size of powder melted nuggets with higher energy carried in the powder and converse (figure 7). With respect to this observations it is possible to explain influence of SLS processes parameters on roughness of the flat lateral areas of produced parts.



a) b)

Figure 8. a) Texture of flat lateral surface part 7,
b) Average shape of the texture part 7



a) b)

Figure 9. a) Texture of flat lateral surface part 99,
b) Average shape of the texture part 99

According to figures 8 and 9 it was impossible to find any kind of dependency between SLS process parameters and texture of flat lateral areas of produced parts and that is the reason why there is no any kind of average shape of sintered lines, although it expected to see that considering to characteristics of the SLS process. Main reason for this is possible to find in the fact that size of sintered powders nuggets is in dependency form input energy carried in then powder during processing phase. Besides of that it is important to notice smaller sintered powder nuggets that "overlay" the main core of layer especially on parts produced with higher processes parameters (figure 7).

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CUTTING FORCES BY TURNING IN DEPENDENCE OF ENTRY ANGLE

T. Udiljak, S. Škorić and D. Ciglar

Abstract

Machinability is assessed by a set of criteria or machinability functions, the knowledge of which is necessary in optimising the machining process. New materials of the cutting tools and new concepts of the machine tools provide new possibilities and cause quantitative changes in machinability functions. This work has studied the cutting forces function, as one of the crucial functions of machinability. The research was done by longitudinal turning the steel 16MnCr5, using the tools made of coated carbides, without the usage of coolants. Obtained results confirm that entry angle significantly influence thrust cutting force, F_p, and therefore is one of the key factors when turning workpieces with high ratio l/d.

Keywords: cutting forces, turning, entry angle, cutting data

1. Introduction

The increase of total efficiency of metal cutting process, requires the analysis of technical-technological and design parameters of a process which will raise the existing process at higher techno-economic level. Main aims of modern machining processes are productivity, economy , accuracy and quality of machined surface, which are achieved by continuous analysis of machinability indicators.

Machinability is a very complex term, and it is most often described as the basic technological characteristic of the material and evaluated by a set of criteria or functions of machinability. In metal cutting, the basic set of machinability functions includes [1][2]:

- function of tool life,
- function of cutting forces,
- function of roughness of the machined surface,
- function of the chip forms.

Apart from the basic functions, also a number of additional functions are applied such as temperature, volume of the separated material in the unit of time, built-up-edge, power, etc.

The study of the machinability of materials results also in obtaining the guidelines for the development of materials of the cutting tool machines. Therefore, the development of tool machines is very intensive, particularly under the conditions of high-speed machining. The development of the existing and new materials of the cutting tools and the new concepts of tool machines provide new possibilities and change quantitatively the machinability indicators. Therefore, the study of material machinability represents a continuous process.

Force modeling in metal cutting is important for a multitude of purposes, including thermal analysis, tool life estimation, chatter prediction, and tool condition monitoring. Numerous approaches, in orthogonal and oblique cutting, have been proposed to model metal cutting forces with various degrees of success [3][4][5].

2. Cutting forces by turning in dependence of entry angle

2.1 Goal and condition of study

The goal of the research is to define the adequate mathematical model, the cutting forces function, that defines the influence of independent factors, machining regime parameters, the major entry angle (κ_r) (figure 1.), machining depth (a_p), and feedrate (f).

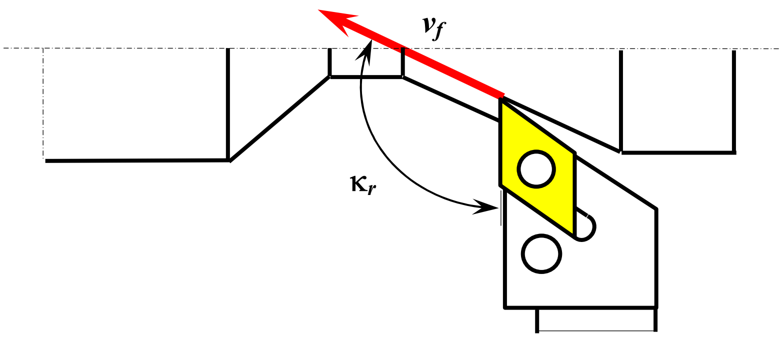

Figure 1. Example of longitudinal turning with exchangeable angle κ_r

This experiment was made in the Laboratory for machine tools of Faculty of Mechanical Engineering and Naval Architecture, University Zagreb, at universal turning machine TES-3, produced by «Prvomajska», Zagreb. Longitudinal turning process has been used, without coolants. For test piece material, steel for cementation 16MnCr5, was selected. We used the tools with mechanically exchangeable coated hard metal inserts, and marked by DCMT 11T304-14, IC9025. The measurement of cutting forces was made by three component measuring «Kistler 9257B».

2.2 Research results

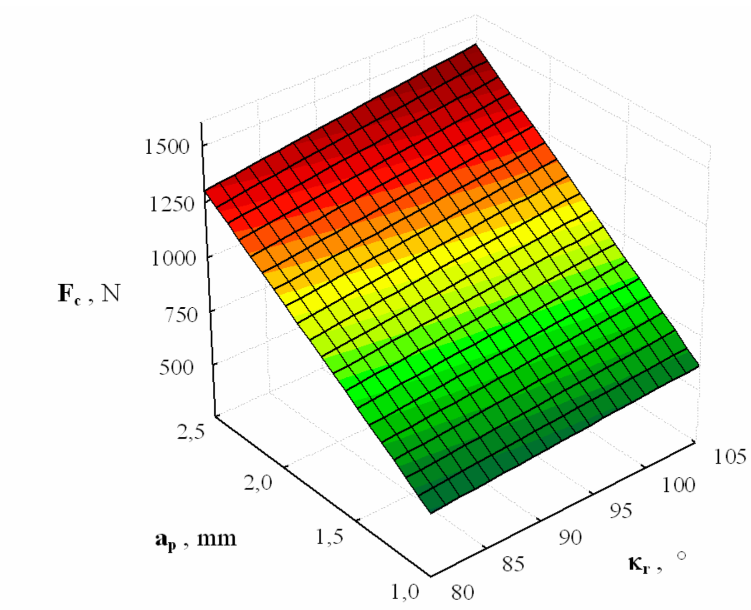

Figure 2. Main cutting force as a function of cutting depth and entry angle (f = 0.22 mm)

Statistical analysis of experimental data (SW Statistica) resulted with mathematical models presented with eq. 1 to 3.

$$F_c = 211{,}76\ \kappa_r^{0{,}4476}\ a_p^{0{,}9518}\ f^{0{,}673} \tag{1}$$

$$F_f = 40{,}91\ \kappa_r^{05182}\ a_p^{1{,}1071}\ f^{01903} \tag{2}$$

$$F_p = 16{,}25\ \kappa_r^{0{,}7413}\ a_p^{22{,}2151}\ f^{-6{,}2218}\ e^{-4{,}8843\ \ln\kappa \ln a\ +1{,}5367 \ln\kappa \ln f} \tag{3}$$

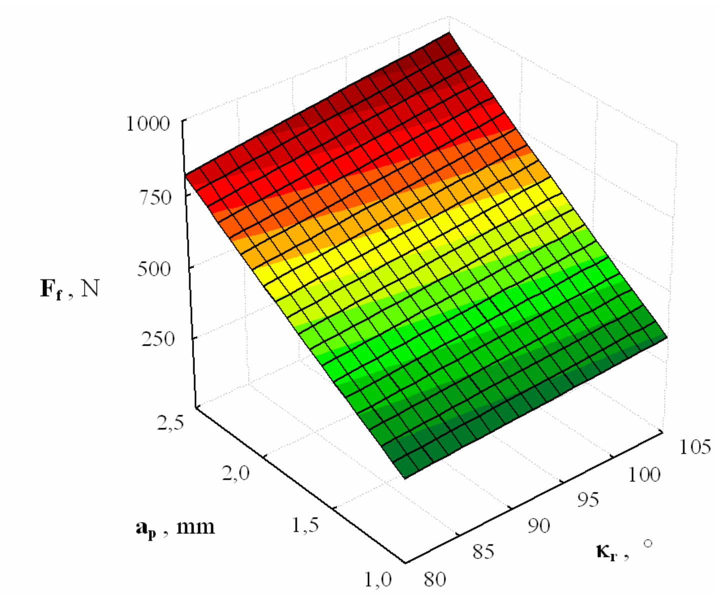

Figure 3. Feed cutting force as a function of entry angle and cutting depth (f = 0.22 mm)

The figures 2. and 3. show that there is no significant influence of entry angle on main cutting force and feed force.

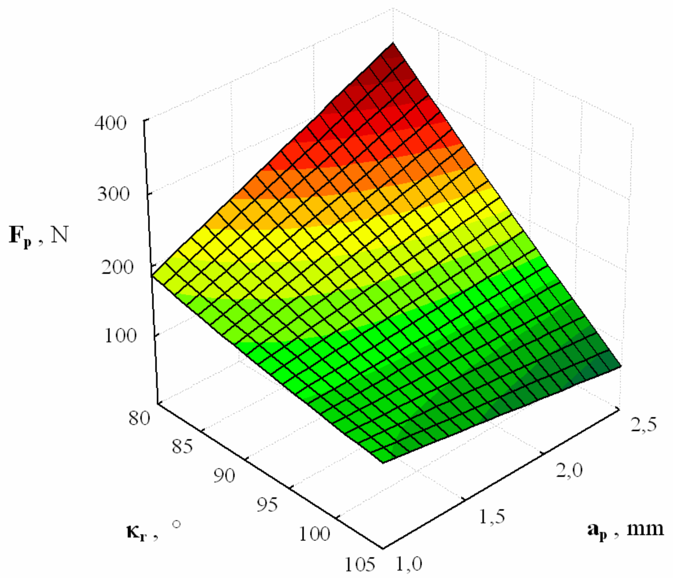

Figure 4. Thrust (passive) cutting force as a function of entry angle and cutting depth (f = 0.22 mm)

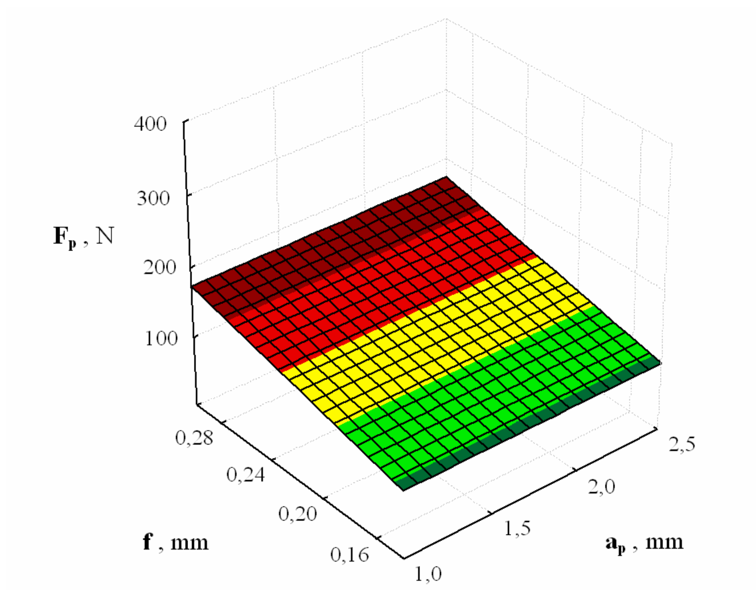

Figure 5 Thrust (passive) cutting force as a function of cutting depth and feedrate ($\kappa_r = 98^o$)

3. Conclusion

Obtained results confirm possibility to control the thrust cutting force with entry angle, what is particularly important when turning lean workpieces (high ratio length/diameter), and thin wall workpieces. However, it should be noted that there is no study of cutting tool temperature, chatter or surface roughness. In situation when cutting tool has significant amount of friction from three sides, and generated heat is almost captured, the complete picture of influence of entry angle is still missing. The generated heat in conjunction with reduced cutting tool cross section (caused with increased entry angle) could significantly reduce tool life, what would, in great extent, neutralize the positive effect of reduced thrust cutting force.

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PROPOSED GENERIC OPTIMIZATION MODEL FOR METAL SANDVICH PLATES

D. Vučina, Ž. Lozina and I. Duplančić

Abstract

The increasing use of metal sandwich structures is based on their desirable properties such as high stiffness and high strength per unit mass with acceptable prices and good overall properties. The objective of this paper is to propose a generic approach for the problem of optimizing the metal-metal sandwiches with corrugated core by treating them as structural elements. The generic model proposed here is a possible way to arrive at optimal structural designs for given conditions. The objective functions and constraints are derived and presented in conceptual- generalized form. This approach could provide designs that demonstrate significant savings in production of the plates, while preserving the necessary properties and load capacity.

It is planned that the proposed model will be solved using nonlinear programming methods including the evolutionary algorithms for several particular cases. The 'product development' cycle also includes the planning of development and manufacturing of several prototypes and experimental testing of some of the designs.

Keywords: metal sandwich plates, optimization model, objective functions, constraints

1. Introduction

The use of aluminum sandwich plates with corrugated aluminum core and glued bonds is attractive with many applications in the industry and construction, as well as interior elements. This is due to the fact that these aluminum sandwiches provide highly desirable properties such as high stiffness per unit mass, acceptable chemical and climatic resistance, relative low mass and price per unit area, very low maintenance costs, relatively simple production technology, favorable visual appearance, etc.

In this paper it is assumed that a small production facility will be established, where the corrugated core will be produced - generated from plane plates using the process of continuous rolling. Therefore, it is furthermore assumed that a process similar to the process of producing gears will produce the shaped rolls or alternatively extruded. As part of this paper, a program that simulates this technological process has been developed to constitute a component within the objective function / constraint functions routines. At this point, the elastic springback effect is disregarded, while an advanced model should include the necessary provision for this geometric correction.

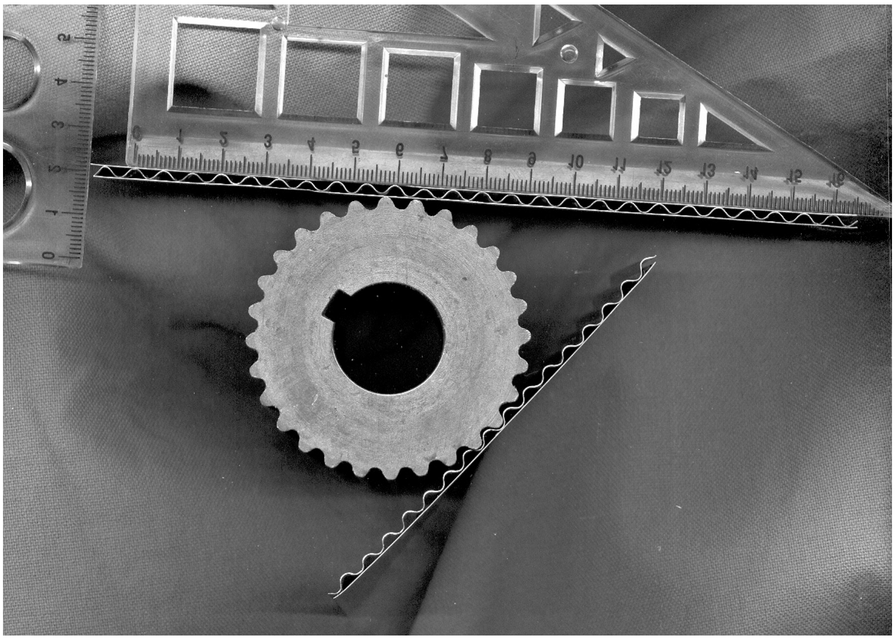

Figure 1. Corrugated core for aluminum sandwiches

2. Problem definition

Let the sandwich plate in general terms be represented as shown in Figure 2. In general, the outside thickness H, load q, and boundary conditions will be given for each particular case. It is also assumed that the sample specimen considered will have a width b.

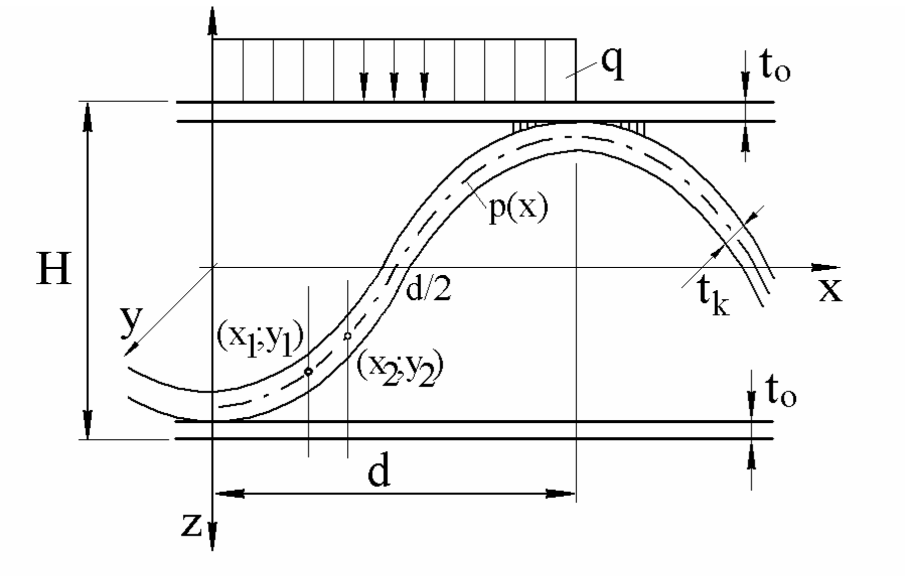

Figure 2. Definition of the metal sandwich optimization problem

2.1 Design variables

As it can be observed from figure 2, the essential basic 'free' design variables for which the optimum values are to be determined are: the thickness of the outside plates, thickness of the corrugated core plate, the 'wavelength', and the shape of the corrugated core plate.

The 'shape' of the corrugated core plate can be mathematically (numerically) described by a set of discrete variables in a number of ways. Amongst several possible interpolation approaches, the method of piece-wise polynomial interpolation with 1--st order continuity is selected here.

Based on this assumption, the following is the selected variables set for the simplified test case problem:

t_o,
t_k,
d,
(x_i , y_i), i=1,mt,
(x_i , y'_i), i=1,mn,

where mt and mn are the number of interpolation conditions (data), function values and slopes, respectively.

2.2 Objective functions

Several optimality criteria can be included in the model in the more general sense of the TCO (total cost of operation). These may include cost of material (aluminum, glue, non-metal inner layers), cost of production, maintenance cost, testing and certifications costs, etc.
However, in this paper, only the cost of aluminum is currently taken into account for reasons of model simplicity:

$$f = 2 \cdot t_o + t_k \cdot \int dl = 2 \cdot t_o + t_k \cdot \int \sqrt{1 + (y'(x))^2}\, dx \qquad (1)$$

where both the values of the integrals, as well as the slopes and curvatures, are evaluated numerically based on the respective current values of the inner corrugated plate shape interpolations, obtained for the current sets of values of optimization variables within the optimization loops.

2.3 Optimization constraints

While many other constraints may exist, the conditions considered in this paper at this point include the constraints that need to be imposed for reasons of sufficient load capacity and technological conditions. Some of the constraints at this point are modeled using relatively simple approximations.

The current constraint set:

- sufficient structural strength and buckling resistance of the outer (o) plates

$$\sigma_o \le \sigma_M \qquad (2)$$

$$p_o \le p_{cr} \qquad (3)$$

- sufficient structural strength and buckling resistance of the inner (i) corrugated plate

$$\sigma_i \le \sigma_M \qquad (4)$$

$$p_i \le p_{cr} \qquad (5)$$

- sufficient structural strength of the glued bonds (b) between the outer plates and the inner corrugated plate

$$\sigma_b \le \sigma_{M,b} \qquad (6)$$

- minimum possible (K_1) radius of curvature of the function p(x) in arbitrary points for reasons of technological feasibility and manufacturability of the corrugated plate, typically manufactured in hardened material condition

$$p''(x) \ge K_1 \qquad (7)$$

- minimum necessary (K_2) radius of curvature of the inner corrugated plate at the locations of the bonds with the outer plates, for reasons of sufficient length of glued joints (load capacity of glued bonds), also related to the maximum thickness of the glued bonds

$$p''(x_b) \geq K_2 \tag{8}$$

- technological manufacturability of the inner corrugated plate using the process of shaped rolling (similar to manufacturing gears), i.e. manufacturability of the corresponding profiled rolls using the corresponding process. This conditions is also a constraint against the blocking (locking) of gear teeth during operation - manufacturing of corrugated core

$$conditions\{p''(x)\} \tag{9}$$

The geometry will be considered symmetric with respect to the x=0 plane and the x=d/2 line, which also makes sandwiches with assemblies of multiple inner layers possible.

3. Optimization model

The problem is considered to be one of multivariable nonlinear programming with constraints and modeled accordingly, lit. [1], [2], [3], [8], [10]. In its general form, the model should include optimization procedures functionally coupled with structural analysis (i.e. finite element analysis) which is needed in the constraint functions. This coupling actually requires structural analysis within all optimization loops. Other numerical methods such as numerical integration are needed for objective function evaluations.

However, in the first models, optimization and structural analysis will be decoupled for reasons of simplicity. Constraints will be built upon corresponding approximate formulas for buckling and bending from the literature [4], [5].

It is planned to develop the coupled models in the follow-up stage. It may also prove feasible to use the strategy of performing structural analysis cases with different sets of data with the purpose of training a neural network to represent the constraint functions, resulting in decoupling structural analysis from optimization loops.

The actual test-case is shown in Figure 3.

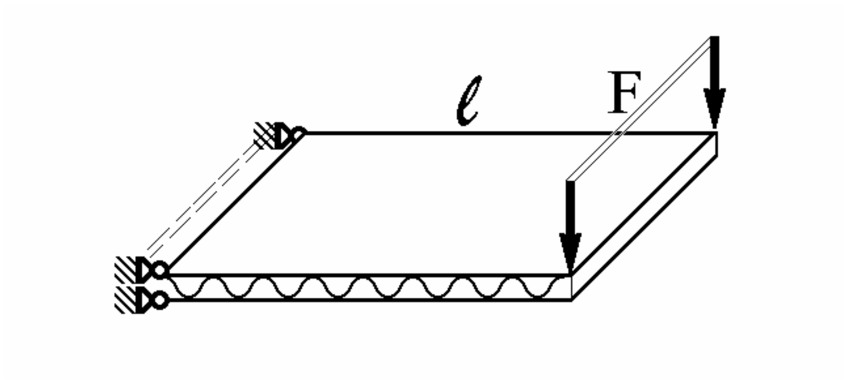

Figure 3. Test case for the metal sandwich optimization problem

4. Implementation of optimization strategy

The following flowchart of the vertical optimization process flow and horizontal model functional units is implemented, as shown in figure 4:

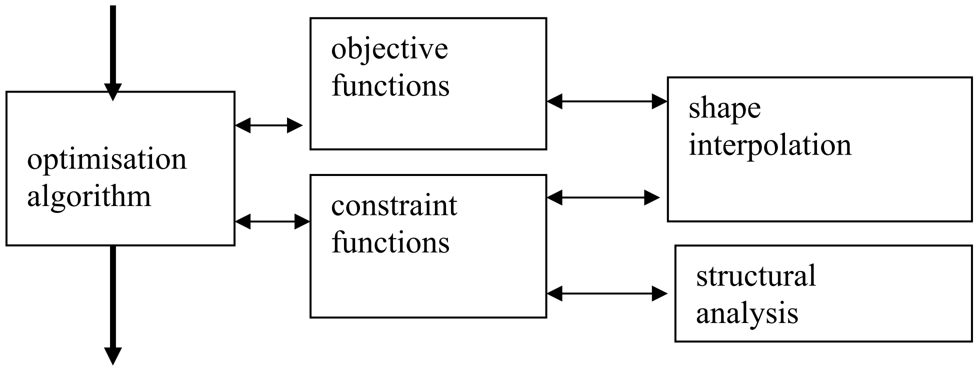

Figure 4. Main functional blocks in the optimization of metal sandwich plates

5. Conclusions

The increasing application of metal sandwich plates in many areas due to their superb properties demonstrates the need for design optimization of the plates based on the particular conditions. In this paper, a generic approach to the design optimization problem of the sandwich plates is presented. A possible generic model for optimization is proposed, and several possible optimization options are discussed.

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CUTTING FORCE ESTIMATION FOR BALL ENDMILLS BASED ON MULTILAYER NETWORK

U. Župerl and F. Čuš

Abstract

This paper uses the artificial neural networks (ANNs) approach to evolve an efficient model for estimation of cutting forces, based on a set of input cutting conditions. Neural network algorithms are developed for use as a direct modeling method, to predict forces during end milling operation. A set of nine input variables is chosen to represent the machining conditions. The extensive experimentation is conducted to train the model and to validate it. Model is tested for a typical machining scenario found in modern flexible production. The predictive capability of using analytical and neural network approaches are compared using statistics, which showed that neural network predictions for three cutting force components were for 8% closer to the experimental measurements, compared to 11% using analytical method. Future work should involve extending the predictive force model to include the dynamic effects of the process in order to predict chatter, surface finish, tool wear etc.

Keywords: End milling, cutting forces, neural network.

1. Introduction

Ball-end milling cutters have been used extensively in CNC machining of critical parts in the aerospace and motor industries. The cutting forces that are developed during the end milling process, can directly or indirectly estimate process parameters such as tool wear, tool life, surface finish, etc. The capability of modeling cutting forces therefore provides an analytical basis for machining process planning, machine tool design, cutter geometry optimization, and on-line monitoring/control. A large amount of work has been carried out on force modeling. These modeling methods can be divided into three types: Experience modeling, plasticity modeling, and geometry modeling [4]. As the machining process is nonlinear and time-dependent, it is difficult for the traditional identification methods to provide an accurate model. Compared to traditional computing methods the artificial neural networks (ANNs) are reliable, accurate and global. Researchers [5], in their ANN implementations, evolve knowledge of the machining environment by training these networks on run-time data.

2. Presentation of the experimental equipment

In order to develop the cutting force component model, experimental results were used. The three components of cutting force were measured with a piezoelectric dynamometer (Kistler 9255) mounted between the workpiece and the machining table. The force measurements were sampled at 20000 points/second, and then digitally low-pass filtered at a cut-off frequency of 250 Hz to eliminate the high-frequency components resulting from the machine tool dynamics. The experiments with the copy end milling cutter were carried out on the NC milling machine (type HELLER BEA1). Material Ck 45 and Ck 45 (XM) with improved machining properties were used for tests. The ball-end milling cutter with interchangeable cutting inserts of type R216-16B20-040 with two cutting edges, of 16 mm diameter and 10° helix angle was selected for machining of the material. The cutting inserts R216-16 03 M-M with 12° rake angle were selected. The cutting insert material is P30-50 coated with TiC/TiN, designated GC 4040 in P10-P20 coated with TiC/TiN, designated GC 1025. The coolant RENUS FFM was used for cooling. The cutting tool flank wear was measured with an instrument microscope of 0.01 mm accuracy. The data acquisition package used was LabVIEW. The set up can be seen in Figure 1. The experiments were carried out for all combinations of the chosen parameters, which are radial/axial depth of cut, feedrate, and spindle speed. Other parameters such as tool diameter, rake angle, etc. are kept constant.

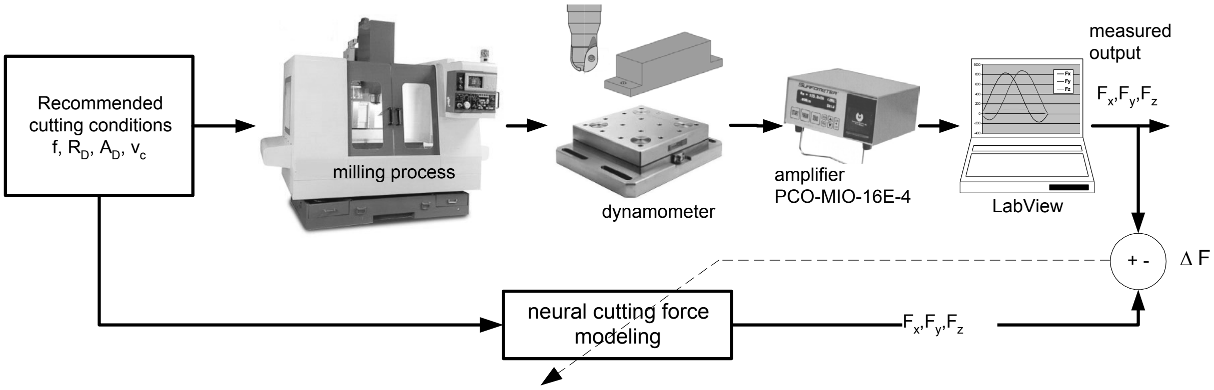


Figure 1. Experimental set-up and general learning architecture

Three values for the radial/axial depth of cut have been selected for use in the experiments: R_{D1} = 1d, R_{D2}=0.5d, R_{D3}=0.25d; A_{D1} = 2mm, A_{D2}=4mm, A_{D3}=8mm; d- cutting parameter (16 mm). In the experiments the following values for feedrate have been selected: f_1= 0.05 mm/tooth, f_2= 0.2 mm/tooth, f_3= 0.4 mm/tooth. Three values of spindle speed have been selected: v_{c1}=125min^{-1}, v_{c2}=185min^{-1}, v_{c3}=250min^{-1}.

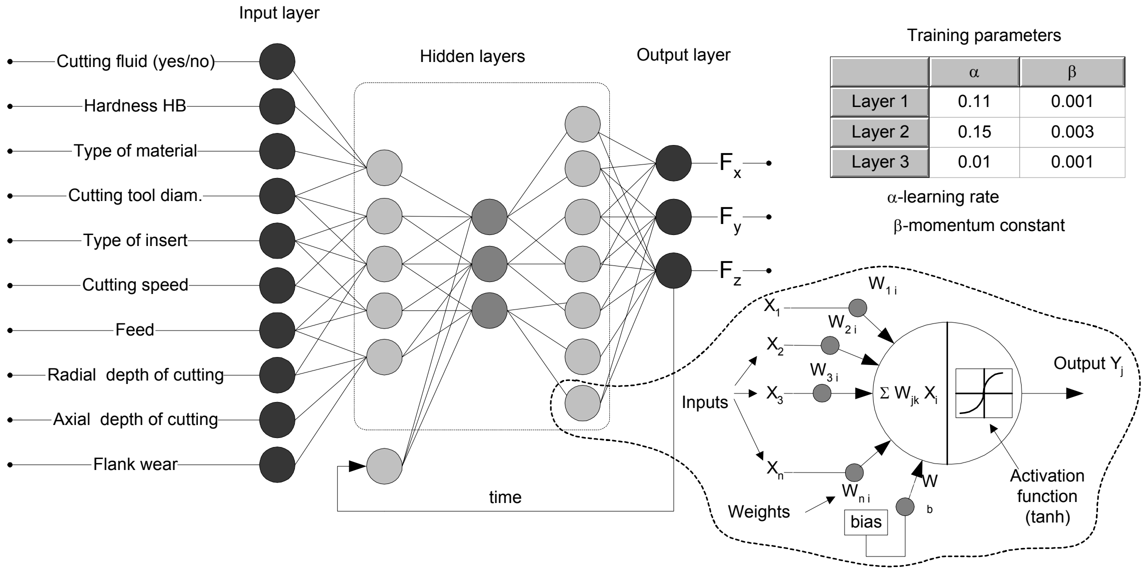
3. Predictive cutting force modeling

Artificial neural networks consist of a large number of processing elements, called neurons that operate in parallel. Computing with neural networks is non-algorithmic. They are trained through examples rather than programmed by software. Detailed information concerning artificial neural networks can be found in [2], [3]. The Multi-Layer BP network is a supervised, continuous valued, multi-input and multi-output feedforward multi-layer network that follows a gradient descent method.

The gradient descent method alters the weight by an amount proportional to the partial derivative of the error with respect to the weight in question. The backpropagation phase of the neural network alters the weights wji so that the error of the network is minimized.

This is achieved by taking a pair of input/output vectors and feeding the input vector into the net which generates an output vector, which is compared to the output vector supplied, thus gaining an error value. The error is then passed back through the network (backpropagation process), modifying the weights due to this error using the equations. Hence, if the same set of input/output vectors are presented to the network, the error would be smaller than previously found. For modeling the cutting force components, three-layer feed-forward neural networks were used (Figure 2). They contained 10 neurons in the input layer, and three in the output layer. The number of neurons in the hidden layer was varied in different experiments.

The detailed topology of the used ANN with optimal training parameters and mathematical principle of the neuron is shown on Figure 2. The ANN were trained with the following parameters: type of machined material, hardness of the machined material, cutting tool diameter, type of insert, cutting speed, feed, radial and axial depth of cutting, tool wear and the presence of the cutting fluid.



	α	β
Layer 1	0.11	0.001
Layer 2	0.15	0.003
Layer 3	0.01	0.001

Figure 2. Predictive force model topology

Network training involves the process of interactively adjusting the interconnection weights in such a way that the prediction errors on the training set are minimized. The back- propagation algorithm is applied to each pattern set, input and target, for all pattern sets in the training set.

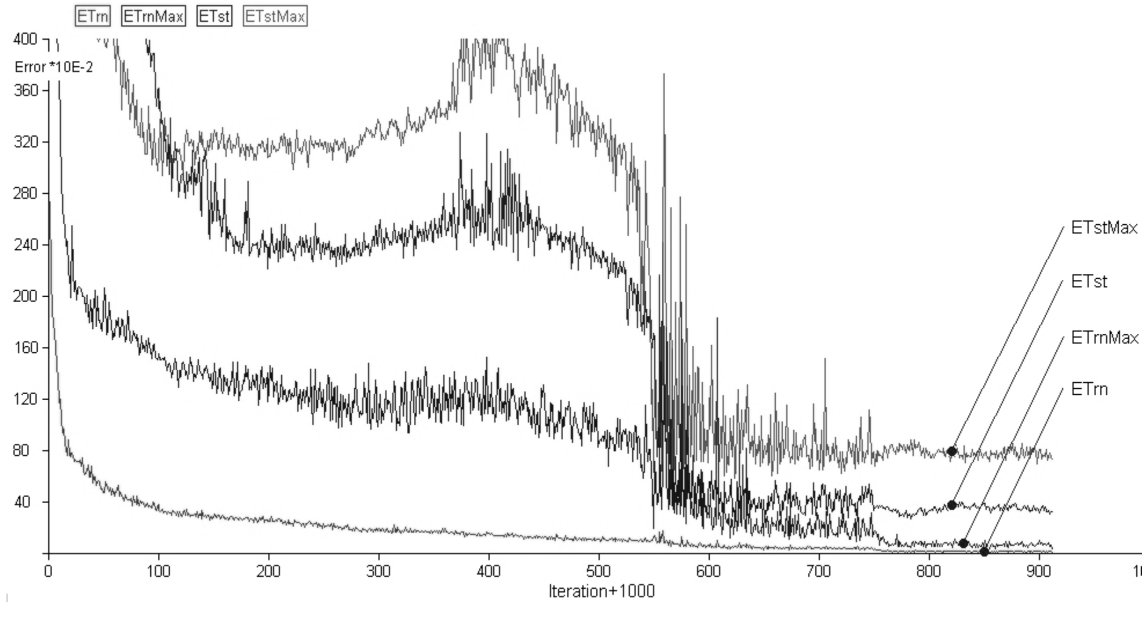


Figure 3. Decrease of errors during supervised training of neural network

Since the learning process is iterative, the entire training set will have to be presented to the network over and over again, until the global error reaches a minimum acceptable value. The basic goal in training any neural network is to minimize the overall error of the network. Matlab Network Tool Box and Thinks-Pro software were used as a platform to create the networks.

Figure 3 shows the uniform falling of the value of all errors (ETst, ETstMax, ETrn, ETrnMax) with the number of iterations during the training and testing process for described network configuration (Figure 2). The smallest error of testing (ETst) is reached at iteration 1780. It can be seen in the Figure 3 that errors converge not to zero but to 0.04 (4%). This is caused by the presence of some contradicting examples in the training set. The prediction of a network trained with tanh transfer function and optimum parameters of 7-6 hidden nodes, learning rate (0.1) and a momentum rate (0.001) are shown on Figure 4.

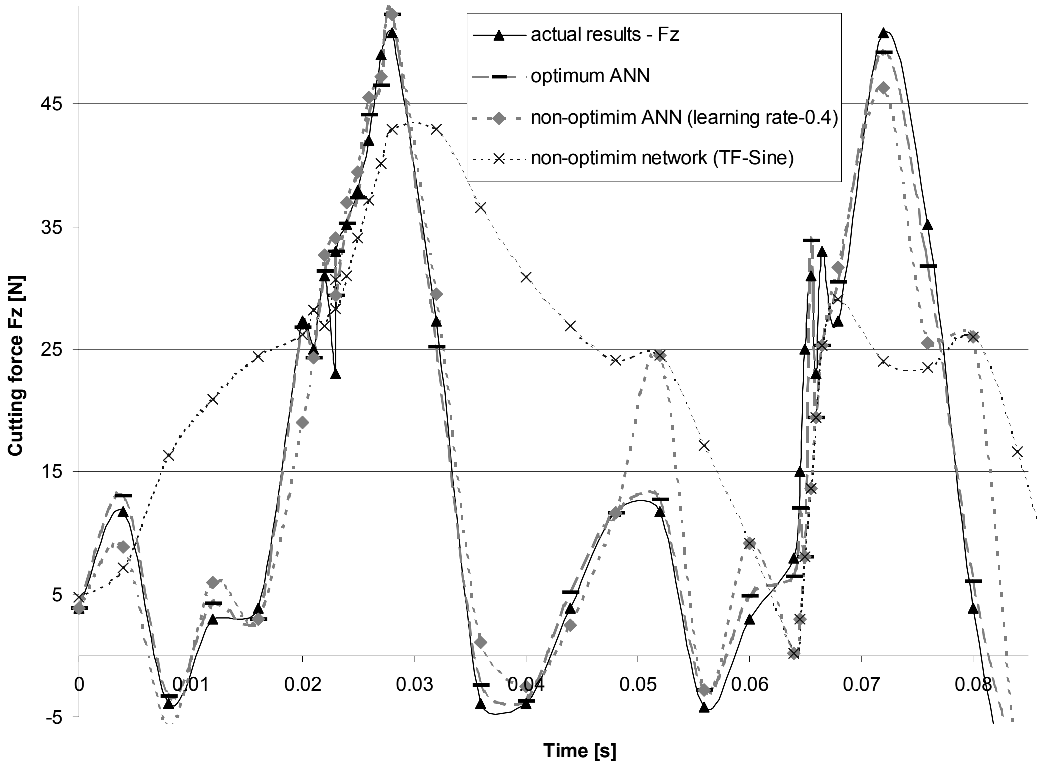


Figure 4. Prediction of the maximal cutting force component (Fz) using networks trained with optimum and non-optimum parameters

The predictions of a non-optimum networks with non-optimal parameters are also shown in the same figure. The ANN registers the input data only in the numerical form therefore the information about the tool, cutting insert and material must be transformed into numerical code. The type of the cutting insert is indicated with a 8-digit systematization code containing the data on the cutting insert shape, rake angle, free angle, tip radius, base material, cutting insert coating and length of the insert cutting edge.

4. Discussion of results

Verification experiments are conducted to evaluate feed forward and Radial Basis networks. It is found that the Radial basis network is superior. The radial basis neural networks require more neurons than the standard feed forward neural networks with the Back Propagation (BPN) Learning Rule, but conceiving of radial basis neural networks lasts only a part of time necessary for training of the feed forward network. The feed forward neural networks give more accurate results, but they require more time (70%) for training and testing. An extensive number of tests were made on the milling machine to confirm the neural model with different cutting parameters.

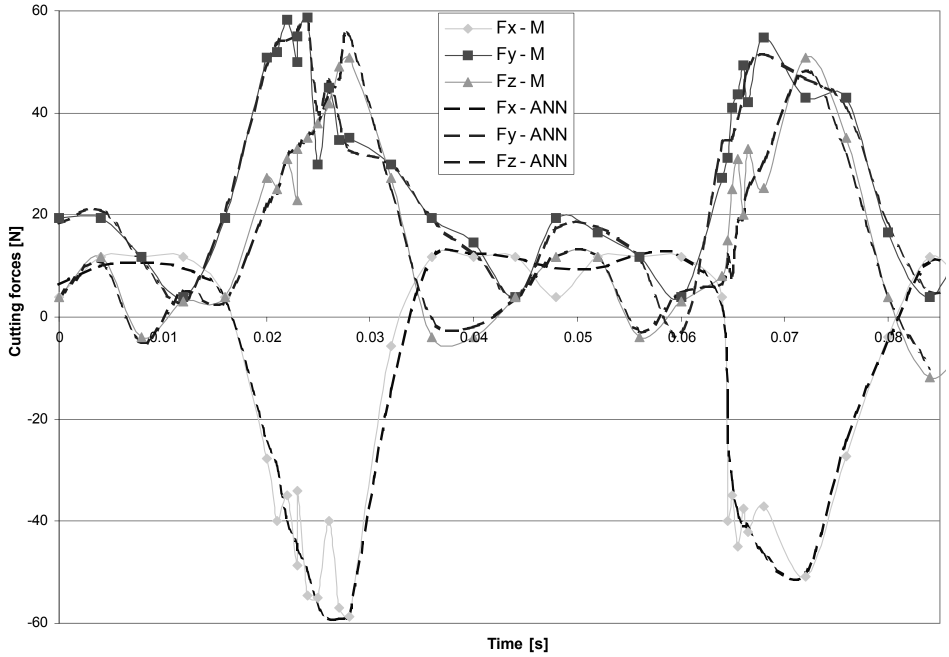


Figure 5. Representation of measured (Fx-M, Fy-M, Fz-M) and predicted (Fx-ANN, Fy- ANN, Fz-ANN) cutting forces. Copy-end milling cutter R216-16B20-040, cutting insert R216-16 03 M-M GC 4040, material Ck 45, milling width R_D=4 mm, milling depth A_D=2 mm, feeding f=0.05 mm/tooth and cutting speed v_c=125 min^{-1}

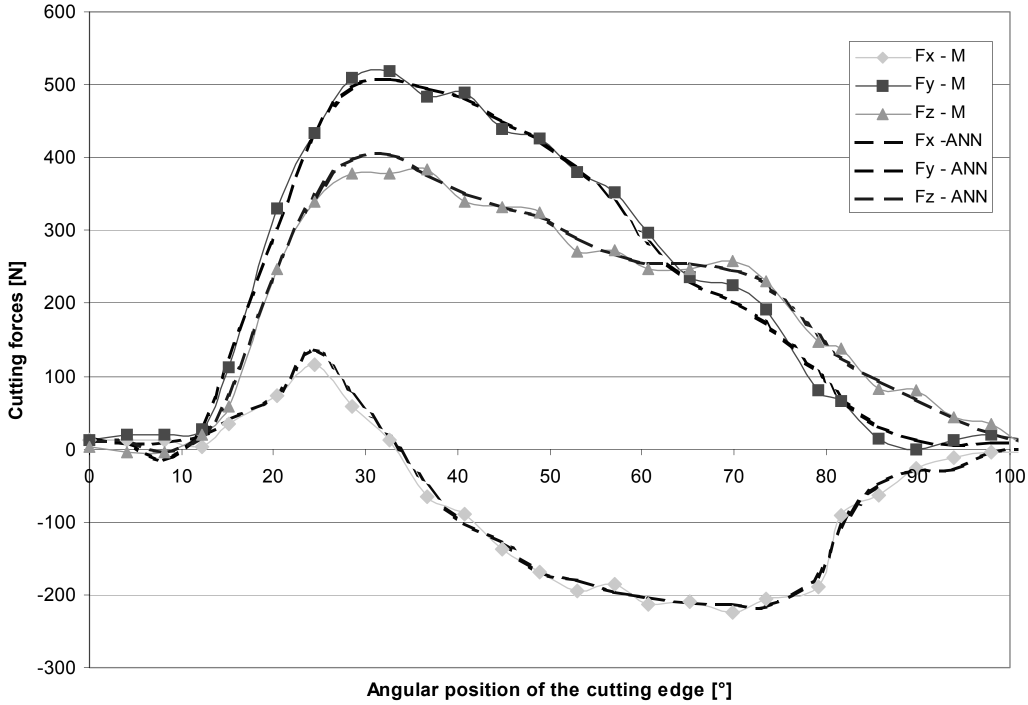


Figure 6. Representation of measured (Fx-M, Fy-M, Fz-M) and predicted (Fx-ANN, Fy- ANN, Fz-ANN) cutting forces. Copy-end milling cutter R216-16B20-040, cutting insert R216-16 03 M-M GC 4040, material Ck 45, milling width R_D=8 mm, milling depth A_D=2 mm, feeding f=0.4 mm/tooth and cutting speed v_c=125 min^{-1}

This chapter presents the results of experiments and the comparison and analysis of results between the experimental and ANN model depending on the cutting parameters. The results and/or the values of cutting forces are graphically represented by means of diagrams depending on the angle of rotation of the milling cutter (Figure 5 and 6). By comparing the results predicted by ANN with the results of experiments the following was established: the values from prediction coincide well with the values from experiments and in addition, the process of the change of the cutting force with respect to the angle of rotation of the milling cutter and the amplitude agree well. Figure 5 shows the comparison of the predicted forces and the measured forces. Also the comparison of maximum values of the cutting forces from simulation with the experimental values in case of different cutting conditions was made.

5. Comparison of the neural network-based model to the analytical model

In this paper, supervised neural networks are used to successfully estimate the forces developed during end milling process. The comparison between the predicted cutting forces and measured cutting forces was made [1]. It can be claimed that the comparison of the results obtained from the neural model and of the experimental results confirms the accuracy of the model for predicting the cutting forces. By using a multi-layer perceptron with backpropagation training method, the neural network is trained to an accuracy of ±2% error for all three forces. In testing the model, the three force components in oblique cutting were predicted to an accuracy of ±4%. An effort is made to include as many different machining conditions as possible that influence the cutting process. Due to high speed of processing, low consumption of memory, great robustness, possibility of self-learning and simple incorporation into chips the approach ensures estimation of the cutting forces in real time. Future work could be directed to application of other preference models and neural networks to machining process optimization and extension of the proposed approach to adaptive control of machining operations or on-line adjustment of cutting parameters based on information from sensors.

6. Conclusion

In this paper, supervised neural networks are used to estimate the forces developed during end milling process. The comparison between the predicted cutting forces and measured cutting forces was made. It can be claimed that the comparison of the results obtained from the neural model and of the experimental results confirms the efficiency and accuracy of the model for predicting the cutting forces. In testing the model, the three force components in oblique cutting were predicted to an accuracy of ±4%.

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INTERNET ORIENTED PROCESS PLANNING

P. Ćosić, A. Levanić and D. Kosić

Abstract

This work is a part of the project creating the technological database and e – lectures necessary for improvement of education of process planning and connection database (MySQL) and PhP by Internet environment. Here we have elaborated few problems of variants of machining in process plans, selecting tool machines and manufacturing processes on the basis of the chosen criterions. We have indicated the problems of selection and the possibility of working out a solution. We have especially emphasized interactions between cutting conditions of tools, part (geometry, raw material, dimensional accuracy, geometric tolerances, surface finish), chucking type, batch of size, time (machining time, down time), and production costs through process of machine tools selection.

Keywords: Database, Internet, Process Planning.

1. Introduction

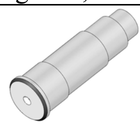
Process planning determines how a product is to be manufactured and is therefore a key element in the manufacturing process. In spite of the importance of process planning in the manufacturing cycle, there is no formal methodology, which can be used, or can help to train personnel for this job. Process planning activities are predominantly labor intensive, depending on experience and the skill and intuition of production labor**.** As different process planners have different experience, it is not wonder that for the same product, different process planners will create different processes. The experienced process planner usually makes decisions based on comprehensive data and intuition without thinking about individual parameters. There is *no time* to analyze the problem, and the result is an empirical solution without justification. On the other hand, understanding and a methodic thinking flow will improve the performance of the process planner. Creation and analysis of different process plans can improve process planning by fast and simple calculation of machining time and costs.

2. Selection of Manufacturing Processes

The basic characteristics of manufacturing processes provide sufficient detail for selection of processes at the conceptual or embodiment stages of design. In a very general sense the selection of a material determines a range of processes that can be used to produce parts from the material. The main characteristics are *shape factors* (two-dimensional, three dimensional, sheet, and bulk, etc.), *process factors* (cycle time, quality, flexibility, materials utilization, operating cost). The array of manufacturing processes is vast and is not easily fitted into a few charts or tables [1, 4]. When process choice is based on the individual's knowledge, close familiarity with one process or one class of processes can led to premanture process choice. Once technical feasibility is established, process choice is further narrowed by cost and availability.

The decision tables give general guidelines only and are based on good standard practices. Each table has *characteristics of part* (material, shape, size of part, minimum section, minimum hole diameter, surface detail, uniformity of cross, section thickness, dimensional accurracy), *cost* (equipment, die, labor, finishing), *production* (operator skills, lead time, rates, pieces/machine, minimum quantity or length) for different processes. As the example we discuss different variants of process plans for forged and rolled raw material, case of workpiece spindle (Table 1, Table 2).

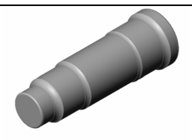
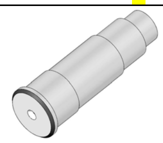
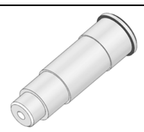
Table 1. Main phases of spinndle machining Variant 1 – 3D main shape change, raw material as rolled part

Phase	3D Picture	Phase	3D Picture	Phase	3D Picture
10/30	 cutting off 1	30/20	 turning θ 65x190 2	30/30	 turning θ 58x181,3 3
30/40	 turning θ 55x141,3 4	30/50	 turning θ 50,7x64,3 5	30/60	 turning θ 40,5x24,5 6
30/70	 turning θ 40x25 7	30/80	 turning θ 50,2x39,8 8	30/90	 turning θ 55,2x76,8 9
30/100	 turning θ58,2x38,8 10	30/110	 turning edge 3/45º 11	30/120	 turning edge 2/45 12
30/130	 turning on θ 58 13	30/140	 turning on θ 55 14	30/150	 turning on θ 50 15
30/160	 turning on θ 40 16	30/170	 cutting screw threads M 40x1,5 17	40/30	 milling on θ 58 18
40/40	 milling on θ 50 19	50/30	 grinding θ50j6x40 20	50/40	 grinding θ55k6x70 21
50/50	 grinding θ 58j6x40 22	**END**	 **finished part spindle 23**		

3. Process Planning

Process planning determines how a product is to be manufactured and is therefore a key element in the manufacturing process. It is one of the most important parts in determing the cost of components and affects all factory activities, company competitivenesses, production planning, production efficiency and product quality. A huge amount of preparation work has to be carried out before final decisions about a manufacturing plan are taken. Process planning can be defined by a *sequence of activities.*

Table 2 Main phases of spindle machining Variant 2 – 3 D main shape change, raw material as forged part

Phase	3D Picture	Phase	3D Picture	Phase	3D Picture
	 **Forged part**	10/30	 milling and drilling of the ends 1	20/30	 turning (rough) 2
20/40	 turning (fine) 3	20/50	 turning edge 3/45° 4	20/60	 turning edge 2/45° 5
20/70	 turning on θ 58 6	20/80	 turning on θ 55 7	20/90	 turning on θ 50 8
20/100	 turning on θ 40 9	20/110	 cutting screw threads M 40x1,5 10	20/120	 milling on θ 58 11
20/130	 milling on θ 50 12		 **finished part spindle**		

3.1 Methodology of Process Planning

Process planning determines the sequence of operations and utilization of machine tools, cutting tools, fixtures, gauges and the other accessory. Feeds, cutting speeds, RPM, depth of cut, number of passes, tool angles, lubrication and other machining parameters of the metal cutting are determined. The machining parameter values for each operation and phases are calculated to practical values or from experience. The recommended process is not only a result of the process planner's experience, but also an outcome of the sequence of decisions made. Using classification of basic processes by shape of part groups, surface roughness range of basic processes, conversion of dimension tolerance to surface roughness, geometric tolerances capability of basic processes, accuracy of primary basic processes and manufacturing costs, process planner can select type of primary process (raw material in rolled or forged shape in our case **Table 1, Table 2**).

3.2 Sequencing the Operations

The operations defined in process planning have to be put in certain order according to precedence relationships based on technical or economical constraints. Operations sequencing depends on many influences like: a) nature of the material, b) general shape of the part, c) required level of accuracy, d) size of the raw material, e) size of the batch, f) possible choice of machine tools and tools, etc [5, 6]. To achieve the nominated goal for definition of sequencing the operations is very complicated, multi-level, particular problem. Therefore, the expected difficulties in the process of solving this problem can be: a) pattern recognition, b) selection of datum, c) connection between machining surfaces and type of operations, machining tools, tools, positioning and work holding, etc.

3.3 Variants of Machining in Process Plans

Process of solution selection between possible process plans (rolling, Table 1 or forging Table 2 as the primary process for the spindle workpiece, different machining conditions, times and costs) can guide the user toward the best result (Fig. 1). Here we emphasized the role of the selected primary process on the machining time. Machining time for the forged and rolled raw material, for the mentioned case, is (turning operation) (Table 3):

Table 3 Comparison for two variants of turning

Primary process	Machining time
rolling	6,48 min
forging	5,69 min
Difference (%)	12,19 %

4. Machine tool and tools selection

For the criteria of selection machine tools we have chosen: in the first phase the *way of tightening and processing*, the *required quality of the treated surface*, *the dimensions of the work piece* and the *technological data*, including performance (n, s, P) which together form the basis for further elaboration in the following phases of the database development. All selected machine tools have possible intervals of cutting condition values (feeds, cutting speeds, revolutions per minute). The values which would be outside of the mentioned intervals would be red colour (**Fig. 1**).

As the first, we choose between the basic turning (*longitudinal and transversal turning, conical turning, sphere turning*, etc.) and additional turning (*groove turning, cutting screw threads on the lathe, cutting off, etc*.) on the basis of the *geometrical shape of the product*. This application displays the descriptive and the pictorial illustration of the processing so that the user decides for the shape best corresponding to his own product.

By choosing a way of turning (internal or external) the window based on the multiple choice questions opens (**Fig. 1**. The questions referred to the *way of tightening*, to the *required quality of the treated surface* and to the *basic and additional processing*. It is important to stress that it is possible to choose only one from the given options about the way of tightening (tightening 3 or 4-jaw universal chuck with hard or soft jaws, segmented head, etc.) [3].

Furthermore, geometrical properties of the machine tools would be next step in the selection process (max. radius of turning, max. length of turning, etc).

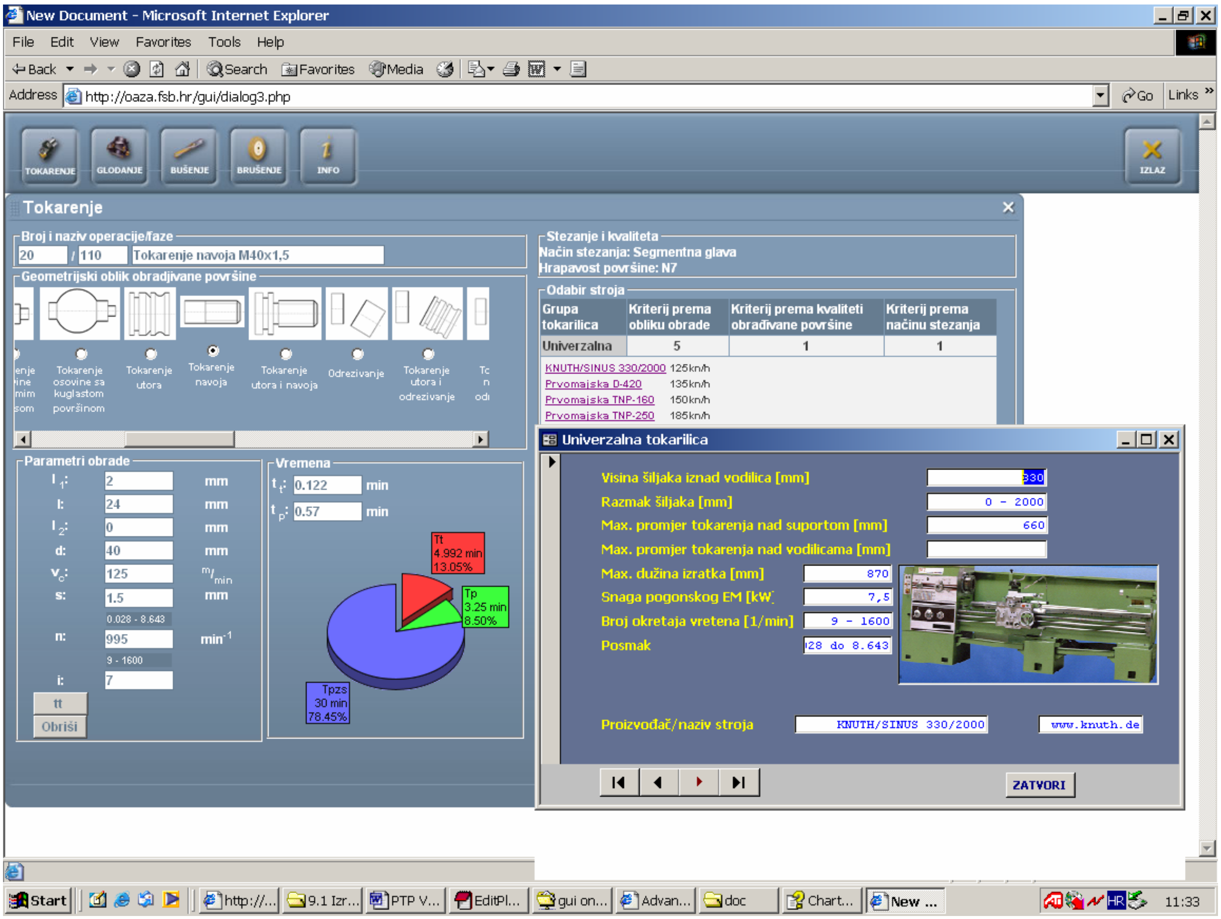


Figure 1. Calculation of machining conditions and times, selection of machine tools; Case - machining spindle (operation turning 20 /110 phase cutting screw threads)

Size of the batch influences very critically the choice of machine tools and associated equipment. So, we come to the *final choice* of the machine through *economic analysis*, which consists of the synthesis of the price of the machining work (price of machine tool, profit rate during a given period of time, the price of the human resource, indirect expenses) and the price of the tools.

The outcome of the first phase is the display of the *resulting groups of the machines* with the ponderated values of the criteria (excellent - 5, very good - 4, good - 3, accepted - 2). From the window of the tool machine displayed in the **Figure 1**, which is the machine identification map, we can see the data about the manufacturer, the type of the machine, the number of revolutions and feed, and other data necessary for the formation of the technological process together with its pictorial and schematic representation.

5. Estimation of machining time and costs

Calculation of the direct machining times, preparation times for batch size, times necessary for machining each member of the batch size is very important for the selection of the best variant of the process plans. In the near future, the next step of the program solution, calculated times would be direct result of the selected tools (and cutting conditions for each operation). With all calculated times and cost per hour for every selected machine tool we can very fast calculate manufacturing costs for every variants of process planning. Graphical review of the direct machining times (T_t)(chart pie **Fig. 1**) represent preparation time (T_{pzs}) for the whole batch size and the cumulative value of the direct machining times (T_t) and adjusting times (T_p) for each member of the batch size in the observed operation (until phase 20/110 cutting screw threads).

6. Conclusion

The considered work presents the development of the variants of the technological process through the criteria of selection, the mechanism of processing, logical approach and database. The accent is placed on the selection of the tool machines with the use of the ponderable criteria of selection (selection of the primary manufacturing process, the way of tightening and processing, the quality of the treated surface, depth of cutting, conditioned by the geometry of the workpiece, the dimensions of the part, the cutting data, the times and costs of the operations processing).

Next phase of project would include implementation criteria of selection in decision support and ponderable multiple solutions of process plans variants for automatic generating variants of process plans.

Acknowledgement

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CREATION OF VALUE IN THE NEW ECONOMY: PRODUCTION OF PHYSICAL OBJECTS VS. INFORMATION

Ž. Dulčić, N. Alfirević and S. Lugović

Abstract

In this paper, authors first discuss the traditional concepts of strategic management related to the creation of value. Special importance is paid to Porter's theory of value chain, which is associated with the production of physical objects, i.e. conventional industrial processes, stretching from inbound to (after-sale) service. At the other hand, development of information & communication technologies (ICTs) enables the enterpreneurs to move 'beyond' the physical world and create value by (dis)mediating information. The authors discuss how 'virtual production' (i.e. production of information) creates new value and review the relevant recent theories that can be applied to the 'virtualization' of the production process and creation of value in the 'cyberworld'.

Keywords: New economy, Production of information, Value chain, Value constellation, Virtual value chain.

1. Creation of value in 'traditional' production processes

Porter [5] introduces the concept of **value chain,** in order to describe the enterprise as a *"collection of activities that are performed to design, produce, market, deliver and support its product"* (p. 36). Regardless of the nature of the production process, the notion of an industrial enterprise, as illustrated by the value chain (illustrated by Figure 1), reflects the flow of tangible inputs (inbound logistics) into the production process, which are processed through a sequence of subsequent operations, in order to form the final product. The product is, then, distributed through the distribution chanell (outbound logistics) and sold, which is followed by performing after-sale service (if such is required by the customers). The flow of these activities, referred to as the 'primary' ones by Porter, determines the nature of the production process.

However, there are also other activities that have to be performed by a commercial organization. Although not directly involved into handling the tangible artifacts of the production process, such – 'support' activities – are an essential prerequisite for the efficient completion of the 'actual' production. Those include administrative and managerial activities, purchasing/procurement, managing employees and developing new technology and products [5].

The support activities could be, sometimes, considered as not contributing enough to the overall creation of value in the enterprise, as they do not produce tangible outputs, but rather handle information. Such a statement does not need to be elaborated much, as the information-processing activities are, in an 'Old economy' business organization, often described in terms of 'overhead'. However, even the 'conventional' strategic management theory emphasizes the fact that the indirect/overhead costs are frequently closely associated with the direct ones, as well as with the opportunities to achieve differentiation [5].

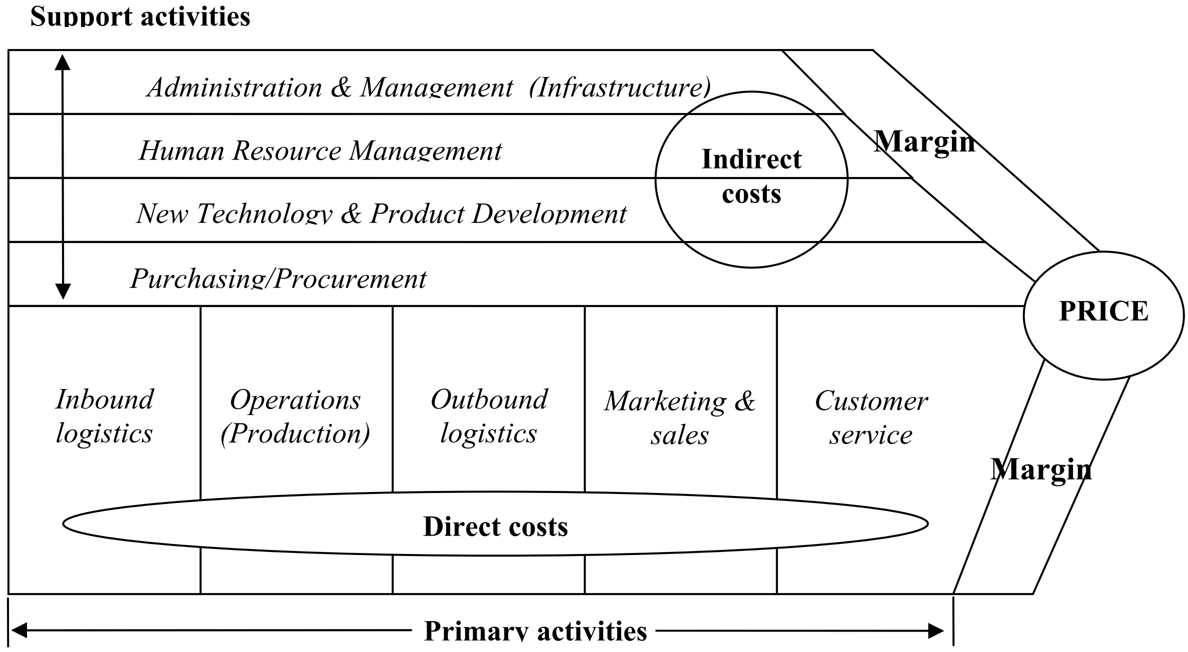

Figure 1. Porter's concept of value chain (Source: Adapted from Porter [5], p. 37)

Although the conventional value chain serves as a valuable tool both in all kinds of business environments, some special considerations may be applied to a new form of production processes, that have emerged in the beginning of 1990s.

2. Creation of value in the 'New economy'

2.1 The disillusionment of e-business

The last two decades of the 20th century have brought about the development of many impressive technologies that have (re)shaped the world of business. Some of those include: flexible (numerically-controlled) machines, Computer-Aided Design/Manufacturing (CAD/CAM), product labeling with bar code (UPC/EAN), etc. Although it is difficult, or even impossible, to single out *the* technology with the most significant impact to the contemporary business, the 'large-scale' introduction of the Internet into the business world has certainly received most of the 'media hype'.

In the 1999-2000 period, the Internet-based businesses ('dot.coms') had attracted large amounts of venture capital and were believed to have the potential to replace the sluggish 'Old economy' enterprises, that have confined their operations to the physical world. The basic idea behind the 'dot.coms' is simple: production and distribution of physical objects (products) can be replaced, at least to a certain extent, by production and dissemination of information. Ultimately, such a business orientation implies transferring part of the conventional value chain to the 'cyberworld'.

The idea of virtual creation of value is reaffirmed by one of the most popular definitions of 'e-business' (electronic business), stating that such a form of economic activity is based on the exchange of information between stakeholders (parties involved into the business processes) in the electronic (i.e. computer-mediated) environment [3].

Although human race will need to satisfy majority of its needs by consuming physical/tangible products, conducting business in the electronic environment enables companies to **separate the two parts of its value chain, i.e. to break up the link between the support and primary activities.** Many authors have already discussed different aspects of e-business and dot.com operations, but the idea of separating the 'upper' and 'lower half' of the conventional value chain still seems to be rather new and unexplored.

The e-business is not a 'hot topic' since the 'dot.com crash' of 2000/2001, when a series of banktrupcies and stock devaluations hit hard on the U.S. dot.coms, dissapointing both the investors and the media/consultants/academics heralding the coming of the 'New economy', based on entirely new rules [1]. Although many principles/rules proclaimed to rule the behaviour of enterprises in the 'New economy' have proved to be nothing more than wishful thinking [1], in 2004, the underlying rule(s) of the (new ?) manners of value creation seem(s) much more transparent than five years ago.

2.2 Shifting of the value chain and the underlying value drivers

Many successful contemporary enterprises use **outsourcing,** i.e. contract out one or more of its 'non-strategic'/'peripheral' activities, in order to concentrate on the 'core' aspects of its operations, which are considered to contribute to/create/sustain competitive advantage. Nevertheless, some authors [8] believe that the outsourcing is not just a business tool/methodology, but rather one of the underlying principles of creating value in the 'New economy'.

Namely, under the adage *"Everything is a service !",* Rifkin [8, p. 73] articulates the idea that, in the 'New economy', **the physical products become less valuable than the knowledge- or communication-based services attached to them.** Furthermore, the same author asserts that the very development of the 'post-industrial' society inherently supports the process of replacing physical property by securing access to networks of premium services, which may (or may not) be associated with renting, leasing, or even obtaining for free the actual/physical product serving as a 'container' for the service. For instance, cellular phones may be given away as the incentive to use a certain telecommunication service; a (printed) book might be converted into an 'e-book', accessible over the Internet, for a fee; possession of a car, weekend house, or even – the own home, can be replaced by a favourable long-term lease, renting and/or time-sharing agreement, etc. [8].

Consequences of such arrangements are manifold. At one hand, consumers are offered convenience of possessing access to the physical objects/products required to satisfy their needs/requirements, without having to worry about depreciation of their initial investment into the object and/or the maintenance costs. In the fast-moving world, it might be much more beneficial to have the access to the most contemporary technology (embodied in a car, notebook computer, DVD player…), instead of owning a piece of 'hardware', requiring continuous maintenance and depreciating so quickly that it can not be (re)sold after several years of utilization. This trend is corresponding to the idea that the future of the 'post-industrial' society can be perceived as a 'netocracy', in which the members of the power wlite will be defined *"by the fact they manipulate information, rather than managing property or producing goods"* [2, p. 132].

At the other hand, the most successful enterprises could be enticed to strip away all the 'unnecessary' physical assets and concentrate on the 'pure intellectual capital'. Some of the recent relevant examples include moving of the **non-strategic/'peripheral' activities** (such as: producing the physical products, providing customer support over telephone, manually entering data into the computer systems, etc.) into the developing Asian countries, providing adequate workforce at a relatively low cost. Therefore, the most venerable examples of the 'New economy' are **not** "Business-to-Consumer" Internet-based retailer, such as Amazon.com, or even the business model innovators (eBay.com, for instance), but rather – the producer of sports equipment Nike. According to Rifkin [8, p. 47], Nike is *"…in point of fact, the company is really a research and design studio with a sophisticated marketing formula and distribution mechanism. Although it is the world's leading manufacturer of athletic shoes, Nike owns no factories, machines, equipment, or real estate to speak of. Instead, it has established an extensive network of suppliers…".*

Therefore, it might be even concluded that the 'New economy' **shifts the view of a conventional value chain:** what once was a 'support' activity, now becomes the core of the company's production process, handling the information about the physical products. At the other hand, the traditional production process becomes a more or less 'marginal' activity, which can be outsourced to the cheapest supplier. Therefore, the original Porter's idea of the value chain becomes questionable, which opens the opportunity for its (re)interpretation.

2.3 Toward the exploitation of the virtual value chain

The idea of **virtual value chain** had been Rayport & Sviokla had been introduced as early as 1995, in an influential Harvard Business Review article [6], building upon the existing discussion of how the value chain concept should be (re)interpreted to fit the 'new realities' (see [4]). These authors differentiate the 'place' (the 'phyisical' world in which convential production processes are performed) from the 'space' ('virtual' world in which information is being processed). Consequently, **two value chains** can be differentiated: the 'tangible' one (as described by Porter in [5]) and the 'intangible'/'virtual' one, consisting of five activities: *"gathering, organizing, selecting, synthesizing and distributing information"* [6, p. 76].

Information, making the foundations upon which the virtual value chain (VVC) is constructed, comes out of the tangible value chain (TVC), as each step of the 'tangible' production process results both in a tangible (material, unfinished product, stock of finisihed products, etc.) and an intangible (informational) output (information about: the materials ordered, the flow of the production process, products stocked, delivered and sold, etc.).

Rayport & Sviokla assert that the two **value chains should be simultaneously managed,** in order to exploit the opportunities arising from both the tangible and the intangible component of the production process. The process of moving toward the exploitation of the VVC begins with the need to optimize the TVC, which provides sufficient incentive to track and optimize the tangible processes by building their informational counterparts in the 'cyberworld'. The comprehensive information systems, arising from such activities, enable managers to optimize the tangible aspects of their business (e.g. stramline the production process, eliminate and/or outsource non-value adding activities, eliminate some of the stocks, etc.). This stage of extracting value from the superior handling of information is referred as **visibility** by Rayport & Sviokla, as the increased flow of information increases the transparency of the tangible production processes.

The other stage of the VVC management is called **mirroring** [6], as certain elements of the physical world are 'mirrored'/reproduced in the 'cyberspace' containing the virtual value chain. Mirroring is, thus, the perfect arena for 'virtualizing' certain aspects of the production process. The most obvious choice are the information-intensive activities, such as development of new technologies and products, resolving customer inquiries/complaints, etc. Although Rayport & Sviokla cite a range of examples related to the computer-mediated research & development of new products, customer service seems to be a field proving significant cost benefits, arising from the use of call centers and interactive voice response (IVR) systems, as well as customer self-service technologies, delivered either over the World Wide Web, or some other chanell for distribution of information.

The most advanced stage of 'tapping' into the VVC is **development of new customer relationships** on the basis of the entirely virtual products, arising as 'byproducts' of information gathered by performing the activities belonging to the tangible value chain. 'Virtual products', consisting entirely of information, have specific features, related to the economic nature of the process of exploiting information. Namely, information is usually licensed, instead of sold, meaning that its recipient is entitled to use the received piece of information for the agreed purpose, during the agreed period, in return for the compensation/fee received by the vendor. It is very difficult to sell the information, as compared to the conventional sale of a physical object, as the value of the information does not 'wear off' as it is being used. Furthermore, digital information can be copied and 'passed on' to the third party without any loss of value and/or any intrinsic quality: the unauthorized receiver will, essentially, receive the same functionality provided to the paying customer of the virtual product.

This feature of virtual products make it quite difficult to enforce property rights in the purely 'informational world'. On the basis of Rifkin's analysis [8], it could be argued that selling continuous access to a certain stream of information (instead of licensing an individual piece of information) could prove to be a key to success in the most advanced stage of the VVC exploitation. Nevertheless, the further discussion of this topic is out of scope of this paper.

2.4 New opportunities for creation of value in the marketplace/space

The idea of **marketspace** (serving as the digital equivalent of the physical marketplace), also introduced by Rayport & Sviokla in the earlier Harvard Business Review article [7], requires that the conventional practices of creating and extracting value (in the 'physical' environment) are enhanced by additional tools, applicable to the virtual world of computer networks. As already mentioned, the 'pure' virtual products can be created on the basis of information extracted from the tangible production process.

Once a piece of information enters the marketspace, it can become the source of the *"autonomous value creation activities"* [9, p. 605], i.e. it can start a 'life of its own' and provide the organisation with the opportunity to create new value in the digital arena. This objective can be achieved by performing the activities of the virtual value chain (gathering, organizing, selecting, synthesizing and distributing information), in order to either (a) use the existing digital assets (developed from the informational component of the tangible value chain) in new markets, or (b) 're-pack' such assets into completely new products [8]. In the former case, the **new economy of scale is created,** as the company 'bank on' the fact that the information does not lose any of its intrinsic value as it is 'packed', 're-packed' and licensed through distribution of different digital products. In the latter case, the organization gains access to the **new economy of scope,** i.e. opportunities for serving new markets and customers are created by formulating various virtual products from the available 'stock' of digital assets. Figure 2. illustrates the described concept, referred to as the **value matrix** [8].

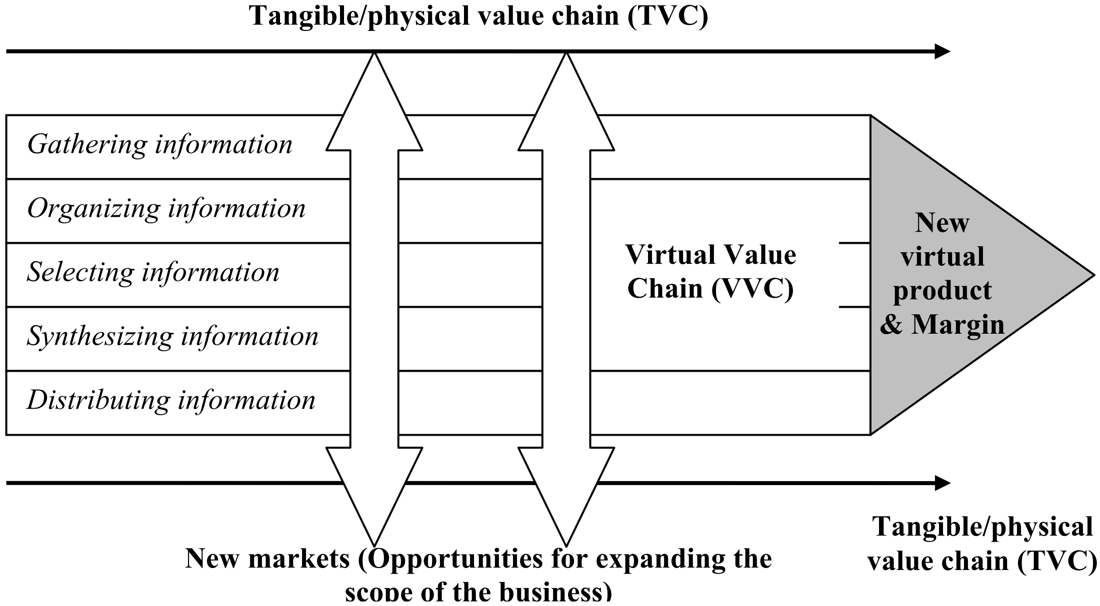

Figure 2. Rayport & Sviokla's value matrix (Source: Adapted from [6], p. 82)

Value matrix also demonstrates that the value-creating processes in the virtual arena should be closely aligned with the coventional/tangible production activities, which provide the virtual/informational assets (serving as a 'raw material' for digital products).

3. Instead of the conclusion: Some issues regarding extraction of 'virtual value'

Creation of value from digital/virtual products seems to be a 'logical' manner of enhancing the existing tangible value chain with opportunities to create new economies of scale (i.e. create new sources of revenue on the basis of the existing digital assets) and/or scope (i.e. differentiate into new markets by utilizing the same virtual assets). However, the appeal of these opportunities can be hindered by the fact that the unathorized copying of virtual products could shrink the potential revenues coming from the exploitation of the VVC (as already explained in section 2.3).

Although many solutions have been proposed and/or implemented for this purpose, ranging from the copy-protection mechanisms to legal actions against the offenders, the authors believe that the full potential of the virtual value chain could be unlocked by changing the business model based on licensing single pieces of information.

Namely, the companies wishing to fully utilize their VVCs might find the opportunity to act as ‘gatekeepers’ (and charge for the access) to the proprietary networks of valuable information (as suggested by Bard & Söderquist [2]), i.e. to try producing and (cros-)selling streams of valuable digital assets.

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SIMULATION MODELING OF THE PRODUCTION DISTRIBUTION SYSTEM

J. Dvornik, A. Munitić and F. Mitrović

Abstract

System Dynamic Simulating Modeling is one of the most appropriate and successful scientific dynamics modeling methods of the complex, non - linear, natural, technical and organizational systems. The methodology of this method, together with use of digital computer, showed its efficiency in practice as very suitable means for solving the problems of management, of behavior, of sensibility, of flexibility of behavior dynamics of very complex systems. All this is made by computer simulating, i.e. "in laboratory", which mean without any danger for observed realities.

System Dynamics simulation models of organizational business system of management of material (raw-materials, orders, money, labor, personnel, population, capital equipment: tools, units and factories e.t.c.) and informational flows in productive company will be presented in this paper. Organizational business-production system is simulated by effective scientific discipline System Dynamic and realized by Dynamo (PD4) and PowerSim program packages, also.

Keywords: System Dynamics, Modeling, Heuristics optimization, Continuous and Discrete simulation, Business System

1. Introduction

For one productive organization which is made up of series of cause-consequence dependent sub systems, i.e. modules, which represents division based on functionality, can be told that this is complex process with large numbers of feedback loops, which are necessary to take into consideration. This interdependence sometimes effects very strongly on the final result of behavior dynamics of organizational business system. The result of dynamics behavior of business-production process can be manifested with fluctuation of relevant business variables, such as: speed of supplying raw materials, speed of arriving the raw materials, speed of finishing the final products, state of unfinished production, state of finished goods - inventory, speed of shipment, state of productive capacities), state of: credits, debt, cash-flow, gross income, net income, speed of investment new capacities police, etc.

Previously it was mentioned that business production process, i.e. production organization business production system, is made up of seven sub system (sub-models), which have direct or indirect flows influence on some or even all listed indicators i.e. production relevant variables. Meaning, it is necessary to have a priori knowledge of this business-production process in order to define relationship between these indicator-variables and between every single module. Furthermore, it is possible to detect ineffective parts of such business organization system by necessary knowledge of this business-production processes and continuous modeling with System Dynamics. Further, with simulation of dynamics processes of production organization different behavior of this organization can be predicted, as response to different stimulus, i.e. test functions. For stimulus (known test functions), i.e. inputs in such processes in consequence consideration can be taken: changes in the markets, such as increase or decrease in credits for sale products or debit of this organization, introduction of new production equipment, change of supplier of components or materials, etc. Subjecting the production organization to different scenarios which are stipulated with changes in the market production organization can become more flexible, adaptive and robust. In this paper SD-continuous model of such production organization will be presented, and also a possibility of application System Dynamics methodology for simulation of this kind of business-production systems. The paper is conceived as follows: sub systems of business production organization, entire model of productive organization system and its simulation, conclusion and used references.

2. Production subsystem

2. 1 Mental-verbal model of the production subsystem

The "order speed" of material (**NM**) is influenced by demand for organization products (**EXPR**) which can be described as exponential average of the demand for products in last 36hrs (see graph "Demand for products" in subsystem of demand for organization products). With a larger exponential average (**EXPR**), the orders of the material (**NM**) are also larger (+), consequently with the increase of the order, the state of unfinished production will also increase (+). Increasing the quantity of finished production (**ZGR**), the quantity of unfinished production (**NP**) is decreasing (-). With a higher speed of product finishing, the supply of finished products will be higher (+) with the consequence of the increase of quantity of delivered products (+). When quantity of delivered products (**IR**) is higher, the quantity of finished products (**ZGR**) in supply is lower (-), which gives a negative (-) sign to the feedback link of FBL 1. The quantity of delivered products (**IR**) will, of course, depend on demand for products on the market (**TRAZNJA**). When the delay of the ordered material occurs, it could be described with macro function DELAY3, which as arguments takes a variable for which we describe the delay of the material flow of III order, and as a time delay parameter KP. The structural diagram is presented on Figures 1.

2.2 Structural model of the production subsystem

According to the described mental-verbal model it is possible to determine the system dynamic structural model of observed subsystem.

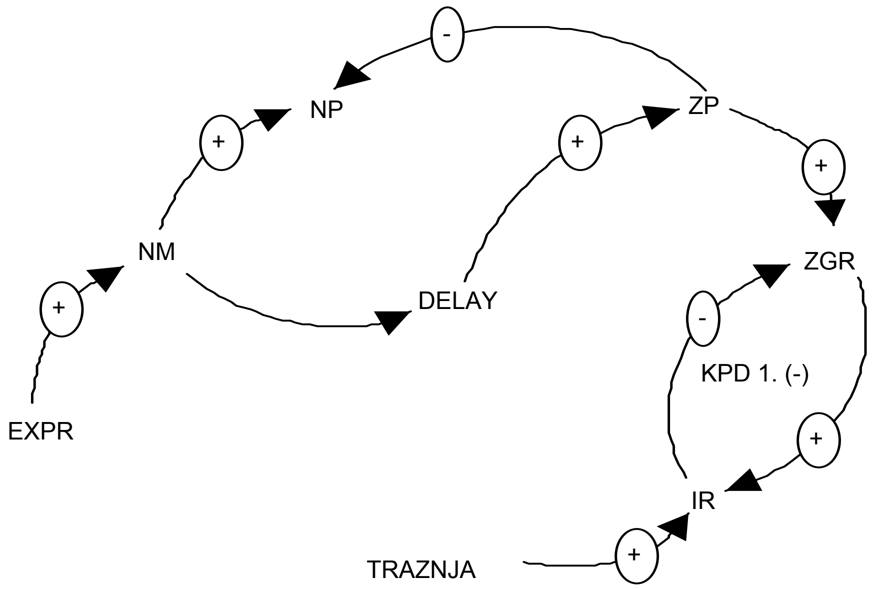


Figure 1. SD-structural flow diagram of the production subsystem

3. Demand subsystem

3.1 Mental-verbal model of the Demand subsystem

The demand depends on the quantity of the delivered invoices (**FI**) meaning the higher the quantity, the higher the state of the demand (**POT**) (+). The value of the delivered invoices (**FI**) is influenced by the price of the product (**JCP**) and the quantity of the delivered products (**IR**), and the larger are those sizes the bigger is the value of the delivered invoices (+). When delivering invoices, a material delay of the III order occurs, and can be described by macro function DELAY3. The bigger the delay is, the quicker is the speed of charging the demand (**SPOT**) on the behalf of production organizations (+). The quicker the speed of charging the demand (**SPOT**) means reduction of the state of demand (**POT**), i.e. the negative sign (-).

4. Debit subsystem

4.1 Mental-verbal model of the Debit subsystem

The debit of production organization (**DUG**) depends on the speed of invoice arrival (**PRF**) and also the speed of payment of the debits to the supplier (**SDUG**). The quicker the invoice arrival is, the state of debit is also higher (+). The quicker the payment of the debits to the supplier is, the state of debit is lower (-). There is a material delay between invoice arrival and payment of the debit to the suppliers and it can be described by macro function DELAY3. The higher the delay is, the speed of the payment of the debit to the supplier reduces (-). The speed of invoice arrival is directly influenced by production expenses (**TRP**) which are: acquisition of the material for the production (**NM**), variable production expenses (**VTR**) and fixed expenses (**FTR**). With the increase of all of these expenses, the production expenses, those that directly influence the invoice arrival (+), increase, as well.

5. Production capacity subsystem

5.1 Mental-verbal model of the Production Capacity subsystem

Desired production capacity will depend on exponential average of demand (**EXPR**) and singular value of production capacities (**JVPK**), and that size can be mathematically determined by product of multiplication of last two. The higher exponential average of demand and singular capacity value means the increase of the states of desired capacities (+). Discrepancy (**RZKIS**, i.e. the difference between desired capacity state **ZELJK** and the real capacity state **SKAP**) will be higher when the desired capacity state is higher (+); increasing the real capacity state by investing in new capacities, the discrepancy reduces, i.e. by higher investment in new capacities, the real state of capacity increases (+) and the discrepancy reduces (-). The acquisition of new capacities (**NKAP**) will naturally depend on the state of existing, i.e. the writing off of the expired capacities (**FOT**). This link between acquisition of the new and the expiration of the existing can be modulated by macro function DELAY3.

6. Money on transfer account subsystem

6.1 Mental-verbal model of the Money on transfer account subsystem

The amount of money on transfer account (**NNZR**) depends on deposits of money on transfer account (**UNZR**) and on payment from transfer account (**ISZR**). Payments from transfer account depend on debits state (**SDUG**) and the acquisition of new capacities (**NKAP**), i.e. the bigger the debit and the acquisition of the capacities are, the payment from transfer account is bigger (+), meaning the smaller amount of money on transfer account (-). Deposits on transfer account depend on demand state (**SPOT**), and the bigger the state is, the bigger are the deposits on transfer account (+), and consequently the amount of money on transfer account (+).

7. Income subsystem

7.1 Mental-verbal model of the Income subsystem

Income (DOHODAK) depends on incomes (UP) and expenses of the production organizations (TROSK). The higher the total incomes are, the higher is the income (+), and these total incomes depend on delivered invoices (IF), i.e. more delivered invoices means higher total incomes (+). The expenses of the production organization can be reduced on expenses of the acquisition of new capacities (investment, NKAP) and the quantity of received invoices (PRF). The bigger the both of these sizes are, the expenses are bigger, too (+), and the increase of the expenses reduces the income (-).

8. Subsystem of demand for organization products

The demand for organization product has a seasonal characteristic and can be shown by graphical preview below:

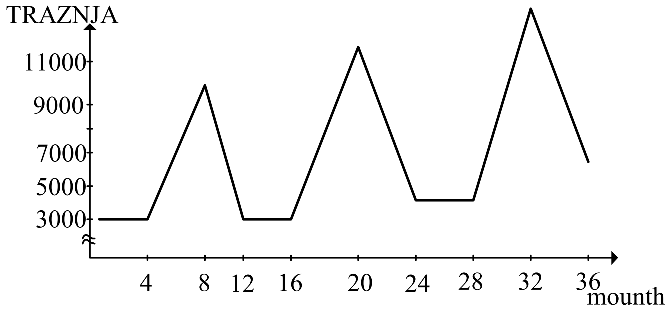


Figure 2. Demand for products

Based on such demand that can be shown by macro function TABLE, so called stimulated demand is modeled. The stimulated demand is a product of factors of delay (value 3) of the product from production department to the sales department with the demand described by upper graph.

Based on determinates mental-verbal and structural model, and according to the POWERSIM program graphical symbolic, it is possible to determinate complete system-dynamics model, i.e. flow diagram

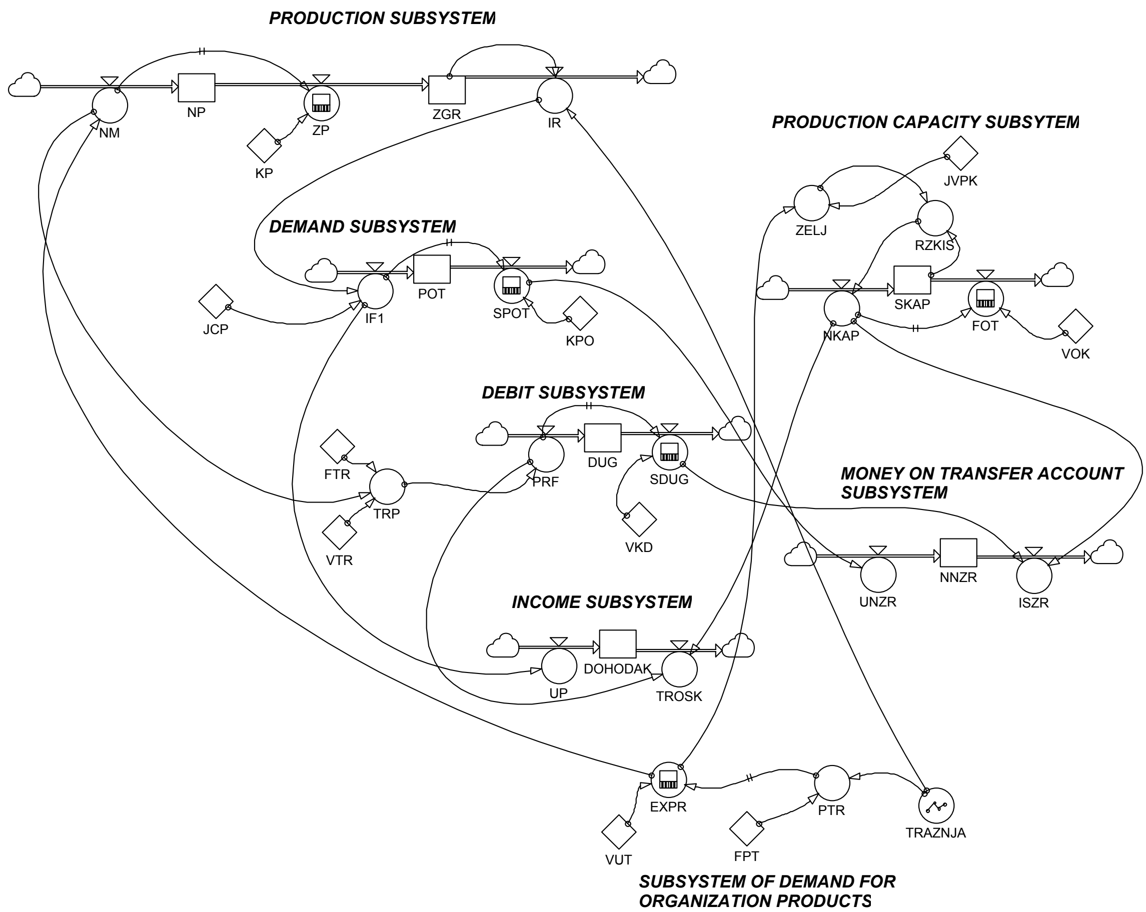
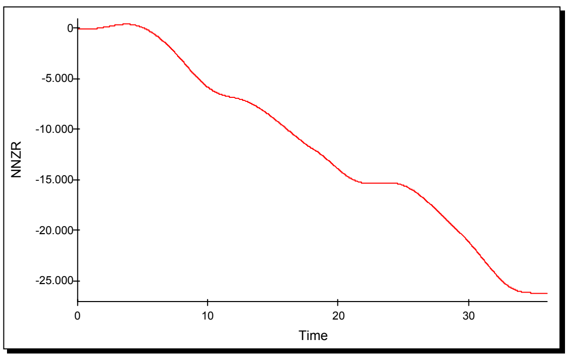


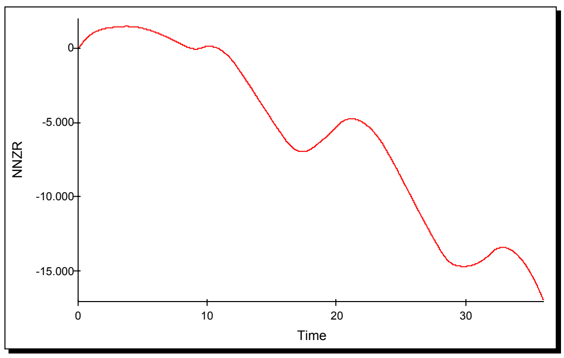
Figure 3. Global System Dynamics flow diagram in Powersim symbolic

9. Simulation results

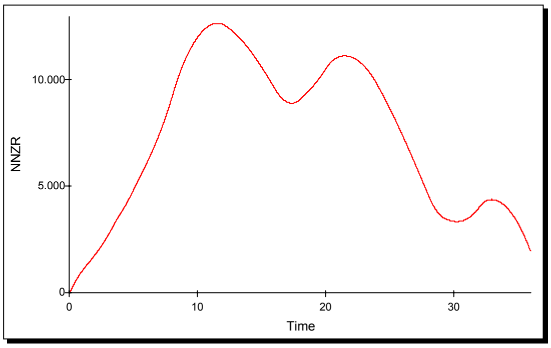
In this paper, due to the space limitation, we will show several interesting scenarios which applied to the money on transfer account, i.e. to the solvency of the business organization considering the changes of KP= production time delay parameter, VKD= debit time delay parameter and KPO=demand time delay parameter.



Scenario I: KP=3, VKD=3, KPO=3,



Scenario II: KP=3, VKD=3, KPO=0



Scenario III: KP=0, VKD=6, KPO=0

It is possible to conclude that the company model is behaving in concordance with economical regulative, and that for Scenario I (KP=VKD=KPO=3 months) dynamics of behavior of the amount of money on transfer account (**NNZR**) indicates relatively sudden fall in company solvency (after 36 months NNZR <-25.000 $). Scenario II (KP=VKD=3 I KPO=0) indicates somewhat slighter fall in company solvency (after 36 months NNZR>-15.000 $) and Scenario III (KP=0, VKD=6, KPO=0) indicates a constant trend of a significantly positive solvency which oscillates and which is after 36 months still positive!

The results are in complete concordance with the economical theory and practice which says that if KPO=0, which means if there is no delay in payment of demand, then the company solvency will be improved (reduced insolvency). Scenario III is a case where there is no delay neither in production KP=0 or in demand KPO=0, and if we increase the delay in debit payment VKD=6, then the company solvency would be constantly positive.

10. Conclusion

Based on ours long term experience in the application of the dynamical methodology of simulating and in this short presentation we provide every expert in need with the possibility to acquire additional knowledge about the same system in a quick scientifically based way of exploring the complex systems. It means:

"Do not simulate behaviors dynamics of complex system using so called "black box" approach, because practice of education and designing of complex system confirmed that is better to simulate using so called "white box" approach, e.g. System dynamics Methodology Approach!"

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ROBOTIC CELLS WITH WEB TECHNOLOGY

M. Hajduk, V. Baláž, N. Daneshjo, M. Groholová and M. Šalatová

Abstract

The submitted article deals with the issue of communication between devices of various types. Robotized workplaces that are situated in the Department of Production Engineering and Robotics are described here. This article proposes a solution for connecting these workplaces, as well as the possibilities for publishing data on the Internet.

Keywords: Visualization, Internet, robot, control system, PLC

1. Introduction

Globalization dramatically increases production demands. Apart from the traditional demands on production, such as: high quality, low price, appropriate flexibility, new paradigms have also emerged: intelligence, agility, virtuality. Their aim is to satisfy the customer in as short a time as possible. Competition in time focused on the customer is a relatively new dimension of production strategies, but with an increasing importance. New production structures have to be created so that time loss is minimal. The one who provides the highest added value for the customer in the lowest possible price in as short a time as possible, will gain success. This new paradigm of success is being established as the new generation of competitiveness. It has been proved that the assessment of time consumption is more beneficial than focusing on the lowering of costs.

In the past plants tried to emphasize their abilities to compete by means of building CIM. CIM was expected to increase productivity, increase quality, and increase the utilization of production equipment etc. Success, however, came slowly. Only after the Internet was discovered, did it enabled the plants to implement their strategies focused on "speed". The arrival of the Internet significantly changed the production environment. Implementation of Web technologies shifts the integration of production systems into the so-called virtual plants. By means of this extremely fast information technology, which is completely independent from place and time, it is possible to exchange information on production and products worldwide 24 hours a day. The Internet enables effective cooperation and remote interaction worldwide. By means of the Internet it is possible to provide the necessary instructions to the operator of the production systems and in cases of emergency even interfere with the operation of the palnt without being physically present. The Internet proved to be a technology suitable also for heterogenous environments.

Within the framework of grant projects the Department of Production Engineering and Robotics (DPER) has implemented a pilot project within a global production system.

2. Present status of robotized workplaces in dper

At present the Department has five independent workplaces that are completed and operational (Figure 1):

1. NC production cell with BOSCH conveyor.

Simulation activity:
entry inspection on base visual system.
Separation objects with irregular parameters (pattern, orientation, defect surface).
Technical and manipulating elements workplace:
manipulators MX-001, CCD camera, apron conveyer
Control system:
Logo!24RCL, I/O 12/8

Simulation activity:
Real cutting, turning and milling operation, interactivity conveying, manipulating and production operation. NC programming.
Technical and manipulating elements workplace:
miller Fc16 CNC/PC, lathe EMCO PC TURN 50, belt conveyer BOSCH
Control system: Simatic S7/300, I/O 32/32

Simulation activity:
palletization, welding
Technical and manipulating elements workplace:
robot Nokia RM-01
I/O 32/32
6 degree of mobility
electric drive
accurancy positioning 0.1 mm
Control system:
Sfera 36, prog. Language ARPS

Simulation activity:
Cyclic and acyclic servising machines
Technical and mnipulating elements workplace:
Two chucking appliance which simulation machines, robot APR 2.5, I/O, container
Control system:
RS-3A

Simulation activity:
Assembly objects to weight 0.4 kg and size 50x100x20 mm.
Technical and manipulating elements workplace:
Manipulators on base SMC elements, sectional conveyer, stacking elevators
Control system:
Omron CPM 2A, camera F160, optical sensors, GSM modul

Figure1. Technological workplaces in the Department of Production Engineering and Robotics

2. Model workplace of the production cell for processing with the APR 2.5 robot.
3. Automated workplace with a Nokia robot for simulation of arch welding, assembly and palletization.
4. Intelligent assembly workplace.
5. Automated line with MX handlers for the sorting of objects.

At present the individual workplaces shown in Figure 1 do not offer the possibilty of education in global production anymore, despite the fact that they are fully automated inside. The aim of the project is to establish information links between individual workplaces, which will present a logical chain of the production plant: the workplace for preparation of materials providing semi-products into the production, processing workplace, welding workplace, assembly workplace, expedition workplace, a technological bus bar with information systems connected to service and economical activities of the plant – preparation of production, monitoring of the operation status, maintenance control. The internet will be used for interconnection.

3. Proposed solution

The proposed project solves the integration of workplaces from Figure 1 on two levels, Figure 2:

1. The integration of workplaces on the basis of a technological bus bar.
2. Connection of a technological bus bar with the server of CAD/CAM laboratory by means of the Internet.

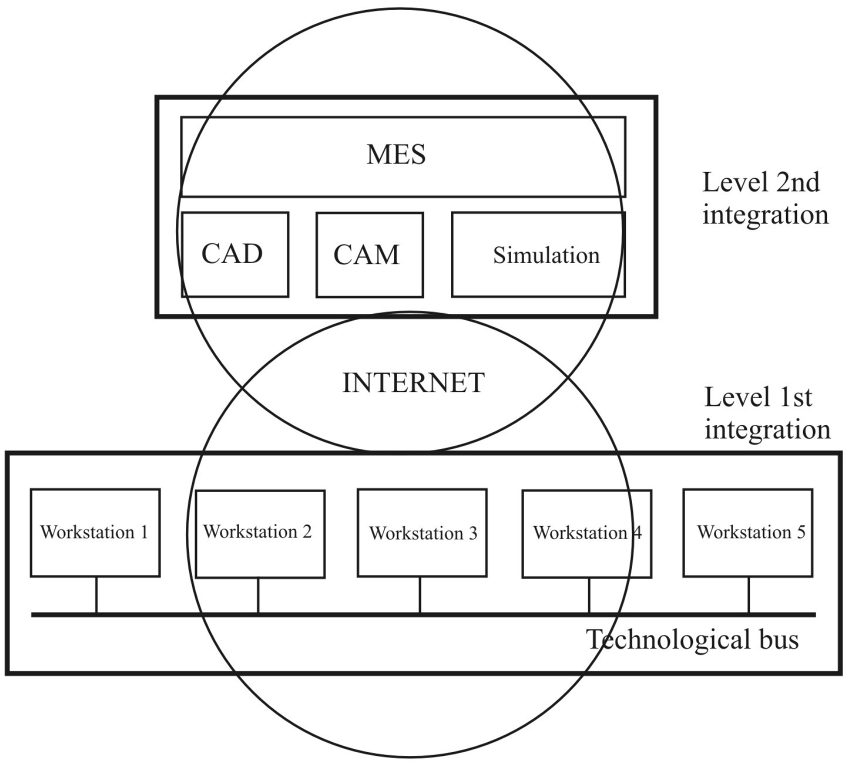

Figure 2. Interconnection of levels of integrated workplaces

The project of integration is based on the present condition of the department's laboratory equipment. Each workplace has its own control system (RS 3A, Sphere 36, Siemens Logo, Omron CPM2A, Simatic S7/300), which are used for collecting information from individual workplaces. The intelligent assembly workplace (IAW) is connected to the GSM line via a Siemens TC-35 modem, which enables the notification of malfunctions and breakdowns by means of short text messages. In order to supervise the assembly of IAW, a digital camera system Omron F160 was proposed. The camera evaluates the defective components (shape, position, orientation, damaged surface).

All the information coming from the laboratory will be collected in the S7/300 system, which is equipped with an OP27 operator panel. A Simatic S7/300 serves for communication with individual workplaces and for direct control of the conveyor, storagerooms and other facilities. For the process of monitoring the NC production cell visualization was designed both directly in the control PC in the laboratory, as well as in the external computer classroom CAD/CAM, where the students can watch the whole process of "production" on computers. In order to supervise the activities of the workplace the monitoring circuit was designed. It is equipped with industrial cameras, which monitor the activities in all modules of the integrated workplace, or the movement of the component on conveyors.

The Workplace is equipped with visualization software, which enables not only a graphic display of the technology, but also gives direct control over the selected elements. From the point of view of further development the FactorySuite 2000 program package has been selected. FactorySuite 2000 is an integrated set of software products for the integration with production control systems, from direct control and supervision of production machines and lines to systems of control and the recording of the real history of the MES (Manufacturing Execution Systems) category production. To ensure that the operator has an overview of the activities of the entire system without having to watch the process all the time, an inTouch program for the visualization of the technological process (Figure 3) is included in the system. This program is included in the

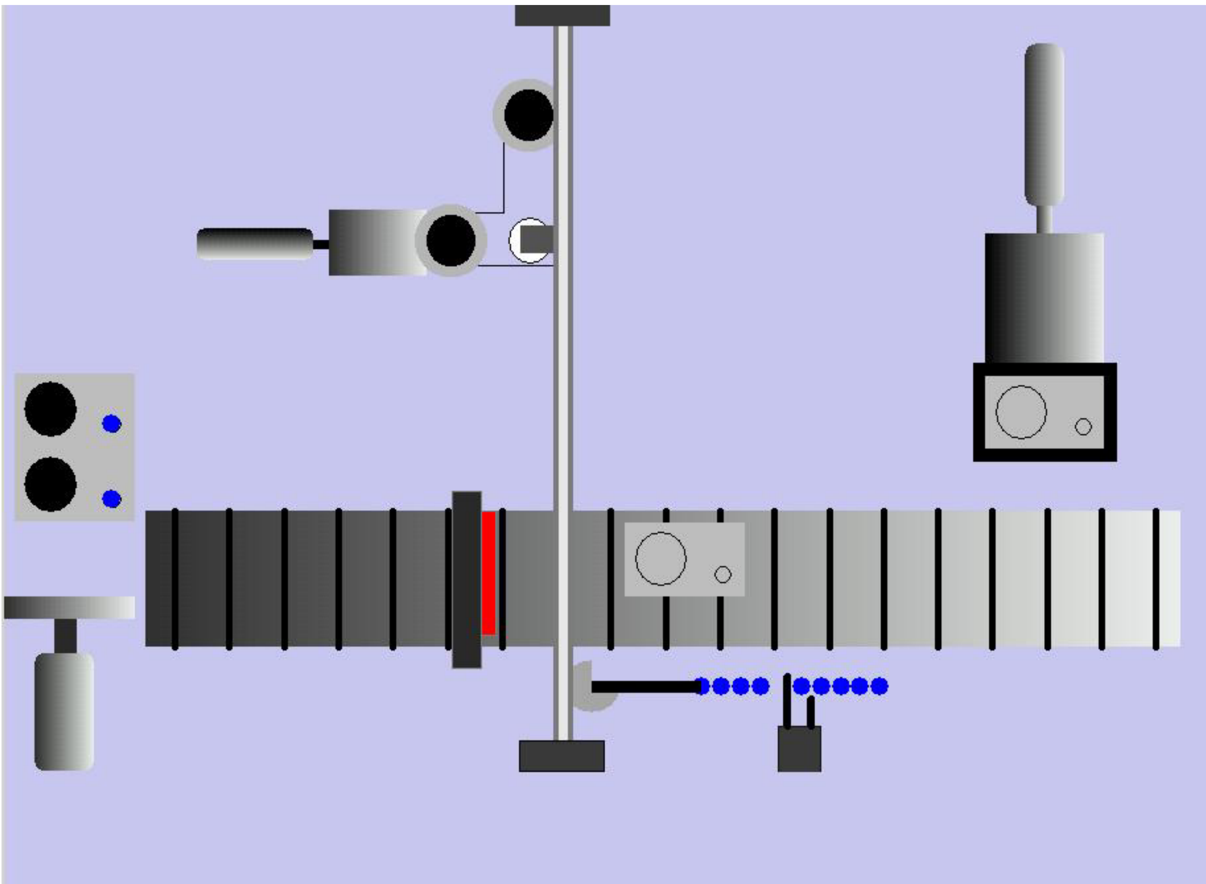

Figure 3. Illustration visualization of manipulation activities

FactorySuite 2000 mentioned above. Also within the framework of visualization the key parameters of the process are observed by means of alarm states. In case of an occurrence of critical values in the technological process the application alerts the operator about the incorrect system behavior. In order to ensure a back check of data in the technological process on the Internet server, a program called IndustrialSQL server is installed, which will ensure the storing the data in the database. If desired, it allows the choice of those items from the database, which are necessary for specific analysis by means of SQL requests. The IndustrialSQL server is based on the Microsoft SQL database product.

By means of the SuiteVoyager program it is possible to connect the application with the Internet and to transfer data to the classroom, where an Internet server will enable the individual clients (students) to view the technology. Students would have an opportunity not only to observe the course of production in the integrated workplace, but to some extent they could also participate in the operation of the workplace. Connection of the integrated workplace to the Internet is shown in the Figure 4.

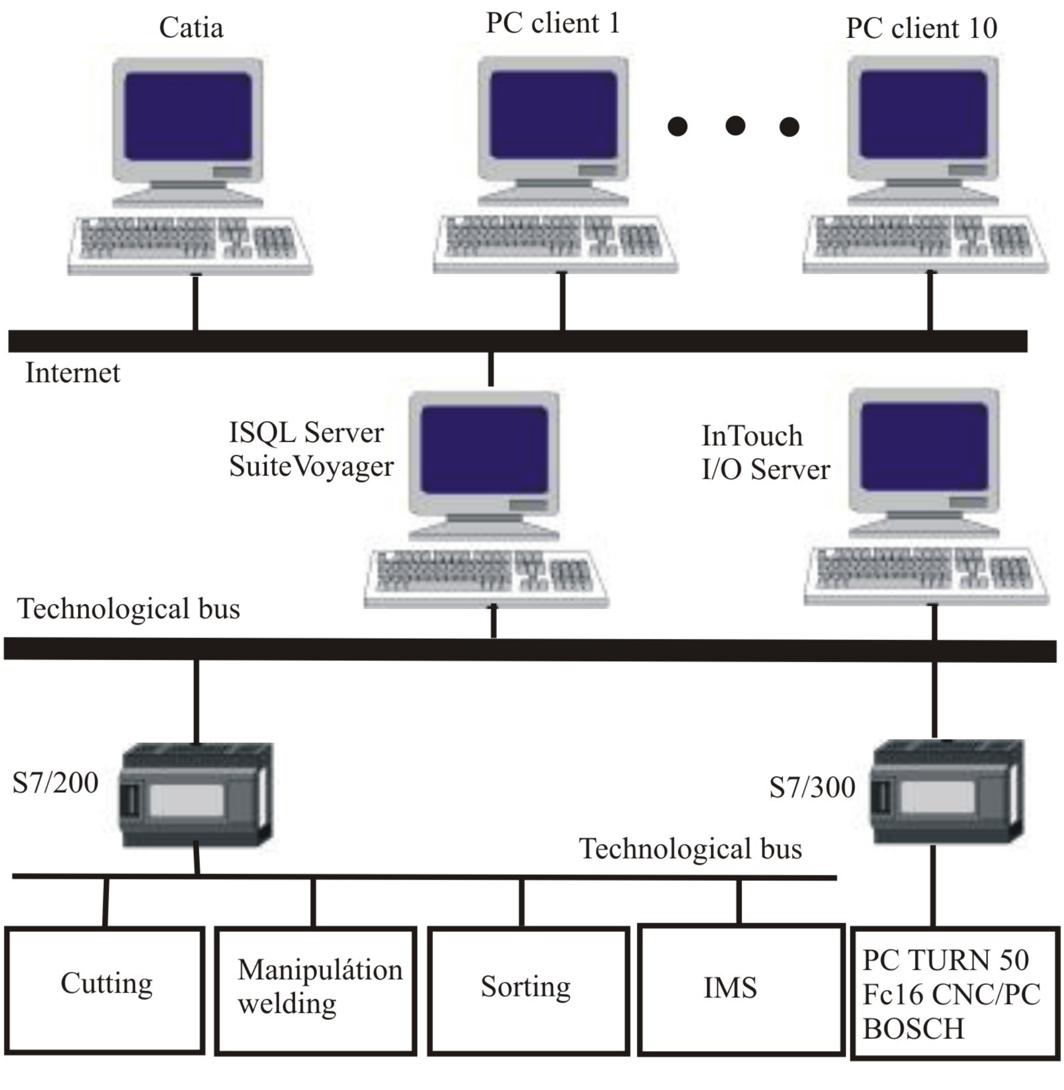

Figure 4. Connection of technological workplaces to the Internet

4. Conclusion

The integration of robotized workplaces by means of the Internet allows the students of the Department of Production Engineering and Robotics to verify their acquired theoretical knowledge in a practical project. The students have the possibility to participate in the programming of NC machines, robots and PLC, in creating visualization programs and publishing information on the Internet. Moreover, they also have an opportunity to control and supervise activities of individual workplaces in mutual interaction, to utilize the information acquired from workplaces for decision-making processes of further activities and evaluating the economical effectiveness of the operation. The system enables them to acquire skills for a new type of communication on various levels by using the Internet. It also serves for an experimental verification of solved research tasks.

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SYSTEM DYNAMICS SIMULATION MODEL OF THE MARINE DIESEL ENGINE

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1. Abstract

Simulation has become an unavoidable tool for carrying out various systems tests thus saving time. It is safe, reliable and above all, economic. Nowadays, simulation of very complex non-linear dynamic systems are made possible by the use of increasingly sophisticated computers such is the case with the cooling system of marine diesel engine. The prevailing results have been obtained in simulation of the entire engine system by the investigations in this respect. Therefore, this paper provides a new approach to simulation of a separate part of diesel engine propulsion system, i.e. cooling system.

The paper deals with the mathematical model of cooling system consisting of five subsystems shown in non-linear differential equations. By scientific method of system dynamic the system dynamic cooling model of the diesel engine has been marked out through the POWERSIM programme. The operation of the model has been tested and the investigations of some possible scenarios, two of which have been contained in this paper, have been carried out.

Keywords: simulation, diesel engine propulsion, cooling system

2. Introduction

One of engine model testing methods in a time interval is simulation. Upon each diesel engine manufacture, dynamic test are made to determine validity of behavior dynamics between wanted and given (real) state and internal diesel engine structure changes. Such research and wanted and acquired characteristics comparison is made on the test bed, i.e. during sea trials. These tests, however have their objective limitations.

In order to allow "harmless" simulation of all possible and extreme work scenarios, a relatively new science discipline philosophy and methodology – system dynamics ("system dynamics" – prof. Dr. Jay Forrester) is used. For science project and educational complex system behavior dynamic research is used. In this paper system research segment is given – marine diesel engine cooling system.

In order to ensure safe and reliable engine operation, special care is placed onto fuel oil combustion quality in the cylinder, making it the subject of this paper.

3. System dynamics mathematical model of the marine diesel engine cooling system

Regulation object can be in a static or dynamic work regime.

Static regime assumes balanced state of regulation object. This regime doesn't change if energy or matter input and output remain the same. Diesel engine cooling process is led by a static characteristic when heat transferred to and from the coolant remains the same, and cooled object temperature (liner cooling water, lubrication and cooling oil, scavenging air) remains constant.

Static characteristics can be shown by formulas, tables and diagrams. They can be linear or non – linear and shown respectfully as linear or by other relations (square equation), curve or broken lengths.

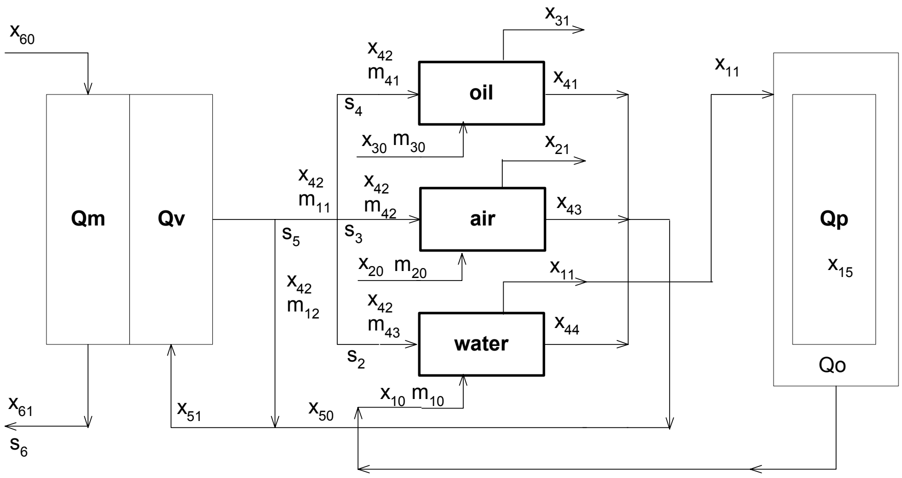

Figure 1. Scheme of marine diesel engine cooling system.

3.1 Cooling system division

Cooling system is divided onto five circles.

Engine liner cooling differential equation is, as follows:

$$T_1 \frac{dX_1}{dt} + X_1 = K_{11} Y_1 - K_{12} X_4$$

Differential equation of water for cooling engine liner cooling water is:

$$T_2 \frac{dX_2}{dt} + X_2 = K_{21} X_4 + K_{22} X_1 - K_{23} X_3 - K_{24} Y_2$$

Differential equation for scavenging air cooling water is:

$$T_3 \frac{dX_5}{dt} + X_5 = K_{31} X_6 + K_{32} X_7 - K_{33} X_3 - K_{34} Y_3$$

Differential equation for oil cooling water circle is:

$$T_4 \frac{dX_8}{dt} + X_8 = K_{41} X_9 + K_{42} X_{10} - K_{43} X_3 - K_{44} Y_4$$

Differential equation for sea water central cooling water cooler circle is:

$$T_5 \frac{dX_3}{dt} + X_3 = K_{51} X_{11} + K_{52} Y_5 - K_{53} X_{12} - K_{54} X_{13}$$

4. Dynamic continuous computer simulation marine diesel engine cooling system

Dynamic mathematic diesel engine cooling system model and its subsystem (cooling circles) form dynamic structure model. Diesel engine cooling system is divided into 5 subsystems (i.e. circles) shown in a mentally verbal model.

X_1 – relative water temperature value change from the engine;
X_2 – relative water for cooling water cooler temperature value change from the cooler;
X_3 – relative water temperature value when entering coolers (oil, water, air);
X_4– relative water for cooling liners temperature value change from the sea;
X_5– relative water temperature value change from the air cooler;
X_6 – relative air temperature value change from the air cooler;
X_7 – relative air temperature value change when entering the cooler;
X_8 – relative water for cooling oil cooler temperature value change from the cooler;
X_9 – relative oil temperature change from the cooler;
X_{10} – relative oil temperature change when entering the cooler;
X_{11} – relative cooling water temperature change when entering the central cooler;

X_{12} – relative temperature change when entering the central cooler;
X_{13} – relative seawater temperature change from the central cooler;

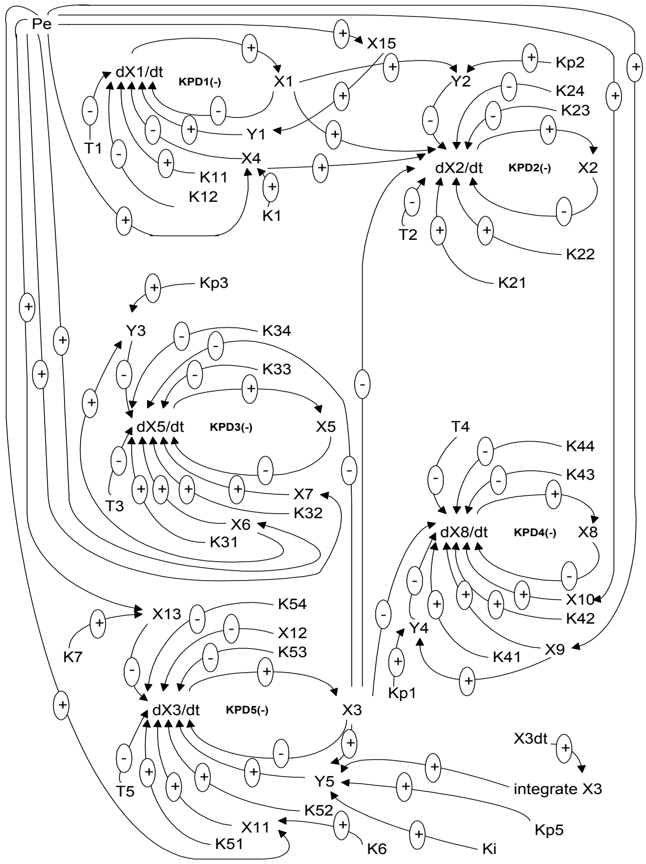

Figure 2. Dynamic qualitative structure diesel engine cooling system model

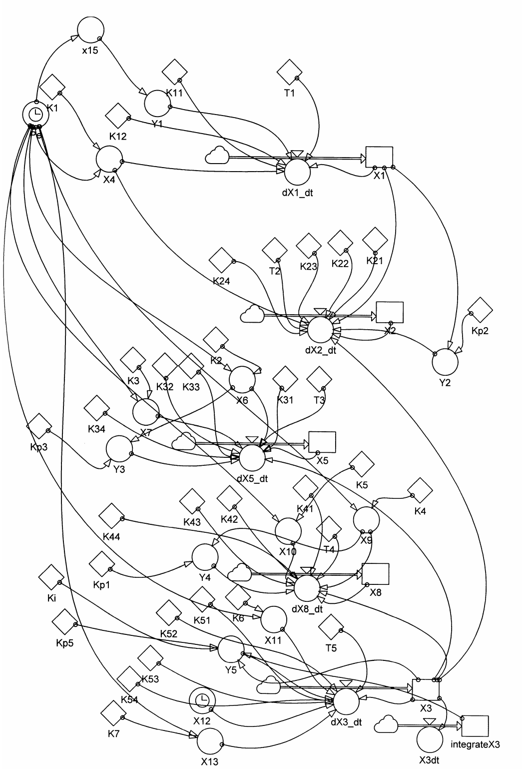

Figure 3. Structure dynamic qualitative diesel engine cooling system model in POWERSIM symbols.

Y_1 – relative gas temperature change;
Y_2 – relative water cooler inlet valve openness change;
Y_3 – relative air cooler inlet valve openness change;
Y_4 – relative oil cooler water inlet valve openness change;
Y_5 – relative water cooler inlet valve openness change;
K_{11} – amplification coefficient in correlation to transferred gas heat;
K_{12} – amplification coefficient in correlation to the heat drawn by cooling;
K_{21} – amplification coefficient in correlation to the heat transferred at liner cooling entrance;
K_{22} – amplification coefficient in correlation to the heat transferred at liner cooling exit;
K_{23} – amplification coefficient in correlation to the heat drawn by cooling;
K_{24} – amplification coeff. in correlation to the heat drawn by cooling water openness change;
K_{31} – amplification coeff. in correlation to the heat transferred from scavenging air cooler;
K_{32} – amplification coeff. in correlation to the heat transferred before scavenging air cooler;
K_{33} – amplification coefficient in correlation to the heat drawn by cooling water;
K_{34} – amplification coeff. in correlation to the heat drawn by cooling water openness change;
K_{41} – amplification coefficient in correlation to the drawn oil heat from the cooler;
K_{42} – amplification coefficient in correlation to the drawn oil heat before the cooler;
K_{43} – amplification coefficient in correlation to the heat drawn by cooling water;
K_{44} – amplification coeff. in correlation to the heat drawn by cooling water openness change;
K_{51} – ampl. coeff. in corr. to the heat transferred by cooling water led into the central cooler;
K_{52} – amplification coeff. in corr. to the heat transferred by cooling water openness change;
K_{53} – amplification coefficient in correlation to the heat taken by seawater led into the cooler;
K_{54} – amplification coefficient in correlation to the heat taken by seawater led from the cooler;
K_{p1} – proportional amplification coefficient
K_{p2} – proportional amplification coefficient
K_{p3} – proportional amplification coefficient
K_{p5} – proportional amplification coefficient
K_i – integral amplification coefficient

5. Testing marine diesel engine cooling system compute model validity

By using dynamic computer simulation marine diesel engine cooling system model in Powersim program with starting variable values and parameters within the model, numeric data and diagrams were acquired for a time interval from 0 to 100 seconds.

5.1 Scenario I

Testing marine diesel engine cooling system compute model validity was made in a following scenario:

Engine strength doesn't change until the 40^{th} second, when a 30% load change occurs by a step function, maintained to the 55^{th} second when power changes by an impulse function for 25%, from where is kept unchanged.

In the print computer model schematics with assigned coefficient and time constant (from T1 to T5 – from 10 to 100) values are given.

Diagrams show the response to the defined engine power changes for each system part (subsystem), i.e. each of the five circles.

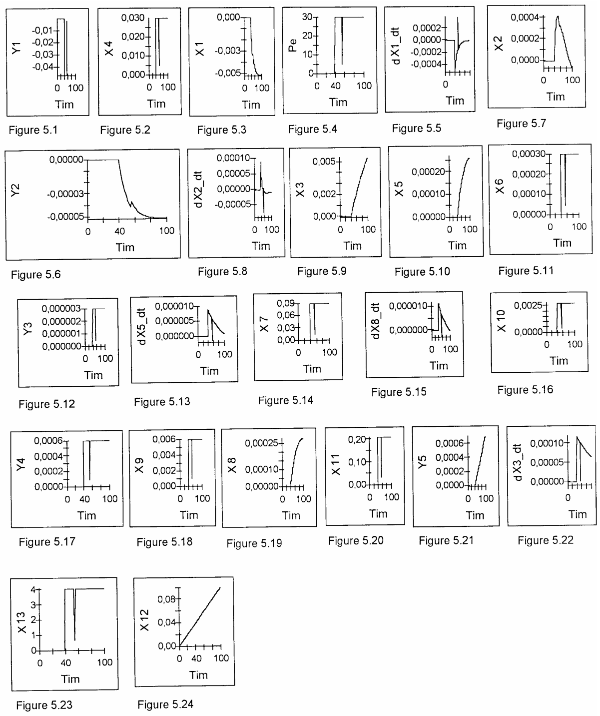

Figure 4. Response on parameters changing according to the I scenario.

5.2 Scenario II

Testing marine diesel engine cooling system compute model validity was made in a following scenario:

Engine strength doesn't change until the 40^{th} second, when a 60% load change occurs by a step function, maintained to the 55^{th} second when power changes by an impulse function for 50%, from where is kept unchanged.

In the print computer model schematics with assigned coefficient and time constant (from T1 to T5 – from 10 to 100) values are given.

Diagrams show the response to the defined engine power changes for each system part (subsystem), i.e. each of the five circles.

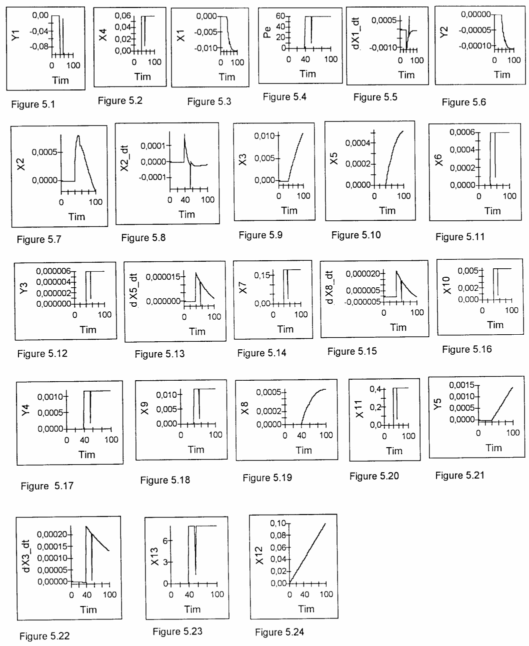

Figure 5. Response on parameters changing according to the II scenario

5.3 Simulation scenarios I and II results analysis

In scenario I power doesn't change until the 40^{th} second, when a 30% load change occurs by a step function, maintained to the 55^{th} second when power changes by an impulse function for 25%. From there power is kept unchanged. For these conditions, from diagrams, following can be observed: relative temperature change from the engine changes in narrow limits of –0,005; this temperature change speed, given in diagram 5.5. illustrates the system inertia. Response on load change in the air cooler, shown in diagram figure 5.12. gives a relative air cooler inlet valve openness change value, enabling needed fluid flow change speed, i.e. air-cooling capability. Similar can be observed from other diagrams that illustrate water temperature changes for cooling a corresponding media, i.e. water mass flow changes when entering coolers (oil, air and fresh water).

Power in scenario II doesn't change until the 40^{th} second, when a 60% load change occurs by a step function, maintained to the 55^{th} second when power changes by an impulse function for 50%, from where is kept unchanged. For second scenario conditions following data can be observed for identical values: from diagram figure 5.27. relative temperature changes from the engine changes for –0,010. Load increase in correlation to the first scenario increases relative temperature change value from the engine, whose change can be ignored.

In correlation to the first scenario relative openness of the air cooler inlet valve increases and enables required coolant flow changing speed for cooling air cooler. From diagram 5.36. relative air cooler inlet valve openness value changes, it can be observed that increased load in relation to the first scenario increases relative valve openness value into air cooler to 0,000006. Load increase in relation to the first scenario changes other diagrams that show water temperature changes for cooling correlating media and water mass flow changes into the coolers. From the coolers constant temperature is kept for each system, achieved for circles I, II, III and IV by proportional regulators, and circle V by a proportional-integral regulator.

Diagrams show that marine diesel engine cooling system with its subsystems (circles) described in this paper function completely, and that acquired results correlate to the assigned automatic temperature regulation system conditions. That means that automatic temperature regulation system insensitivity in all subsystems (circles) cannot be grater than 1°C, unevenness (static regulator deviation) cannot be greater than 12°C, temperature deviation in transition process grater than 6°C for the assigned scenario. These demands are chosen, because these conditions must be satisfied by each automatic temperature regulation system.

6. Conclusion

Diesel engine cooling system regulation is a prerequisite for its safe and economic operation. Cooling draws a quantity of heat thus reducing heat that is turned into mechanical work. It is a mission of all diesel engine manufacturers to minimize heat drawn by cooling.

By system dynamics diesel engine cooling system behavior dynamics complexity is shown. In this paper a nonlinear mathematic cooling system with subsystems (circles) model as regulation object that enable cause-effect connections analysis between single variables and observed system and subsystems parameters is given.

Using simulation model enables cooling system parameters optimization and work regime simulation according to a wanted scenario, with possibility of assigning conditions that could not be achieved when testing a real diesel engine.

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DAVID'S FIGHT AGAINST GOLIAT – CROATIAN ERP SYSTEM ON THE INTERNATIONAL MARKET

N, Majdandžić, I, Majdandžić, R. Lujić and G. Šimunović

Abstract

The article shows results that have been achieved in development and applying of ERP (Enterprise Resource Planning) systems in Croatia. The specific single and low batch production demands and originally developed models for priority rule, launching, planning, scheduling and production monitoring for such kinds of requirements will be presented. Reengineering results achieved in implementation of ERP system in Croatia, Austria and Bosnia and Herzegovina will be shown. Comparison with the World leader manufacturers of ERP systems (SAP, MAX and BaaN) will be done.

Keywords: Enterprise Resource Planning (ERP), priority rules, planning, launching, monitoring

1. Introduction

Today, Integrated Information System (IIS) presents the basic assumption for production or service enterprise management. IIS is not only efficient tool for work measuring of each employee in enterprise, but also essential communication tool for cooperation, connection in higher organizational forms (simultaneous engineering, virtual factory) and information exchange with enterprise environment (banks, associations and chambers of economy).

Through the applying of new informational technologies, planning and control models based on optimisation methods, IIS amplifies its possibilities in business, production and service management and through this it becomes ERP (Enterprise Resource Planning) system.

ERP integration with CA packages (CAD, CAPP, CAM, CAMI, CAQ, CAE), production and transport equipment (CNC, work cells, FPS, manipulators, robots, sensors, automaton warehouse, transport system) makes possible creation of highly automated digital factories.

ERP system development requires high investment which makes his prices very high. Usually, large enterprises implements ERP system without analysis and without qualitative organisational, technological and human resource preparations. It is the reason of relative long time implementation and disproportion between realised and expected results.

For small and middle enterprises it is necessary to have flexible ERP systems which will allow short implementation time, quick return of investment, and which will be adaptable according to existing business processes in enterprise.

Croatian ERP system - ERPINS (Enterprise Resource Planning ININ Solutions) for small and middle enterprises will be shown which takes into consideration special demands that occur in single, batch and continued production.

2. ERPINS content

The picture shows content of ERPINS system.

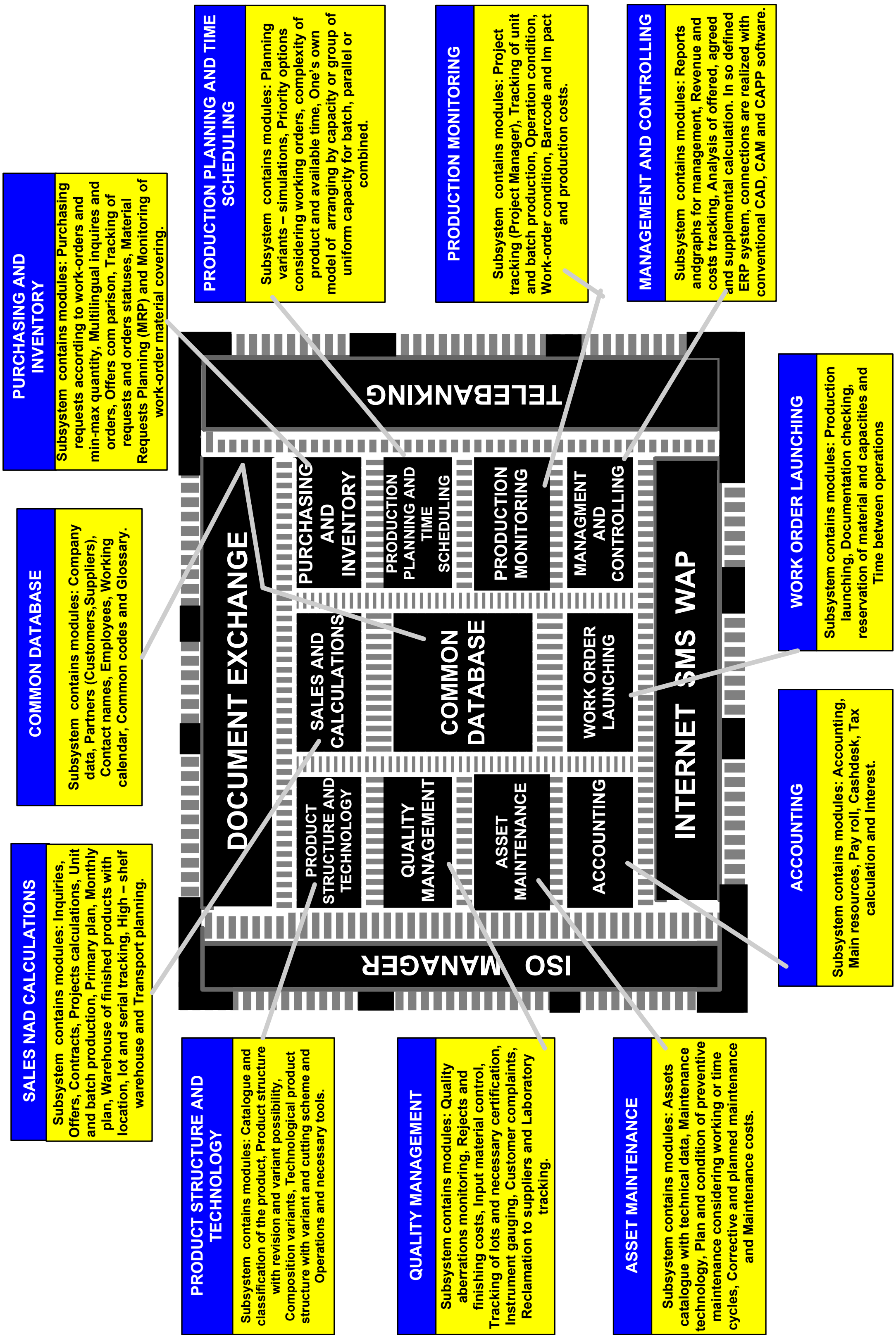

Figure 1. ERPINS content

Special features of ERPINS system are:

- multilevel product structure with calculation of necessary materials, structure/composition combination,
- own designed planning and scheduling models based on MRP, MRP II and JIT, calculation of priority rules that is based on work-order, hierarchical levels and relation between required and available time,
- production plan variants that take into consideration additional production possibilities with the main goal to achieve planned dates. Each variant has different costs,
- high level integration between business, technical and production data that is covered by numerous reports/graphs which are necessary for enterprise management,
- assets maintenance subsystem with preventive, corrective and planned maintenance,
- inputs and reports are adapted according to user demands and commonly together with user (prototype implementation),
- bar code applying enables monitoring of finished operations, raw material input and output of finished products,
- high-shelf warehouse with RF terminals,
- high level password protection (each user has password and according to that password realises particular rights),
- applying of modern communication aspects (TeleBanking, Internet-WAP),
- managing with binary content (texts, pictures, drawings…),
- integrated errors and new requests notification,
- ORACLE database.

ERPINS system contains original developed models for: [2]: planning, scheduling, priority rule, launching and supplier selection. Brief description of priority rule and launching models will be done.

2.1 Priority rule model

To determine technological operation priority rule exists lot of rules [3] (First Come First Served – FCFS, Last Come First Served – LCFS, Shortest Operation Time – SOT, Longest Operation Time – LOT etc.).

Basic data for mentioned rules is technological operation lead time. However, for ERPINS proper work it is necessary model which determines technological operation priority according to work order.

The technological operation priority $PR_{n,i1,i2,j}$ will be calculated as:

$$PR_{n,i1,i2,j} = 1000PR_n + 100PS_{n,i1} + 10PD_{n,i2} + \frac{1}{j} \tag{1}$$

where:

$PR_{n,i1,i2,j}$ - priority of j technological operation on $i1$ assembly, $i2$ *part of n* work order,
$j = 1, 2, \ldots . j\,j$, technological operations,
$i1 = 1, 2, \ldots .\ i\ i\ 1$, assemblies,
$i2 = 1, 2 \ldots .\ i\ i\ 2$, parts,
$n = 1, 2, \ldots .\ n\ n$, work orders.

The priority of product (work order, service) PR_n will be done as:

$$PR_n = Kd_n + Kt_n + Kz_n \cdot Kr_n \tag{2}$$

For determination of Kd_n (coefficient of expected profit), Kt_n (coefficient of available time), Kz_n (coefficient of customer significance) and Kr_n (coefficient depends on complexity of resource assurance) are developed separated methods [2].

The priority of production element (assembly) $PS_{n,i1}$ will be calculated as:.

$$PS_{n,i1} = \frac{h_{n,i1}}{10} + \frac{jj_{n,i1}}{1000} \tag{3}$$

where:

$h_{n,i1}$ - hierarchical level of *i1* production element (assembly) on *n* work order,

$jj_{n,i1}$ - overall number of technological operations of *i1* production element (assembly) on *n* work order.

The priority of production element (part) $PS_{n,i1}$ will be calculated as:.

$$PD_{n,i2} = \frac{h_{n,i2}}{10} + \frac{jj_{n,i2}}{100} + PT_{n,i2} \tag{4}$$

where:

$h_{n,i2}$ - hierarchical level of *i2* production element (part) on *n* work order,

$jj_{n,i2}$ - overall number of technological operations of *i2* production element (part) on *n* work order,

$PT_{n,i2}$ - technological complexity that is expressed as technological operation complexity of *i*2 production element (part) on *n* work order,

$PT_{n,i2}$ can have the following values:

$$PT_{n,i2} = \begin{cases} 1 & \text{production element (part) that has high demands in a way of form and measuring accuracy,} \\ 0{,}5 & \text{production element (part) that has normal demands in a way of form and measuring accuracy,} \\ 0{,}25 & \text{production element (part) that has low demands in a way of form and measuring.} \end{cases}$$

2.2 Launching model

Single and small-scale production enterprises especially in transition countries and countries in development because of wide range of necessary supplies (materials) require specific launching model. New model enables:

- launching per series,
- launching of necessary quantity for rework,
- launching of necessary quantity that is scraped,
- launching of production elements that have required materials quantity,
- launching of production elements with materials which is unreserved on warehouse,
- review of material reservation with possibility to “remove reservation”,
- reservation of finished products on finished products warehouse,
- selection of substitute materials that exist in required quantities,
- increasing of launching quantity according to expected quality deviation.

Figure 2 shows launching model that is used in ERPINS [4].

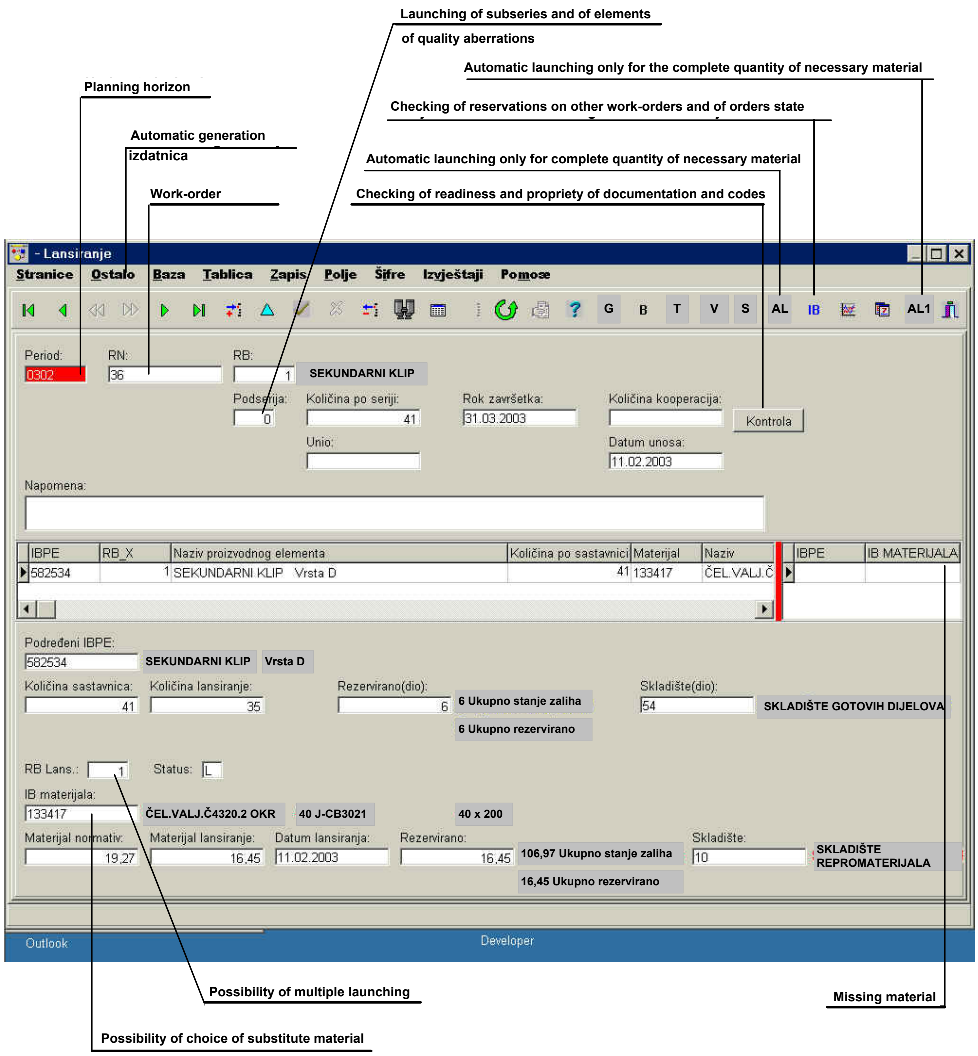

Figure 2. Launching model

3. Comparison between ERPINS and World leader ERP systems

Applying of ERPINS in Austria, Croatia and Bosnia and Herzegovina evaluated as very efficient and useful by enterprise managers [1] which has showed it concurrence on the International market.

According to results that are achieved during the competition process can be concluded:

- ERPINS is few times cheaper than other ERP systems,
- ERPINS implementation lasts from 4 till 6 month towards few year implementation of some other ERP systems,
- input documents have been created and adapted according to user during the implementation process,
- user gets ERPINS variant that is adapted to his requirements,
- ERPINS has no possibility to be significant market presented on the International level.

4. ERP integration in u Educational digital enterprise EDP

Educational digital enterprise EDP project adjusts as necessity for technology transfer form developed countries and participation of Croatian scientists in development of manufacturing sciences. EDP project connects CIM manufacturing systems on Mechanical Engineering Faculty in Slavonski Brod, Faculty for Electrical Engineering, Mechanical Engineering and Naval Architecture in Split, Technical Faculty in Rijeka and Mechanical and Naval Faculty in Zagreb with other laboratories and ERP system [5].

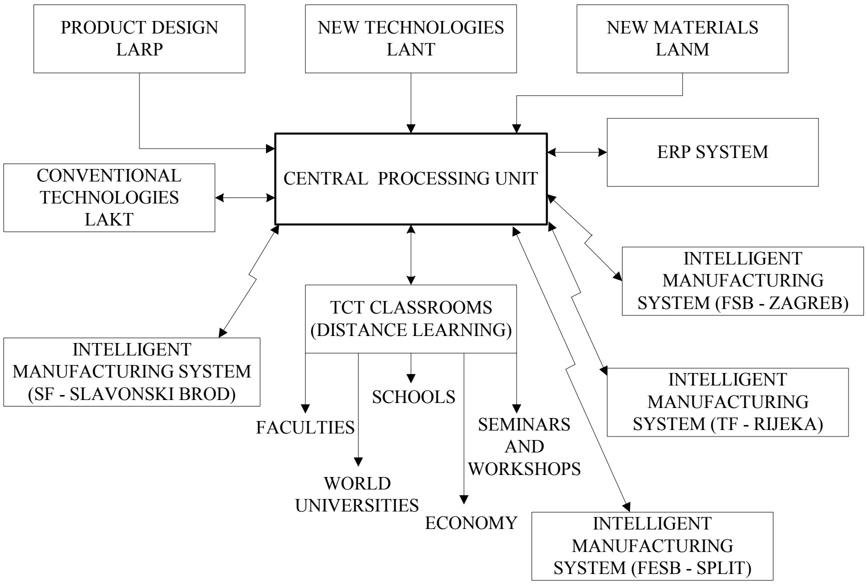

Figure 3. Content of Educational digital factory

5. Conclusion

The fact is that Croatia has scientists and experts in manufacturing sciences that are able to transfer of new technologies in Croatian enterprises and give contribution in manufacturing sciences, as well.

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ASSISTED RESEARCH OF THE DYNAMIC BEHAVIOR WITH THE VIRTUAL LABVIEW INSTRUMENTATION

A. Olaru

Abstract

The paper presents one new method for the analyze training of the industrial robots dynamic behavior. The method consists in an on-line simulation of the real and frequency characteristics with the virtual LabVIEW proper instruments. The paper presents many virtual instruments for analyzing the hydraulic, electric and pneumatic motor, the complex systems with many closed loops, the electrical and mechanical correction, and s.o. All the instruments have the possibility to show on-line, and to see what is happening when changing one of the functional or the constructive parameters. For analyzing and optimization the elements and the systems is presented some instruments for comparative analyze. This method and the all created virtual LabVIEW instruments can be applied in many others mechanical systems.

Keywords: assisted simulation, data acquisition, dynamic behaviour, and virtual instrumentation.

1. Introduction

The real revolution in the experimental research had begun with the LabVIEW and the graphical programming (G). In 1986 National Instruments it was created version 1.0 of LabVIEW (Laboratory Virtual Instrument Engineering Workbench) with the purpose to assure the researchers one produce, what to contain the best tools of the research and the analyse. We actually pioneered, the virtual instrumentation revolution, a revolution that is changing instrumentation in both, the test and measurement marker, and the industrial automation market, by driving down costs without sacrificing performance. The virtual LabVIEW instrumentation assures reduction the apparatus number, the research time and finally, the cost. In these conditions, all stage of the research are optimised, and reduced. Mathematical modelling and analyses of the elements and the systems are better when it is known the dynamic behaviour of all components. For this reason it is necessary to analyse all elementary transfer functions, and create proper simulation LabVIEW programs (VI). In this case it is possible to apply very easy the electrical corrections and regulator and comparing the real or frequencies characteristics of the output results. Some of the mathematical model for elementary transfer functions and icon of the virtual LabVIEW instruments are presented in the references [1], [2], [5], [7], [8], [9]. With these instruments, the researchers will have the possibility to analyze, on-line, the influence of some constructive and functional parameters, for the dynamic behaviour of elements and robot systems. The paper presents some virtual proper LabVIEW instruments for the hydraulic and the pneumatic motors, the electrical and mechanical corrections, for the some closed loop system analyse with transfer functions, the different control law, and s.o. The present paper shows the assisted method of the dynamic behaviour analyses by using the elementary transfer functions. These functions are coupled in the different way to approximate with small errors the physical robot model. The assisted method of the research, presented below, contents the most important elementary transfer functions. For all of them have been created the virtual instruments by using LabVIEW soft 6.1 from National Instruments USA. Many of these VI, where approximate the dynamic behaviour of the robot modulus, have been researched by comparing with the real dynamic behaviour obtained by experimental research and data acquisition. The results after this is that the errors for modelling with the transfer functions are smaller that 10%. For these reason in the most scientific works of the world are used the linear model with the elementary transfer functions. All the proper LabVIEW instruments offer the large possibilities to show the results, to compare in a short time the real with the simulate results, to establish very quickly the constructive or functional optimal parameters for the amplify coefficient, for the PID, PD_2 or for the others control laws parameters, or the place to applied the different rheological damper. The most of them shows on-line the real characteristics near the frequency characteristics, established in this mode, in the corresponding domain, the frequencies resonance, the mode when the different constructive or functional parameters determines the change of the magnitude, phase or the resonance frequency. The virtual instruments for the mechanical, electrical or hydraulic parts were created in a simple or complex panel.

2. Virtual driving instrumentation

Some results of the on-line optimization, for the dynamic behavior of the pneumatic motor, are presented below. With the proper analyze method of the influences coefficients, presented bellow, have been determined the most important constructive and functional parameters in a dynamic behavior of the motor. Functional schema is presented in figure 1 [1], [2]. The mathematical model was written by consideration the adiabatic transform, the conservation mass and the conservation of the impulse laws. After the comparison between the simulation and the acquisition results that the error with this mathematical model is in a 10% error domain.

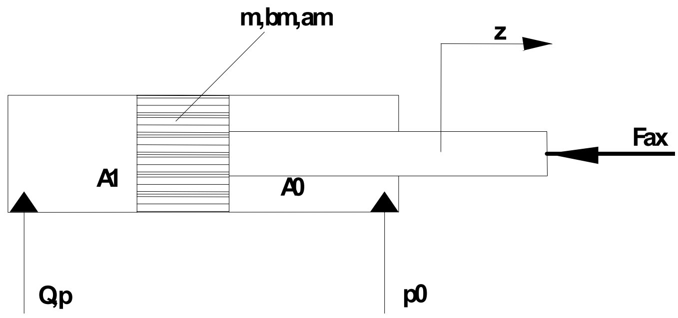

Figure 1. Functional schema of the linear pneumatic motor

The mathematical model of the dynamic behaviour determined bases of this functional schema, is given by:

$$Q = A_1 \frac{dz}{dt} + a_m \Delta p + \frac{V}{\chi p} \cdot \frac{d\Delta p}{dt}$$
$$m \frac{d^2 z}{dt^2} + b_m \frac{dz}{dt} + F_{ax} = A_1 \cdot \Delta p ; \, p \cdot V^{\chi} = ct \tag{1}$$

where: Q is the air flow 20-100 [cm^3]; A – active motor area 50-80 [cm^2]; z- active movement 30-40 [cm]; a_m- proportional gradient of loss flow with pressure 0.2-0.7[cm^5/daN]; Δp- loss pressure 4-6 [daN/cm^2]; ΔV – air volume of the motor 500- 1000 [cm^3]; m- reduced mass on the motor axis 0.1-0.6 [daNs^2/cm]; b_m- gradient of loss forces proportional with velocity 0.8-1.8 [daNs/cm]; F_r – resisting forces 10-30 [daN]; χ- adiabatic coefficient 1,4 [-].

The final transfer function is:

$$H(s) = \frac{z(s)}{Q(s)} = \frac{A_1}{s[\frac{V}{\chi p} \cdot m \cdot s^2 + (\frac{V}{\chi p} \cdot b_m + m \cdot a_m)s + (A_1^2 + a_m b_m)]} \tag{2}$$

The influence coefficients are determined by formulas:

$$C_i = \frac{R_{PCD}}{R_{PCF}} \tag{3}$$

where:

$$R_{PCD} = \frac{PCD_i - PCD_f}{PCD_i} ; \; R_{PCF} = \frac{PCF_i - PCF_f}{PCF_i} \tag{4}$$

and PCD_i is the initial value of the dynamic behavior parameter; PCD_f – the final value of the dynamic behavior parameter; PCF_I – initial value of the constructive-functional parameter; PCF_f – final value of the constructive- functional parameter. The results after changing some of the functional or constructive parameters are presented in fig. 2…4 [1], [2], [3].

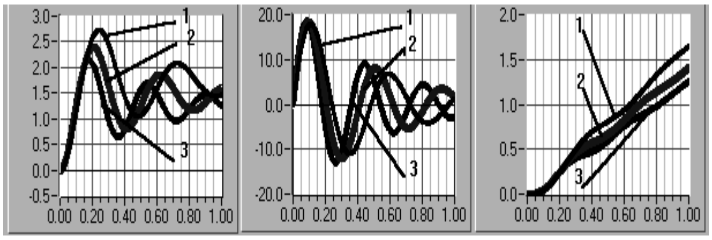

Figure 2. The real time linear displacement, velocity and acceleration characteristics when was changed the active area *A;* 1, 2, and 3 correspond at the area values: 60 (cm^2), 70 (cm^2) and respectively 80 (cm^2)

This extended assisted research with many others constructive and functional parameters, which have been changed, are presented in the book [1]. The analyze results with the values of the influence coefficients are presented in the table 1. The mode analyze when each of the constructive and functional parameters were changed the dynamic behavior of the pneumatic motor have been made with the reading the bigger value of the influences coefficients in the each row, respectively in the each column of the table 1. Reading by rows the bigger values of the influences coefficients on observe that, the increases of the active area A, determines with priority the increases of the critical frequency, the increases of the volume V, determines with priority the increases of the answer time t_r, the increases of the mass m, determines with priority the increases of the answer time t_r and the critical frequency ν_c. The last one is the most important dynamic parameter, because influences the acceleration time in a velocity characteristic. By reading the bigger values of the influences coefficients for each columns of the table 1, we can observe that the all dynamic parameters are influenced with priority by active aria A. With this method and with the proper VI of the numerical simulation is possible to see to change on-line of all constructive and functional parameters and to obtain the optimal answer of the outputs. Training with these instruments assures one optimal middle in the researcher's hands. Some icons of the assisted virtual LabView instruments for analyzing the linear hydraulic motor (LHM) and electrical motor (DC) are presented in figure 5 and 6 [3], [4], [8].

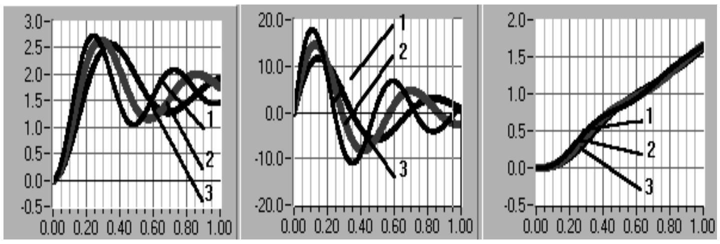

Figure 3. The real time linear displacement, velocity and acceleration characteristics when was changed the active volume *V;* 1, 2, and 3 correspond at the volume values: 500 (cm^3), 700 (cm^3), and respectively 1000 (cm^3)

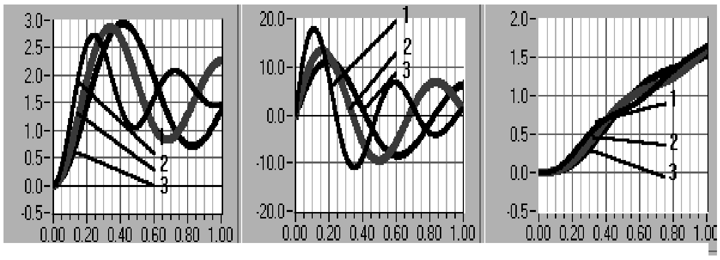

Figure 4. The real time linear displacement, velocity and acceleration characteristics when was changed the mass *m;* 1, 2, and 3 correspond at the mass values: 0.2 (daNs^2/ cm), 0.4 (daNs^2/ cm) and respectively 0.6 (daNs^2/ cm)

Table 1. The influences coefficients of the dynamic behavior

	t_r	a_{max}	ν_r	ν_c
A 0.15	0.28 1.86	0.11 0.73	0.3 2.0	1.0 6.66
V 0.40	0.5 1.25	0.11 0.275	0.25 0.625	0.16 0.4
m 1.0	0.33 0.33	0.22 0.22	0.25 0.25	0.33 0.33

All these VI shown on-line and offer to the researchers one fast possibility to choose the optimal value of the constructive or functional parameters.

The analyse was make by applying some P, PD_1, or PD_2 control laws on the command block of the (LHM) [5], [6], [7], [8].

We observe that after application of the PD_2 control law, the acceleration time and the oscillation was reduced by 50% for the same others constructive and functional parameters. The conclusions after analyzing the results of the hydraulic motor simulation, with the virtual LabView instrumentation, are: the position of the characteristic equation root is difficult to establish in a precision- stability field, without the virtual instrumentation; by changing on-line, the different constructive or functional parameters, with aid of the virtual instrumentation, was possible to easy make that; the proportional closed loop determines the amplitude increases and the answer time decreases; by the introduction of the general control PD_2 closed loop law, it was possible to optimize the dynamic behavior (the answer time and the amplitude are very small, the critical frequency is bigger and the phase is happened in the bigger frequency). For the assisted research of the dynamic behavior with comparing between the real and the frequency characteristics was created the mcc_fis_up.vi instrument, [1], [2], [4], [9]. The VI for the assisted comparative analyzes use the input data from file, where was changed one parameter. The VI works on-line with the possibility to input some others row of the input data file.

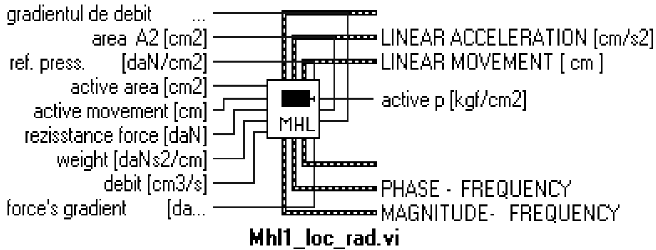

Figure 5. The icon of the virtual LabView instrument of the assisted dynamic behavior research of the (LHM)

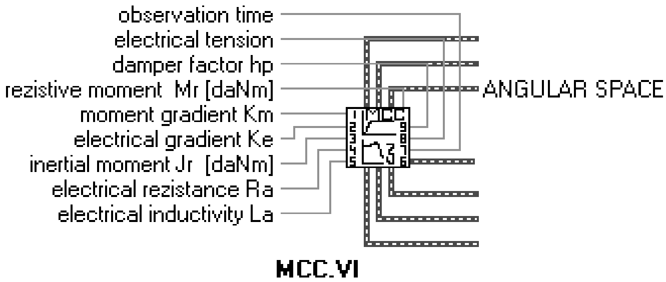

Figure 6. The icon of the (VI) for the assisted research of the (EM)

The characteristics, which were analyzed, are the same. With this facility is possible to see, in a comparative way, what some functional or constructive parameters change the real and frequency characteristics and finally is possible to choose the optimal value to obtain the desired output for one typically robot application, when is necessary, for example, good precision, or stability, or a good following capacity.

3. Acquisition virtual instrumentation

For the acquisition it was designed many virtual LabVIEW instruments. With these it was possible to analyze and validate the theoretical instruments, by compare the theoretical with the experimental results. The acquisition instruments assure the cinematic characteristics of acceleration, velocity and space, the frequency characteristics, spectrum of vibration, fast Fourier transform (FFT), Fourier transfer function, power spectrum density, magnitude and phase of frequency function and s.o.

For the assisted research was used the experimental research stand, figure 8, and many virtual LabVIEW instruments, figure 7.

All of the virtual instruments were designed in the LabVIEW 6.1 soft, from National Instruments USA [1], [3], [9]. For the assisted experimental research of the vibration behavior of the robot, have been used the following components: linear velocity transducer, accelerometers 601A01 IMI type of USA, the preamplifier for the accelerometers, the electrical stabilised 12V source, the connector for conditioning signal, the conditioning modulus SCM 5B38 type, from National Instruments USA, the apparatus for the measurements of the vibrations from Bruel and Kjaer Denmark, didactical robot arm type, robot command amplifier, personal computer, power source, generator of function type POF-1 from KABID Poland, amplifier for the generator, type LV 102 from MMF Germany, two accelerometers type 601A01, SN 30710 from IMI USA, electronic amplifier for the accelerometers, the electromagnetic exciter type 11075 from RFT Germany, connector type CB- 68 LP from National Instruments USA, acquisition board type PCI 6024E from National Instruments USA [1], [4]. The VI for the assisted research with data acquisition contents four blocks. One assures the command on-line of the robot movements, other the acquisition parameters, other show the vibration power spectral density characteristic and the last the transfer function between the excitation signal and the end-effectors robot vibration.

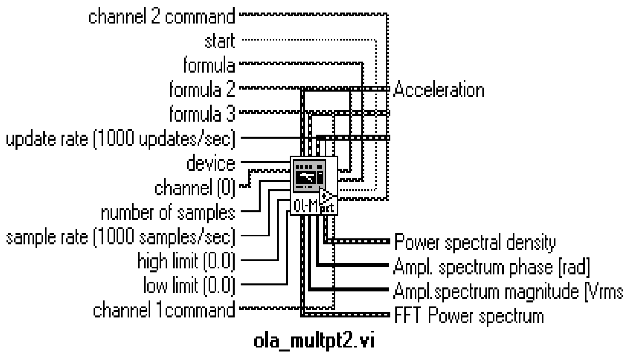

Figure 7. Icon of the experimental research with data

Figure 8. The experimental stands for the assisted research in the frequency domain and validation of mathematical models with data acquisition for the of the didactical robots

4. Conclusions

By using the proper VI-s and with the assisted experimental research by data acquisition, are assured the most important information about the dynamic behavior and it is possible to compare and validate the theoretical results by the experimental one. The optimization of the dynamic behavior in this case isn’t expensive and is made in a best condition and in a short time. With the VI is possible to establish very easy, the most important constructive or functional parameters, to move some frequency components in other domain to obtain the optimum vibration results. By using, the personal VI and the results of the modal vectors, the vibration proper modes and the vibration spectrum, we can establish the vibration (magnitude, phase and frequency) of all components and the Fourier transfer function between some points of the robot’s structure. The VI-s are generally and its can be used in analyzing of all others mechanical structures, transport-transfer and manipulation systems. The methodology has been applied in this paper also is very generally; it is possible to apply in many others mechanical systems. Mathematical model presented in the paper offers many interesting results about linear velocity and acceleration, frequencies spectral density, magnitude and phase in a frequencies domain. Experimental results by data acquisition assures the mathematical validation of the theoretical model and offer the possibility, in the future, to optimize the dynamic behavior by applying the proper VI-s. All created VI for the theoretical and experimental research will be can develop in the future for many others mechanical applications. The VI with transfer functions offers the possibility to choose optimum value of the magnification and for the all others control law parameters. In this mode is possible to simulate the Bode characteristics and establish the optimum frequency domain, the resonance frequencies, and s.o. The present paper assures all conditions for application in the future the smart structures, the smart panel and the smart components in a robot industrial construction.

In this paper also, was presented and the assisted training procedure in the dynamic behaviour of industrial robots with utilizing the elementary and the complex compose by open and closed loop block schema of the elementary transfer functions. For each elementary transfer functions was created a proper VI with there was possible to develop the complex simulation schema for one degree of drive system of articulated industrial robot arm and to study and optimise the function.

The created VI for the assisted research of the dynamic vibration behaviour is also generally. It is one very similar Fourier analyser, but with very reduced cost. It can be used in many mechanical applications when is necessary to establish and to optimise the vibration spectrum, the vibration Fourier transfer functions between some robot components. Use frequently this VI is possible to move some frequency components, or to decrease the vibration magnitude of someone vibration components, to obtain desired optimal frequency vibration spectrum.

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THE WEBLABS- DESIGNED FOR ENGINEERING DATABASE EXCHANGES

M. Risteiu, I. Ileana, G. Marc and S. C. Banacu

Abstract

The engineering developments implicates interdisciplinary efforts. On the other hand, experiments costs become too high, even the scientific idea is brilliant. It means that the engineering network research become a possible way of sustained research. The web databases for different techniques offers the networked contribution to the reengineering and change management. The paper offer the designed logistic via XML- PHP technique. The paper offers the related connection to the virtual lab, as thermometer, wind measurement system, remote optical measurement system, for demonstrating the possibility of change methods in the frame of reengineering task.

Keywords: *webdatabase, SCADA, measurements, virtual labs, data exchanges, reengineering, XML, php*

1. Introduction

1.1 Concepts

WebLabs is creating new ways of representing and expressing mathematical and scientific knowledge in communities of young learners (10-14 years). The focus is on collaborative construction, description and interpretation of how things work. Our aim is to transform the web into a medium in which European students collaboratively construct and critique each others' evolving knowledge and working models.

WebLab is investigating mathematical and scientific concept in three knowledge domains: numbers, big numbers and infinity, kinematics and dynamics, and complex systems. A further component will be tangibles: we are building an interface with physical devices together with the set of sensors and actuators capable of instantiating a two-way mapping between experiments in the real and virtual worlds.

Some of the most important reasons of "virtual learning and research" are summarized:

- Engineering Education Needs
- More involvement of off-campus faculty in teaching students
- More planned outreach instruction from campus
- Distance & time are the main constraints.
- Knowledge based databank
- Remote Real-Time Control & Collaboration

1.2 Educational Point Of View

In addition to providing vastly superior educational environment and material, the solutions are extremely cost effective making its adoption easily affordable by any educational institution. Up till now, the hardware needed to implement a meaningful lab for students suffer from the following factors:

- High acquisition costs, costly repairs and maintenance costs
- Difficult and sometimes unsafe to operate by young students
- Need expensive lab bench space
- Incompatible with internet technology

The educational software or paper texts used to deliver education to students often suffer from the following:

- No interactivity to guide and encourage student learning, lack of multimedia enhancements to make material more interesting or easier to comprehend.
- Costly to students with texts often approaching $100.
- Poor response to feedback. Content improvements occur slowly. The convenience of online graphing and calculation aids not available.

A revolutionary new instrument e-LAB fully integrated into on line lab content WEBlabs provide the solutions to overcome all the above stated problems.

1.3 Research Point Of View

All too often it was the technologists leading the charge with scant regard for pedagogical aspects. There is a growing realization that the time has come to take a step back, reflect and proceed in a manner that respects learning processes whilst realizing the full potential that ICTs can offer eLearning. WebLabs tackles the field of science and mathematics and looks at new means of representing and expressing this knowledge in European communities of young learners.

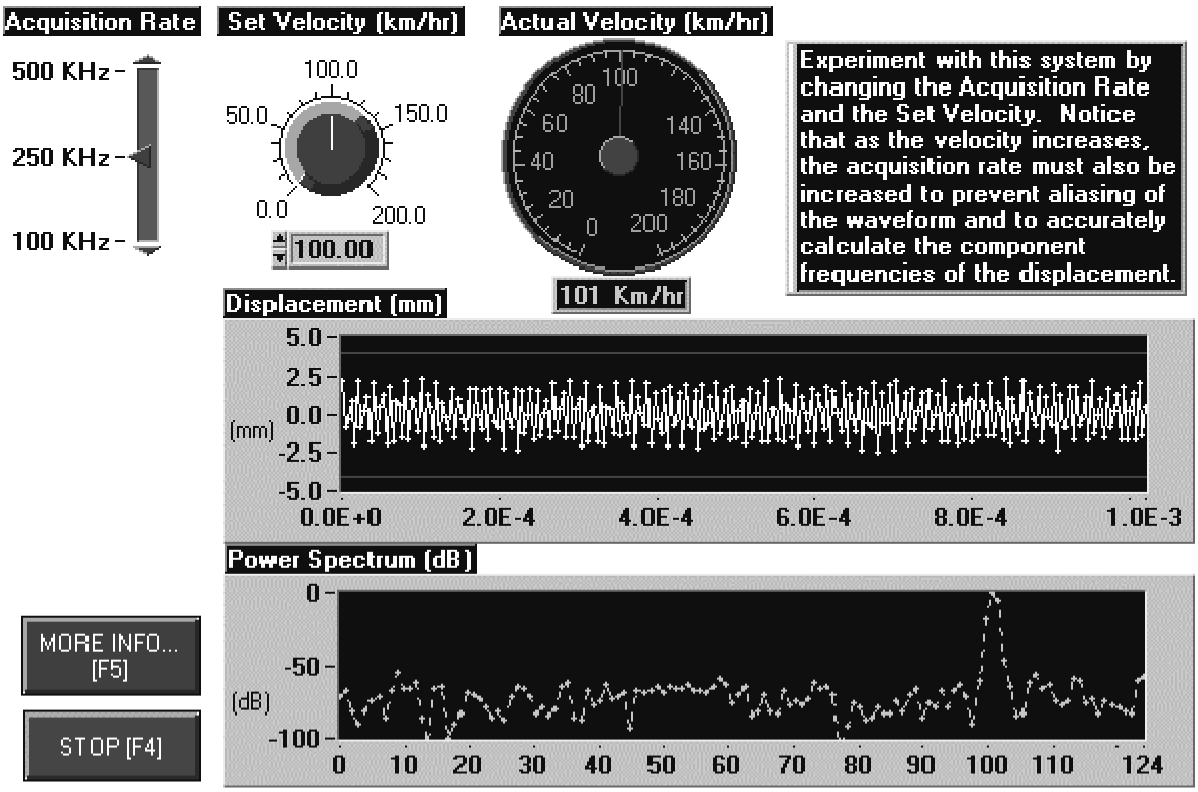

Figure 1. Web- based vibration measurement system- lab setup

The central tenet of WebLabs' research is to design and create new ways of representing scientific knowledge in communities of learning which exploit state-of-the-art technologies to enhance learn ability and accessibility across Europe. The team will focus on collaborative construction, description and interpretation of working models of mechanisms and the sharing of knowledge across cultures and countries.

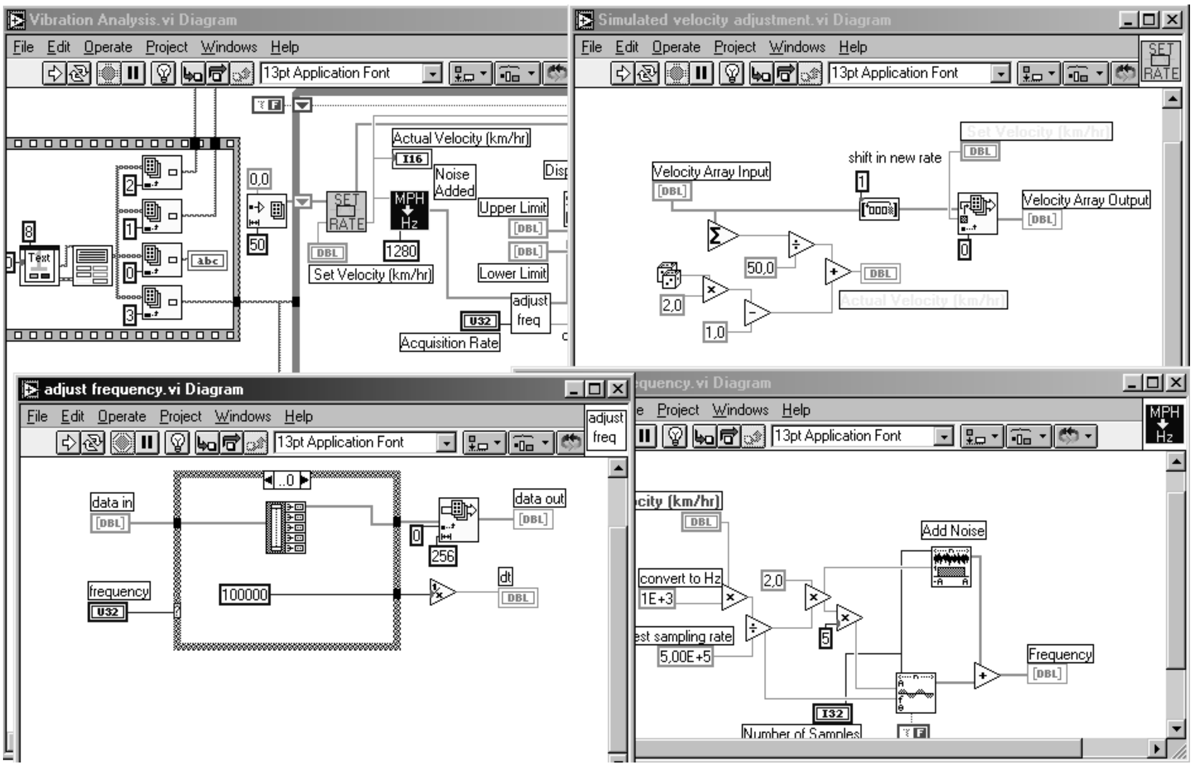

Figure 2. Data flow model of the front panel lab setup- digital signal processing phase

Changes in representational infrastructure (the ways in which knowledge is represented) are intimately linked both to learn ability and to the democratization of intellectual power i.e. the extent to which less privileged groups in Europe can gain access to knowledge. Systems depend on the particularities and interconnectedness of the representational infrastructure in which they are expressed for their learn ability. They are also dependent on the extent to which they productively exploit multimedia tools.

2. Reusable architectures

Therefore to rise to this, a system which is at once open and accessible, that offers students/educators/researchers a functional portal into operating within new, formal worlds, yet simultaneously allows them to see what works and how it works, is called for.

The main condition related to these is the development process of reusable architectures, like frameworks or products lines, in order to provide support for different development activities.

There are different starting points for building reusable architectures, each with emphasis on other activities: based on the generalization of several similar applications, on the reengineering of legacy software, on pattern language, or completely new systems, or models. All approaches require a smooth cooperation of stakeholders, whose roles vary in different development phases.

There are three kind of competences what are implicated in the continue process of development: domain expert, developer of reusable architecture, developer of the application.

3. Problem solving

Usually, specific field solution offers a solving pattern. By applying PHP- XML techniques, the main benefit is open –source facility, open- platform tool, data mining solution.

For the first stage of the development process, requirements for a particular domain need to be acquired. To reach good results, a close cooperation between domain experts and developers is necessary. The domain experts specify the variable and common parts of the architect- developers and application users during the evaluation of an application. The architecture developer may request new or missing properties as a result of the evaluation. Every evaluation development results in extensions and changes. Each changes affects the maintainability of the particular reusable architecture.

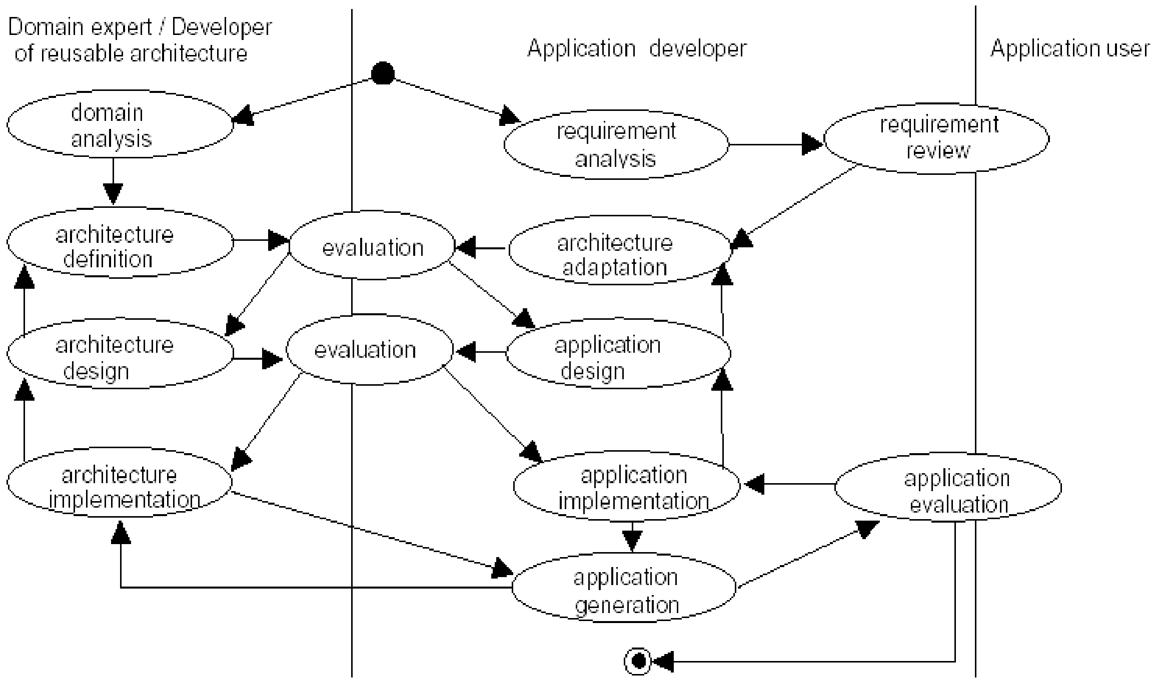

Fig.3. Some of the identified activities in a reusable architecture [3]

The process structure shown in figure 4 explains the information management for a reusable architecture by PHP- XML cluster structuring. Benchmarking activity uses the three competences for dynamic evolution. Based on object-oriented methods, K. Khang and K.Cohen [2] introduced Feature Oriented Method as a domain design strategy, as a product line management.

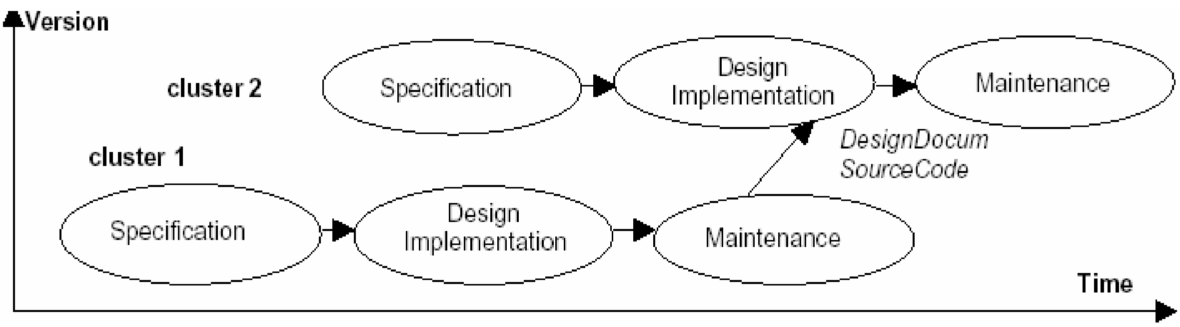

Fig. 4. PHP- XML opportunity of software maintainability in reusable architecture

Once an organization has defined its maintenance process, software reengineering tools provide support for the migration of legacy software systems into the new maintenance environment; in particular, they provide support for:

- to capture design information and to comply with standards
- to restructure the system, even if unstructured
- to retarget and resource the code and to support and encourage reuse
- to assess the system
- to elicit business information embedded in the application, and to use them in performing a more general reengineering of the overall company's business process.

Based on the fact that software systems evolve during and after development, but requirements for evolution is hardly ever addressed at the start, Application Evolution aims at providing software built specifically to facilitate evolution.

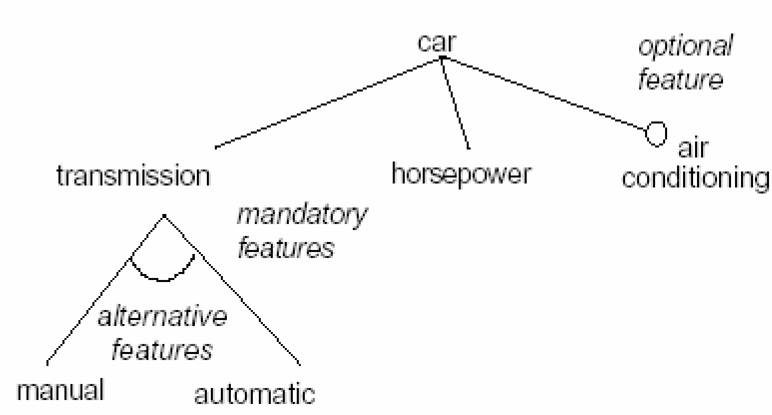

Fig. 5 Feature diagram example- as a Feature Oriented Method

4. Solutions

4.1 e-Lab

By building together the three experts parts, the developing activity become more difficult, more complicated, and require new information management techniques. The e-LAB, is a real instrument that has dual channel high-speed data acquisition, signal generation and multiple user controlled devices. Capabilities of e-LAB are equivalent to a complete suite of laboratory equipment. Its operational face (computer based control panel) can look as simple as a battery or as complex as a bench-full of engineering instruments with the following real capabilities:

- **Functions Features Dual channel - digital storage oscilloscope**
  Strip chart recorder
  Dual digital voltmeter
  Digital frequency meter
  Waveform segment analyzer
  Continuous spectrum analyzer
  Triple power supply
- **Function generator Rear connection to PC Parallel Port**
  Triggered with AC or DC Coupling
  Scope or Real-time Record Mode
  16 frequency ranges in scope mode
  Triple Power Supply 5v 500ma & dual tracking 0- 8v 250ma
  Store results to disk or print
  Built-in DC, RMS, PK to PK and Frequency Meter (10Hz to 2MHz)
  10 gain ranges: 5v/dv to 5mv/dv
  TTL level square wave generator 0- 2MHz, crystal controlled
  0-5v peak sine wave generator 0- 2MHz, crystal controlled
  3 bit Output for Control Purposes

4.2 WEBlabs

Because e-LAB is a computer-controlled instrument, it permits a totally integrated approach to delivering lab experiments on line. By embedding custom instrument control panels for each lab, doing lab experiments is made safer and easier. The advantages of this integrated WEBlab delivery system include the following:

- Built in interactivity ensures comprehension and prevents mindless data taking; easily provides colorful supporting multimedia to clearly illustrate theory or procedure

- Permits immediate and easy access to unlimited internet resources for research; provides timely helpful tutorials
- Built in graphing aids and report templates rewards students with clear and useful reports, allows instant student feedback to permit rapid continuing improvements to overall lab presentation
- Web based material can be quickly revised and updated; good material is easily disseminated to a worldwide audience
- Makes teamwork and collaboration easier

4.3 Transparent Modules Act As Building Blocks

Students will construct models [1, 4] of knowledge domains in terms of a representational infrastructure that will be built using software designed in the form of transparent modules. These have three defining characteristics:

- they are simultaneously re-usable and transferable for building more complex functionalities;
- they are shareable;
- they can take on multiple grain sizes according to diverse learner needs.

To do this requires transparency in the sense that the mechanisms (how and why the modules work) can be easily inspected and modified. To maximize the inspectability and appreciation of a module's functionality, WebLabs will adopt multimedia and multimodal means. To be able to be modified implies that in the development of TMs, WebLabs must go beyond the ability to combine Web component technology [4]. They must explore how modules can be adapted according to the needs of a range of educational activities, which again depend on the requirements of diverse European curricula and classrooms.

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FOLLOWING OUTLINES BY ROBOTIC RETINAL EYE MOVEMENTS

T. Rončević and V. Zanchi

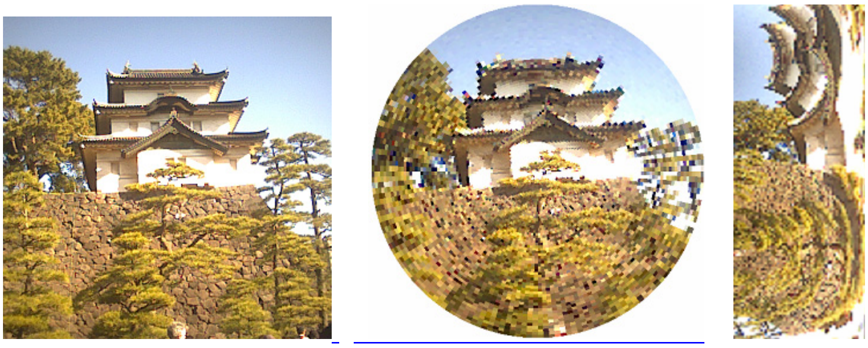
Abstract

Traditional systems of robotic vision have severe drawbacks. Acquiring large quantities of data from high-resolution camera it often results in long time of image processing. An interesting alternative is emulation of retinal vision using log-polar cameras [1]. The difference in resolution between centre (high resolution) and periphery (low resolution) of the image acquired with this type of camera can be fully compensated by use of active vision, exactly as humans do. Active vision allows moving camera over different points in the perception field so it is possible to reconstruct a high-resolution image of entire visible space. Doing so we would again have the same (or larger) quantity of data as with traditional cameras. That is why we need to define and search only the points of some interest for the intended task again in analogy with human vision [2][3]. It has been noted that human eyes usually prefer points with sharp change of colour or intensity. That is why we can assume that eyes are searching mostly for object's edges. This work proposes methods for finding and extracting outlines of objects using an anthropomorphic robotic head equipped with log-polar digital camera.

Keywords: robotic vision; active vision; retinal vision

1. Introduction

Vision is one of the most important robotic perceptive systems. Especially if robotic system has to operate in a non-structured and time-variable ambient, vision system permits it to coordinate and function normally. Drawback of every vision system is the quantity and complexity of acquired data. Since for most vision problems no generally efficient solution has been found it is worth trying to improve efficiency by reducing the quantity of processed data. Reducing image resolution this quantity can be reduced immediately during acquisition but this necessarily leads to proportionally worse quality of data. Using log-polar camera this problem can be solved in optimal manner since we can consider either high or low quality parts of the image. Problem is still not solved until we decide a good criterion when to consider high-resolution parts of the image. Traditionally, methods for extraction and recognition of objects are developed for use on single image of object. This approach is less likely to be used on images acquired with log-polar cameras. The reason resides in the particular structure of the image that has very small high-resolution area in the center so that object usually won't be entirely enclosed inside it. Most of the object will reside in the low-resolution periphery of the image and accurate elaboration won't be possible. Obvious solution is to move the log-polar camera until we have all the necessary information for the object's representation reconstruction. Of course, we will also be interested in minimizing the movement of camera. Log-polar cameras were inspired by the human vision illustrated on Figure 1. That is why we can assume that some solutions for these problems can be found in analogy with natural solutions. The first observation is that human eyes can move, even more they are constantly moving even if the observed scene is motionless. So the active vision is certainly solution that we need to adopt with log-polar cameras. It has been noticed that human eyes prefer the parts of the observed scene with great variation of color and intensity from which they succeed to reconstruct entire scene. In our case we can assume that edges (parts with great variation of color or intensity) of the observed object are interesting for object recognition. Better, most of the times these parts will be sufficient for the object recognition. In this paper will be described application of different standard methods from image analysis on the retinal image combined with control of the robotic retinal eye finalized for the extraction of objects outline.



(a) (b) (c)

Figure 1. Cartesian image (a), its log-polar emulation (b) and cortical representation of log-polar image (c)

2. Methods

Two main problems have to be resolved before we start following the object's edge. First we have to find the object in the robotic eye's visual field. Second problem is bringing the object's edge in the center of the log-polar image. First problem can be achieved by systematic search (for example following an imaginary spiral with eye) until we find an object in periphery of log-polar image. Of course we have to determine how to detect the part of object inside the image. To do this we search strong variation of intensity or color in periphery of the image using the Equation 1. For any image part: ipiv is its intensity variation, σ is its standard deviation of intensity and μ is its medium intensity.

$$ipiv = \frac{\sigma}{\mu} \tag{1}$$

We use the same method to find in which direction the eye must move until the edge is inside the fovea (central part of the log-polar image). We simply apply the equation 1 on parts of the periphery. Figure 2 is showing an example of detection of an object in periphery of the image.

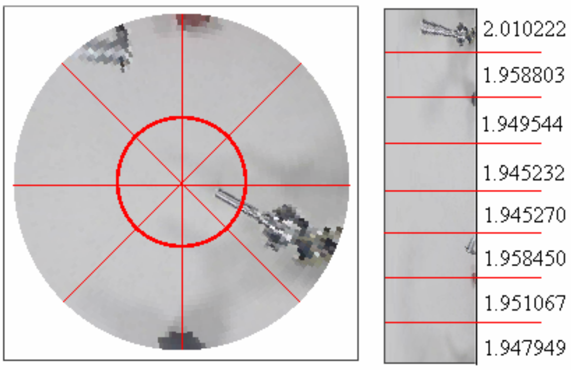
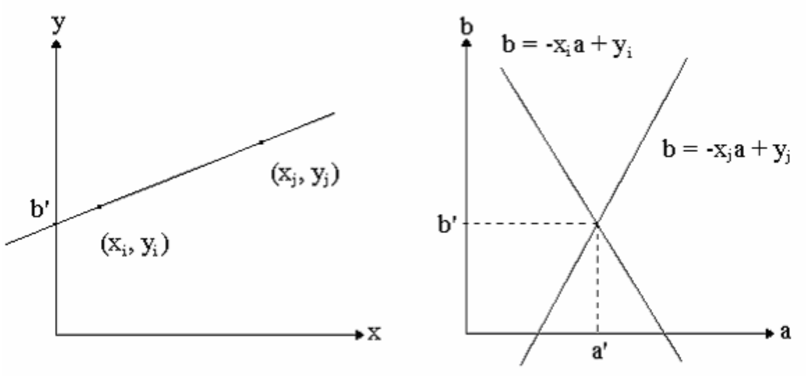


Figure 2. Results of applying Equation 1 on the image, red lines are dividing the periphery in parts and red circle is dividing fovea from periphery of log-polar image

Once the edge is in the center of the image we can apply an edge detector over entire fovea. It is possible to apply any edge detector that is suitable for the cortical representation of the log-polar image. Now we have a matrix of the same dimension of fovea containing ones and zeros showing where are the possible edge fragments. This information is still useless as it is for establishing direction and positions of linear edges. That is why there is necessary step that compacts these edge fragments in completely described linear edges in fovea. The Hough transform [4] is the method chosen for this need. It is applied on each edge fragment. Principles for this method are illustrated on Figure 3 and Equation 2.

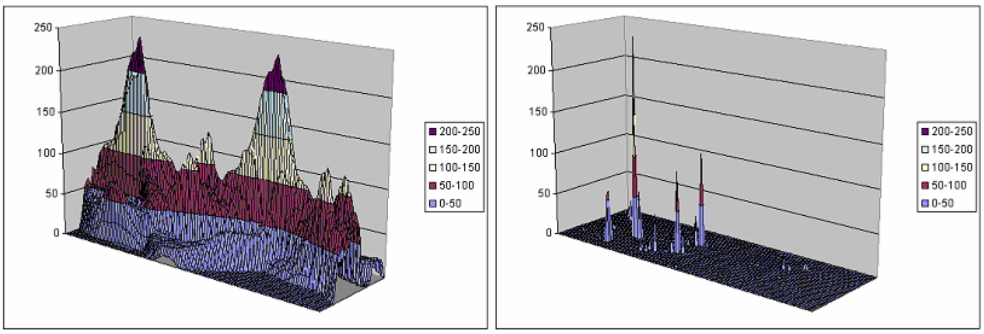


(a) (b)

Figure 3. The Hough transforms: image (a) and parameters (b) space

$$\begin{aligned} &\forall(\theta,\rho): x\sin(\theta) + y\cos(\theta) = \rho \\ &H(\theta,\rho) = H(\theta,\rho) + 1 \end{aligned} \tag{2}$$

Principal problem with Hough transform is that it gives as output a matrix similar to matrix showed on Figure 4a. We still need to determine which cells of this matrix are containing polar coordinates of existing linear edges. This problem is not trivial because discrete version of Hough transform is introducing lots of error. If we where looking only for most distinct edge, we could confidently take the highest value of the matrix. Since we need to find all of the edges present in fovea we need another solution. Back mapping algorithm in combination with Hough transform gives us the matrix showed on Figure 4b from which the wanted lines are extracted easily with a threshold.



(a) (b)

Figure 4. 3D representations of matrix produced during detection of lines with Hough transform: before (a) and after back mapping (b)

Once we have found the direction and the position of the line that partially describes an edge we still need to find second part of information. We need to know exact part of that line occupied by that linear edge. For that purpose the center of robotic eye is posed over the edge's line moving along direction correspondent to line's θ polar coordinate. Then the edge fragments along that line are examined. That is how robot decides in which direction the eye has to move along the edge.

Every time an angle between two edges is encountered all lines entering the center of the image are examined and the new direction is chosen. Eye chooses any direction different than direction that it is coming from. During this movement along the edge all eye positions are memorized in a list from which it will be possible to reconstruct entire object's outline. This algorithm proceeds until the eye reaches already examined position. Now we gathered all the needed information for reconstruction and representation of object's outline. For validation purposes the chain-code method [4] of outline representation was implemented.

3. Experimental results

Realization and testing of this system was made entirely in ARTS (Advanced Robotics Technology & Systems) Laboratory of the Scuola Superiore Sant'Anna in Pisa, Italy. An image of experimental set-up is shown on Figure 5a. All joints of manipulator and robotic head except two eye joints where fixed. Objects were posed in eye's visual field and outline extraction was preformed. Since there was no log-polar camera available, the cortical image was emulated starting from normal Cartesian image acquired with an web-cam, transforming it into its log-polar representation and then mapping it to cortical plane using "Giotto 2" camera [6] specifications (developed at University of Geneva).

(a) **(B)**

Figure 5. Experimental set-up (a) and robotic eye's view (b)

In Table 1 are shown results obtained over experimental set of 5 objects. Medium time is time that passes between two movements of robotic eye. Medium error is the relative difference of the object's surface and surface enclosed by chain-code. Success column is number of successes of detection of entire object's outline.

Table 1. Experimental results

Object	Medium time (sec)	Medium error	Success
A	0.44	0.15	5/6
B	0.45	0.10	6/6
C	0.96	0.17	3/6
D	0.39	0.20	6/6
E	0.57	0.03	6/6
Total	0.56	0.13	26/30

Confronting memorized positions during edge following and chain-code reconstructed we discovered that most of the error was introduced in chain-code reconstruction. Also the number of successes, precision and speed could be significantly improved by smoother robotic eye control, which was not yet complete during these experiments.

Acknowledgement

Special thanks to Cecilia Laschi and Giancarlo Teti, members of the ARTS Laboratory, which allowed this entire project to be realized and tested.

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VISUAL IDENTIFICATION OF HUMAN KINEMATIC DATA BY WALSH METHOD

T. Rončević and V. Zanchi

Abstract

Human tracking is currently one of the most active research topics in computer vision. This paper proposes a marker-based approach for recovering of human motion parameters from monocular video sequences. In many previous works [1][2] identification of human kinematics was crucial problem in analysis of quality of locomotion. There are developed commercial systems in visual identification of movement like VICON's Workstation, Ariel system or others. Principal problem relies in complicated structure and variable pose of human body resulting in an often self-occlusion of particular segments. Visual identification using markers placed on crucial positions of the body for the specific motion observed is matter of many actual investigations. Tracking of markers is still a problem because of the occlusion of markers and noise introduced capturing video sequences of motion. Simple correlation techniques often fail to track all the markers over entire video sequence. That is why there is still the need of improving the marker identification. In this work is offered the new software that identifies markers using the Walsh transform [3]. It also reduces self-occlusion problems by prediction of next marker's position and distinguishes markers closely posed using markers of different colour.

Keywords: markers; visual identification; human motion; Walsh transform

1. Introduction

Simplifications introduced with markers for tracking of the human motion are not completely solving problems of visual identification. Idea is basically to find a marker identified on one frame of the video sequence on the following frames. Most of the problems with marker identification can be classified in four groups: detection of the marker, detection of occlusion, estimation of occluded marker and distinction of markers on sequences with more than one positioned marker. These problems are especially accented in visual identification of human motion. The marker detection is problematic since makers are usually posed on cloth that is flexing during the motion and so the image of the marker is changing drastically over the sequence. The occlusion can be hard to identify and the simpler methods of marker position prediction will faille whenever the segment of the body is changing direction of movement. For some smaller body segment (e.g. foot), which needs more than one marker, markers positioned closely are hard to distinct. This paper is presenting software that deals with most of these problems successfully. It still needs to be controlled and marker tracking corrected manually for some frames of the sequence especially for the low quality video registrations.

2. Methods

By TV-PC system the acquisition of data was done in form of video sequence. The quality of the registration is essential for the marker tracking. Not only its quality of resolution and illumination but also frame frequency since images of markers are usually chaining rapidly over time. This software was developed and tested for video sequences of 25 frames/sec, with 320x240 resolution and 24-bit per pixel RGB colour definition. Markers used were circles with diameter of approximately 5cm positioned on crucial points of human body as showed on figure 1.

Figure 1. Examples of markers positioned on human body

Different options for marker tracking were implemented. For both standard and Walsh correlation technique three marker-updating types can be selected. For standard correlation another important option is weight distribution. All these methods are explained in subparagraphs 2.1 and 2.2. Approximation of markers was used only as an indication of where to search for the marker and is explained in subparagraph 2.3 together with general strategy of marker tracking. In subparagraph 2.4 format of output produced by this software is explained.

2.1 Marker updating

This is an important method that determines the way the image of selected marker is conserved changed. The simplest way is to record an image of the marker cutting it from the first frame of the sequence where it was selected and then use that image for entire sequence of frames. Principal problem with this technique is that image of the same marker is changing so the difference between images of marker on first frame and current frame can misguide the tracking process. Second possibility is to cut the image of marker from each frame examined and use it only for the next frame in sequence. Problems occur because the marker is not always precisely found so new image of marker accumulates all the error committed until that frame and eventually introduces more error. To reduce this accumulation of error and keep the image of marker actual for current part of the sequence there is the third technique implemented. This technique combines the "none" and "full" updating by summing it and dividing that sum by two. So marker image will be the sum of all marker images until the current frame weighted by a distance from it (equation 1). This partial update gave best results with both standard and Walsh correlation.

2.2 Marker confrontation

Measurement of marker image similarity is essential part of the marker-tracking algorithm. For that need, we construct the function $f : \mathrm{Im}\, x\, \mathrm{Im} \rightarrow R$ that gives us the real number proportional to the difference or similarity two images.

$$marker\_image(k+1) = \sum_{i=0}^{k} \frac{marker\_image(i)}{2^{1+k-i}} \qquad (1)$$

If we look at the image as a vector composed of pixel intensities then this function can be seen as dot product of two vectors that will be proportional to the their similarity. Another possible function is the Euclidian distance of the two vectors, which was implemented in this software. The image of a round marker will be often disturbed, but it can be noticed that the central part of the marker image will be disturbed less then the peripheral parts. This fact can be used for improvement of the standard correlation measurement technique by giving different weight to pixels in base of their position. In this software were implemented four different weight types, resulting in different types of correlation shown in equations 2,3,4 and 5. In these equations (x, y) are Cartesian coordinates from the centre of the pixel on marker image while I_a and I_b are intensities of confronting images.

$$corr(I_a, I_b) = \sum_{x=-W}^{W} \sum_{y=-H}^{H} (I_a(x,y) - I_b(x,y))^2 \tag{2}$$

$$corr(I_a, I_b) = \sum_{x=-W}^{W} \sum_{y=-H}^{H} [(W^2 + H^2) - (x^2 + y^2)](I_a(x,y) - I_b(x,y))^2 \tag{3}$$

$$corr(I_a, I_b) = \sum_{x=-W}^{W} \sum_{y=-H}^{H} (\sqrt{W^2 + H^2} - \sqrt{x^2 + y^2})(I_a(x,y) - I_b(x,y))^2 \tag{4}$$

$$corr(I_a, I_b) = \sum_{x=-W}^{W} \sum_{y=-H}^{H} e^{\sqrt{W^2+H^2} - \sqrt{x^2+y^2}} (I_a(x,y) - I_b(x,y))^2 \tag{5}$$

Another possibility is to transform the images before confrontation. The 2-D Walsh transform [3], applied on an image, gives us a set of parameters that corresponds to differences between parts of the image as shown on figure 2.

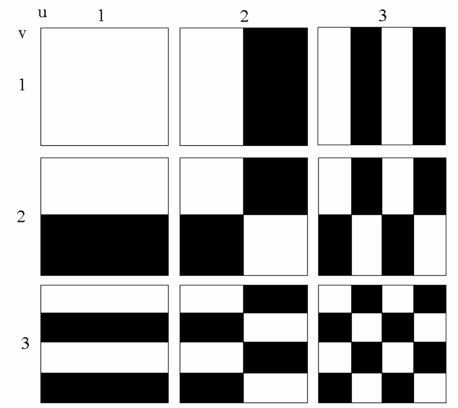


Figure 2. Parts of the image (for u=1…3, v=1…3) that are being subtracted in 2-D Walsh transform, black parts minus white parts

This transform conserves the shape of the image and, if normalized, is invariant to changes of illumination. Sets of parameters from marker images were obtained using Walsh transform show in equation 6 and then confronted using equation 7. In equation 6 bi(n) indicates i-th bit of binary representation of n, while f(x, y) is intensity of pixel (x, y).

$$W(u,v) = \frac{1}{N} \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \prod_{i=0}^{n-1} (-1)^{[b_i(x) b_{n-1-1}(u) + b_i(y) b_{n-1-i}(v)]} \tag{6}$$

$$corr(I_a, I_b) = \sum_{u=0}^{U} \sum_{v=0}^{V} (W_a(u,v) - W_b(u,v))^2 \tag{7}$$

2.3 Marker approximation and tracking

Simple approximation of next marker position was obtained by assuming that direction and velocity will be nearly constant from one frame to another. This assumption is logical for the quality video sequence of the human movement that usually doesn't have any sharp changes of speed or direction. This approximation gave us the point from which (in certain range) the marker should be found. Using both standard and Walsh correlations we obtain two possible coordinates for marker: (x_standard, y_standard) and (x_walsh, y_walsh). If this coordinates coincide the marker is assumed found in that point. Otherwise the next marker coordinates are assumed either:

1. Closest from (x_standard, y_standard) and (x_walsh, y_walsh) to the approximated marker position, if close enough
2. Approximated marker position, otherwise

In this case marker image is not updated. This gives us the possibility to continue marker tracking even if for some frames marker isn't found correctly.

2.4 Output matrix

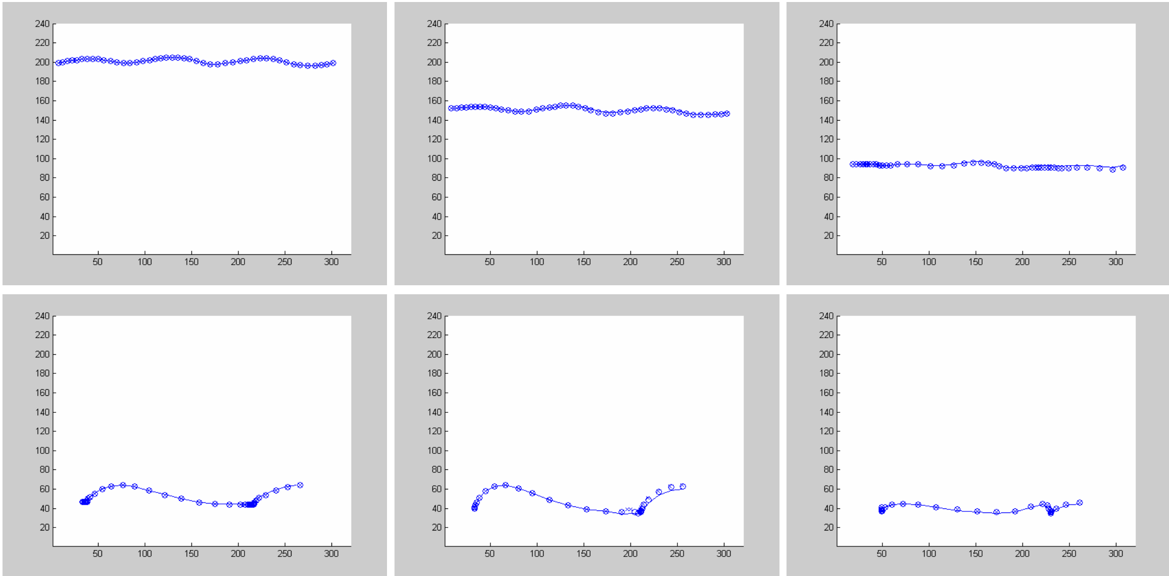
Results of marker tracking were memorized for each frame as (x, y) coordinates in pixels starting from left-bottom corner of the image. Since not all of the markers have to be tracked over entire video sequence, for the frames where some marker was not tracked x and y are 0. In the end the MATLAB compatible matrix of the form showed on figure 3 was written in a text file. Odd columns are x coordinate while even columns are y coordinate of each marker, rows correspond to each frame of video sequence.

```
a = [
0   0   0   0   ...   0   0   0;
0   0   0   0   ...   0   0   0;
.
.
.
0   0   0   0   ...   0   0   0;
48   25   34   32   …   211   66   91;
62   23   47   28   …    211   70   91;
.
.
.
305   30 284   29   ...    210 310 100;
0   0   0   0   ...   0   0   0;
];
```

Figure 3. The output matrix

3. Results

The software was developed and tested several cases: walking person and rower on an ergometer, similar to figure 1. From the matrix, obtained by this software, following graphs were made with MATLAB. These graphs show the coordinates of 6 markers during human gait tracked by: Walsh correlation (circles), standard correlation (full line) and combined techniques (crosses).



It was noted that all techniques had problems to track fifth marker (heel) on frames 27 and 28. Both Walsh and standard correlations failed to track it and all following tracking of fifth marker was compromised (this failure was manually corrected). Combined techniques succeeded in detecting the failure and to continue the tracking correctly from frame 29. This showed clearly advantage of combined techniques for reliability of marker tracking. Smaller errors introduced by frames where tracking failed can be easily removed with appropriate techniques.

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DYNAMIC STABILITY IN OPEN CIRCUIT HYDROSTATIC SYSTEM

D. Siminiati

Abstract

The main function of spring loaded relief valve is to limit pressure in hydrostatic system in the moment when hydro motor is overloaded. The relief valve opens and allows working fluid to begin to flow to reservoir. In that moment, pressure drops in the pump pressure pipeline. That is the way of prevention from damage all the equipment in the system. A great problem of direct acting relief valve is the phenomenon of oscillation of the flow rate and pressure that appears during operation. That is the reason for vibration and noise. An analysis with various values of limitation pressure and flow rate, that relief valve has, is made to get a dynamic stability on open circuit hydrostatic system. An optimisation of limit pressure and flow rate is possible for knowing characteristics of the other components on hydrostatic system. Based on the simulation process made with simulation software ITI-SIM 3, the analysis of the system dynamic behaviour has been made.

Keywords: relief valve, setting pressure, dynamic stability

1. Introduction

It has been analysed simply open hydraulic circuit (Figure 1.), which purpose is to lift or lower the load mass in vertical direction.

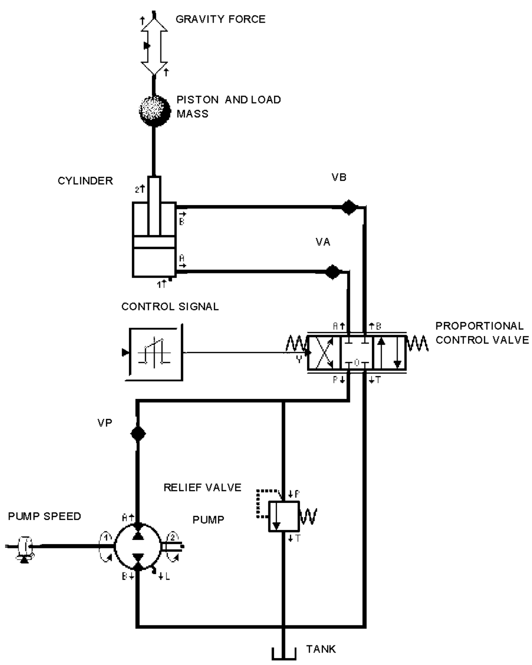

Figure 1. Model structure of the open circuit cylinder drive

Hydro motor is the two acting cylinder, which is loaded with piston and load mass. The proportional directional control valve has command signal. For pressure supply is used a constant displacement pump, driven at a constant speed. The direct acting relief valve is connected with the pressure pump pipeline. The flow rate through relief valve is 120 l/min, the upper limit for direct acting type.

For such configuration of open circuit hydrostatic system, a simulation with simulation software ITI-SIM 3 [2] has been made.

We can put feedback of the actual cylinder position to the control valve. However, in the aim of analysing on dynamic behaviour of the system, influenced with characteristics of the relief valve, system has been made quite simplified.

2. Properties of the elements

The constant displacement pump had displacement volume of 50 cm^3 and constant speed 1000 min^{-1}. The flow through the proportional control valve has been 60 l/min. The two acting cylinder had maximum stroke 400 mm, piston diameter 50 mm and piston rod diameter 36 mm. Piston and load mass was 100 kg. Those were variables, which have been unchangeable for the first part of the analysis.

Control signal was with normalised stroking from −1 to +1. At an input signal of zero, the valve will be in its centre position. We can see the form of the control signal on Figure 2.

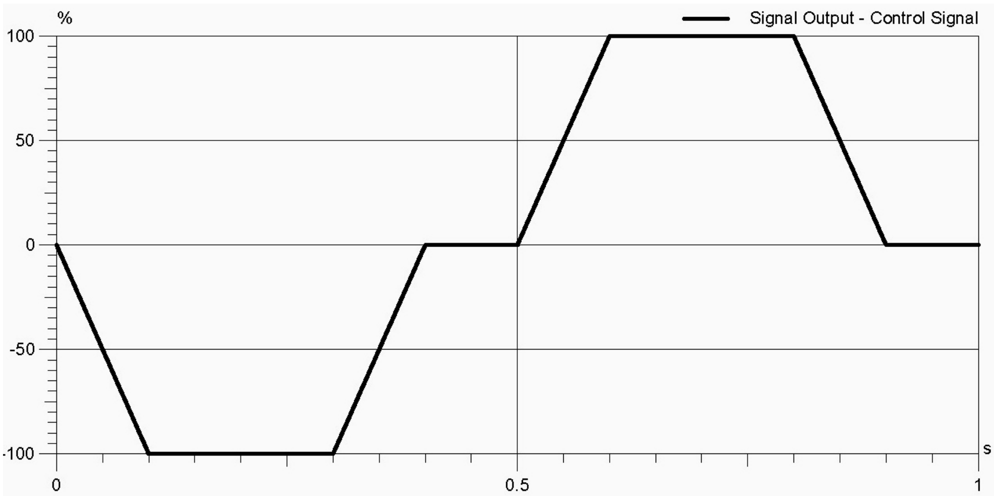

Figure 2. Control signal for the proportional control valve

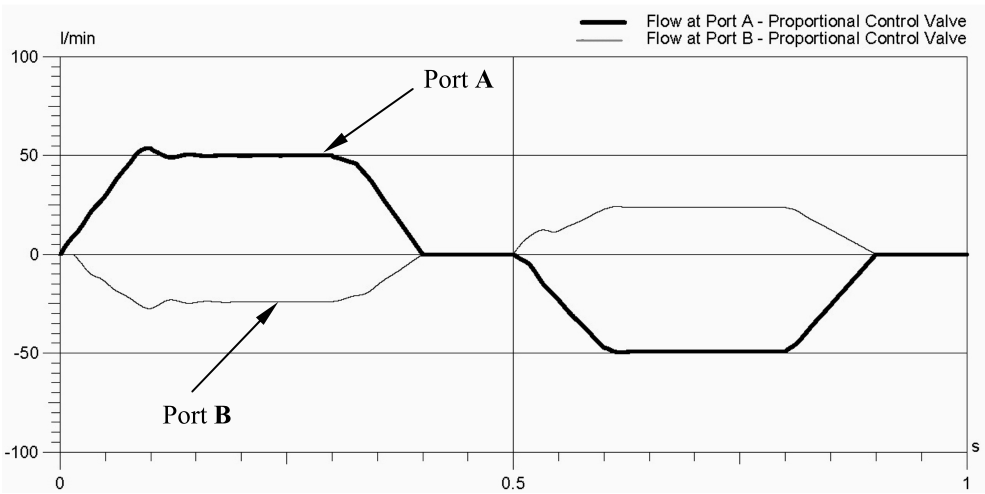

Figure 3. The flow at port A and B of the proportional control valve

The flow at port A and B in proportional control valve (Figure 3.) is somehow proportional to the stroke signal. Because we have a differential cylinder, the flow shows an unsymmetrical behaviour. The maximum positive flow cannot exceed 50 l/min, which is the flow of the pump.

3. Simulation and analysis

3.1 The analysis with relief valve setting pressure

The analysis has been made with mineral oil ISO VG 46 and working temperature of 40°C. Relief valve had set pressures of 50, 100 and 200 bar and static flow 120 l/min. Friction forces and inner losses of oil in cylinder were supposed.

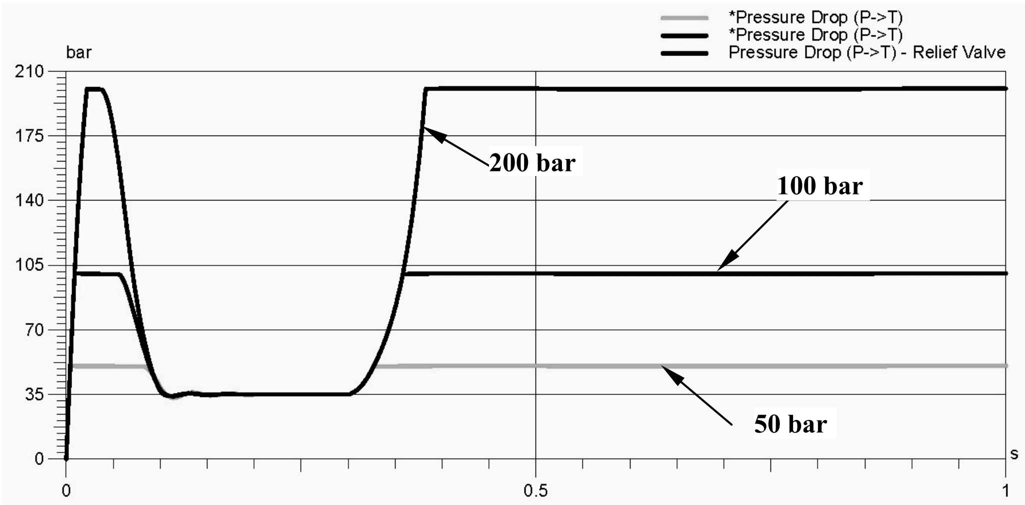

Figure 4. Pressure drop in the relief valve

Pressure drop through relief valve has been always up to 32 bar (Figure 4.). Therefore, it means that hydraulic energy losses for setting pressure of 200 bar are the greatest, which can be seen on Figure 5.

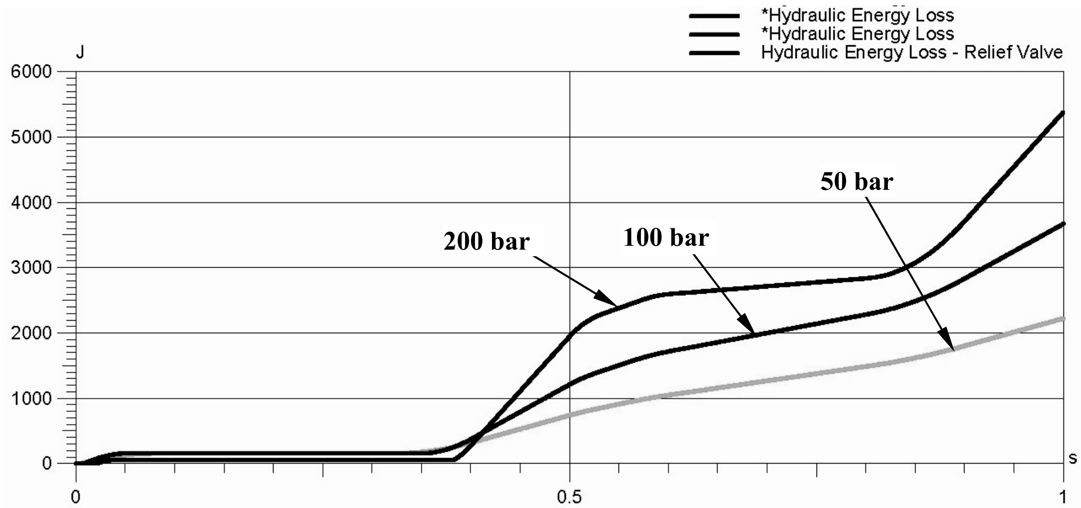

Figure 5. Hydraulic energy loss through the relief valve

The cylinder force shows a great instability as Figure 6. shows. At the beginning and at the end of stroke, cylinder force oscillates about 1000 N. Those oscillations are greater for higher setting pressure of the relief valve. Therefore, if we do not expect a greater loading on the cylinder rod, it is much better to set a lower setting pressure on the relief valve.

The velocity of the piston (shown on Figure 7.) is proportional to the flow in the control valve. As the pump pressure drops from 50, 100 and 200 bar to 32 bar, the velocity also decreases slightly. When the control valve is closed, the piston velocity oscillates because of the oil compressibility.

Figure 6. Cylinder force

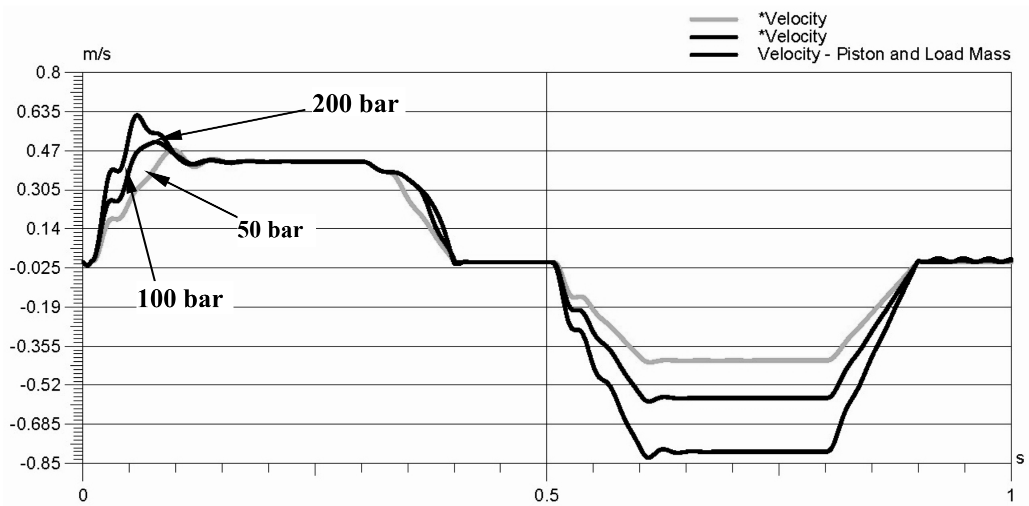

Figure 7. Velocity of the piston

3.2 The analysis with various flow rating

When setting pressure of the relief valve is 50 bar but flow rate through proportional control valve is changeable, the flow rate through relief valve is changeable, too. For that analysis the flow rates have been 20, 60 and 120 l/min.

For the greatest flow rate, system shows very high degree of instability, especially for filling up the port A of the cylinder, which can be seen on Figure 8. The instability is obvious in the velocity of the piston (Figure 9.), too. The only advantage of greater flow rate is higher velocity of the piston rod, not for 120 l/min but 60 l/min because the system is a little more stable.

A difference between constant flow of the pump and flow rate through proportional control valve streams through relief valve. For above mentioned characteristic of the relief valve, and that is static flow of 120 l/min, system is relative stable for greater flow rate through the relief valve. Any enlargement of flow through relief valve would require another type of relief valve (for instance servo-commanded).

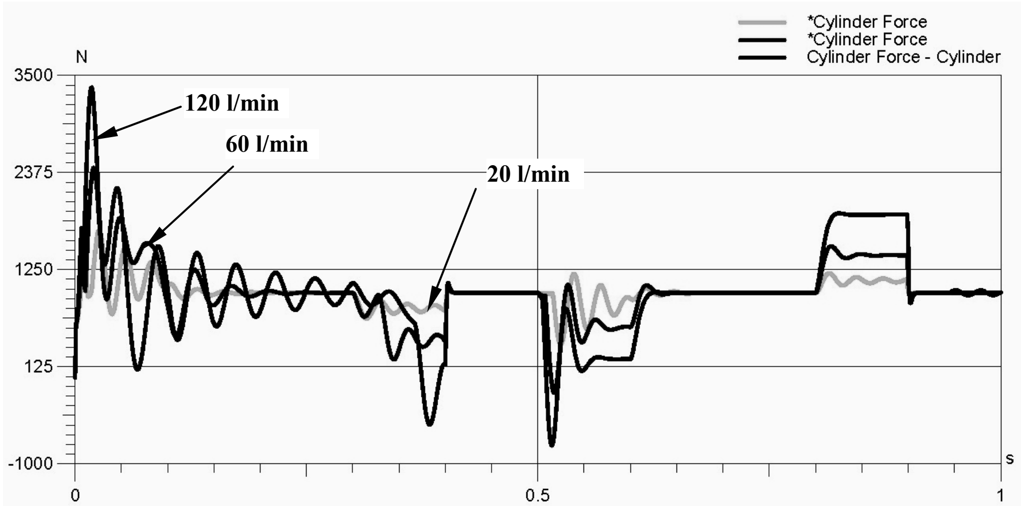

Figure 8. Cylinder force for various flow rate of the proportional control valve

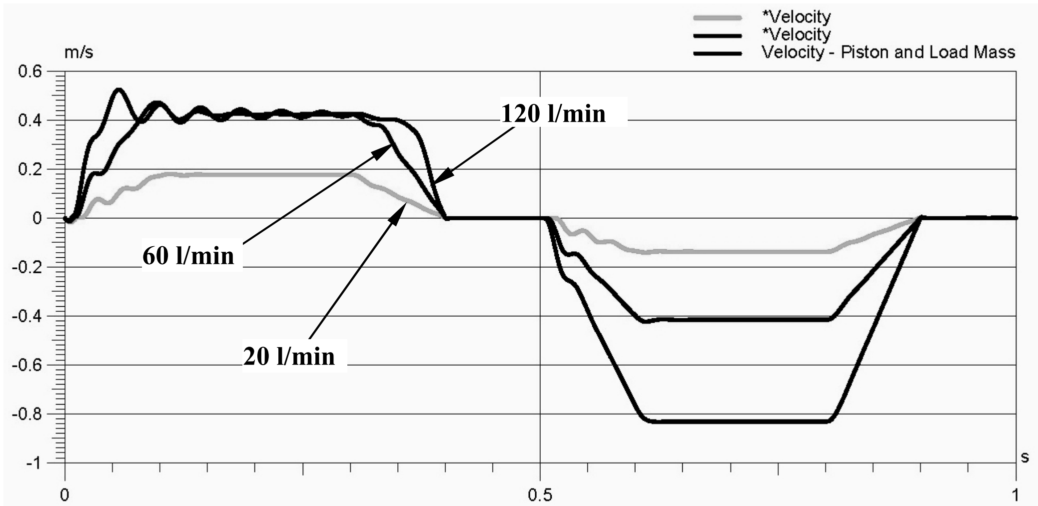

Figure 9. Velocity of the piston for various flow rate of the proportional control valve

4. Conclusion

The simple open hydrostatic circuit has been analysed and its acting simulated by ITI-SIM 3 software. It can be seen that characteristics of the relief valve have a great influence to dynamic stability of the system. Dynamic stability of the system means still acting of the hydro motor, no vibrations of the pipelines and connections and at last working without noise [3].

For given characteristics of the components, the main conclusions are:

- The cylinder force and the velocity of the piston are stable for smaller setting pressure of the relief valve. Therefore, if we do not expect a variation of the load, it is opportune to set limit pressure of the relief valve as small as system requires.
- Up to 120 l/min of permissible flow rate for direct acting relief valve [1], stable work of the open hydrostatic system is guaranteed. If velocity of the piston is enough, it is better to choose a smaller proportional control valve, because in that case system would be much stable.

For many industrial applications, an open circuit cylinder drive is not sufficient. Closed systems are used in such cases. That means adding a feedback of the actual cylinder position to the control valve, when cylinder position is measured and compared to the position command signal.

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PERFORMANCE MEASUREMENTS OF STORAGE AREA NETWORK IN THE CASPUR COMPUTING CENTRE

L. Vicković, E. Mudnić and S. Gotovac

Abstract

ALICE (A Large Ion Collider Experiment) is one physics experiment for the LHC (Large Hadron Collider) project at CERN (European Centre for Nuclear Research) in Geneva. Its aim is to study the physics of strongly interacting matter at extreme energy densities, where the formation of a new phase of matter is expected [1]. The final step of the ALICE raw-data flow is a data storage system. The throughput performances of the disk drives incorporated in data storage system as well as the connection between disk drives and host computer have a huge impact on overall system performances. This paper describes the performance measurements of Storage Area Network (SAN) system installed as a part of a CASPUR computing centre in Italy.

Keywords: Storage Area Network, SAN, disk performance measurements.

1. Introduction

During the LHC era two main architectures are being considered for data storage. Both are based on a two-stage hierarchy of storage. In the first architecture, the secondary storage is a temporary buffer consisting of hard disks. The second architecture proposes a disk buffer large enough to store all the data acquired in one year of data taking. In this second model, the archiving to tertiary storage is realized in an offline manner, decoupled from the data taking. This would have the advantage of saving one restore operation from tape before the first reconstruction pass.

The baseline for the ALICE data storage system is based on the first architecture. It should, however, be noted that the DAQ and Mass storage system (MSS) software support both architectures. The difference will reside in the deployment of each storage level and the migration strategy from the first to the second storage level. In this paper we describe the results of performance measurements of CASPUR SAN.

2. CASPUR architecture

CASPUR began in mid 1992 as a consortium of six central and southern Italian universities with the main goal of providing supercomputing services and expertise. From then, CASPUR has become one of the most competent specialists on supercomputing in Italy and is a key promoter of the supercomputing environment. Specifically, it is known mostly for parallel computing and simulation in the scientific and technical fields of Computational Fluid Dynamics, Condensed Matter Physics, Computational Chemistry, Seismology, and Climatology [2].

In the last quarter of the 2003 we had a chance to test the performance of the CASPUR SAN. The CASPUR architecture, at that moment, is shown on the Figure 1.

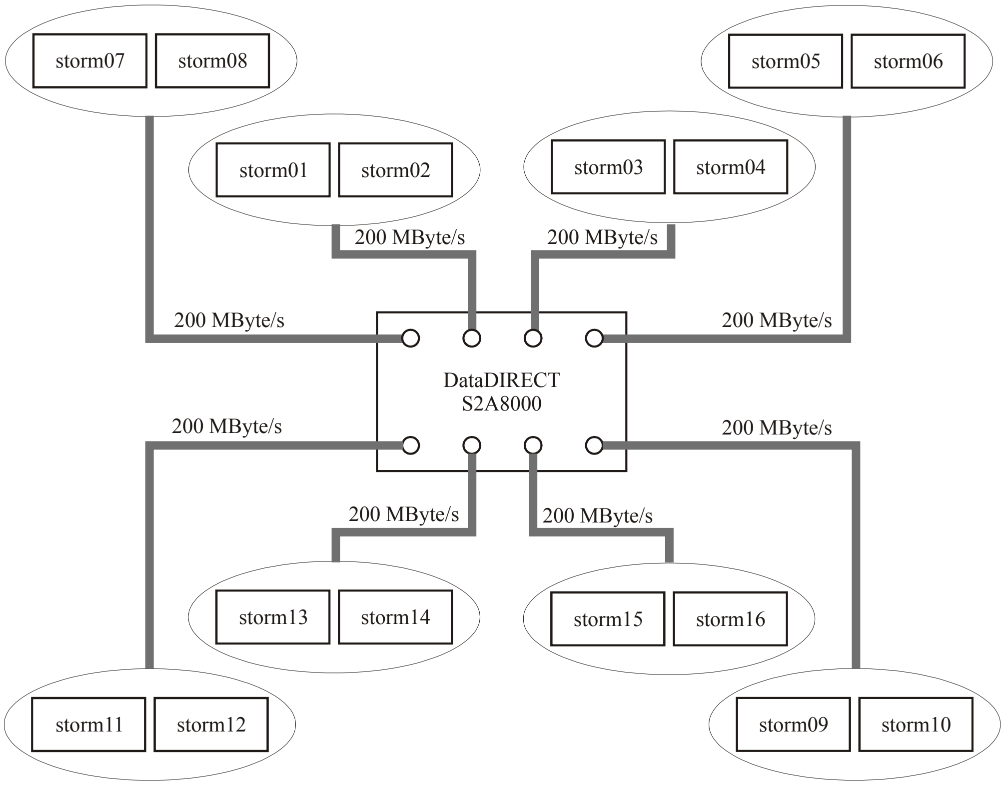

Figure 1. CASPUR FC zone configuration

DataDirect S2A8000 is a storage networking controller that in theory should exceed 1GByte/s of sustained throughput. In this architecture there are sixteen nodes connected to the SAN controller. Eight nodes (storm01, storm03, storm05,… storm15) have mounted a file system on the DataDirect box (/ddn_ext2), while nodes storm02, storm04, …, storm16 have mounted the afs file system. Different file systems are mounted because they have different characteristics. For example on afs the maximum file size is 2GBytes, while ddn_ext2 supports bigger file sizes. Given the limited time we had at our disposal, only the behaviour of ddn_ext2 has been tested.

On each node there is a 2.4 GHz P4, with installed Linux kernel 2.4.18-27.8.0 smp, 1GB of RAM and Data Direct Network (DDN) controller share 2560 MB of cache.

3. Testing program

The testing program [3] is a standalone client running in the background. It continuously writes fixed length records filled by random data. It stops when the predefined output file size is reached or it may continue writing a new file of the same size if the user wants to write several output files. It is possible to run several programs simultaneously in the background on the same machine or on different machines, and put several parallel writing/reading streams to the same disk or to different disks and to measure the aggregate performance.

4. Test results

The intention of the test we run on the CASPUR SAN was to explore write and read performances for different file and record sizes. Beside single write and read tests on a single machine, we tested concurrent read/write performances, concurrent write performances for several streams (up to 5) on the same machine and concurrent write performances on several machines (up to 5), too.

To explore the impact of caching on system performances all tests were done with and without a call to the fdatasync() function. The fdatasync() function force (flushes) all data buffers of a file to the disc.

In order to get the most precise results, all tests were repeated 15 times.

Tests were done for different small (10, 30 MBytes), medium (100, 300 MBytes) and large (1000, 2000 MBytes) file sizes to see the impact of file size on read/write performances. Moreover each file size was tested with different record sizes (8, 32, 128, 512, 2048, 8192, 32768, 131072 kBytes).

Care should be taken when considering write results for 10MBytes files with record size of 8192, 32768, 131072 kBytes since the record size is too large and the final file exceeds the defined files size. The same applies to 30 Mbytes files for 32768, and for 131072 kBytes record size, and for 100 MB files with 131072 kBytes records. All tests were run on the machines with ddn_ext2 file system mounted.

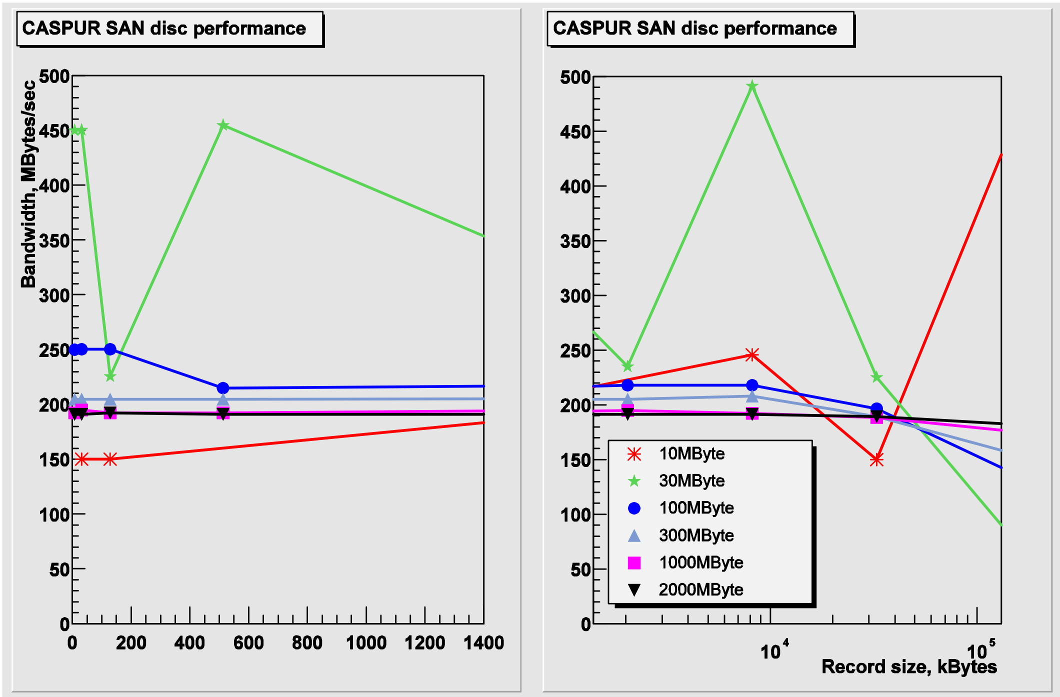

Figure 2. Burst performances for single write stream on CASPUR (without flushing)

On Figure 2 it is possible to see burst performances, or performances obtained without flushing, for single write stream on single machine. As it was expecting, we got the best performances for small files (10 and 30 MBytes), because they were written in cache, not to disk. Also bandwidth for those files was very changeable, and that is because of cache too. Once, when writing stream fill up whole cache the transfer from cache to disk starts, and that slows down the whole process.

The impact of caching is fully visible on Figure 3, where we forced the transfer from cache to disk. Bandwidth for small files was reduced significantly, while large files kept it almost the same.

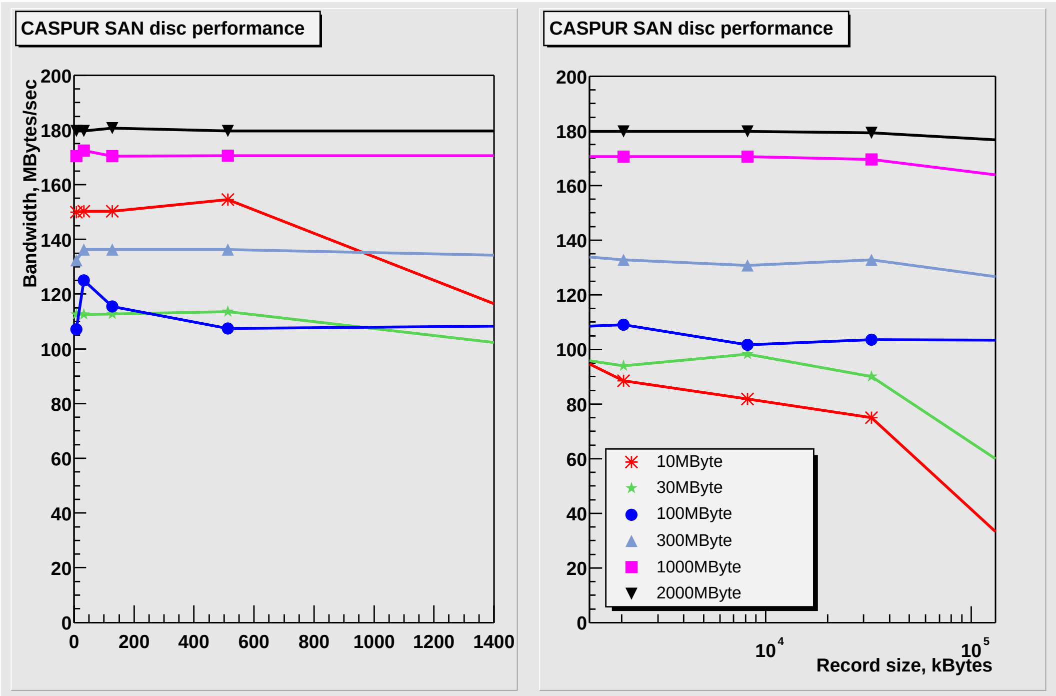

Figure 3. Sustained performances for single write stream on CASPUR (with flushing)

On Figure 4 is shown that more write streams on the same machine degrade the system performances even more, but the complete amount of data stored on disks will remain the same. So it just degrades performances per single stream.

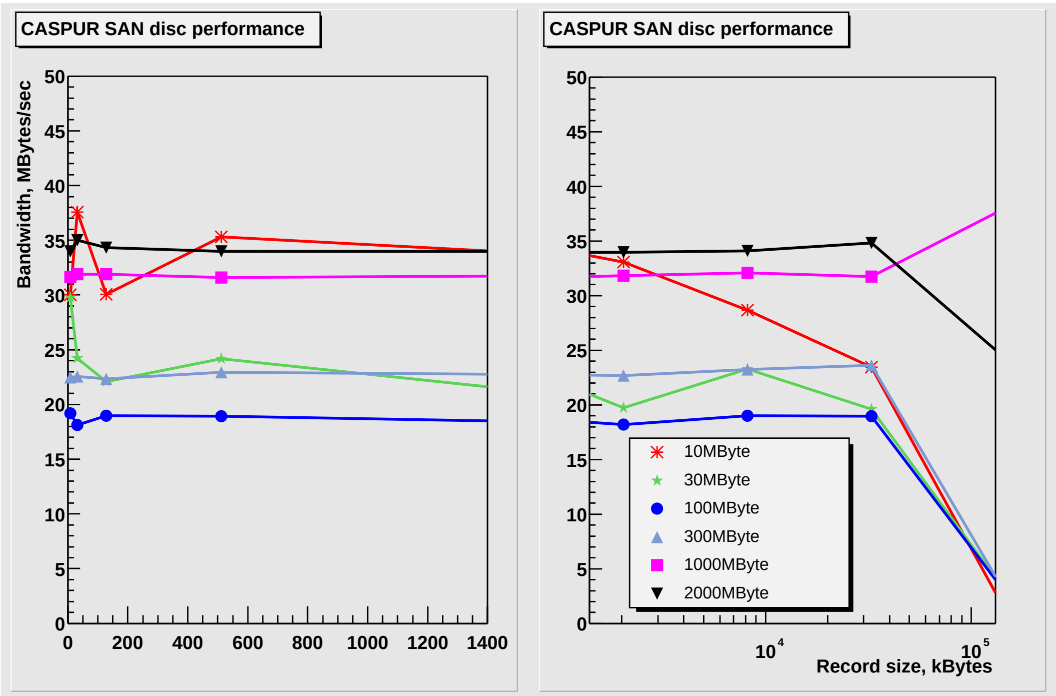

Figure 4. Sustained performance for 5 write streams on CASPUR (with flushing)

Finally, Fig. 5 shows achieved bandwidth for several streams writing to SAN, from several machines, and in this case we definitely got the best performances.

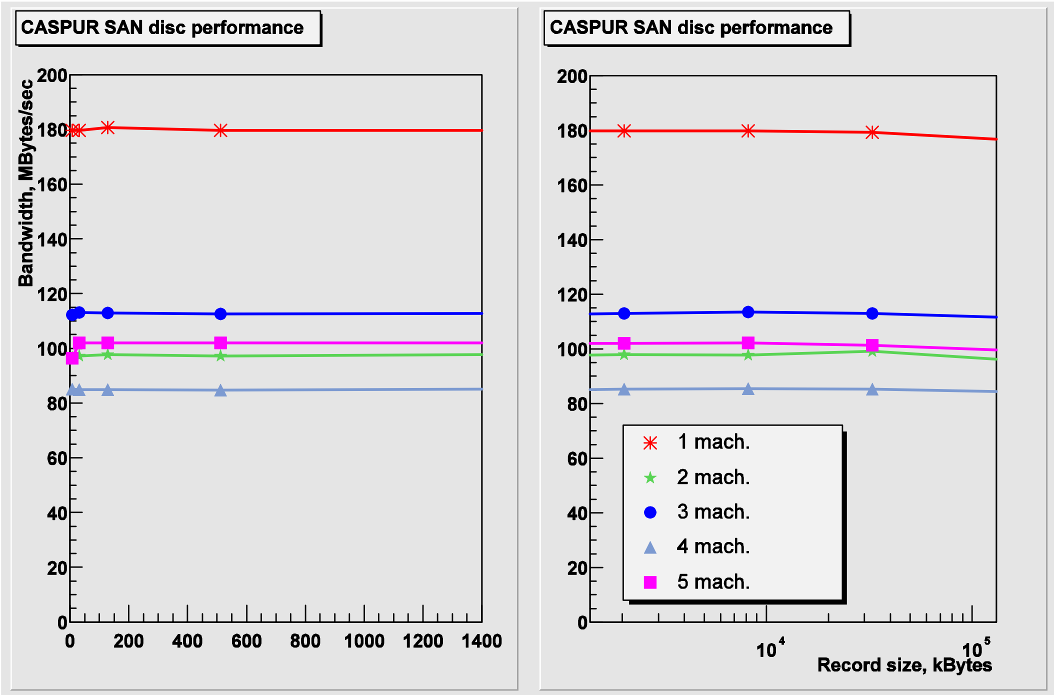

Figure 5. Sustained performance for1 concurrent write stream on several CASPUR machines (with flushing)

5. Conclusion

The main intention of this test was to explore read and write performances of some storage area network, with the aim to use it for the storage of raw physics data generated by ALICE experiment.

During this test we observed that forcing the execution of the fdatasync() function degrades the write/read performances for all file sizes, but it has the greatest impact on the small files (10 and 30 MBytes). Although those small files without flushing were very sensible to the change of record size, they reached the best bandwidth. As the system performances for large files (1000 and 2000 MBytes) were approximately same or even better from the performances of medium files, definitely it is recommended to use large files. Running several streams on the same machine degrades performances and degradation grew with the number of streams, but the overall throughput is approximately the same. Running several streams on different machines with one stream on each also degrade the performances, in comparison with single stream on single machine, but the bandwidth was greater than the bandwidth for several streams on a single machine and it did not change significantly with the number of streams.

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CALL ROUTING METHODS FOR MOBILE NUMBER PORTABILITY

I. Visković and D. Begušić

Abstract

The Mobile Number Portability service (MNP) in GSM/UMTS environment provides the subscribers with the possibility to change the GSM/UMTS operator without changing the MSISDN number. In this article the call routing methods for Mobile Number Portability service implementation have been presented and compared. The role of the database query mechanism has been discussed, too. The choice of the most appropriate routing method for implementation of the MNP service in Croatia has been discussed.

Keywords: Mobile Number Portability, routing method, GSM, UMTS

1. Introduction

Mobile number portability MNP is a service which allows any subscriber of a GSM/UMTS mobile operator to change the operator and keep the mobile telephone number MSISDN (ITU-T Recommendation E.164). The MNP service plays a very important role in the process of telecommunication market deregulation. It should enhance the competition among network operators. Its final effects should include the decrease of prices and easier entrance to market for new operators.

Main issues that must be taken into consideration are the choice of the call method routing to ported numbers and administration and management of ported numbers. The list of available routing methods includes the following: Onward Routing method (ONR), Drop Back method (DB), Query on Release method (QoR), and the All Call Query method (ACQ). The choice of the call routing method depends on market characteristics and may have different influences on network resources [1][5].

In this article the call routing methods for Mobile Number Portability service implementation have been presented and compared. The choice of the most appropriate routing method for implementation of the MNP service in Croatia has been discussed.

The paper is structured as follows. The section 2. describes the MNP environment. In section 3. the short survey of call routing methods is presented. In section 4. the call routing methods have been compared and their appropriateness for implementation in Croatian telecommunications network has been discussed.

2. MNP environment

Networks which are included in call routing process of ported numbers are as follows:

- Originating Network – network in which the call to ported number is initiated,
- Donor Network – subscription network from which a number is ported out,
- Recipient Network – subscription network to which the number is ported in,
- Transit Network – a network between the two networks,
- Visited Network – a network into which the ported subscriber is roaming.

Networks included in call routing process of ported numbers are shown in figure 1. Portability subscriber is ported from donor network to recipient network. Originating network initiates call to user. Recipient network is responsible for routing of the call to subscriber, which resides in visited network.

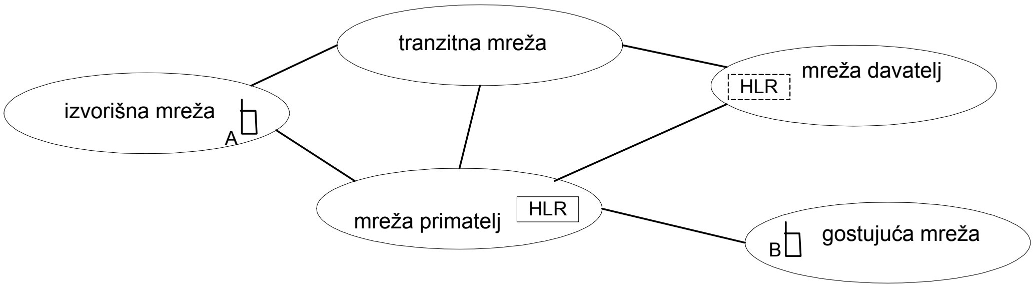

Figure 1. MNP environment

Originating network can be another GSM/UMTS network within the same country, PSTN/ISDN network in the same country or network in another country. Call to the ported number can also be originated in donor network or recipient network. In that case originating network is the same as donor or recipient network. Existance of the transit network is not obvious. It could be network between donor and recipient network, network between originating and recipient network or network between originating and donor network. Ported subscriber can be registered in visited network in national or international roaming. The presented model should support all possible scenarios.

3. Call Routing Methods

Routing of calls from an originating network to recipient network can be performed by using any of the following four methods [3], [4], [5]:

- ONR method (Onward),
- DB method (Drop Back),
- QoR method (Query on Release),
- ACQ method (All Call Query).

ONR method requires the setup of call from originating network to donor network and then the setup of call from donor network to recipient network. Donor network should identify correct terminating GMS/UMTS network.

QoR and DB methods require the setup of call from originating network to donor network first but release the call back to the originating network or transit network. Originating network or transit network sets up a new call to recipient network.

ACQ method means directly routing of a call from originating network to the recipient network. Donor network is not included in process of call routing to ported numbers.

Originating, transit or donor network should support database query mechanism. Database query mechanism means that Number Portability Data Base is accessed in order to find out whether a number is ported. In such database the Routing Numbers for destination networks are stored. Which of these networks must support database query mechanism depends on call routing method.

There are two database approaches – centralized and decentralized. Centralized approach means existence of master or referent database. All operators update their local databases in accordance with that referent database. This database could be administrated by one of involved operators or independent company. This is point of discussion for regulator and operators. Decentralized approach means direct updating of databases between operators – one operator sends message to other involved operators about the ported subscriber [5].

3.1 Onward routing - ONR

In Onward routing method (ONR) the Donor network is involved in the procedure of call routing to correct network – recipient network. Donor network should support database query mechanism [2], [3], [6].

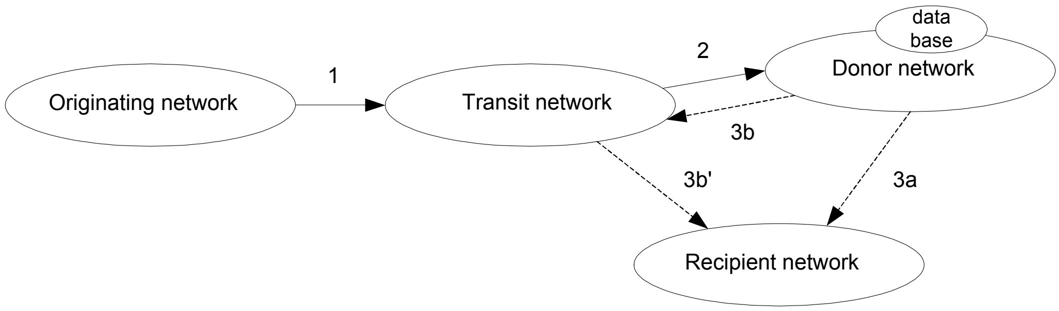

Figure 2. Onward routing

Originating network routes the call to donor network directly or via transit network in accordance with the numbering plan (1,2). MSC (Mobile Switching Center) of the donor network analyses the received MSISDN and sends the database query to check out if this MSISDN is ported out. Database returns routing number of subscription network. MSC uses routing number to route the call to recipient network.

Call is routed from donor network to recipient network directly if there is a direct interconnection between these networks (3a). In opposite, the donor network routes the call to transit network (3b, 3b').

Recipient network is responsible to request the routing information from the visited network where the subscriber is registered.

3.2 Drop Back method - DB

In the Drop Back method (DB) the Donor network is responsible for detecting the call to ported number. This network must support the database query mechanism. Another network is responsible for call rerouting [3], [6].

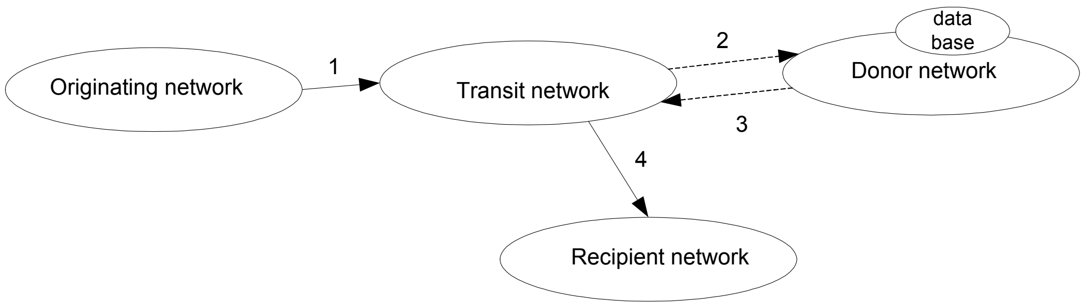

Figure 3. DB method in transit network

Originating network routes the call to donor network based on the MSISDN (1,2). MSC of the donor network detects the potential ported number and initiates the database query. Database returns the routing number of subscription network to MSC. MSC of donor network releases the call and sends the routing number and MSISDN to transit network (3). Transit network sets up the call to recipient network in accordance with the routing number and MSISDN (4).

Drop Back mechanism can be supported in originating network, too. In that case the donor network sends the routing number to originating network via transit network and originating network sets up the call to recipient network.

The Recipient network is responsible for requesting the routing information from visited network where the subscriber is registered.

3.3 Query on Release method - QoR

In this method the Donor network is involved in call routing procedure in terms of detecting a call to ported out subscriber. Originating network or transit network is responsible for database query [3], [6].

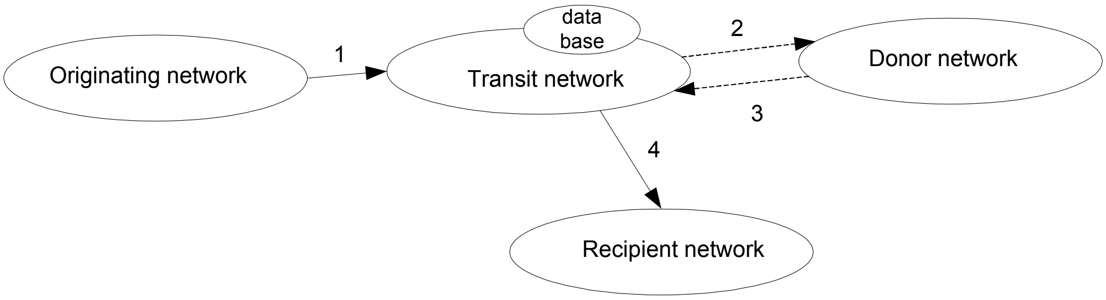

Figure 4. QoR method in transit network

Originating network routes the call to donor network in a usual manner via transit network (1,2). Donor network indicates that the subscriber has been ported out and releases the call (3). MSC of transit network recognizes the specific release of the call and initiates the database query to find out the routing number of the subscription network. Database returns the routing number and MSC of transit network routes the call to recipient network (4).

QoR method can be implemented in originating network, too. In that case, the donor network sends the call release message to originating network. Originating network is responsible for the database query and the call routing to recipient network.

3.4 All Call Query - ACQ

In the All Call Query method (ACQ) the Donor network is not involved in call routing procedure at all. Originating network or transit network routes the call to recipient network directly. This network is responsible for the database query [2], [3], [6].

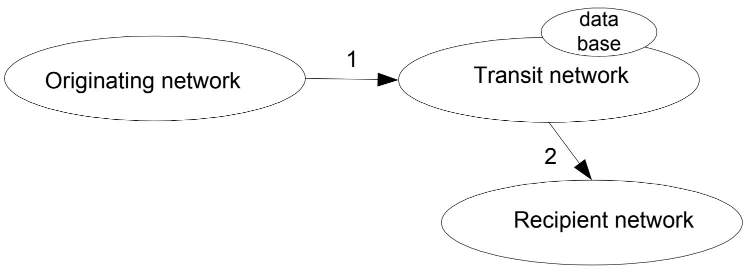

Figure 5. ACQ method in transit network

Figure 5. shows the ACQ call routing method used in transit network. Originating network routes all calls with MSISDN of recipient network to transit network (1). MSC of transit network initiates the database query. Database returns the routing number of subscription network. If the MSISDN is ported, the MSC of transit network routes the call to recipient network based on the routing number and MSISDN (2). If the MSISDN is not ported, the call will be routed to GSM/UMTS network in accordance with the numbering plan.

ACQ method can be used in originating network, too. MSC of the originating network sends the query to database and routes the call to recipient network directly.

4. Database Queries in the MNP Environment

In accordance with the used call routing method the originating network, the transit network, or the donor network must support the database query mechanism. MSC sends a database query to the number portability database as a result of analysis of the received MSISDN in order to find out whether or not a MSISDN is ported. The MSISDN is included in the query to the database [2], [7].

Intelligent Network can be used to provide the capability to obtain the routing information. Concept of Intelligent Network is already implemented in PSTN/ISDN networks and GSM/UMTS networks. IN based solution is a step forward to convergence of these networks since this solution is applicable in both networks. Intelligent Network based solution offers the following three techniques for database query:

- Terminating Query on Digit Analysis - TQoD,
- Query on HLR Release - QoHR,
- Originating Query on Digit Analysis - OQoD.

TqoD and QoHR techniques are defined for Mobile Termination Calls (MTC). TQoD technique means that MSC performs database query after analyses of received MSISDN. QoHR technique means that MSC initiates database query after it receives information from HLR that subscriber does not exist as a result of the usual procedure of finding visited MSC.

OQoD technique is defined for Mobile Originating Call (MOC). When MSC receives query for call setup it initiates database query as result of digit analysis. If the donor network originates the call to port subscriber one of these methods should be supported.

Database query can also be supported via the MNP Signalling Relay Function. SRF function is used to modify the SCCP Called Party Address parameter in the MAP messages so that they can be routed to recipient network. There are two SRF based methods. SRF function can be used in originating network or in donor network – direct routing and indirect routing, respectively.

Mobile Number Portability environment should support handling of non-call related signaling to provide some non-call related services – SMS (Short Message Service) or CCBS (Completion of Calls to Busy Subscriber). Non-call related a Signaling Relay Function relays signaling messages.

5. Comparison of calls routing methods

ONR method requires two physical call setups – one from originating network to donor network and one from donor network to recipient network. This leads to insufficiently efficient use of network resources. This method does not require complex database – only ported out numbers of that network are stored. Billing differentiation in originating network is impossible. Donor network must support functionality of the call to ported number and the donor network must exist.

QoR and DB method require the existence of the donor network, too. Use of these methods can cause the increased signaling between the networks. Specific signaling has to be to support by networks for implementation of these methods.

ACQ method is the most efficient among the mentioned methods in terms of using network resources. It enables optimal routing from originating network to recipient network. Interconnection signaling impact is minimal. Donor network is not involved in the call setup procedure. This method requires complex database, which contains ported numbers of all networks in MNP environment. Another disadvantage is potential internal signaling increase due to database queries prior the call setups.

Potential MNP environment in Croatia consists of two existing GSM/UMTS networks and one PSTN/ISDN network. The direct interconnections between these networks have been established. New GSM/UMTS network(s) and PSTN/ISDN network(s) are expected to enter the market in accordance with the process of telecommunications market liberalization. IN such an environment it is difficult to predict the number of ported numbers.

The choice of the MNP method may be based on the implementation complexity and efficiency. The advantages of ONR method include the simplicity and the low level of investment. This method can be supported in all networks. GSM/UMTS networks are quite compatible and the existing services should be supported. There are no differences in tariffs for calls originated in PSTN/ISDN network to GSM/UMTS networks. However, this method does not guarantee the efficient use of network resources. For these reasons the ONR method can be implemented in the first phase of MNP in Croatia. Implementation of QoR method or DB method requires the support of specific signaling in networks. It requires modification of existing signaling in switching nodes. These methods do not show special advantages for implementation in Croatian MNP environment.

ACQ method can be implemented in all networks and it may ensure optimized routing and efficient use of interconnections between operators. On the other side ACQ method requires complex databases and frequent database queries. For these reasons ACQ method may be a suitable solution for the second phase of MNP service development in Croatia. All Intelligent Network based solutions are available in networks due to fact that all networks support Intelligent Network capabilities. QoHR method is suitable in case of minor number of ported subscribers. In opposite this method leads to increase of internal signaling. In that case TQoD technique should be used.

6. Conclusions

Key issue of implementation of the mobile number portability is to choose the appropriate call routing method. If the call routing method is not defined as the regulatory obligation, different networks may use different call routing methods.

In the case of ONR, DB and QoR method, the number range holding network is involved in the routing of a call. ACQ method provides directly the routing of the call from originating network to subscription network. ONR method is the simplest but the network recourses are not use efficiently. These four methods could be implemented in GSM/UMTS networks in Croatia. Implementation of any of these methods requires some technical modifications of networks. Every operator can independently choose technique for database query in accordance with the used call routing method. In the first phase of MNP in Croatia, ONR method could be implemented in all GSM/UMTS networks with the least level of investment. However, in case of great number of ported subscribers, the ACQ method, implemented in PSTN/ISDN networks and GSM/UMTS network, would be the most efficient method to route the call to ported subscriber.

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NEW APPROACH OF PRODUCTION QUALITY MANAGEMENT IN THE FRAME OF EU INTEGRATION

M. I. Achim, R. Tudoran, D. Florin and M. Risteiu

Abstract

The study indents to present and sustain with real data the major advantages occurred after the Quality Management System implementation and certification in conformity with standards family ISO 9000.The study is structured on presentation of SC APULUM SA, Quality System Personnel triangle, Quality Management System presentation, the advantages of implementing the Quality Management System, the advantages of applied quality management system: average class of quality, labor productivity, personnel evolution, clients satisfaction and trust evolution, quality product improving.

Keywords: Concurrent market, EU integration, SME, sustainable development, quality ensuring

1. Introduction

1.1 "State-of-arts"

SC APULUM SA production capacity is about 11000 tons porcelain products and vitrus per year , in various forms, models, ornamentations:
- ménage products, public alimentation;
- ornamentals;
- knick-knack.

The products' quality corresponding with Romanian and international standards, also with client exigencies from the entire world. A proof in this way is that over 70% from the output is exported especially to European market.

Products are made by hard feldspathic porcelain, total vitrified, translucent, with high white degree or from vitrus with high vitrification degree, icing or without icing. These characteristics are put in value by forms and ornamentations of a high aesthetic level.

1.2 Technological flow description

Technological flow is a joining of the classical technology (raw materials grinding, plastic molding or by casting) with modern technology (molding by isostatic squeezing).

After the advanced drying, products are burned, obtaining "the biscuit".

The biscuit is iced and then burned in quick burning furnaces or in classical tunnel furnaces, obtaining the porcelain product or vitrus.

The final aspect is given by the manually applied ornamentation on the white product or by varied mechanized procedures (with ceramic dyes, decalcomania, lüstere).

The ornamentation is fixed by burning, thereupon products are sorted, assembled and packed in conformity with client's desires.

Among the whole route of technological flow was made optimizations by endowing with very good installations, as follows:

- isostatic presses;
- quickly burning furnaces;
- automatic installation for gypsum sprocket preparing;
- under pressure casting installation in tandem;
- advanced grinding mill for icing;
- loading/unloading installation for capsules;
- rows and bands dragging machine;
- packing machine.

2. Quality management system

2.1 Quality – system – personnel triangle

Armed with the understanding of client's motivations and with a developed concept for quality which will situate the organization favorable on the market, we have to exploit interfaces quality, system and personnel from the organization.

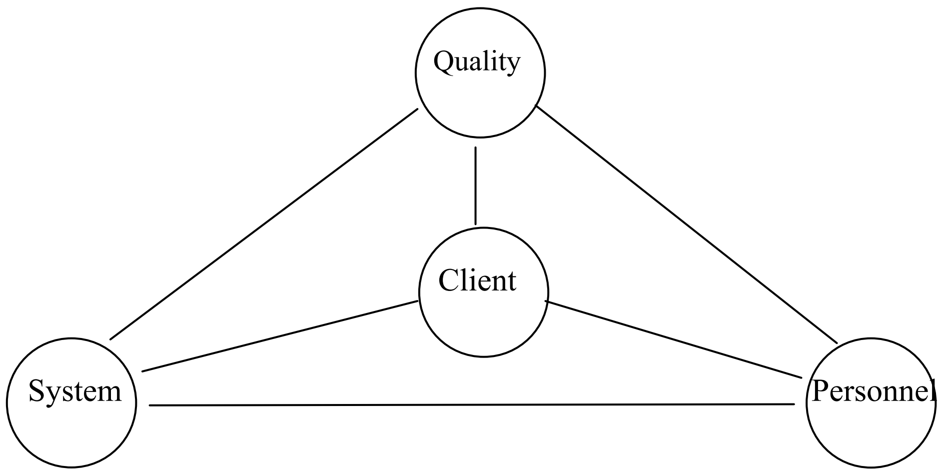


Figure 1. The client is framed by the quality management system

Every side of the triangle is very important and the lines which join triangle tips with the client, which is the focus around that is evolving the whole activity from the organization, are elements which are powerful feelt by the client.

The relation between Client and System includes abstract procedural systems and physical hardware. A lot of negative moments of the truth appear because of singularities and unfunctioning of systems.

When the client interest is insufficiently treated in systems planning for output – delivery, the situation is virtual programmed for mediocrity and insatisfaction. For this reason, SC APULUM SA implemented a developed and improved Quality Management System which is powerfully oriented to the client.

Porcelain output migration from west to east, from Europe to Asia has a special impact on our organization.

Due to this reason, a major preoccupation for the management from SC APULUM SA is client's desirable quality obtaining. The price – quality report is the most important advantage in the competition fight.

In this context, since 1997 a quality system has been implemented after standards family ISO 9000, which was finalized by certification after ISO 9001 standard with the prestigious organism for certification TÜV CERT.

Table 1. Quality standard evolution

1.	Quality System of reference planning ISO 9001:1994 – trainings with prestigious firms for consultancy in area – STICEROM – COMETAM – QUASQRO – CALITOP – elaboration of ~ 400 specific documents – quality book – system proceedings – working proceedings – technological proceedings – technological instructions – internal trainings and personnel awaring	1996-1998
2.	Quality System Certification with certification organism TÜV RHEINLAND in conformity with ISO 9001: 1994 standard	1999
3.	Quality System Recertification with certification organism TÜV THURINGEN in conformity with ISO 9001: 1994 standard	2002
4.	Quality System Certification with certification organism TÜV THURINGEN in conformity with ISO 9001: 2000 standard	2003
5.	Implementation/ maintaining/ improving of Quality Management System, performing and evolving of over correction and preventive actions, performing of over 200 internal audits and 5 external audits of a second part to major providers of materials and raw materials.	1997-2004

Table 2 Standard family ISO 9000

ISO 9000: 2000	Quality management systems Fundamental principles and vocabulary;
ISO 9001: 2000	Quality management systems; Requirements;
ISO 9004: 2000	Quality management systems Directive lines for improving performance
SR EN ISO 19011: 2003	Guide for quality and/or environment management systems auditing

3. PDCA cycle

PDCA cycle for improvement, assumed from ISO 9000 standard, assures a permanent evolution of improving quality management system.

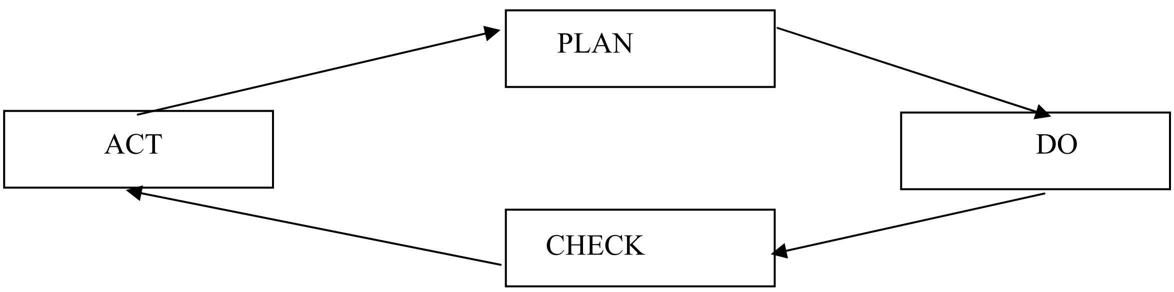


Figure 2. PDCA structure and improvements

PLAN – objectives for obtaining results in conformity with the client requirements and with the organization's policies

DO – implementation of processes

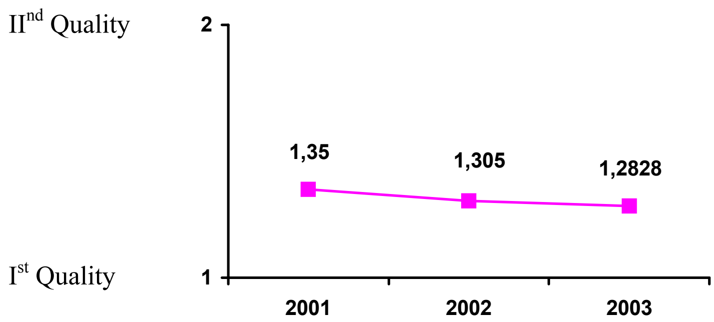
CHECK – monitorization and measuring of processes according to policies, objectives, requirements
ACT – actions for improving processes' performance

3.1 Quality Management System implementation advantages

- The rust enhancing of - clients;
  - own employees.
- Valorification of improvement potential.
- Making aware and training of all employees.
- Firm image improvement.
- Effective instrument in management activity.

As follows, are presented some graphics with the evolution of diverse aspects taken from quality recordings, which have to answer to the question: *Which is the gain of this kind of system implementation?*

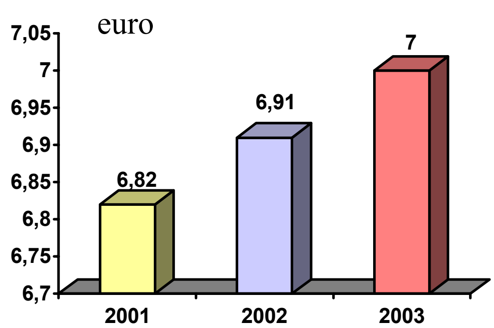
- *Average class of quality*



Note: The closer the average class of quality is to 1 - the better, that means that are more products of 1st quality.

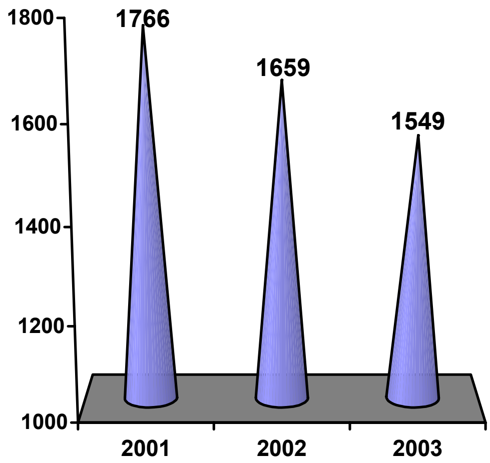
The average class of quality is an important indicator for porcelain production, where products can be of different quality categories, their sorting being made in conformity with STAS 3152: 1992. Porcelain menage articles. General technical quality conditions.

- *Labour productivity euro/ people/ hour*



By technological flow organization, judicious using of labour force and clear determination of personnel responsibilities and authorities labour productivity has continuously increased lately.

* *Personnel evolution*



In quantitative keeping conditions and qualitative increasing of production, the number of employees has naturally decreased.

* *Satisfaction and trust evolution*

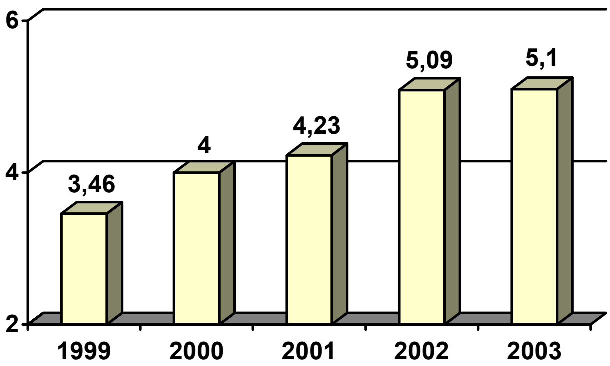


Table 3. The major criteria for satisfaction and trust calculation

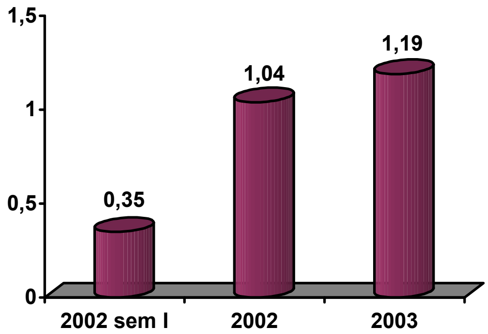
– The turnover of the client with SC APULUM SA – collaboration duration – complaints and intimations – commands constancy – using the brand Apulum	Alba APULUM Iulia

* *Continuous improving*

The main criteria for the improvement calculation are:

- average class of quality
- clients satisfaction and trust
- export value
- objectives reaching
- processes improving
- plan realization

- corrective actions effectiveness and
- preventive supplies decreasing
- nonconformities evolution
- profit rate



- *Quality products improving*

By enterprise retechnologization, isostatic squeezing of plates on isostatic presses DORST in furnaces RIEDHAMMER has improved their quality.

classical moulding (lathing)		isostatic squeezing
burning in tunnel furnace	⟶	quick burning
~ 60 % I quality		over 85 % I quality

4. Conclusions

Implementing of Quality Management System is a challenge, not a requirement and results can be seen in time, ascending and descending on the continuous improving scale.

In this way we have a banner- diagram which metaphorically express the effectiveness of the quality management system.

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OPTOELECTRONIC MOISTURE MEASUREMENT

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Abstract

By interaction of the component particles of any substance, molecules or atoms and electromagnetic radiation the result can be some complex motions and/or the position change of these particles within the observed substance. Together with these motions the energy content of these particles is being changed as a result of electromagnetic radiation. The energy changes are quantised and their amounts primarily depend on the motion type, which prevails, and then the translating, rotational, vibrational, electronic and nuclear energy levels can be taken into consideration. By radiation in NIR (Near InfraRed) region the particles are excited on symmetrical and asymmetrical stretching and curving and particles vibrate on elastic deformation. The particles own frequency vibration depends on their masses and strength of their mutual relation. These magnitudes are different for different groups of atoms and each group predominantly absorbs NIR radiation of the accurate specific wavelength, which is characteristic for these atom groups. It has been established that the water molecules particularly absorb electromagnetic radiation with the wavelength of 1200, 1450, 1940 and 2950nm, and explicitly with the wavelength of 1450 and 1940nm. Thus those ones for water are called absorbing and on the basis of absorption with these wavelength the water content can be determined in thin foliaceous and granular substance structure. The creation of the transmissible infrared moisture meter, whose functioning is based on the above mentioned principles, is the research final goal in this paper.

Key words: optoelectronics, moisture measurement, near infrared spectrometry

1. Introduction

The total energy comprised in any substance consists of the numerous components i.e. it exists as a result of the numerous interactions between the component particles like molecules, atoms, atom nuclei, electrons, etc., and their interaction with the surroundings. The interaction of electromagnetic radiation with these particles is also possible and so either the observed substance energy is changed and the absorption or emission of radiation can occur or only the radiation properties are changed and the radiation direction is then changed. All energy contributions of any particle are quantized and they can't have any discrete values but only a great number of specific discrete values. They differ by the cause of their creation. Then the translating, rotational, vibrational, electronic, or nuclear energy levels can be considered. The exchange of energy can occur while interaction of electromagnetic radiation and substance only if the photon energy of electromagnetic radiation is equal to the difference of two particle energy levels. The particle can absorb the photon and pass from the lower to the higher energy level. The similar thing can also happen when the substance sample is exposed to the influence of the specific monochromatic spectrum of the wavelengths of electromagnetic radiation. As the energy levels are different for different substances, the content of the specific substance in the observed specimen can be quantitatively determined by the measurement of the specific spectrum intensity, which depends on the wavelength of electromagnetic radiation.

1.1 Moisture Measurement

The moisture content is the essential parameter in many basic and industrial products and processes. E.g. it is crucial for the quality and durability of victuals. Further, the higher speed and shorter process duration as well as the big energy economy, etc., can be achieved in the processes of dehydration by using the precise and accurate determining, Two different definitions can be applied in expressing the solid substance moisture level. The first definition is exclusively based on the mass water shave determining in the total quantity of the observed substance. Its influence on that substance property is not essential. The second definition is based on the analysis of the contained water influence on the physical, mechanical, chemical and microbiological properties of the observed substance. The result is the relative humidity, which is the topic in this paper. The various, more or less reliable procedures can be technically achieved for the moisture measurement [1]. Some procedures are demanding to be performed, some are unreliable, and some are very dangerous like the physical-nuclear methods. The clear and general recommendation is not momentarily possible. However, together with the development of the automatized processes as well as with the technological development in general, the demand for the continued measuring and the shortening of the measuring duration has been increased. As distinguished from other well-known measurement procedures, the humidity measurement via absorption at some wavelengths in NIR makes it possible. Also, by using this procedure the moisture measurement can be realized without the direct contact of the measuring device and the measuring specimen. Neither the specimen nor the measuring device is damaged. Therefore, the orientation in this paper is just directed to the above mentioned procedure. The penetration of IR rays on the thin layer under the surface of the solid substances represents the basic limitation of this procedure in the cases when it is required to measure the humidity in the deeper specimen layers. For calibration the standard and very reliable thermo gravimetrical procedure can be applied.

1.2 Spectrometric Techniques

Concerning the wavelength, i.e. the accompanying energy, the electromagnetic radiation can be divided into several regions, Table 1.

Table 1. Spectrometric Regions

Spectral regions	wavelength	Interaction kind	Experimental techniques
gamma-radiation	0.0005-0.15nm	Nuclear transmissions	Mössbauer spectrometry
x-radiation	0.01-10nm	Internal electrons transmissions	x-rays absorption spectrometry
ultraviolet	10-380nm	External electrons transmissions	UV-VIS; AAS
visible	380-780nm	External electrons transmissions	UV-VIS; AAS
Infrared	780nm-1mm	Vibrations	IR; Raman
Microwave	1mm-1dm	Rotations	Microwave absorption spectrometry
Radio waves	>1dm	Nucleus and electron spin change	EPR; NMR

Between the mentioned regions there is not any essential difference in the nature of electromagnetic radiation. The demarcation only exists in the instrumentation required for the production and/or detection of the specific radiation and also in the energy level required for the individual interactions within the observed substance particles. The photons of IR radiation posses the energy, which is sufficient to excite the atom vibration energy, changes in a molecule.

2. NIR Measurement

The energy of IR radiation gives rise to the symmetrical and asymmetrical stretching as well as curving or deformation. Each molecule part own frequency depends on the masses of mutual related atoms the intensity of their mutual relation. For different atom groups these magnitudes are different and each group predominantly absorbs IR radiation of the exact specific wavelength, which is characteristic for these atom groups. The absorbing spectra are developed in that way that some individual atom groups, e.g. OH or COOH in a molecule absorb IR radiation of that frequency which is equal to the vibration frequency of that atom group. The position of the absorbing maxima within the frequency spectrum can be designated by wave number, which is reciprocal to the wavelength. In a so-called far IR region the molecule energy rotation is changed. That is the reason why the spectra in IR region can be called the molecule spectra, and the measuring procedures are based on the infrared, microwave or radio frequency spectroscopy. In the spectroscopy the absorption is expressed like optical density or absorbance. This is the logarithm of incident light intensity ratio I_0 according to the light transient intensity I. IR electromagnetic radiation spectrum can be divided into the near IR (NIR) of the wavelengths 780-2500nm, the medium IR (MIR) 2500-40000nm and the far IR (FIR) 40000-10^6nm.

2.1 NIR Spectrometry

In NIR spectrum part the stretching vibrations of methyl C-H, methylene C-H, aromatic C-H and O-H groups prevail. Moreover, the great influence in this region is found in the stretching methoxide vibrations C-H, carbonyl C-H, N-H groups of the primary, secondary and tertiary amides of this N-H group of the ammoniac salt, which can't be considered as dominant. Thus NIR region contains the chemical information CH, OH and NH of the functional groups because they have the strongest absorption. The quantitative measurements of the chemical concentration in a material can be possible in this way. NIR spectrum also gives information about the physical properties of samples and it can be employed for the average magnitude particle estimation or e.g. for the determining of the biomass percent in the fermentation. While in MIR and FIR spectrum parts the result can be only the basic swinging of the multi atomic molecules exited by electromagnetic radiation, in NIR part very complex motions occur but only with the mentioned groups like C-H, N-H and O-H. For that reason NIR is inconvenient for the qualitative spectrometry, but it is very acceptable for the quantitative analytics of some individual substance kinds, which contain the mentioned groups. The water [4], [5] is also included to these groups. On the other hand, the more complex motion in the water molecules results with the more ambient substance influence, and it makes the water content measuring in some substances to be somewhat more complex.

2.2 NIR Water and Some Organic Materials Spectrum

The water is a very good absorber in NIR region and as being such it is very convenient for the quantitative analyses. These analyses are used in agriculture and in chemical, textile, foodstuffs and pharmaceutical industry. The water consists of the three-atomic nonlinear molecules (H_2O)

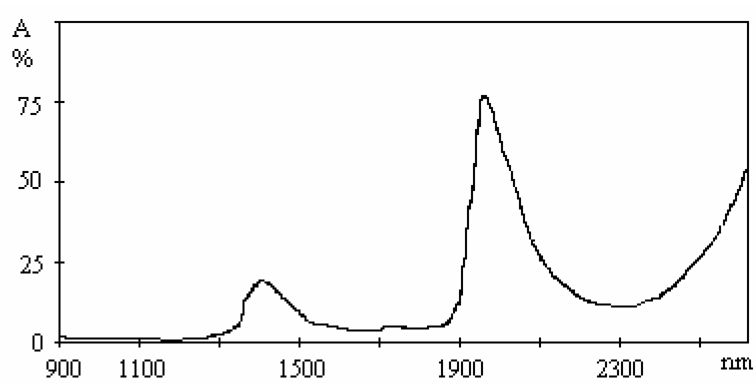

Figure 1. NIR Water Spectrum

which under the influence of NIR radiation can perform very complex motions for what they need energy, which is taken from radiation. This absorption has been established with the wavelengths of 1200, 1450, 1940 and 2950nm, and especially it can be seen with 1450 and 1940nm. Those for water can be called the absorbing wavelengths, Figure 1. [2]. The mark A on the ordinate in Figure 1. designates the relative electromagnetic rays absorption. For the moisture measurement the first stretching of O-H group at about 1450nm can be used and/or the second stretching at about 1940nm where a very high absorption can be achieved because of the strong organic materials, e.g. starch and fat has exhibited a very similar behaviour, Figure 2., [2].

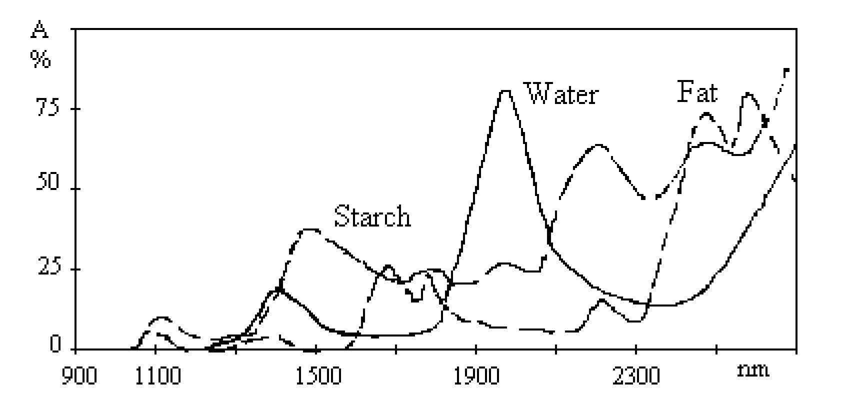

Figure 2. NIR Spectrum of some Biological Materials

3. Possible Solutions

The absorbing spectrometer capable for the work in NIR is the basis for the moisture meter, and the goal is to determine the ratio between the absorbed and totally emitted radiation at the absorbing wavelength. By taking this ratio into consideration it is necessary to (conclude) notice the relative moisture in the measuring substance i.e. in the sample. The material sample in which a part of moisture has to be determined can be placed between the source of IR radiation and detector. On the detector side the decreasing of radiation can occur because of the absorption in the sample. The source can be dispersive or non-dispersive. The polychromatic radiation is divided into the narrow wave bands. The transmission ratio for the different wavelengths is measured, e.g. one is absorbing (1940nm) and the other reference wavelength (1800nm), Figure 3.

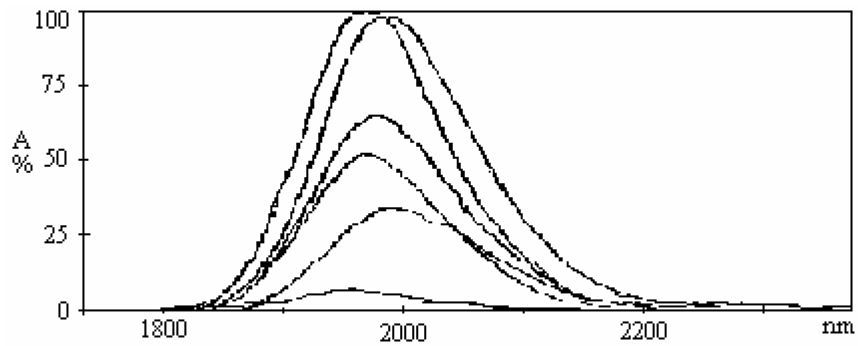

Figure 3. NIR Spectrum of the Linen with Different water quantity

The detector can be filled up with gas, the pyroelectric, semiconductor or scintillated counter, with the appropriate optical or gas filters in the adequate wave band. The thickness of the sample which is convenient for a successful moisture measurement depends on the sample structure and on the wavelength band, which is emitted by the source. E.g. for the moisture measurement in NIR spectrum region between 1850nm and 2500nm because of the characteristic wavelength for water of 1940nm, the sample thickness has to be about 1mm. In the wavelength measurement region less than 1300nm because of less absorption, the sample thickness can be about 5cm. The stronger source of NIR radiation also enables the longer path of the measuring (or measured) electromagnetic rays so the maximal sample thickness depends on the instrument design. As to the solid substances the less transmission paths are needed. Therefore, it is more convenient to apply the reflection procedure from the surface for the solid substances moisture measurement. And then the moisture is determined on the basis of the ratio between the monochromatic radiation of the two wavelengths, one absorbing and the other for water, which is not absorbing. However, the solution of a spectrometer with two rays is also possible, one, which is directed to the sample and the reference one which is directed to the detector. Both spectrometer solutions are shown in Figure 4., and the marks 1-6 may be represented as follows: 1 light source, 2 lens, 3 filter wheel, 4a absorption ray, 4b reference ray, 5 sample, 6 detector.

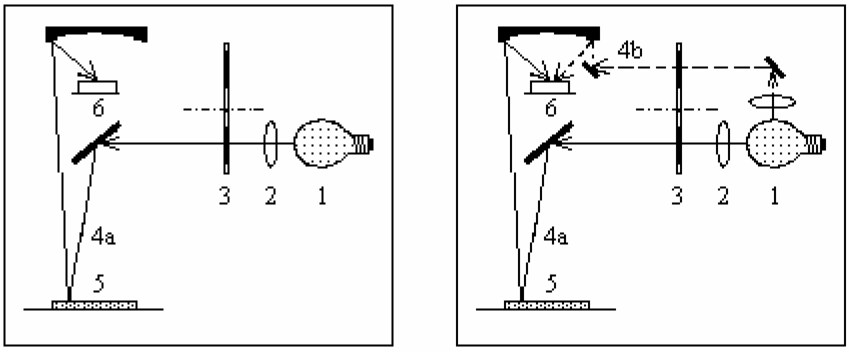

Figure 4. Spectrometer with one ray, left, and with two rays, right

The spectrometer advantage with two rays lies in an increased accuracy because it eliminates some negative influence factors, and its disadvantage is in an increased expense for its realization. In other words the measurement with one ray uses only the absorption of the measuring wavelength and it can result with one ray uses only the absorption of the measuring wavelength and it can result with instability and inaccuracy. It occurs because of the surface influence, particle size and sample colour. By introducing yet another ray of the reference wavelength, which is not in the contact with the sample, this problem can be removed. In both solutions one thing is required, the sample must have the diffuse reflection for the radiation to penetrate into it and then to reflect in a certain degree. The surface must be characteristic for the observed material, and the system must be calibrated separately for each material. The moisture concentrations from 0.02% to 100% can be measured in that way. In the case of the mirroring reflection this procedure can’t be used. In granulated samples application the following effects emerge: the mirroring reflection, the diffuse reflection/absorption and the total absorption. The ratios of emerging of these effects depend on the sample structure, state (solid or liquid) and on the granules size. With large granules the internal reflections occur and it can particularly complicate the measurement. The criterion for the choice of NIR source lies in a request for the sources operating by using high operating temperature and also high exploiting of radiation and the criteria in detector selection are: high lifetime, the wave region in which it realizes high susceptibility, the appropriate ratio between signal and noise and also as less as possible the time response constant.

4. Next Steps and Outlook

After the theoretical preparing has been conducted, the next step is to choose the optimal

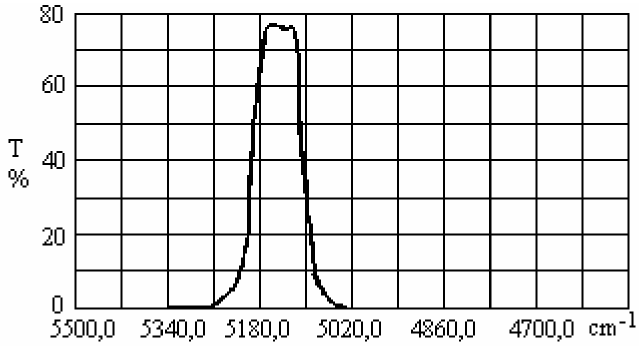

Figure 5. Band pass filter for wavelength 1940nm

main component parts, starting from the radiation source choice over the optical system and detector to the electronic signal processing. Their creating into the appropriate whole and the experimental measuring on the chosen samples are the next steps. Figure 5. and Figure 6. represent the choice complexity of the adequate filter as the monochromator and also the moisture detector choice. The mark T on the ordinate in Figure 5. represents the omitted rays transmission in %, and the abscissa contains the wave number data, the magnitude that is particularly introduced in IR region. It is particularly introduced in IR region. It is equal to the reciprocal of one wavelength and it is given in cm^{-1}. The with of the omitted band along one of the water absorption wavelengths can be seen in that figure. The detectors on the basis of PbS, InSB and InAs are taken into consideration in NIR region because in that region they have the highest susceptibility D^* in $\mathrm{cm}\cdot\mathrm{Hz}^{1/2}/\mathrm{W}$. The ambient temperature is very important in choosing of detectors as shown in Figure 6. for PbS detector. Its highest susceptibility at temperature of 25°C lies at 2200nm and it can increase at -20°C but it can also shift to 2500nm.

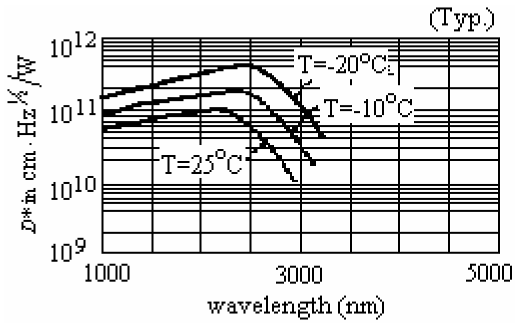

Figure 6. Spectral response of PbS detector

The determining of the functional dependence of Moisture content %=f (Absorbance)% which is typical for every substance is included into the experimental phase along with the corresponding application of the moisture meter working by using the gravimetric procedure. It must be established before the very moisture measuring and must be stored in NIR moisture meter memory.

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IMPACT OF QUALITY MANAGEMENT SYSTEM ON ENTERPRISE FINANCIAL RESULTS

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Abstract

Quality is the concept found in all areas of human life and activities. So we can talk about work quality, management quality, product quality, service quality, study quality, life quality, etc. This work will discuss quality in terms of care for business processes and its impact on business entities.

The starting point of the paper is that enterprises caring for operation quality have lower operation costs and better business results than the enterprises, which are not concerned with quality in the first place. Some of our researches have already dealt with this;[1] this one however will focus on the performance of those companies for which quality presents the primary goal of their business and production strategy. In the business world such companies are recognised as companies with ISO certificates. The analysis of their performance will be carried out in terms of seven financial indicators: gross profit per employee, gross profit per equity capital unit, loss per employee, loss per equity capital unit, gross profit margin, and net profit margin.

Keywords: Quality, Quality Management System, Enterprise Financial Results

1. Introduction

Investigating company performance is the matter of daily analysis. Each company has a defined business and production goal, the achievement of which should result in a positive business result (profit). As business and production goal quality is a very complex area, because it is not limited to the quality control of the final product or service, but involves all the operation segments to ensure the quality product or service at the end of the process.

Enterprises that have realised the importance of quality as competitive advantage undertake a number of actions in their operation to prepare for the introduction of the ISO standards, as one of the signals that the enterprise manages and ensures operation quality and thus also product quality. Although care for quality was appreciated already in the middle of the 20th century, the early nineties recorded a boom of international standards appearing as barrier to poor quality. Since then, the number of companies with at least one international quality standard has been growing worldwide and in Croatia as well.

In Croatia there are now 550 companies with ISO standards, with a total number of 794 certificates.[2] Since the issue of the first certificate in 1993, the number of companies obtaining the ISO standards has been constantly increasing, which shows that care for quality has become the primary business and/or production goal of many companies.

[1] Grubišić, D., Čerina, D., Product Quality as Factor of Enterprise Efficiency and Prerequisite of Competitiveness, Fourth International Conference on Enterprise in Transition, Split-Hvar, May 24-26, 2001, The Faculty of Economics, Split, pp. 97-99. (CD ROM: 323-349)

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2. Scope, methodology and hypotheses of research

Research into effects of the quality management system on company performance was carried out in two Croatian counties: Split-Dalmatian and Varaždin. While the Split-Dalmatian County belongs to the less developed part of Croatia characterised by the permanent rise of unemployment and company closedown, the Varaždin County is situated in the northern, economically more developed and generally more successful part of Croatia.

Even though product quality is equally important for both manufacturing and service companies, the research was carried out only in manufacturing companies. The reason for that lays in the fact that manufacturing is the basis of economic growth and development. In these terms we wanted to find out to which extent the manufacturing companies from the two counties are aware of the need to take care of quality in their operation and manufacturing procedures.

In order to obtain a realistic insight into performance of the observed manufacturing companies, we decided to analyse it in a 10-year period. The first ISO standards in Croatian companies were introduced in 1993; therefore that year seemed a good starting point for our research. However, as the period of 1990-1994 was characterised by privatisation, restructuring, setting up of private companies, galloping inflation, and Croatian dinar as currency, 1994 looked as a better choice as the starting year of this analysis. Namely, in 1994 kuna was introduced as the national currency and inflation was brought under control, which eliminates the need to de-inflate the data. This choice, however, made us limit our analysis to the 9-year period. Nevertheless, the period of nine years seemed long enough to allow relevant conclusions.

Possession of ISO standards is not by itself a guarantee that a company will have quality process and product but it is an important factor that enhances the probability of quality in both process and product. In these terms the issue to be dealt with in this work is company performance analysis in comparison to the attention paid to quality. Although it would be unreasonable to state that companies without ISO standards do not pay enough attention to product quality, we assume that those companies that possess the ISO standards do pay more attention to quality. Furthermore, we assume that care for quality or higher quality will provide better business results.

Consequently, the basic hypothesis of this research is:

Companies that have introduced ISO standards achieve approximately equal performance regardless of the county in which they operate.

3. Research results

3.1. Research methodology

The testing of the hypothesis was based on the mathematical-statistical processing of the collected data. The analysis of financial indicators involved mathematical-statistical methods for calculation of total, average and relative values, as well as relative numbers of coordination and their standard deviation.

3.2. Performance analysis of companies with ISO standards

In the Split-Dalmatian County there were 22[3] registered manufacturing companies with the ISO standards, while in the Varaždin County there were 17 of them in 2002. The number of these companies varied: in the SDC it went up from 14 in 1994 to 22 in 2002 and in the VC from 8 in 1994 to 17 in 2002. Although the SDC is much larger than the VC, and had in all the years a larger number of companies, the share of manufacturing companies in the total number of companies was larger in the VC. The number of companies with the ISO standards is not significantly different, although it could be expected that there would be more of them in the SDC.

The operation efficiency of the observed companies in the SDC is shown in comparison to those in the VC in the Table 1.[4]

[3] Although 22 companies were registered, they were not all active, so the processing involved 20 companies with ISO.

[4] The mark * in the Table 1 means that there was no deviation (in the VC there were no loss-makers) or that it was not possible to calculate the deviation, as some companies (in the SDC) had equity capital equal to zero.

Table 1. Finantial results of companies with ISO in SDC and VC

	Year	1994.	1995.	1996.	1997.	1998.	1999.	2000.	2001.	2002.
Number of employees	**ST**	**2965**	**3481**	**3232**	**3252**	**3234**	**2993**	**2885**	**3363**	**3261**
	deviation	455	413	298	276	310	268	244	325	331
	VŽ	**2699**	**2635**	**4820**	**5045**	**5368**	**5839**	**5673**	**5780**	**8523**
	deviation	511	457	949	961	925	1001	965	963	1031
Gross profit per employee	**ST**	**2371,61**	**5104,06**	**5720,81**	**15495,28**	**9917,89**	**6406,21**	**8057,05**	**24796,13**	**54375,90**
	deviation	11186,27	11071,29	22037,75	42989,31	28651,04	32219,07	35174,17	34589,48	52604,50
	VŽ	**13367,97**	**18002,15**	**6603,49**	**14601,03**	**6820,05**	**8143,26**	**9042,08**	**8802,19**	**23245,25**
	deviation	10997,65	9614,63	290758,61	10005,71	891892,43	662454,48	679012,59	3277148,06	39131,24
Gross profit /equity capital	**ST**	**0,48%**	**1,81%**	**2,20%**	**6,59%**	**4,48%**	**2,60%**	**2,84%**	**5,09%**	**9,58%**
	deviation	39,18%	48,21%	51,19%	55,61%	226,52%	29,55%	39,28%	23,57%	24,38%
	VŽ	**6,67%**	**5,52%**	**6,83%**	**8,32%**	**5,67%**	**6,87%**	**7,15%**	**5,81%**	**9,68%**
	deviation	13,19%	17,44%	20,69%	20,53%	14,62%	14,37%	15,98%	14,96%	16,72%
Gross loss per employee	**ST**	**68435,48**	**76171,73**	**152593,36**	**160961,17**	**161430,82**	**119703,06**	**85821,16**	**78958,55**	**43145,90**
	deviation	32918,90	24488,28	60017,35	44168,71	80938,54	74992,61	37000,42	114755,62	52947,55
	VŽ	**17665,60**	**17743,45**	**2670,78**	**371,25**	**0,00**	**0,00**	**0,00**	**0,00**	**5045,95**
	deviation *									
Gross loss/equity capital	**ST**	**13,71%**	**21,21%**	**45,54%**	**38,15%**	**72,11%**	**79,36%**	**159,82%**	**12600,86%**	**24,23%**
	deviation	14,00%	47,12%	155,23%	*	32,38%	*	*	*	*
	VŽ	**134,80%**	*	**1,89%**	**0,36%**	**0,00%**	**0,00%**	**0,00%**	**0,00%**	**4,58%**
	deviation *									
Gross profit margin	**ST**	**1,45%**	**3,22%**	**3,20%**	**7,28%**	**3,72%**	**2,06%**	**3,69%**	**4,76%**	**10,76%**
	odsupanje	3,58%	3,38%	6,98%	12,27%	12,79%	4,93%	8,55%	5,53%	7,21%
	VŽ	**2,58%**	**2,26%**	**1,11%**	**1,49%**	**1,68%**	**1,96%**	**1,80%**	**1,55%**	**3,30%**
	odsupanje	1,59%	3,17%	3,74%	3,28%	4,90%	5,56%	5,52%	10,37%	8,31%
Net profit margin	**ST**	**1,36%**	**3,13%**	**2,97%**	**6,86%**	**3,43%**	**1,94%**	**3,36%**	**4,72%**	**10,67%**
	deviation	2,90%	3,30%	7,14%	11,25%	11,81%	4,20%	7,49%	4,35%	6,39%
	VŽ	**2,02%**	**1,87%**	**0,89%**	**1,17%**	**1,42%**	**1,58%**	**1,68%**	**1,26%**	**2,86%**
	odsupanje	1,25%	2,86%	2,86%	2,23%	3,99%	4,37%	3,89%	9,15%	7,25%
ROE	**ST**	**0,45%**	**1,76%**	**2,05%**	**6,21%**	**4,14%**	**2,45%**	**2,58%**	**5,04%**	**9,51%**
	deviation	24,65%	34,80%	37,93%	33,03%	227,96%	18,29%	28,58%	18,84%	20,97%
	VŽ	**5,21%**	**4,57%**	**5,50%**	**6,51%**	**4,81%**	**5,55%**	**6,69%**	**4,72%**	**8,40%**
	deviation	7,23%	9,98%	14,80%	16,68%	8,77%	8,74%	9,94%	11,59%	12,93%

The performance indicators for the observed companies were calculated as the average relative coordination numbers, and not as simple arithmetical means. Their deviations were also calculated as arithmetical means of absolute deviations of individual relative coordination numbers from the average relative coordination number. In this way, companies with better performance are those having lower deviations.

The results are as follows:

1. *The total number of employees* in the VC companies was increasing after 1996 in relation to the SDC companies. So in 2002 in the VC there were 2.6 times as many employees as in the SDC companies. Oscillations in the number of employees were higher in the VC companies, but in spite of this, it is clear that the VC companies employ more workers than the SDC companies.
2. *Gross profit per employee* varied in both counties, with a growing trend in the last years. One cannot argue that either of the counties was in a better financial position in terms of this indicator as deviations in profit per employee were extremely high in both counties.
3. *Gross profit per equity capital unit* was higher in the VC throughout the period. It can be stated that not only was the calculated indicator better in the VC, but also that the VC, in terms of profit per equity capital unit, was more successful than the SDC (deviations in all the observed years are significantly lower than in the SDC).
4. In terms of *the gross loss per employee* it can immediately be seen that the VC was more successful than the SDC. Namely, in the period from 1998 to 2001 no company from the VC made a loss, while in the remaining observed years this loss was significantly lower than in the SDC.
5. Results were similar in terms of *gross loss per equity capital unit.* Namely the companies in the VC were here more successful too, since they either did not make any loss per equity capital unit or it was very low in comparison to the loss made by the SDC companies.
6. *Gross profit margin* was much higher in the SDC companies than in the VC companies. However, the dispersions perceived were much higher than those in the VC indicating that there were large differences in the realised gross profit margin between the observed companies. These dispersions do not allow us to conclude that the SDC companies were more successful than the VC ones, although in the last two years the dispersions were lower than in the VC companies.
7. *Net profit margin* shows the same trend but on a lower level, therefore this indicator allows us to accept only with great reserve the fact that the net profit margin is higher in the SDC companies than in the VC ones.
8. *ROE* or *net profit per equity capital unit was* in most of the years higher in the VC than in the SDC. Only in the last two years the SDC companies had higher ROE, but the measured deviation was much higher than in the VC. As throughout the period ROE was much higher in the VC where the companies also had lower oscillations in its value, it can be concluded that in terms of this indicator the VC companies were more successful than the SDC ones.

These indicators are presented by graphs showing the trend components of each indicator in the SDC and VC companies.

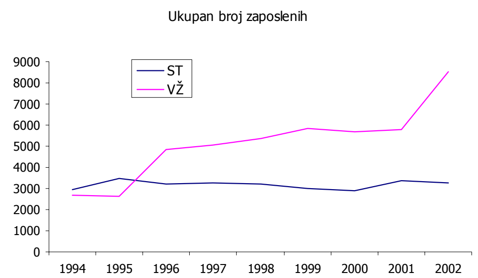

Figure 1. Number of employees

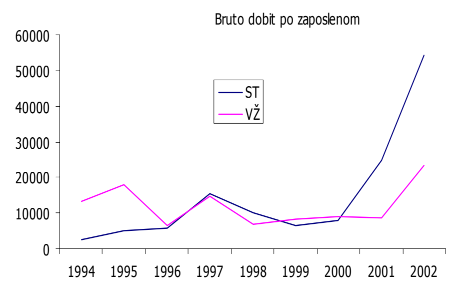

Figure 2. Gross profit per employee

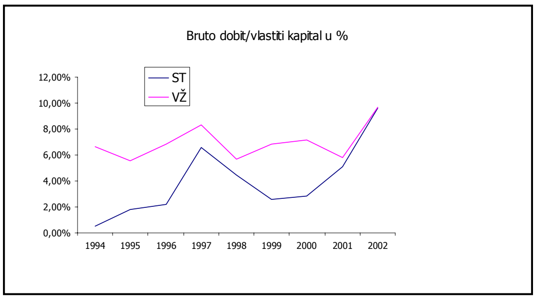

Figure 3. Gross profit/equity capital in

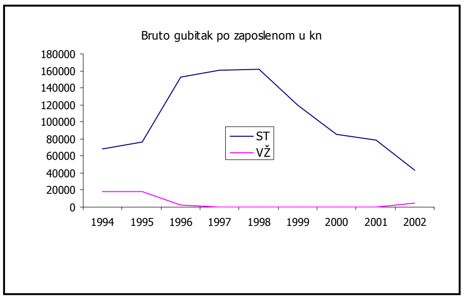

Figure 4. Gross loss per employee in kn

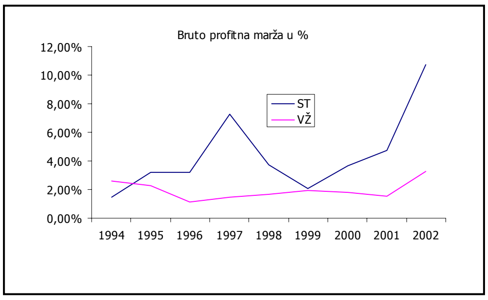

Figure 5. Gross profit margin in %

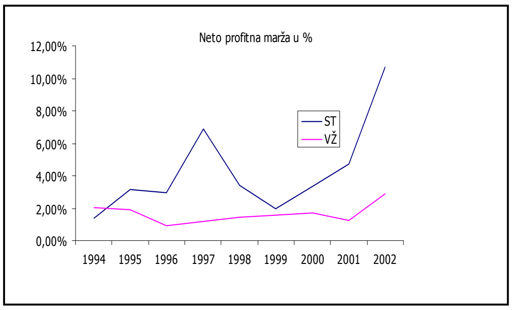

Figure 6. Net profit margin in %

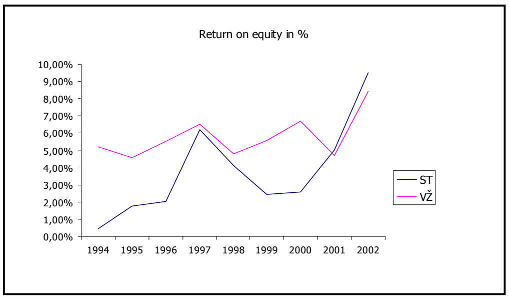

Figure 7. Return on equity in %

4. Conclusion

Comparison of companies with the ISO standards in the SDC and VC shows that the companies in the latter county were more successful. This is obvious particularly from the profits and losses, as all the companies in the VC made profits after 1997, while before that year only two companies made losses in two years. In the SDC half of the companies were making losses, of which five constantly, but these losses were as a rule decreasing. This certainly confirms the thesis that companies improve their performance after the introduction of the ISO standards.

Better position of the VC companies in comparison to the SDC ones is also confirmed by the most important financial indicator - net profit per equity capital unit. In terms of this indicator companies in the VC were realising higher returns on investment throughout the period (except in the last two years, but the dispersions in those years are higher in the SDC). Improvement of the financial result can be perceived in both counties after 2001, which is partly the result of the ISO standards introduction. The hypothesis that there is no significant difference between the companies with the ISO standards regardless of the county in which they operate is not confirmed. Namely, in terms of the most important performance indicators (return on equity, gross profit per equity capital unit, loss per employee, total number of employees) the VC companies are more successful, while according to the smaller number of indicators showing better performance of the

SDC companies it cannot be concluded that these companies are more successful due to the far larger deviation measured than in the VC companies.

In conclusion it can still be argued that most companies in both counties were improving their performance in the last observed years. As most of them introduced the ISO standards about the year 2000, the positive effect of that important venture (in terms of investment, human resources and organisation) could not immediately be fully reflected in the financial result of the company. Nevertheless it can be clearly perceived that the value of all the indicators is increased in the last two years of the observed period.

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ISHIKAWA DIAGRAM AND SERVICE ACTIVITES IN A LIBRARY

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Abstract

The quality management system standards of the ISO 9000:2000 series are based on eight quality management principles. Principle 6 says: "Continual improvement of the organization's overall performance should be a permanent objective of the organization". Applying this principle requires having knowledge of methods and tools for solving problems and/or continual improvement. One of these tools is "The Cause & Effect Diagram" or Ishikawa diagram. It is used to document the possible causes of a given event. The paper will present an example where this diagram is used in the Library Department. Naturally, Faculty of Mechanical Engineering in Zenica has certified the quality system according to the regulation ISO 9001:2000.

Keywords: Ishikawa diagram, quality management system, service, library.

1. Introduction

Customer satisfaction is an accepted indicator of an organisation's quality and success, which is becoming increasingly important not only in the world's market but in the local environment as well. Care about customer's satisfaction cannot be avoided in any segment of business, especially where the market requirements rule. ISO 9001:2000 standard stresses the importance of customer satisfaction and the whole model of the standard starts from customers and their demands, and ends again with their satisfaction.

Customer orientation is also in the first place, therefore, their current needs should be observed and their future needs anticipated and satisfied in the best possible way. Customer orientation itself has been stressed throughout the standard at several levels, such as:

- management tasks,
- process management and
- measurement, analysis and continuing improvements.

2. What is customer satisfaction and how to measure it?

Satisfaction, being a complex feeling of fulfilment, joy, positive affectionate relationship towards something, is not easily accessible to analyses. One of the most commonly used definitions says that customer satisfaction is a ***"degree to which customer demand has been met compared to the current organisation's potentials".*** Several parameters should also be kept in mind:

- satisfaction is a dynamic process and it changes continuously,
- there is no universal, general customer satisfaction and
- satisfaction is a relative term.

This means that the definition of customer wishes and needs as precise as possible from the aspect of customers themselves is the basis of successful business in the future. A satisfied customer is usually a loyal customer and organisations should do their best to turn their potential customers into true customers and their current customers into their regular customers, due to the fact that the price of winning over new customers is five times bigger than the price of keeping the current ones. The data from the Harvard Business School show that removing the flaws which customers point to can increase profits from 25% up to 85%, which sufficiently confirms customer orientation. [5]

Within the quality system, the term product covers the term service. The opposite might be satisfactory too given that customer satisfaction surely depends on what they receive for their money, how they receive it, i.e. on the service and the relationship of the organisation's employees in providing the information, product delivery etc, which the customer rightfully expects. This means that organisations have to pay attention to how they treat their customers, who may be satisfied with the product but not with the service and vice versa. All of that should constantly be kept under control in an attempt to keep the customers since keeping the current customers by winning over their loyalty pays out much more than investment into new ones. Satisfied customers are free marketing to the company, they are less sensitive to other offers and they are happy to accept other products of the same company. They communicate their satisfaction to a few and their dissatisfaction to a few times bigger number of people. [4]

How to measure customer satisfaction? There are many ways available to an organisation, such as: market analysis, benchmarking with competition, research and analysis of the customer wishes and needs, contacts established with them, satisfaction of their demands, establishment of personal, telephone, and written contacts, sincere partnership relationship, advertising material, instructions, warranties, service after purchase, servicing, training, etc. ***Customer has to be a subject that is being listened to and respected, and not someone a product will be sold to and forgotten about.***

In all the contacts, valuable information is gathered about customers; their wishes, satisfaction and dissatisfaction, and it should be recorded and monitored. In addition, if we wish to have reliable information, research into customer satisfaction should be approached in a systematic and planned manner by applying appropriate methodology. Research into customer satisfaction has been systematically approached in the past ten years and several customer satisfaction models have been developed.

3. Faculty of Mechanical Engineering in Zenica and Quality System

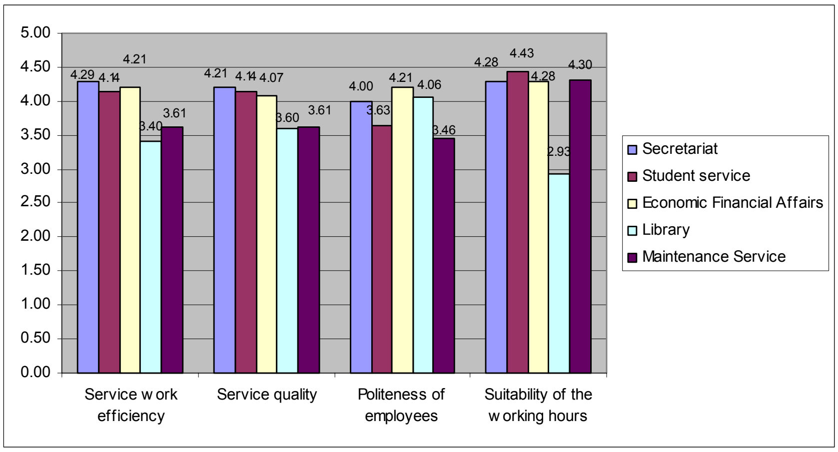
Although there is a great deal of those who believe that the introduction of quality system in education institutions, especially in BiH, is a luxury, most analyses show that it is necessary in order to gain international support in the development of university education and its harmonisation with the European and world's trends implemented in BiH. The data available show that the ISO 9000 standards in the field of university education in the world are applied beginning with the laboratories to faculties and universities.

Faced with the post-war complex situation in the university education in BiH and Zenica-Doboj Canton, significantly negative trends of the enrolment of student into technical faculties, the management of the Faculty of Mechanical Engineering in Zenica has accepted these "threats and dangers" as an opportunity for improvement and reengineering of its processes directing them towards quality. In the attempt to find an adequate quality system model and viewing modern trends of university education, the Faculty Management passed a decision as early as 1999 about the selection of model and introduction of quality system according to ISO 9001.

Although from the very beginning there was an unambiguous, clear and strong support to this activity, a whole range of objective circumstances in the environment has lead to prolongation and delays in the project implementation. Our experience has shown that the delays have mostly been caused by prolongation and excessive preparations of individual activities, but at the same time by stronger current obligations in teaching-scientific process and the demands developing as a result of increasingly present market sprit in the university education of BiH ("fight for students", decreased inflow of the budget funds, active participation in the implementation of projects for external contractors, international cooperation etc.). Among the reasons for delay were some unknowns caused by audit of ISO 9001:2000 standards. Namely, by publication of these standards in December last year, the project team had to make adaptations to the new requirements almost at the very end of activities. As the audit has brought many new things and a different concept of quality management, the situation related to the project implementation has become significantly more complex. All of that has resulted in the end by the certificate award, i.e. a confirmation by a suitable certification body (TUV Bayer Munich) that the Faculty has met the requirements of ISO 9001:2000 standards, and that, as of September 2003 the Faculty is the holder of this Certificate. [5]

In the course of preparation and maintenance of the system introduced, the Faculty of Mechanical Engineering took a series of steps to identify customer satisfaction, among which we would like to pay special attention to a survey conducted by students, related to assessment of the teaching staff and the support services, such as: Student Service, Library, Economic-Financial Affairs, Secretariat and the Technical Service. The survey is anonymous and conducted once a year (mainly because of the fact that there is a bigger number of two-semester courses). The survey is analysed at the Teaching-Scientific Council of the Faculty and the correction measures are adopted, which need to be taken in the following period. [7]

In the last two years, it has been noticed that the Faculty Library has poorer average assessment than other services. Figure 1 shows the relationship of the grades from the survey for some issues of the faculty services (grades by students of the fourth and fifth year of the studies), which shows the basic elements that were the subjects of the assessment. The average grade has also decreased compared to last year, which is not satisfactory in terms of the quality improvement system.



Following this and the assessments from previous years, where there were not many deviations, and the remarks from the survey by students of the fifth year of the studies, within the course Quality Management, an exercise was done related to application of certain quality management methods in the work of some services, more precisely, the Faculty Library.

Figure 1. Faculty services work assessments by students of the fourth and fifth year of the studies [3]

3. Application of the Ishikawa diagram on the work of the Faculty Library

3.1 What is, when and why is the Cause-Effect diagram used?

The **CAUSE-EFFECT diagram** represents a method of a detailed analysis of the relationship between a certain system condition under consideration (**effects**) and the influencing values conditioning the occurrence of the given condition (**cause**). The term [9]:

- **EFFECT** – denotes a specific work process OUTCOME in the observed system cross-section, in the given time and under the given conditions. Given that outcomes are results of influences related to environment impact and disturbances in the work processes, it is clear that these are the sizes of random nature and can be divided into two basic classes – within and outside the limits of the acceptable deviations of the set target function,
- **CAUSE** – implies a set of environment conditions and disturbances in the system work processes resulting in a certain condition – work process OUTCOME. From the viewpoint of the implementation of the project conditions – effects, these are the sizes of a disarranging nature.

Ishikawa diagram can help resolve problems or bring improvement in the cases when: [8]

- **Potential causes need to be identified -** basic reasons for a specific effect or a problem.
- **The existing problems need to be analysed** during implementation of the correction actions.

That is also the tool useful for identifying and organizing familiar and potential causes of poor quality or problems, whose application:

- **Helps establish the causes to the problem** by using a structured approach.
- **Encourages active participation of the team members** and the use of the acquired knowledge on the process under consideration.
- **Represents the cause-effect relationship** in an orderly and easily readable manner.
- **Increases the knowledge on the processes** or factors affecting the work respectively.
- **Identifies areas where data should be gathered** for further study.

3.2 Construction of the Ishikawa diagram

The diagram is constructed in several steps:

Step 1 – Effect identification-Problem definition

In the biggest number of cases this diagram can be used in the case when **a specific problem** is defined as an effect – poor spare part, poor installation or product quality, failure, long production cycle time, low capital turnover coefficient, and a whole range of similar problems. Then it is necessary to identify the causes of some problems as effects.

The situation is also possible that a certain (**desired, projected**) **effect – positive effect** is defined as an effect. The use of a positive effect can create an optimistic atmosphere that will encourage participation of the team members as opposed to a negative effect – problem, which can distract the team members' efforts to finding a justification for why the problem occurred and to apportion blame. It is recommended, whenever possible, to express an effect in a positive manner.

In our case, we have taken a **positive effect – better work of the Library of the Faculty of Mechanical Engineering in Zenica**, which avoids discussions in the sense of blaming somebody, and attention is directed to steps which can lead to positive effects.

Step 2 – Cause identification

The procedure of cause identification leading to the above defined effect consists of the following:

Shaping of the overviews of all the potential causes to the problem – effect analysed.

The given overview is in this case a result of a group work (students of the fifth year of the studies), who presented their proposals for improvement by the **brainstorming** method. Attempts were made for the overview of the cause-effects to be comprehensive, that is, not to exclude in advance a single cause that might, in a subsequent analysis, result in the basic cause-effect relationship. The overview is presented in the Diagram itself.

Step 3 – Basic Structure Selection

Classification of the cause-effects by character, manner of effect and similar characteristics

In the given stage, a set of all causes is divided into basic groups and each individual cause is assigned to a certain group. The references state some of the possible groups or cause categories, such as:

- **4M system**; where all the causes from the overview of causes are divided into one of the groups: **M**anpower, **M**aterials, **M**ethods and **M**achines.
- **7M** (4M+3M), where the basic structure of 4M is added **Marketing**, **Money** and **M**anagement.
- 3P and O - policies, procedures, plants, people and others.

The classification in our example relates to: **Methods, Manpower, People (staff) and Money**.

Step 4 – Identification of other causes – Dissemination procedure

For each of the main groups, other specific factors are identified that might represent the CAUSE EFFECTS:

It is necessary to identify at this stage as many causes or factors as possible and attach them as sub-classes to the main groups and try to state the details for each cause. If a lower-class cause is applied to several causes of higher rank, below each of them is stated where the cause-effect relationship can be of the order or parallel nature. This can be done by asking a series of **why** questions (for a problem***) or how*** questions (when a positive outcome effect has been set).

Step 5 – Diagram analysis

Analysis helps us identify the causes that justify further research. Since the "cause-effect diagram" identifies only the **possible causes,** Pareto diagram can be useful in further work to determine the cause which will be in the focus first. Analysis of the said diagram (Figure 2) points to the following:

- Level of the detail is almost balanced.
- One of the causes repeats, which points to the root of the problem or the **main direction of action** (effects related to introduction of an IS in the Library, which then results in an easier and faster response in terms of search, information update and access).
- "Money for specific literature procurement" is also an expressed problem.

It has been found that the most efficient problem (**identified by the Pareto method**), which can be solved, is "Procurement of an appropriate software" for the Library data, which would resolve a set of issues related to efficient records, fast search within and monitoring of the situation through local network and Internet (All the Library computers are connected in a local network and have access to Internet).

The above has been proposed to the Faculty Management and specific software has been procured. In addition to that, the local staff has received training for the work with the software itself, and there are ongoing activities related to entering data for specific groups of the library resources. So far, data for the PhD, MSc, final paper (for the first level studies) theses have been entered, and the graduation paper data are being entered for the papers which have been defended by now at the Faculty. The next stage will be related to entering data for books and teaching materials in the Library as well as to opening readers' cards through computers.

4. Conclusion

The basic characteristics of the method under consideration are as follows:

- Clear visual overview of the potential causes of the phenomenon under consideration and the consequences of their effects,
- There is an opportunity to analyse the relationships among certain effects – causes, their importance for the consequence under consideration and its position in the overall structure of potential causes – one cause may occur in several positions in the diagram (in several different cause groups),
- The method can be used in a situation when the desired affect is defined as positive, or as a desired situation (which is more efficient),
- The relationships between cause and effect and the relationships among the causes are, in general, qualitative and hypothetical and serve as a foundation for more efficient resolution of a problem using some other, adequate method,
- By focusing on the dominant problem identified by the Pareto or some other analysis, significant positive effects can be reached.

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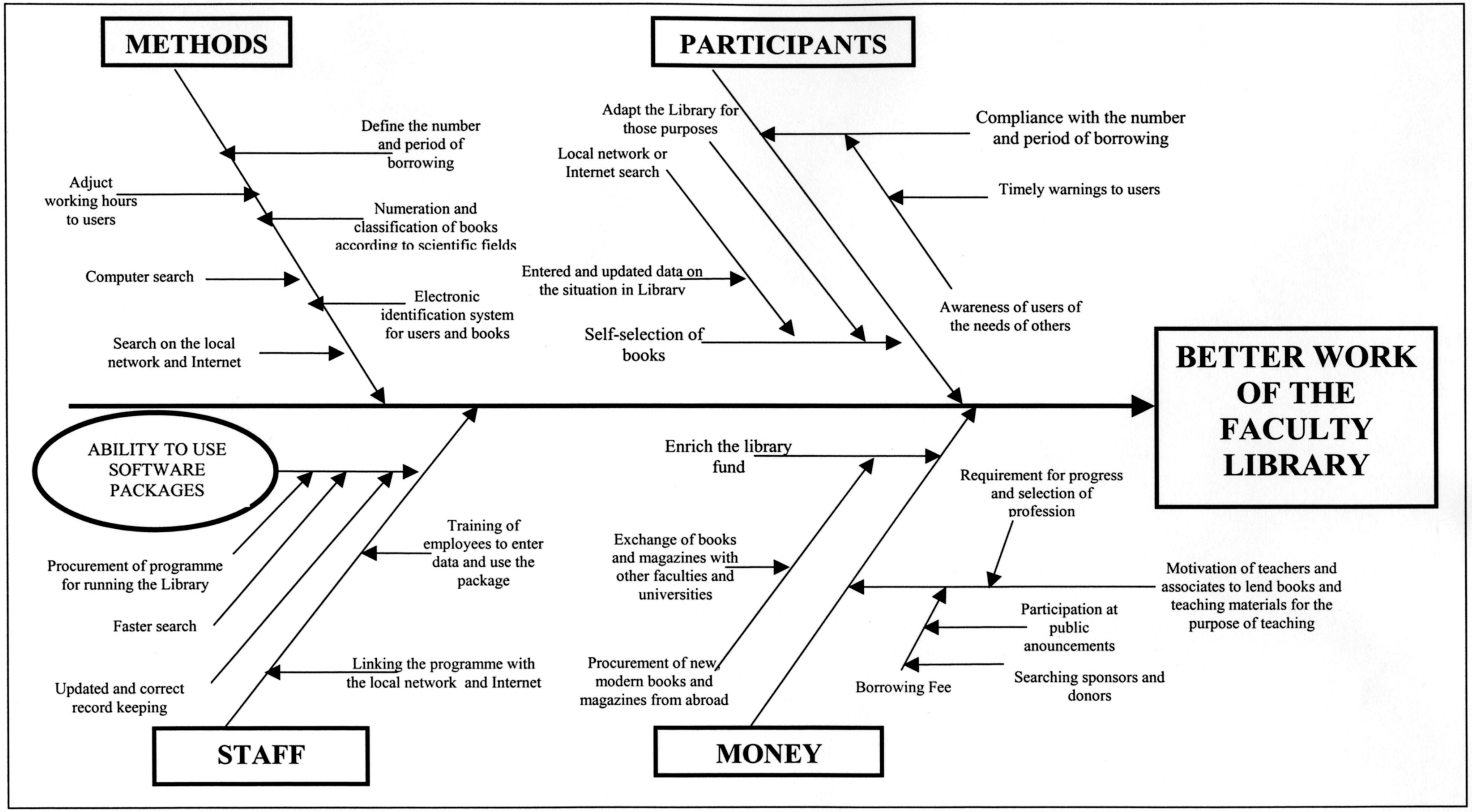

Figure 2. Overall Ishikawa diagram of the problem under consideration (desired effect)

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ECOLGICAL RISKS FROM TYPICAL TYPES OF SHIPS

V. Jelavić and D. Radan

Abstract

With implementation of new technologies in ship building and ship operation ships are getting bigger, faster and more complex. Power for propulsion exceeded hundred thousands kW, amount of cargo on some ships reached *half a million* metric tons and number of passengers and crew on big cruisers equals population of smaller city. Over dimensioning of the ships and all installed ship systems, simultaneously over dimensioned all ship pollutants and increased variety of environmental risks during ship operation and cargo handling. Therefore it is very important to distinguish different types of the ships considering hazards to environment and find out what are dominant sources of pollution from each ship type.

Keywords: pollution, environmental risk, environmental hazard, ballast water, cargo, oil tanker, passenger cruising ship.

1. Introduction

Public is often reacting after ecological catastrophes caused by oil tankers, but all other ships are periodically or continuously polluting environment. Different types of pollution and different ways to harm environment must be taken into consideration when discussing about environmental risks. Today there are four main ways of environmental pollution caused by ship operation and handling pollution by harmful substances and organisms; pollution by heat, pollution by noise and pollution by physical damage to environment. This paper will mostly consider all kinds of wastes, harmful substances and organisms carried as cargo or water ballast on the ships.

2. Ecologically risky ship systems

Before any precise ecological analysis it is necessary to divide ship into different environmentally hazardous systems (Figure 1). These systems are:

- ENERGETIC PLANT SYSTEM is mainly related to all ship's sources of energy and its pollutants. Harmful substances, heat and noise, released mainly into the air and water are main types of pollution associated to energetic plant.
- ACCOMMODATION SYSTEM is considerable source of pollution on passenger cruising ships. Generations of different liquid and solid urban wastes, containing toxic substances are typical for such ships.
- CARGO SYSTEM is considering all ship spaces for cargo storage and all ship accessories for cargo handling. Main types of pollution from ship cargoes are toxic substances harmful for nature and humans.
- BALLAST WATER SYSTEM is part of almost every cargo ship. Like cargo system ballast water system consists of ballast tanks and ballast handling equipment. Main type of pollution is *non-domicile* harmful organisms transported from one aquatorium to another. Non domicile organisms are especially dangerous because of very high expansion rate within environment with no natural enemies.

- HULL AND HULL ACCESSORIES SYSTEM is related to ship's hull and all equipment mounted on the hull for different purposes. Such equipment are ship's propulsors, fishing equipment, special equipment for underwater works etc. Main type of pollution from the hull is biocide from antivegetative paints, while hull accessories physically harm environment.

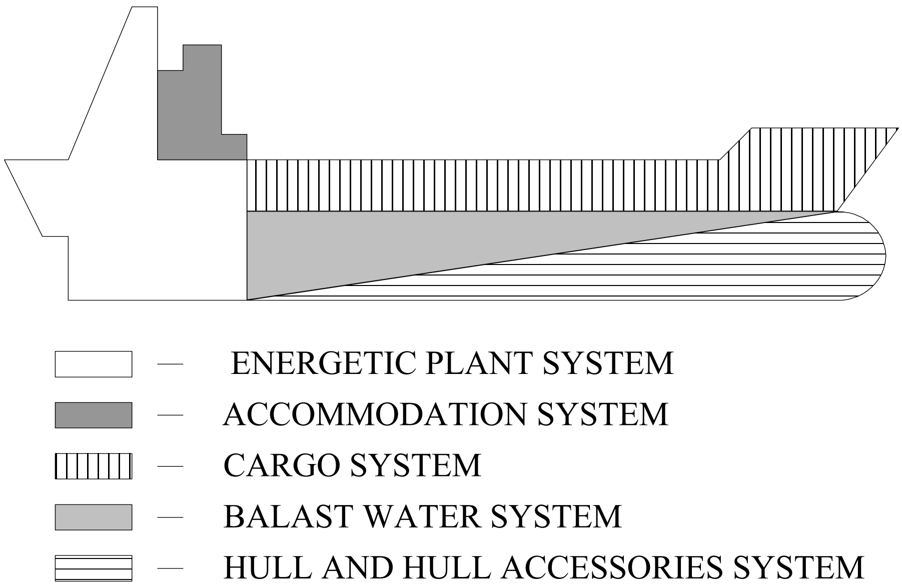

Figure 1. Ecologically risky ship systems

3. Typical ship types considering dominant environmentally risky ship systems

Ships have systematically been analyzed mostly from constructional and economic points of view, but very seldom from ecological point of view. Therefore it is very important to find out what are dominant environmentally risky ship systems and main sources of pollution for each ship type. Sometimes there will be few sources of different types of pollution that should be considered causing synergic effect to environment. All *visible* spills from the ships are often being attracted by media and processed, but there are other *invisible* harmful effects to environment from all kinds of ships. *White Passenger ships* are not dangerous because of oil spill, but very dangerous because of human toxic waste and garbage. *Small fishing boats* that look like *lifeboats* for some other ships can be extremely dangerous when fishing with inconvenient fishing equipment and in wrong period of fishing season. It is obvious that different ships have different impact to environment that should be carefully considered.

3.1 Typical Ship types considering cargo system

Cargo system is recognized as environmentally hazardous in different ship operating conditions. Cargo mostly enters environment as a result of mistake during loading, unloading, transportation or collision and grounding. Liquid cargo often gets into the sea after tank washing operations.

3.1.1 Crude oil carriers

Crude oil carriers are the biggest polluters among all ships. These ships are constructed to have small number of big capacity tanks. In case of accident causing hull & cargo tank damage big amount of oil could potentially flow into the sea. It is significant that modern crude oil carriers are getting bigger and bigger. According to oil spill database [6] amount of oil spilled into the sea during the period from 1990 to 2000 exceeded 10^5 tons. Crude oil tankers cause on an average one ecological catastrophe per year, such as the last one from the ship "Prestige" that sunk in 2002, 270 kilometres far from the shore line on depth of 3.500 meters. Even it seems to be too far from shore and too deep on the bottom of the sea, about 125 tons of oil daily spills into the sea for another year. With implementation of strict rules and regulations in shipbuilding, as well as ship operation, number of oil spills and amount of spilled oil is decreasing.

3.1.2 Chemical carriers

Chemical carriers are not big polluters according to amounts of chemicals that get into the sea from these ships, but could be very dangerous polluters according to toxicity of some of the chemicals. These ships are specific because of having big number of small capacity tanks enabling transportation of many different chemicals in the same time. Potential incident in only one tank would therefore cause relatively *small* spill. There are four categories of chemicals depending on environmental impact. Environmentally friendly chemicals are aloud to be pumped out under some conditions, while extremely dangerous chemicals are forbidden for pumping out. The most frequent reason for pumping chemicals out is tank cleaning and very high standards for tank cleanliness before loading cargo.

3.1.3 Liquefied gas carriers

Liquefied gas carriers are generally the least polluters in tanker fleet but some of them are continuously polluting environment. Some tankers exhausting evaporated cargo gasses into the air instead of reliquefaction and return of such gasses into the tank. About 0,25 % of the cargo gas evaporate daily, thus making considerable amount of gas.

3.1.4 Bulk carriers

Bulk carriers are mostly polluting environment during loading & unloading of cargo with old cargo handling devices. Such devices are leaking cargo into environment and causing pollution. Most of the ordinary bulk cargoes are not directly harmful for the nature.

3.1.5 Container carriers

Container carriers are according to the cargo characteristic environmentally friendly ships. Some polluters could enter environment only as a result of incident with container handling or ship handling.

3.2 Typical Ship types considering accommodation system

Accommodation facilities provide adequate living and working conditions for guests and crew. Waste collected from accommodations varies from sewage waters, food waste, solid waste, *special dangerous* wastes etc. Every waste should be collected and adequately treated on the ship or shore facilities.

3.2.1 Passenger cruising ships

Passenger cruising ships are specific because of carrying huge number of passengers and crew, providing in the same time very high cruising and living standards. Modern cruisers are hosting more than 5000 guests and crewmembers. Careful and efficient management of waste is one of the main conditions for living and working on such restricted area like ship is. Without continuous waste handling ship would be very soon suppressed in her own garbage. Therefore advanced cruising companies like *Royal Caribbean* [7] set position of *environmental officer* on board of their fleet. Amount and variety of garbage accumulated on cruising ship equals garbage collected in a small city (like Omiš – where conference takes place).

3.2.2 Ferry carriers

Ferry carriers are specific ships because of carrying vehicles and passengers in the same time. From environmental point of view passenger waste should be considered with more respect, especially if ferry carries bigger number of passengers.

3.3 Typical Ship types considering hull and hull accessories

Basic form of pollution from ship's hull is toxic biocide emission into the water. Beside that, different forms of ship hulls and propulsions are causing different effects when moving through the water. These effects are more radical for bigger, faster and more powerful ships. Accessories mounted on the hull for different purposes are also physically affecting environment.

3.3.1 All ships

All boats with antifouling coatings applied below the water line are environmentally dangerous. Antifouling coatings are continuously releasing poison, thus stopping all marine species to attach the ship's hull. Some of the poisons and toxic substances are active long time after being released from the coating, specially those based on tin (tributiltyn). These substances are directly dangerous for the marine life and for humans after being absorbed by fishes or shells.

3.3.2 Fishing boats

Fishing boats are specific because of direct destruction of marine life with fishing equipment. Weather fishing tools and accessories are used for fishing *on the surface* or fishing *on the bottom* results for environment is similar.

3.4 Typical Ship types considering ballast water system

Over 10 billion tons of water and more than 3000 species of plants and animals per year is being transported by ships [5]. Those that already caused ecological catastrophes are *Dreissena polymorpha* (Great Lakes), *Mnemiopsis leidyi* (Black Sea), *Alexandrium minutum* (Australia), *Caulerpa Taxifolia* (Mediterranean including Adriatic Sea) etc [1].

3.4.1 All ships

All boats carrying periodically water ballast are environmentally dangerous. Ship ballast water systems are closed systems convenient for survival and expansion of marine species during transportation of ballast waters. Periodical exchange of ballast water during ballast voyage is necessary to reduce environmental risk. There are few methods for water ballast treatment that is currently in experimental phase, but none of them is proposed for official practice.

3.5 Typical Ship types considering energetic plant system

It is estimated that 750 x 10^9 kW of power is installed on the ships [4]. That huge amount of energy releases about 40 x 10^6 tons of different pollutants into the atmosphere. Main types of energetic plants are diesel engines, steam turbines and gas turbines. There are also combined energetic plants from these three main types. Main pollutants are NOx-es, Sox-es, Cox-es, heavy metal particles and other pathogenic particles from residual marine fuels. Beside toxic substances energetic plants are also releasing considerable amounts of heat into environment.

3.5.1 Diesel engines

Diesel engines are the worst polluters out of all types on energetic plants used on the ships, especially two-stroke engines supplied by residual fuels. These engines are producing about 87 kilograms of Nox-es per one ton of fuel. Average NOx production per kW of power is close to 17 grams.

3.5.2 Steam turbines

Boilers used in steam turbine plants are producing *much cleaner* smoke than diesel engines. Steam turbine plants are used for propulsion of bigger ships with very high power requirements. Considerable amount of heat is continuously released into the sea from cooling systems of such plants.

3.5.3 Gas turbines

Gas turbines are the least polluters out of all energetic plants. They produce about 3 grams of NOx-es per kilowatt of power, and that is far bellow requirements of IMO (International Maritime Organization).

4. Ecological overview of typical ship types

After introducing ecologically risky ship systems and considering environmental risks for typical ship types, it is possible to create graphic overview of such ships. Graphic is presented in a pie chart form, including five pie sections – each section for each dominant ecologically risky system (Figure 2.).

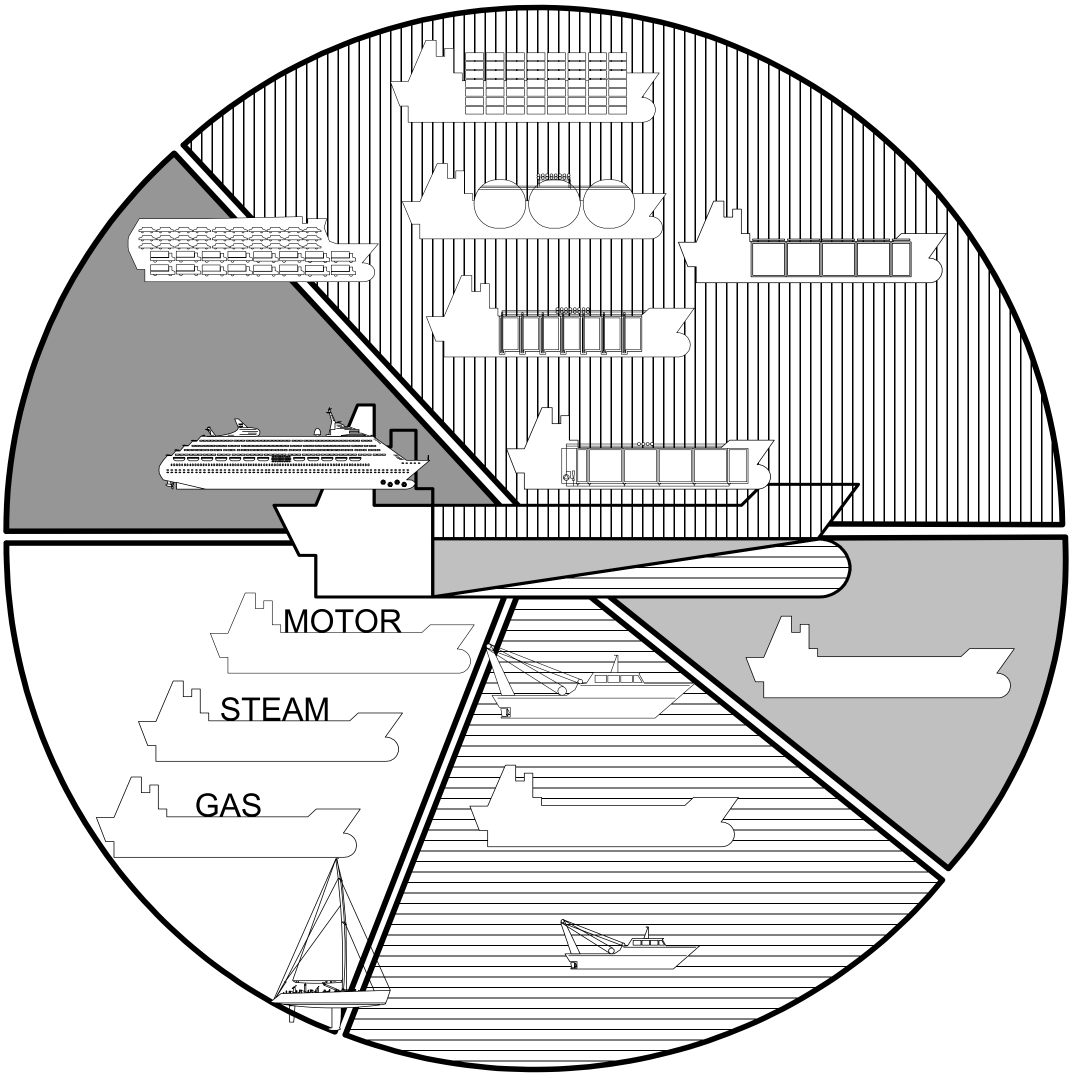

Figure 2. Ecologically risky ships pie chart

Position of the ship is symbolizing environmental risk, where ships close to the center of the pie have bigger risk and those far from the center of the pie have smaller risk. Most of the ships are concentrated within cargo area of the diagram because of variety of environmentally unfriendly cargoes. Accommodation area of the pie cart is almost exclusively belongs to passenger cruising ships. Ecological risk from ferryboats is partly coming from cargo systems and partly from accommodation systems. Risk from the ship hull and special ships like fishing boats presented in the chart mostly cover accessories. Risk from energetic plant ranges from motor propulsion to the gas propulsion, while ecologically the friendliest propulsion will be wind/sail propulsion.

For better understanding of the pie chart it is necessary to look at the symbols for typical types of ships (Figure 3).

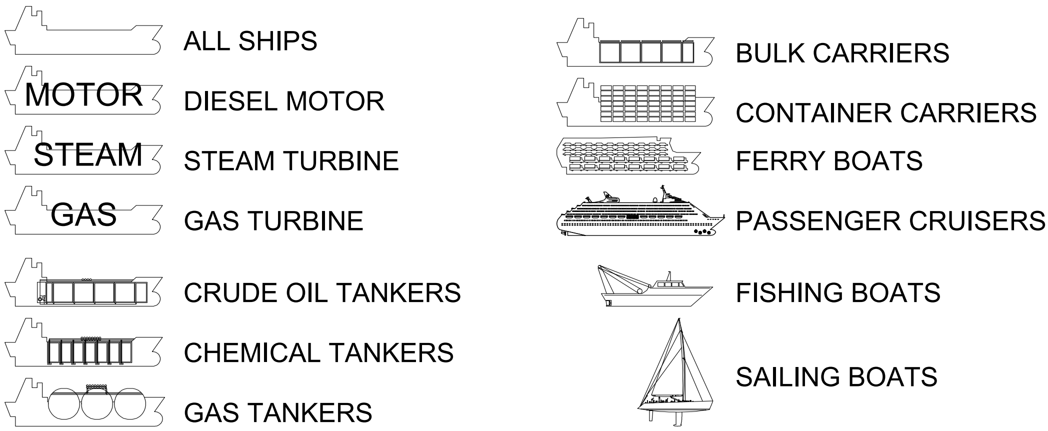

Figure 3. Symbols of typical ships

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MEASURING & REDUCING TWO – STROKE LOW SPEED DIESEL ENGINE EXHAUST GAS EMISSIONS

M. Jurjević, I. Prce and N. Jurjević

Abstract

Strict rules and regulations related to air pollution, proposed by IMO (International Maritime Organization) and EPA (Environmental Protection Agency), forced manufacturers of two stroke diesel engines to seriously consider pollution standards. Exhaust emissions are therefore challenging both engine manufacturers and manufacturers of exhaust monitoring and measuring equipment. Environmental approach to the problem is technically improving new generations of diesel engines and contributing to general awareness for ecologic problems.

Keywords: air pollution, ship, prevention, exhaust emission, control, MARPOL 73/78 Convention, Annex VI

1. Introduction

Awakening of human conscience has made men turn nature in an attempt to correct what was done wrong & restore the balance. On this path, IMO (International Maritime Organization) & EPS (Environmental Protection Agency) regulations serve as guidelines. Projectors & technologists follow these rules that represent a mean for better understanding of engine combustion processes. Better understanding leads to spreading environmental conscience in maritime industry. Many maritime diesel engines manufacturers (e.g. B&W) have started monitoring and reducing exhaust gas emissions in accordance to IMO regulations. In this paper, in addition to monitoring methods, an effort for finding ways of exhaust gas emission reduction in two – stroke engines was made.

2. Diesel emission

Increased "green" perception resulted in rigorous control of human activities in areas that can affect the environment.

Main polluters from diesel engines (as in other internal combustion engines):

- Nitrogen Oxides (NOx); influences smog and acid rain production
- Sulphur Oxides (SOx); acid rains
- Soot; some cause cancer
- Carbon Monoxide (CO); smog and ozone holes;
- Hydrocarbons (HC); some cause cancer, greenhouse effect;
- Carbon Dioxide (CO_2); main factor that causes greenhouse effect.

By observing these emissions it was determined that the influence of Hydrocarbons (HC), Carbon Monoxide (CO) and soot is low compared to emission of other industries; the same was determined for Carbon Dioxide (CO_2) and Sulphur Oxide emission due to superior diesel engine thermal efficiency. While the type of used fuel is the most important in determining emission composition, important factor that determines the quantity is engine speed, where medium speed engine gives 12.0 g/kWh NOx, low speed engine 17.0 g/kWh; content of CO, HC, CO_2 and SO_2 are approximately the same.

3. Measuring methods

There are several ways of measuring elements in exhaust gas. For acquiring reliable results, in addition to measuring equipment (analyzer) measuring processes and sampling techniques.

There are two ways of measuring NO_x: attested chemiluminescence's analyzer and electrochemical sensor, used in almost all portable instruments. CIA can be heated in order to avoid NO_2 condensation (with sampling tube). Chemical cell measure each component (NO, NO_2) separately.

CO and CO2 are usually measured by infrared method. It is an optic – luminescent method that utilizes analyzers that can measure other gas components. In correlation to the quantity of these components, multi-sensitivity must be compensated.

There are several methods of measuring SO_x: infrared, ultraviolet or ECS cells. Accuracy of all cell types still poses a problem. According to that ISO calculates SO2 in exhaust gas from fuel oil sulfur content. If SO3 is measured, other method can be used.

4. Maritime exhaust gas measuring system

In near future ships will have to satisfy international diesel engines exhaust gas emission standards as stated in new MARPOL 73/78 convention appendix 6. The system should enable measuring and data recording, that will serve for control by state administrations. Each monitoring system must be attested, for marine application In relation to electric power source, frequent temperature changes and air dampness.

4.1 Testing procedure

Emission analysis equipment was distributed aboard before departure so that it could be used for testing before starting the diesel engine. Analytic equipment was installed near the funnel. Heated tube was connected between sampling and analysis sites.

Instrument calibration was made for the purpose of work temperature stabilization. Zero points were set within nitrogen or cleansed air. CO, CO_2, NO, SO_2 and CH analyzer calibration was made by gases that give 70 – 100 % calibration in the most frequently used area. Thus according CO, SO2 and NO concentrations of 1400 ppm and 100 ppm propane (for CH analyzer) were used for calibration. For =2 calibration air was used. Gas calibration was made gravimetrically within punctuality +-1%, before during and after engine emission tests.

Emission measuring was made in stabile number of revolutions engine area load. Engines were set onto five load points: 100, 75, 50, 25 % of maximum power and idling where possible, emissions were recorded at power increase and reduction for showing engine set point and emission readout.

4.2 Device for complete exhaust gas emission measuring

Figure 1. represents a complete measuring system, followed by a text that describes separate parts. All elements in gas sample have to be maintained at correct temperatures for each system.

SP – 2 sampling HC in diluted exhaust gas probe has to satisfy the following:

- length from 254 – 762 mm from heated sampling tube HSL – 1
- minimum 5 mm inner diameter
- installed in the DT tunnel where diluted air and exhaust gas mix well
- sufficiently distanced from other probes and tunnel wall in order to remove eddying influence
- be heated so that exhaust gas temperature is increased (190+-10 c) at the probe exit
- SP2, CO, CO2, NO_x sampling in diluted exhaust gas.

Probe must be:

- in the same plan as SP2
- sufficiently distanced from other probes and tunnel walls so that it is out of eddying influence
- heated and insulated throughout the whole length at min. 55 C, so that water condensation is prevented

HSL 1 – heated sample tube

Sample tube leads exhaust gas sample from the tube to segregation point and HC analyzer. Sample tube must:

- have a minimum 5 mm and 13,5 mm maximum inner diameter
- be made out of stainless steel.

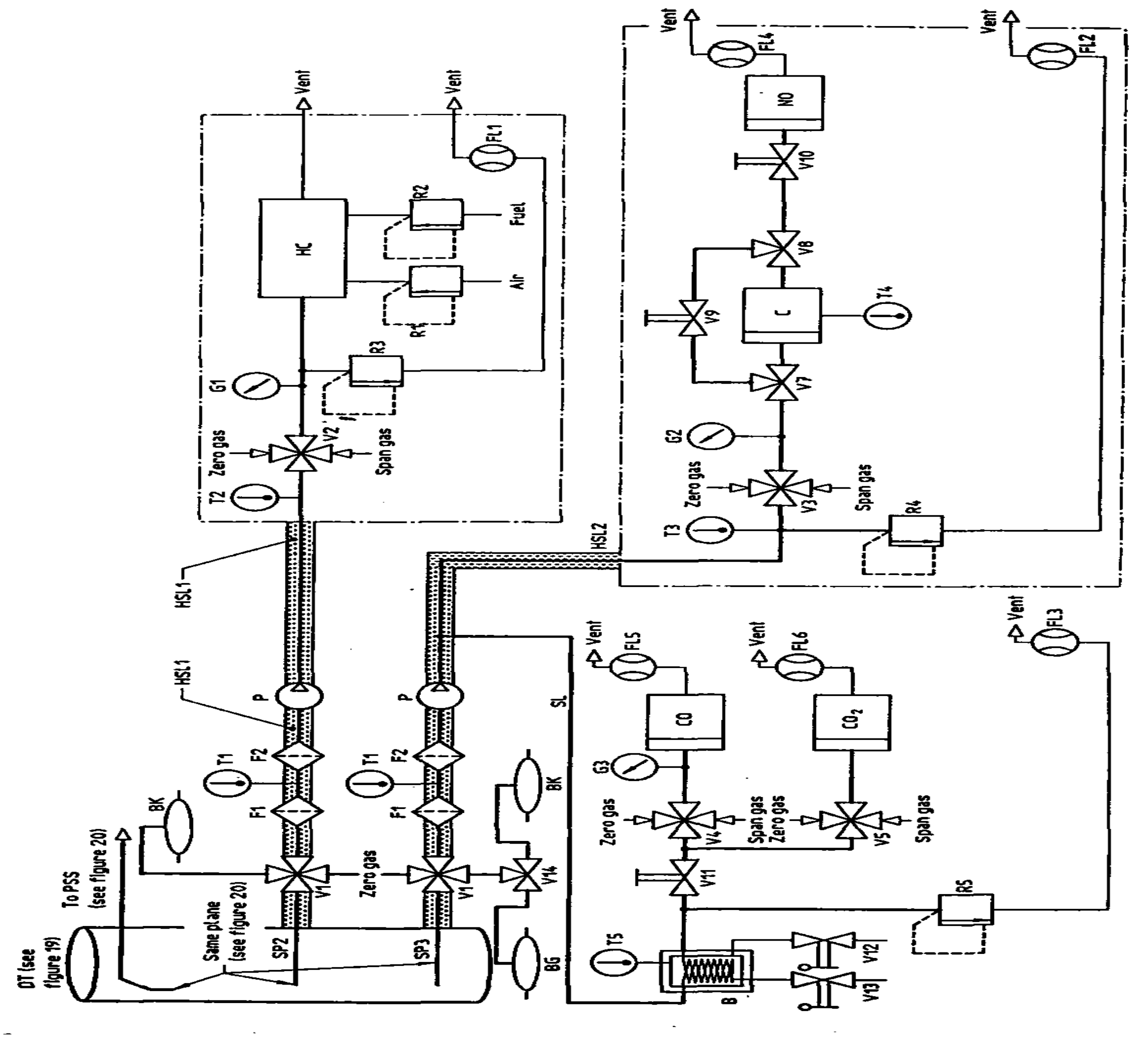

Figure 1. Complete measuring system

5. NO_x reduction methods

NO_x content in exhaust gas can be reduced by primary and secondary reduction methodson methods

Primary methods directly influence engine combustion process. Real reduction degree depends upon engine type and reduction method and varies from 10 to 50 %.

Secondary methods reduce emission level, without changing engine construction i.e. fuel setup, by using equipment that isn't a part of the engine.

5.1 Atomizer nozzle adoption

Atomizer nozzle adaptation is a natural part of every test, including a layout attest.

During their tests it was proven that different atomizer types and fuel injection intensity have a considerable influence onto NO_x.

Table 1. Atomizer performance and nozzle arrangement for 12k90MC engine at 90 % load

Test results	NOx	CO	Smoke	ΔSFOC
Units	ppm/15% O_2	ppm/15% O_2	BSN_6	g/kwh
Standard valve/nozzle	1594	109	0,35	0,0
6-hole fuel nozzle	1494	108	0,23	+0,4
Slide type fuel valve	1232	87	0,18	+1,8
BSN_6 is the direct reading of the Bosch Smoke Number after six pump strokes				

Table 1 shows atomizer nozzle type influence onto NO_x composition, fuel consumption and other contaminants.

Man B & W has presented a sliding type atomizer installed on new engine types.

These atomizer types maintain the engine clean, reduce emission, fuel consumption, HC (hydrocarbon emissions, rigid particles for 30 % and NO_x emission.) IMO recommend their usage, so they are used for engines with cylinder diameter 600 mm or greater.

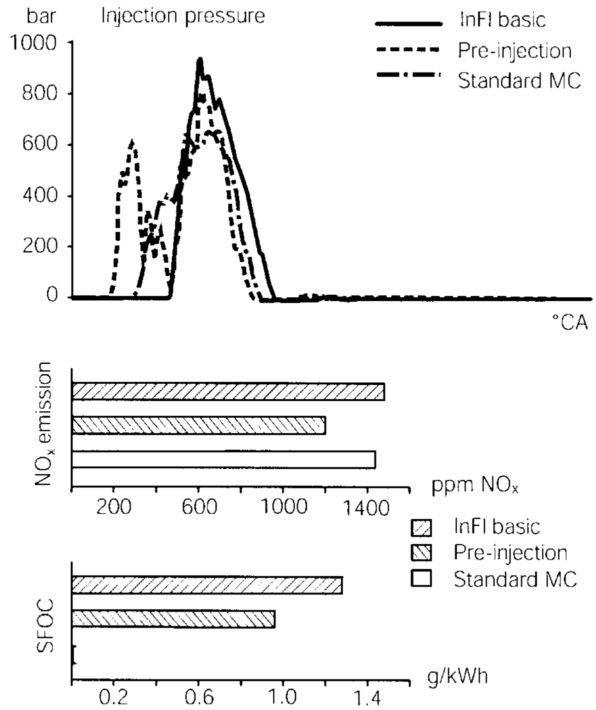

Figure 2. Fuel injection example that includes pre – injection and influence onto SFCO and NO_x emission

5.2 Water emulsification

Several years ago it was proven that water emulsification leads to considerable NO_x reduction and two man B & W engine systems use this method for controlling NO_x without impact onto maintenance cost.

Standard engine construction allows adding 20 % of water at full load, due to high pressure fuel pumps capacity, but it does not represent combustion limit. System that utilizes 50 % water and 50 % fuel was tested. In commercial applications, this water quantity demands engine construction alterations. Figure 2. shows the influence onto NO_x and fuel consumption. Emulsification influence varies with engine type, but generally 1 % of water reduced NO_x by 1 %.

While water and residual fuel oil emulgate well, gas emulsification is possible only with an emulsification reagens. They are available, easy to use and inexpensive.

Emulsification occurs before the state of circulation in fuel oil system, i.e. there is no return line from the entry towards the engine. This makes the engine flow follow the water flow. Measuring NO_x in exhaust gases can control adding water. This would be the case if NO_x content were constantly monitored.

6. An example of two – stroke ML engine with water emulsification

These engines produce NO_x emissions well bellow IMO regulations. Nontreated NO_x was expected at 1500 ppm, so it was decided to emulsify 50 % of water into fuel oil. 90 Mc fuel oil pump was installed in order to increase water and fuel mixing volume that will be injected.

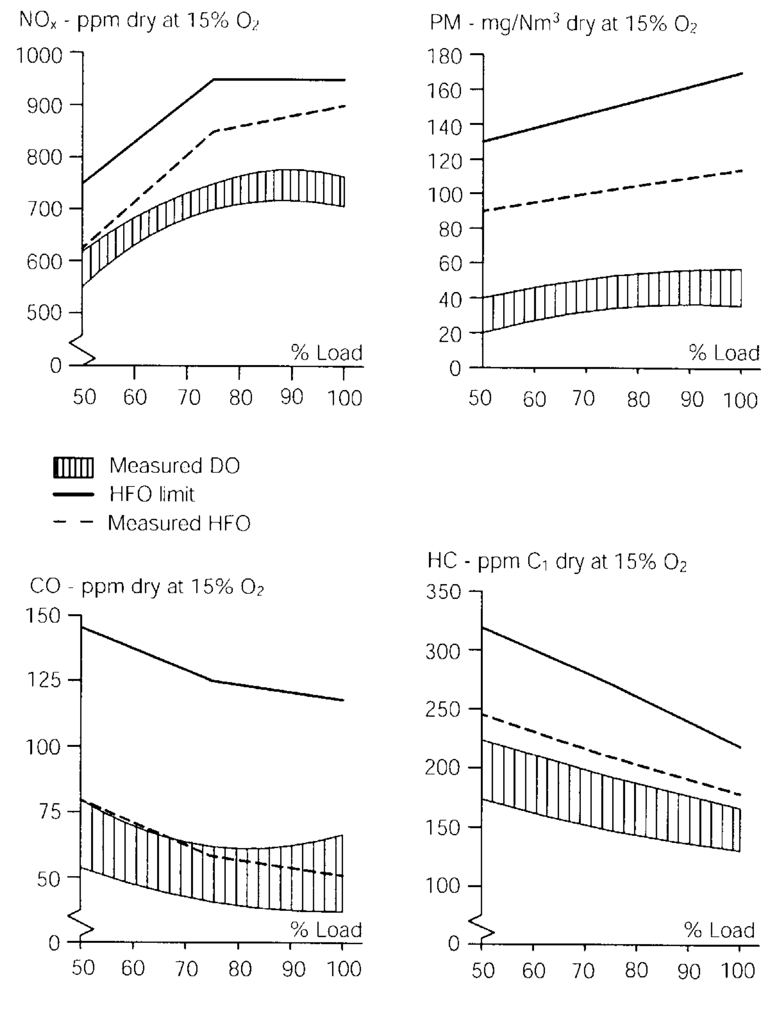

Figure 3. Emission limits 12k80mc engine emissions for the emission control version

Other polluters have also been subjected to limitation in September of 1994; the engine was subjected to long term testing with and without water emulsification and several atomizer nozzle types. As a result, figure 3. shows all emission limits, acceptable when taking into consideration modern fuel limitations.

Plant was tested also in the second half of 1995. The plant consists of 7L90GSCA engine with the non-treated NO_x level from 1150 – to 1200 ppm (figure 7)

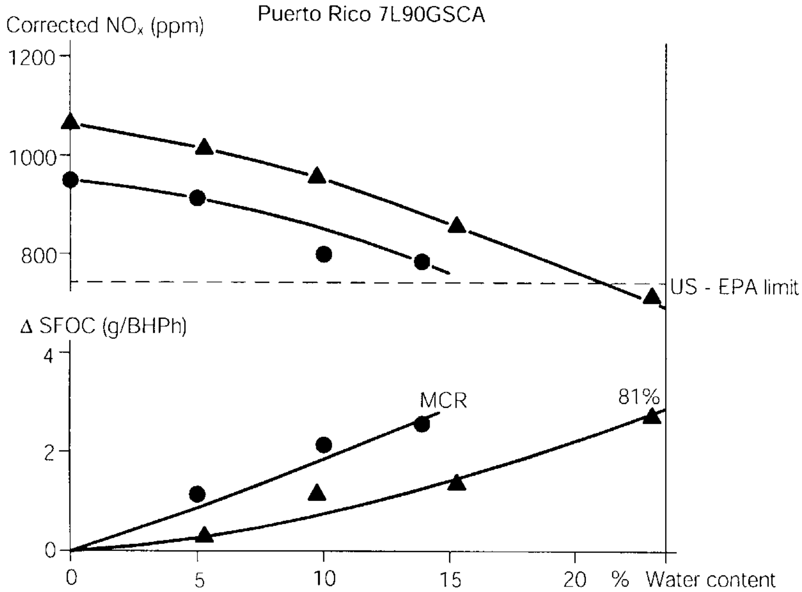

Figure 4. NO_x control by use of water emulsification on a two – stroke low speed 7L90GSCA diesel engine

EPA regulations allow 600 ppm emissions, at 15 % oxygen content, for engines with heat coefficient of 35 %. Since regulations take proportional correction for high efficiency engines, limit for this engine would be around 770 ppm. Residual fuel and water emulsification with maximal pressure reduction was chose for NO_x reduction. In concordance with USA – EPA NO_x emission regulations (at that time) usage of 22 % water emulsion, and maximum pressure reduction of 5, as shown in figure 4, were decided upon.

7. Conclusion

IMO regulations for air and sea pollutions prevention were made on time by MARPOL annex VI. However, it is not only atmospheric pollution, but soil pollution due to contaminants that get in the atmosphere by exhaust gases (acid rains) from the above stated, it can be concluded that exhaust gas NO_x emissions regulations will be tightened in the near future.

Direct water injection into combustion chamber can reduce NO_x emission for 50 % of course; this results in engine losses efficiency.

In the future, reduction of not only NO_x, but also other exhaust gas elements that affect atmosphere changes, but in smaller proportion. These elements (SOx, CO2) not only increase soil acidity, but cause greenhouse effect. The best way of reducing CO_x, exhaust gas emissions is to remove sulfur from fuel oil, as a preventive measure for exhaust emission pollution.

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CONTRIBUTION OF RELIABILITY ASSURANCE IN RAILWAY TRAFFIC

I. Vitez, I. Kladarić and B. Vitez

Abstract

Under contemporary conditions of railway exploitation rails are exposed to a constant increase of speed and loading on the vehicle axles and to constant residual stress increase in welded railway tracks. This more stringent operating requirements call for obligatory improvements of Quality Assurance in new standards for railway rails in order to better reliability in Railway Traffic like standard EN ISO 9002 and latest proven technology from manufacturers.

This work elaborate clearly methods of Qualifying criteria and Acceptance tests from series of new European standards for railway rails.

Keywords: Railway Traffic, Reliability Assurance, Railway Rails, Qualifying criteria, Acceptance tests

1. Introduction

Railway rails are a very important element of the overall railway track and have the basic role of supporting and guiding railway vehicles and to endure the exploitation life time with an acceptable level of damage. Under contemporary conditions of railway exploitation rails are exposed to a constant increase of speed and loading on the vehicle axles and to constant stress increase in welded railway tracks. Due to the increased exploitation requirements, new requirements regarding rail steel quality have been set out in standards for manufacture and delivery of railway rails. The standard of the International Railway Union UIC 860 V was obligatory for manufacturers of railway rails first forcing them to produce rails having the best properties regarding following parameters:

- Residual stresses
- Content of nonmetallic inclusions and
- Fracture toughness.

The manufacturers have responded to the constantly growing railway loading and the increased quality requirements in the last 50 years introducing the following novelties:

- Increase of the rail mass on meter of length from 45 to 77 kg/m. Nowadays, in Europe rails with fixed mass of 60,34 kg/m are predominating, instead of rails of the type 49,43 kg/m, made of different types of rail steels.
- Increase of steel tensile strength from 700 to 1300 MPa at naturally hard rails (without heat treatment) and with change of steel composition.
- Increased content purity of track steel with strength greater than 900 MPa and reduction of the allowed content of harmful mixtures of phosphorus and sulfur from 0,050 to 0,030% max.
- Production of longer rails, from 12 to 120 m.

The increase of mass on meter of length and the greater tensile strength have enabled better resistance to wear and tear, and larger axle loads with simultaneous decrease of material wear. The increase of tensile strength of steels for railway rails and its dynamic endurance has been realized primarily through change of chemical composition and purity of steel. The required safety against brittleness has been realized through achievement of specified properties of workability (elongation, impact resistance), fracture toughness, microstructure and purity of metal.

The modern railway rails production technology and the requirements of high speed on railways have demanded a permanent improvement Quality Assurance System what lead to a supplement of relevant norms with new testing methods for establishing the prescribed properties [1 to 6].

2. The Requirements of the Draft new European Norm

The draft of new European Norm pr EN 13674-1: June 1999.-Part1 covered flat bottom symmetrical rails having a linear mass 46 kg/m and above. This draft EN has prepared under the direction of the European Committee for Standardisation (CEN*) from national standards bodies of 19 states** and it is distributed for review and comments.

Modern rail production technology and the requirements of high-speed railways within the Community have demanded a completely new look at the philosophy and content of this part draft pr EN XXXX. Whenever possible this part of draft pr EN is performance based, adopts the European Quality System standard EN ISO 9002 and requires manufacturers to offer the latest proven technology. Two major divisions of the draft proposal EN are: qualifying tests and acceptance tests. The qualifying tests introduce a number of performance requirements not previously seen in national or international standards (such as fracture toughness K_{Ic}). They also include typical results from relevant acceptance tests. The acceptance tests have been designed to control those characteristics of the rail steel and rail that are of relevance to the production of high quality rails and the demands of the railway operator. The principle of the acceptance criteria is based on measured hardness values and not on measured tensile tests, which form part of the qualifying tests. On this hardness values are given new markings steel grades for railway rails [7, 8].

Table 1 gives seven steel grades for rails, hardness range, minimum fracture toughness values, description and branding lines on web. These steel grades reflect trends in railway usage (either non heat treated – HT * on heat treated steels).

Table 1. Steel grades hardness range, fracture toughness and other [3b]

Steel grade	Hardness range	Fracture toughness, K_{Ic} (MPa $m^{1/2}$) Minimum value		Description	Branding lines
	HBW	Single	Mean		
200	200-240	30	35	C-Mn	
220	220-260	30	35	C-Mn	
260	260-300	26	29	C-Mn	
260 Mn	260-300	26	29	C-Mn	
320 Cr	320-360	24	26	1 %Cr	
350 HT	350-390	30	32	C-Mn HT*	
350 LHT	350-390	26	29	Low alloyed H.T. *	

2.1 Qualifying tests

All qualifying tests shall be undertaken at least once every five years and as a results of any significant production process change for all grades. In addition the residual stress shall be carried out on all available grades every two years. The maximum longitudinal residual stress in the foot shall be 250 MPa. For residual stress tests there shall be 6 sample rails and the test pieces shall be taken at least 3 m in from each rail end. Each of the 6 test pieces from the rail section shall be 1 m in length.

* Comite Europeen de Normalisation (CEN) = European Committee for Standardization;

** Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland und United Kingdom;

For the determination of rail foot surface longitudinal residual stresses are used electrical strain gauges of the encapsulated type, 3 mm in length with gauge factor accuracy of better than ± 1%. This strain gauge is to be located at the centre of the 1 m length of the sample rail set in accordance with the recommendations of the manufacturer. While cooling the rails to maintain a constant temperature, made two saw cuts to remove a 20 mm thick from the centre of the rail length (Fig. 1).

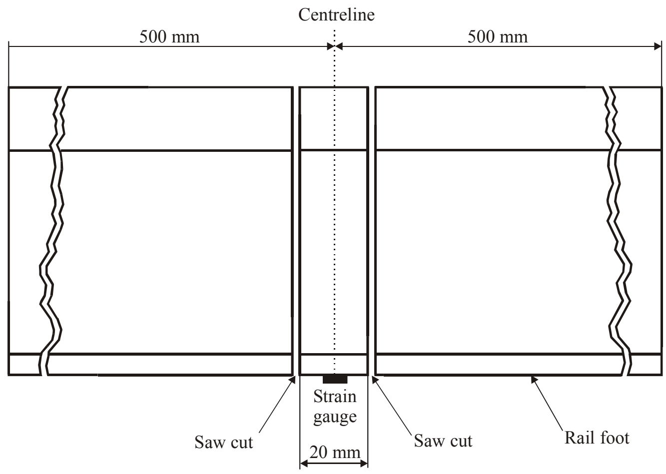

Figure 1. Location of strain gauge to measure residual stresses and slice removed the rail

The residual stresses are calculated from the differences between the first and second sets of relieved strains by multiplying by 2,07 x 10^5 MPa.

Standard test method for the determination of the plain strain fracture toughness (K_{Ic}) of rails shall be performed in accordance with the requirements of ASTM E399: 1991. The location of the test piece in the rail's transverse section is shown in Figure 2.

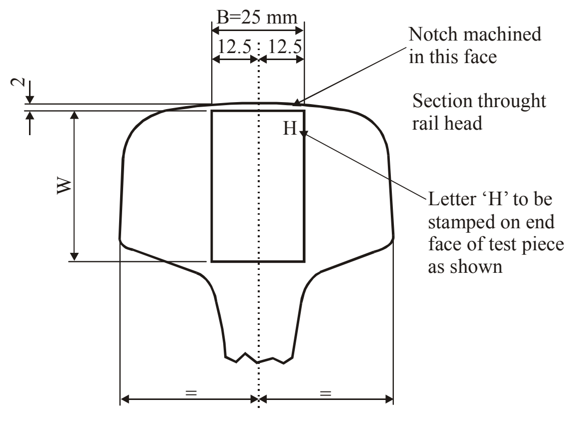

Figure 2. Location and section of fracture toughness test pieces

The thickness "B" of all test pieces shall be 25 mm. For any rail head transverse profile the test piece width "W" shall be the maximum achievable of the following dimensions: 40, 45 and 50 mm. A minimum of 5 tests from each sample shall be performed. It is recommended that the chevron notch in ASTM E399 be used to avoid crack front curvature problems. Fatigue pre-cracking shall be carried out in the temperature range +15 to +25 ^{o}C using a stress ratio in the range > 0 < + 0,1. Fatigue pre-cracking shall be carried out at a cyclic frequency in the range 15 to 120 Hz. The final crack length to test piece width ratio shall be in the range 0,45 do 0,55 and during the last 1,25 mm of crack growth K_{max} shall be in the range 18 to 22 MPa $m^{1/2}$. The single edge notched bend test piece shall be loaded under displacement control using three point bending with a loading span (S) equal to four times the test piece width (W). Tests shall be performed at a test temperature of -20 ± 2 ^{o}C. Test piece temperature shall be measured using beadles thermocouplespot welded to the test piece at the location shown in figure 3.

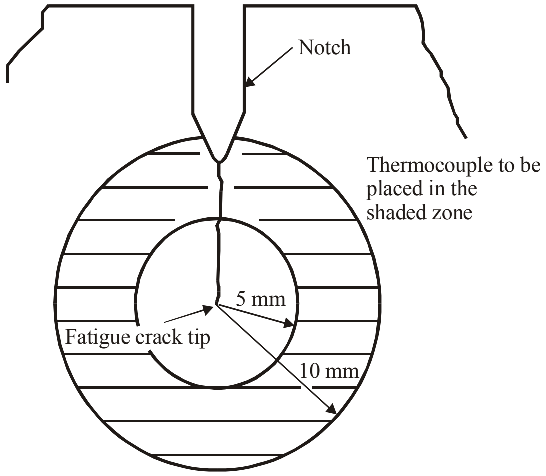

Figure 3. Location of thermocouple on fracture toughness specimens

The supplier shall only carry out testing on the 60 E1 profile or the heaviest section produced. Prescribed are the following qualifying tests: fracture toughness (see table 3, with five test samples three point bend); fatigue crack growth rates (17 m/Gc by ΔK=10 MPa m$^{1/2}$ and 55 m/Gc by ΔK=13,5 MPa m$^{1/2}$ for steel grades 200 and 320 Cr); fatigue test (min. 3 test pieces, the life of each samples shall be greater than 5x10^{6} cycles by total strain amplitude ε_{uk}=0,00135); residual stress in rail foot; variation of centre line running surface hardness of heat treated rails (till ±15 HBW from of the mean result obtained); tensile strength and elongation (calculated using multiple regression analysis); segregation (sulfur prints by ISO 4968); other qualifying requirements [3b].

2.2 Acceptance tests

Within this tests shall be performed a sequence laboratory tests: chemical composition (general, hydrogen content in heat, total hydrogen in heat); microstructure; decarburisation; oxide cleanness (K3<10 on minimum of 95% samples); sulfur prints; hardness (HBW 2,5 mm/1,839 kN, 15 s; max. variation till 30 HBW); tensile test (R_m and A_5 are mostly calculated by the predictive equation, except for 350 HT and 350 LHT are tested on diameter of 10 mm, L_o=5 d_o).

Testing frequency for laboratory tests, which shall be performed during production, is given in Table 2.

Samples for oxide cleanness shall be prepared and assessed in accordance with DIN 50602. For orders less than 5000 tones, only one sample with a K3 greater than 10 and less than 20 is allowed. Samples shall be taken from one of the last blooms of the last heat of the sequence but from each sample 2 specimens shall be tested. The following limits shall apply:

Total index 10 < K3 < 20 for a maximum of 5 % of samples
K3 < 10 for a minimum of 95 % of samples.

The testing position in the rail head is shown in figure 4.

Other acceptance test of rails are: dimension tolerances; gauges (control calibers for height, web and foot thickness, crown profile etc.); inspection requirements / tolerances for internal quality and surface quality.

Internal quality of rails shall be ultrasonically tested by a continues process ensuring that entire rail length and cross-sectional area are inspected (at least 70% of the head and at least 60% of the web). Surface quality included control: all protrusions, hot marks and seams from rolling, wear patterns, hot scratches, slivers etc.; cold marks, surface microstructural damage (martensite or white phase), automatic foot inspection on surface defects (cracks).

Table 2. Testing frequency [8]

Laboratory tests	Steel grades	
	200, 220, 260, 260Mn, 320Cr	350 HT, 350 LHT
Liquid chemistry	One per heat	One per heat
Hydrogen	One per heat (2 from first heat in sequence)	One per heat (2 from first heat in sequence)
Total oxygen	One per sequence [1]	One per sequence [1]
Microstructure	Not required for grades 200, 220 and 260 One per 1000 tonnes or part thereof for grades 260 Mn and 320 Cr	One per 50 tonnes of re-heated [1,3] One per 100 tonnes of mill heat treated [1,3]
Decarburisation	One per 1000 tonnes or part thereof [1,2]	One per 500 tonnes of re-heated and mill heat treated [1,3]
Oxide cleanness	One per sequence [1,2]	One per sequence [1,2 or 3]
Sulfur print	One per 500 tonnes or part thereof [1,2]	One per 500 tonnes or part thereof [1,2 or 3]
Hardness	One per heat [1,2]	One per 50 tonnes of re-heated [1,3] One per 100 tonnes of mill heat treated [1,3]
Tensile	One calculation per heat/one per 2000 tonnes [1,2]	One per 1000 tonness (test) [1,3]
1: Sample shall be taken at random but only from blooms outside the mixing zone between heats when continuously cast in sequence. 2: Initial samples shall be cut after rolling. 3: Samples shall be cut from heat-treated rails.		

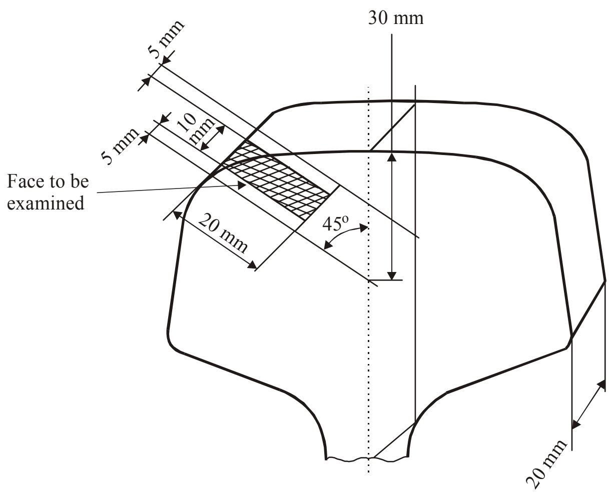

Figure 4. Oxide cleanness sampling position in rail head

Rail profiles, dimensions, properties and linear masses shall be in accordance with is prescribed in draft pr EN. This draft pr EN contains 21 different profiles railways rails with linear masses from 46 till 60 kg/m (Table 3). The profiles given at the figure 1 have following designations: 49 = 49 E1 (previous DIN S 49), and UIC 60 = 60 E1 [3b].

Table 3. List and designation of profiles and previous rail profiles [3b]

Ser. No	Profile	Previous profile	Ser. No	Profile	Previous profile
1.	46 E 1	SBB I	12.	50 E 4	UIC 50
2.	46 E 2	U33	13.	50 E 5	50 UNI
3.	46 E 3	NP 46	14.	50 E 6	U 50
4.	46 E 4	46 UNI	15.	52 E 1	52 RATP
5.	**49 E 1**	**DIN S49**	16.	54 E 1	UIC 54
6.	49 E 2	S49 T	17.	54 E 2	UIC 54 E
7.	49 E 3	DIN 549 b	18.	54 E 3	DIN S54
8.	49 E 4	HUSH 113lb/54 Kg	19.	55 E 1	U55
9.	50 E 1	U50E	20.	56 E 1	BS 113lb BR Variant
10.	50 E 2	50EB-T	**21.**	**60 E 1**	**UIC 60**
11.	50 E 3	BV 50			

3. Conclusions

According to norm Codex UIC 860V/1986. four pearlitic steel grades for railways rails were prescribed with tensile strength 700 till 1100 MPa, but in draft pr EN/1999. seven pearlitic steel grades are specified giving a hardness rang between 200 to 390 HBW (see table 1).

Draft pr EN 13674-1 has two mayor divisions: qualifying tests and acceptance tests. The qualifying tests introduce a number of performance requirements not previously seen in earlier norm (see point 3) and they also include typical results from relevant acceptance tests. The acceptance tests have to control the prescribed properties of the high quality rail steel according norm EN ISO 9002 and requires manufacturers to offer the latest proven technology.

The principal of the acceptance criteria is based on measured hardness values and the tensile test values are only form part of the qualifying tests.

The new properties of steels for railway rails on qualifying tests are: fracture toughness, fatigue crack growth rate, fatigue test, residual stress in rail foot etc.

More stringent operating requirements and higher speeds call for significant quality improvements. This has resulted in elaboration of the new European standard which mainly introduces new testing methods to be implemented in order to achieve greater safety in railway traffic.

Acknowledgement

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ERGONOMIC ANALYSIS IN PURPOSE OF WORK PLACE ENVIRONMENT/ MICROENVIRONMENT DESIGN

M. Car

Abstract

Research of works requests coordinating for three basic components in system "man- work place-environment/ microenvironment". Some of more important environmental/ microenvironmental parameters in practice are: temperature, air relative humidity, air stream-line speed, light, noise, vibration, etc. Environmental/ microenvironmental analysis and projecting of giving real/ work place request performing for proposal ergonomic research methodology, using of recommendations and standards as well as additional laboratory or simulating researches.

Keywords: ergonomics, system "man- work place- environment", microenvironment.

1. Introduction

Problems of work have been solved by one of five ergonomic familiar kinds (conceptive, systemic, corrective, software and hardware ones), [4]. Between more familiar conceptive level approaches, in this paper is exhibited scientific approach of ergonomic research methodology for real/ work situation on basis four basic models: open loop, closed loop, system and structure.

Combustion of food in a human body produces energy needed for muscles work, but limitations of system there are: emission mechanism of producing heat to environment/ microenvironment, maintenance of constant body temperature and maintenance of balance between heat losses and temperature and heat increasing. Every bigger strength causes increasing of oxygen consumption, energy consumption, etc. and decreasing of work ability, work efficiency, etc. and its combined functioning, too, [3].

Work conditions environment/ microenvironment are divided in groups on basis of different criterias, but it contains a series of affecting parameters like: energy consumption, air temperature in shade, air moving speed and the others, [5].

Because of a great information quantity, caused by ergonomic multidisciplinarity and interdisciplinarity, in this paper is exhibited only smaller part of methodology and some parts of it.

2. Research Methodology in Ergonomics

Between more familiar approaches, scientific approach of research ergonomic methodology for real/ work situation is selected according to four basic models: open loop, closed loop, system and structure, [9].

Open loop model or laboratory experience without testing in practice: it is established by operator's efficiency and tiredness, work duration, performing speed and work operator's choice.

Closed loop model or dialectics between real/ work situation and laboratory: procedure contains phases of collecting data and experimental model design for real/ work situation, "simulating" of such situation by model in laboratory beside measuring of results and testing for model in real/ work situation. Real/ work situation doesn't contain the whole complexity of conditions and parameters. System man- machine model has a limitation: diminishing of harmful problem solving; there exist borders of too much model expansion**;** basis is functioning of man-machine relation, but not the system men- machines; numerous relations of man- technical devices offer division in subsystems; relations between subsystems have to contain some requesting features; concrete directions for application of ergonomics in firm are desirable.

Ergonomic activity model in the middle of technical, economical and social structures: it requests a setting of ergonomics between cited structures, where idea of structure contains two phases of approximation: the first, expressed by transformation system beside embracing properties of totality, transformation and auto regulation and the second in which structure has to stimulate some formulations in mind.

Review of available conceptions and real/ work situation model choice gives universal procedure with five phases: estimating of technical, economical and social structure; analysis of requests; work analysis on the widest sense; suggestion and debate about model; proposing of solution for set problems. The development of information technology ensures model design by supporting of computer, too, [1].

3. Affecting on environmental/microenvironmental conditions and parameters

3.1 Introduction into Classification of affecting envirommental/microenvironmental Conditions and Parameters

Phenomenon of exhibiting operators, which are professionally connected to occupational exposure, it's claimed when contact exists between singles and potentially harmful work conditions, [2]. Environmental/ microenvironmental factors can be from different origins, but this fact is seamed in one exhibited classification of harmful impact**:** chemical causing (fluids, smokes, dusts, fog, evaporates or various gases, etc.); biological causing (insects, worms, bacteries, viruses, ietc); ionizating or nonionizating radiation, noise, vibrations and extreme temperatures or pressures; psychological factors as cause of stress, by example special body position in work, monotony, motion repetition, care, tiredness, etc..

International Labour Organization **ILO** has selected following factors and polluters of environment/ microenvironment: gases and smokes as well as evaporates; dust in atmosphere; ionizating and nonionizating radiation; ; temperature stability, stability of humidity, good lights and reflection as well as industrial garbage (fixed, fluid, gas and biological).

One of more backgrounds for cumulated data of parameters and environmental/ microenvironmental values, classification of sense/ sensors and its stimulators on basis of physical character, intensity and possibilities of identification in environment/ microenvironment, published in [2] on basis (H.Dreyfuss, 1963.) and modified as well as showed in table 1.

3.2 Some features of relations for man physiology- environment/ microenvironment

From view of physics, affecting of environmental/microenvironmental conditions is described by simple hypothesis: human body submissions by elementary law of heat exchange. Metabolisation/ adapted food represents source provision of energy, where mechanical energy is produced on basis of food components and cumulated chemical energy in it by acting of man muscles. For work it is available maximum of 50% such producing energy and 100% of producing energy cannot be transferred in mechanical work. Man absorbs or emits heat by convicting or emitting and evaporating of sweat.

From view of biology, balance of human temperature can be reached by series of regulators divided in the following four defending lines: quasi-constant temperature; mechanisms for nervous and endocrine auto regulation; changing of body behavior; affecting of intelligence and ratio, [7]. Balance of man body heat can be expressed by formula, in [3]. on Gagge basis:

$$M \pm S - E \pm R \pm C = 0 \qquad (1).$$

Experts for nourishment established responding theoretical parameters values in purpose of determining energy balance for man's body, [3]: maximal values of man's energy accepted from food in rate about 4800 kcal/ man,day; average work energy consumption about 1700 kcal/ man,day (phenomenon of basal metabolism!); value of transferred energy about 600 kcal/ man, day, consumed in man's free time for washing, clothing, etc..; value of consumption for living every day, excluding work in profession, in rate 1700+600= 2300 kcal/ man,day; value calculating from 4800- 2300= 2500 kcal/ man,day; on basis energy rate accepted from food of 4300 kcal/ man,day, finally energy value of 4300- 2300= 2000 kcal/ man,day or about 4 kcal/ man,min, rate which is established normal for man in acting of hard job. Women/ workers significantly differentiate in work efficiency because normal border of daily energy consumption has maximum rate 1600 kcal/ man,day, respectively about 3 kcal/ man,min, where the hardest work aren't typical industrial jobs, but "typically women employments" (wash women, cleaning women, housemaids, etc.) and significantly increased quantity of home works in its "free" time.

Table 1. Classification of Sense/Sensors and its stimulators in environment/ microenvironment

Sense/ Sensors	Sensory organ	Level of stimulating stimulator		Stimulation and stimulants frequency		Possibility of frequency changes differations	
		the smallest	the biggest	minimal.	maxim.	relativ.	apsolut.
sight	eyes	2.2-5.7x 10^{-3} J (Ws)	10^{9} of starting intensity	specific electromagn. waves			
				300 m	50 interrupts /s at med. light intensity	128 shades at optimal. intensity	12-13 shades of colour
				one interrupt	50 interrupts /s at medium light intensity	375 types of interrrup. at 1-45 interrup./s and med. light intensity	5-6 types of interrupts
hearing	ears	1x10^{-2} J/cm^2 (Ws/cm^2)	10^{14} of starting intensity	specific changes of air movement frequency			
				1 Hz	10000 Hz with high intensity	1800 diff. tones between 20 and 20000 Hz and 60 db of loudness	4-5 different tones
tone interrupts				one interrupt	2000 interrupts /s with med. sound intensity	460 types of interrupts at 1-45 interrupt./ s and medium intensity	unknown
mechanical vibrations		0.00025 mm average amplitude on finger	40 db above starting intensity	amplitude and pressure frequency changes			
				1 Hz	10000 Hz with high intensity	180 different frequency between 1-320Hz	unknown
touch (pressure)	skin	0.026x 10^{-2} J (Ws)	no data	surface skin deformations			
scent	nose	2x10^{-7} mg/m^3 of vanilin	no data	chemical substances			

taste	mouth and tongue	tx10^{-7} of kinin sulphat coloid solution	no data	chemical substances		
heat	skin and subdermal tissue	0.00015 gcal/cm^3 expositi-on 3 sek/200 cm^2 of skin	0.218 gcal/cm^3 expositi-on 3 sek/200 cm^2 of skin	specific wave types		
state and movement	ends of muscular nerves	0.2-0.7 degrees at 10 degrees/ min	no data	muscular tenseness and contractions		
cornered acceleration		0.12 degrees/ sec^2	positive gravitat. at 5-8g in duration of more than 1 s negativ gravitati-on 3-4 g			
linear acceleration		0.08 g for deccele-ration	same limitation .as for corner acc. when force works vertically on body`s height			
pain	unknown, but it is taken as these are nerve endings			strong pressure, heat, cold, strikes and chemical substances		
rotation and fall	semicircular ear channel					

3.3 Some features of relations for sense/ sensors- environment/ microenvironment, [7]

In purpose of more successful work, worker is forced to control performing work/ operation on basis information from work environment/ microenvironment. Every sensoring mechanism, by that, is in environmental/ microenvironmental conception two interpersonally connected problems: under which conditions sensoric mechanism functions the best, information canal, under which conditions sensoric mechanism stays source of tension.

Appropriate sensors, for instance sensors of taste and smell, very rarely are used in work duration. For job conception the most important are three sensors: sensors of sight/ eye , sensors of hearing/ ear and sensors of movement/kinesthetic system.

Sensors of sight/ eye is the most exactly represented like sensor with double mechanism of functioning, simultaneously is detector of moving and changing, which manages eye motions through brain, but it realizes a comparison of ray of lights of clear sight projector, too. Residual part of retina serves to register motions which are acting in peripheral zone of sight field, giving useful data for management of eye motions. Analysis and pictures fusion of eye retina in space and time, happens in part of the brain, creating in brain three-dimensional, or 3D, "optic picture" of given work place and environment/ microenvironment.

As the sight is main man`s sensor, analyzing and conception of environmental/ microenvironmental lightning represents special importance. There is dualism of measuring units, physical one for physical definition and the one for measuring of luminiferous phenomena or photometry, expressed in only four main parameters: strength of light, lightning flux/ flow, lightness and luminous impact and color temperature.

Project of total luminosity would be to take into consideration increasing of luminosity depending on dimension, contrast, time availability, moving in work, blindedness, entering angle, color and about relationship of natural and artificial light (fototropic effect). There are published many norms with same or unlike values for various works or various work conditions, but that ones are gratuitous and there aren't scientifically approved and represent "recommendation" with permanent tendency of increasing. How it doesn't exist neither one precise or exact norm in area of luminosity, it's using a principle by whome is better to sin by using more intensive than weaker light (beside avoidance of blindedness). Colour has to take into consideration three elements: tone colour/ tonality, density or degree of colour saturation and fleshing colour or luminosity. Colour serves, mainly, for improving of impression about subject in a total environment/ microenvironment, but it can be used like codes for colour on information and signalization tables and on cables and pipelines, as stimulator to reach much better contrast of machine part which has to expressively attract a worker.

Sensor of hearings/ ear by special sensor loop registrates noise like special aspect of vibrations. From view of worker, at first, vibration detection depends on body motion which is detected by vestibulary device, or by inner ear device, expressed in aspect of cornered acceleration, line acceleration and the others.

Over 1 Hz, or in frequency area 1 to 500 Hz, moving is observed more like vibration than like moving. When body is in peace, vibration detection of low frequency depending on sensor of contact. To 20 Hz vibrations are observed as clear and successive pressures, but at 20 Hz progressively occurs sense of vibration, which is maintains to 250 Hz. Auditory device functions in area from 20 to 20 000 Hz (0,02 do 20 kHz), where upper border can be reduced at older persons to 12 000 Hz (12 kHz).

Analyzing of this phenomenas is more harder because of appearance that tone is simultaneously surogat for describing of physical and sense changing. Because of previous fact, tone measuring justifiably belongs into physician`s work, which is used to measure unit of tone intensity of one decibel dB, and psychologist, which registers tone intensity, expressed in measure unit one fon, whose scale is identified with scale of decibels only for tones with frequency of 1000 Hz (1 kHz). Subjectively, sensitively, phenomena isn't expressed lineary (tone of 40 fons is not observed as two times louder than 20 fons). Level for tone value of 1 fon is 40 dB, or analogous, previous cited 40 fons is for 1000 Hz (1 kHz).

Beside of much lower tone level it can become indirect nuisance, at which the noise disturbs every communication of the worker, and that's why it exists big danger of injuries and drop of worker’s moral. It's hard to account all harmful noise consequences, because there are varying, depending on machine in shop, as well as on the worker.

For successful battle against noise, it’s needed to solve a problem on the source of its start-up, [6; 8]. There exist various types of performing personal resources for noise prevention, for instance by changing of mechanism, isolating of the worker by withdrawing him from tone source or setting of protection barrier between worker and tone source. In some countries, employee is legally responsible for damage of hearing sensors of its own workers.

Part of realizing research is resulted by establishing of principles, recommendations or, even more, standards, [8].

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PREPARATION OF CROATIAN RAILWAYS FOR INTEROPERABILITY AND MARKETING WITH A CLOSE LOOK AT THE TRANSPORT SAFETY

P. Čubelić and D. Magličić

Abstract

In this work, it is shown how Croatian railways are preparing for a transformation from a big and a slow company into a modern and profitable company, which will not need financial help from the state's budget. In the introduction are described the advantages of the railway compared to its the biggest competitor – road transportation, and how countries of European Community are more turning to railway transportation because of its advantages. The second part shows the railway stabile plants, i.e. the state in which they are now and which things are been taken considering a long term plans. In the third part are shown mobile railway capacities, a trend of reducing of their inventory, keeping requests for extra repairs, and what Croatian railways are doing and planning to do in order to modernise the rolling stock of the railway vehicles. In the fourth part, it is given a close look at extraordinary events as one of the important markers of the safety of the railway traffic for period 1995 – 2003 with a scope to show the nature of the most common causes of the extraordinary events. Finally, in the fifth part is shown what Croatian railways, except the modernisation of stabile and mobile capacities, are doing to prepare the company for a market game VS road transporters and foreign railways operators, which will be able to take the part in the railway transport equally, after the putting the Law about Croatian railways in force[1].

1. Introduction

According to the big costs of the fuel and a small participation of beginning - ending costs, the road transport is more economical for a shorter distances (less than 150 km), and the railway is more economical for a longer distances (from 150 to 450 km). For distances, over 450 km the railway has bigger costs than a river transport, and further smaller than the road transport[1].

Until now, the development of the railway depended of the state which was its owner, and the consequences of that were different technical solutions, different technology and different regulations. By that, the interoperability was very limited, and for a purchase of the almost all spare parts the railway was mostly leaned on domestic industry, and according to this the competition was restricted and the state had to take part in financing that kind of products. The solution for this situation was a directive about the interoperability of the high-speed lines, where are introduced European norms for technical level of the line equipment and a complete opening of the market.

The interoperability means the coordination of the differences in the railway traffic according to law (coordination of the regulations), technical and operative field of performing[2]. According to evaluation of the railways, the biggest obstacle to the interoperability make the state's crossings and the systems of electrical pulling, signal and telecommunication systems. The development of integrated informatics' systems should contribute a lot to the interoperability.

2. Infrastructure

The infrastructural costs are the main part of the total costs in the railway transport. Because of that, the opinion of EU is that those costs are too high, and that they are the main reason of the loss in the railway traffic. In order to apply the experiences of European railways, Croatian railways changed its organisation to separate the costs of the infrastructure from the costs of the railway transportation. Because of that was brought a Law about Croatian railways, which foresees "a set-off against usage of railway stabile plants" from the transport users who will be equal in the usage of the infrastructure.

According to the investment plan in the next period the activities will be pointed to the maintenance of the main line net through the modernisation and capital remounts of the lines and the line buildings, the reconstruction of the stations, the building of the second track on certain lines, and the construction of the new lines[3].

2.1 Croatian railway's lines

After a long time, only in 2003. started capital remounts of certain parts, even the moving of the route on certain critical parts including the construction of new bridges and tunnels.

31st December 2003, the length of railway lines is 1.056,583 km and in usage is 851,605 km. The most of station tracks have non-standard types of rails and track equipment, and that makes more difficult the maintenance and their replacement. The sleepers are worn out or in a bad condition. Because of that, the level of the safety of the traffic is ensured by the restricted speed of the trains.

31st December 2003, total number of switches and cross points is 4.670. During 2003, both on the switches and on the cross points started the investments in the technical improvements to reach the necessary safety of the traffic during higher speeds through the stations.

According to the plans of the development of the Croatian railways until 2010 is the enlargement of the number of the kilometres of the lines, especially in the parts of Lika, where is planned the usage of the electricity instead of the diesel fuel.

2.2 Croatian railway's buildings along the lines

The Croatian railway lines are built in heterogeneous relief that demanded the usage of different ways of constructing and the construction of different line's buildings. On the Croatian railway lines there are 524 bridges in total length of 15,2 km, 109 tunnels in total length of 32,4 km, 1.610 rail-road crossings, 28 wagon's balances, station buildings, eaves etc. which are older than 100 years in average[4]. At certain number of the railroad crossings, which are ensured by signal (light) signs, the triangle of the visibility is not ensured and because of that was necessary to slow down the train speed. On those critic points is tried to ensure the necessary train speed, together with a shorter keeping of road vehicles, by built-in some sensors. At this moment the condition of line buildings is acceptable, they satisfy the necessary safety conditions of the train traffic, while the state of the working spaces (offices) is not acceptable.

3. Railway's vehicles

The success of the reconstruction of the Croatian railways, the improvement of its interoperability, as well as the competitive ability at the market, depend a lot of the modernisation of the rolling stock and the effects which are brought by that. The consequences of the modernisation of the rolling stock are: smaller costs of the maintenance, the improvement of the quality of the services, the comfort improvement, the improvement of the traffic ability and at the top of all the improvement of the reliability and traffic safety.

Between 1980 and 1990, Croatian railways purchased and put into traffic total of 3276 railroad vehicles. At that point, capacities of the railroad vehicles were adequate to the range of the transport that was performed by ŽTP Zagreb, and their usage structure were satisfying[5]. After the war in the Republic of Croatia the production, as well as the market, was decreased and changed. Because of that, after the war actions stopped and according to their financial capability, Croatian railways tried to adjust their rolling stock, in order to be better competitors to other transporters, and to be ready for bigger market needs and demands.

3.1 Pulling vehicles

The modernisation and the reconstruction of Croatian railways, speaking of pulling vehicles is going towards the reducing of the existing inventory park, adjusting it to nowadays need as well as to the market demands. Because of that, the number of diesel and electric locomotives, DMV and EMV of older structure, is reduced (which is shown in the table), making the space for new pulling equipment.

The table shows inventory park of pulling vehicles on 31st December of the down listed years. The dates for previous years are inaccessible. The number refers to Diesel locomotives, DMV, electrolocomotives and EMV.

Table 1. The state of pulling vehicles [4]

	1999	2000	2001	2002	2003
Inv. park	519	480	397	401	393
Akt. I. P	382	322	332	322	320
Nonakt. I. P.	137	158	65	79	73

The latest move that Croatian railways have done is the purchasing of eight trains with the leaning technique from the Bombardier company (24 passenger wagons) for the line Zagreb – Split, which according to the division of pulling vehicles belongs to diesel motor trains (DMV). After a complete remount and the electrification of the line, it is planned to purchase and to put into the traffic new electro motor trains with leaning technique, while those that were purchased before would be put into other lines in Croatia. In that way, according to the

3.2 Pulled vehicles

Modernisation and reconstruction of the Croatian railways, regarding pulling and pulled vehicles, is going towards reduction of the existing inventory park of passenger and cargo wagons, adjusting it to nowadays needs of transportation, as well as to the market demands. In order to content the high market standards permanently, the inventory park of passenger and cargo wagons, which belong to the older structure, is reduced and some wagons are reconstructed and adjusted to nowadays need.

3.2.1 Passenger wagons

The reducement of the inventory park of the passenger wagons, as well as the number of the demands for extra repairs is shown in down shown table. Total number of the wagons is valid for 31st December of down listed years. There is also the number of the wagons, which remained in the other states of Ex-Yugoslavia, as well as the number of the demands for extra repairs that are valid for the whole year.

Table 2. The state of the passenger wagons [4]

	1995	1996	1997	1998	1999	2000	2001	2002	2003
Totally wagons	802	678	632	583	578	578	555	534	497
Inaccessible wagons	44	44	44	44	39	38	38	38	38
Extra repairs	3.535	4.106	4.116	2.878	3.130	2.451	2.790	3.128	2.693

Certain numbers of the existing passenger wagons, which are not used with the trains with leaning technique, are reconstructed, modernised and adjusted to nowadays needs of the passengers, satisfying the existing norms of international traffic. Therefore, TŽV "Gredelj" has projected until now, according to the order of Croatian railways, and built the prototype of air-conditioned passenger wagon of Bt seria. Certain number of these wagons has been adapted for transport people in wheel chairs and in 2003 finished the production of 12 passenger wagons of at seria. In addition, they made reconstructions on “Mimara” wagon and sleeping wagon of WL seria. It is ordered another 26 passenger wagons of B1 seria from the same supplier.

3.2.2 Freight wagons

Reducing of freight wagons inventory park and number of extra repairs are shown in the table below. Total number of wagons is valid for day of 31st December of each listed year, number of inaccessible wagons witch stayed in other Republics of former Yugoslavia and the number of demands for extra repairs, which are valid for completely listed year.

Table 3. The state of the freight wagons [4]

	1995	1996	1997	1998	1999	2000	2001	2002	2003
Totally wagons	13.310	11.736	11.447	10.346	10.270	10.111	9458	8918	7920
Inaccessible wagons	5.018	5.018	5.018	5.018	1993	1678	1604	1603	1264
Extra repairs	14228	15605	14457	15295	13574	13584	12467	13653	14800

Certain number of the freight wagons, are reconstructed to satisfy all the existing norms of international traffic. Factory “ĐĐ Specijalna vozila d.d.” take a main part in yobs of reconstruction and building new types (seria 697) of the freight wagons which have been produced mainly in foreign factories[6].

4. A look at the traffic safety

Uniform security level in railway traffic is one of the important elements of the interoperability and market business, which is especially expressed in comparing to the demands set down in road traffic. According to this, it can be expected the new technical solutions with bigger usage of modern telecommunication solutions.

In the valuation of the traffic safety, important factor on Croatian railways are extraordinary events. In this work (see tables below) is especially put attention on extraordinary events happened by railway’s omits and they are caused by technical nature.

Table 4. A list of extraordinary events according to their cause [4]

EXTRAORDINARY EVENTS	1995	1996	1997	1998	1999	2000	2001	2002	2003
Disasters	125	95	94	115	95	113	107	103	87
Accidents	329	403	332	330	320	328	310	279	319
Difficulties	1449	1655	1591	1724	1731	1536	1674	1761	1947
TOTAL	1903	2153	2017	2169	2146	1977	2091	2143	2353
Railway’s omit	1595 83,82%	1861 86,44%	1750 86,76%	1862 85,84%	1840 85,74%	1683 85,13%	1749 83,64%	1810 84,46%	1933 82,15%
Elementary tempests	57 3,00%	66 3,06%	47 2,33%	93 4,29%	89 4,15%	30 1,52%	108 5,16%	110 5,13%	178 7,57%
Passengers and third parties	251 13,18%	226 10,50%	220 10.91%	214 9,87%	217 10,11%	264 13,35%	234 11,20%	223 10,41%	242 10,28%

EXTRAORDINARY EVENTS	1995	1996	1997	1998	1999	2000	2001	2002	2003
Worker's omits	202 12,66%	237 12,74%	176 10,06%	198 10,63%	161 8,75%	153 9,09%	129 7,38%	108 5,97%	135 6,98%
Technical causes	1393 87,34%	1624 87,26%	1574 89,94%	1664 89,37%	1679 91,25%	1530 90,91%	1620 92,62%	1702 94,03%	1798 93,02%
Railway's omit	1595	1861	1750	1862	1840	1683	1749	1810	1933

EXTRAORDINARY EVENTS	1995	1996	1997	1998	1999	2000	2001	2002	2003
Pulling vehicles	1238 88,87%	1425 87,74%	1353 85,96%	1444 86,78%	1446 86,12%	1301 85,03%	1356 83,71%	1378 80,96%	1458 81,09%
Pulled vehicles	43 3,09%	63 3,88%	63 4,00%	74 4,45%	84 5,01%	53 3,46%	65 4,01%	70 4,11%	110 6,12%
Line plants	56 4,02%	82 5,05%	110 6,99%	74 4,45%	86 5,12%	104 6,80%	115 7,10%	148 8,70%	131 7,29%
SS and TK appliances	27 1,94%	23 1,42%	12 0,76%	36 2,16%	37 2,20%	45 2,94%	49 3,02%	62 3,64%	61 3,39%
Stab. plants for electrical pulling	29 2,08%	31 1,91%	36 2,29%	36 2,16%	26 1,55%	27 1,77%	35 2,16%	44 2,59%	38 2,11%
Technical causes	1393	1624	1574	1664	1679	1530	1620	1702	1798

In shown tables it is visible that total number of extraordinary events, of each year in considered period, over than 82% is caused by railway's omit and 87% of that number are caused by technical reasons, which are in permanent growth. In the last table are shown the types of technical causes and how big their part in total number of extraordinary events of technical nature is. It is obvious that all technical causes, except stabile plants for electrical pulling have tendency of growing, and among them with more than 80% are leading pulling vehicles.

5. Modernisation

With a scope of raising competitively and efficiency of Croatian railways and it's restructuration from 1993 started with setting apart of nonbasic activities into societies of restricted responsibility, which are 100% owned by Croatian railways. The next step of setting apart of nonbasic activities has been made first in 1998 and then in 2001. The main target of this setting apart is to enable nonbasic activities for independently giving services to the other societies.

Here is important to underline putting the new Law about Croatian railways, which will be in force from January 1st 2006. With the enforcement of that Law, railway carriers of passenger and freight traffic will have competitors on Croatian and European railway lines. In that way, Croatian railways are preparing for putting the law on the market and financial business where subventions of the State will be less expressed. In that document are given further directions of the restruction of the Croatian railways that are kept with directions of European community about development of railway traffic. Regarding to positive opinion (Avis) given from EU 20th April 2004 it is real to expect that Croatia will be accepted in EU, so application of that Law is very important for accommodation of Croatian railways to traffic processes which are already started in Europe.

The number of employees, regardless the age and personnel reconstruction, in the last few years until the last day of the shown year, is shown in the following table.

Table 5. A list of employees on Croatian railways [4]

Number of employees	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
HŽ matica	38.815	21.812	22.973	22.908	20.688	19.468	18.535	18.170	16.077	14.905
d.o.o., d.d.	0	3.139	3.189	3.066	3.582	3.400	3.120	3.041	5.272	6.835
TOTALY:	38.815	24.951	26.162	25.974	24.270	22.868	21.655	21.211	21.349	21.740

In the shown table it is visible that the number of employees in the main company of Croatian railways is lowering, while the number of employees in the separate societies, which are 100% owned by Croatian railways, is rising. In that way, which is aknowledged by the World and European bank, the total number of employees is not lowering. The main activity is, only, reconstructed, and it separates from the non-primary activity, which surpasses into a separate society.

In order to act with profit in the intense competitive surrounding, by offering transport services in the country and out of it, the management of the Croatian railways 7th February 2001 brought a Decision about putting into force projects of quality systems on Croatian railways according to the norm ISO 9001:2000. The quality system will be reflected on the increasement of the traffic safety. This project should be finished until the end of 2004 by the audit of the authorized company, and certified with a certificate of quality system on the Croatian railways.

6. Conclusion

Analysing the dates listed in the work it can be concluded that Croatian railways decided on very serious, responsible and wide task of the modernisation and reconstruction of the railway's stabile and mobile capacities. To be honest, for realisation of the predicted task successfully, railways need a certain financial funds, which will be ensured by Croatian Government. In that, way the process of transformation will be ended and Croatian railways will pass from a slow into a modern and profitable firm with a good base for a market business.

Analysing the dates listed in the tables in this work, we conclude that the number of extraordinary events in the period of 1995 to 2003 is increasing, in spite of the reduction of the railway vehicles inventory park. The extraordinary events are not selected according to the consequences, but according to their causes. Comparing the reduction of number of the railway vehicles with the increasment of the extraordinary events caused by them, it can be concluded that railway inventory park needs accurate modernisation, because a remount of the line itself cannot guarantee reliable and safe traffic.

According to all this, it can be concluded that Croatian railways with a help of the Republic of Croatia are making huge efforts to change into the interoperability and market business and to reduce as much as possible the number of extraordinary events, which are caused by technical reasons. The fact is that the adjustment to market demands is behind the adjustment done by European Community, but this process will never be finished, and it cannot be finished completely.

After all, it is important to point out that according to the current plans until the end of 2007 the Croatian railways will be ready for a complete market business and interoperability with the countries of European Community.

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HOLISTIC MANAGEMENT OF THE MANUFCTURING MODERNISATION – THE GERMAN CASE

C. Dreher and P. Jung Erceg

Abstract

To meet the requirements of the turbulent environment the continuous preoccupation with the analysis and exploitation of improving performance potentials has become one of the most important production management tasks. To fulfill this task the companies should be able to identify performance deficits and improving potentials crucial for success and to point out the carefully tuned system of modernization measures which can positively influence the selected performance factors.

The first part of this paper presents a systematic overview of common modernization measures illustrating their possible positive but also negative impacts on different factors of company performance, which can be used in the practice as a search pattern for selecting an appropriate system of modernization measures for improving of targeted performance factors. Based on the empirical survey covering over 1,600 industry companies the second part of the paper examines the planning practice of manufacturing modernization in Germany. Given the behavior pattern of the surveyed companies the modernization in manufacturing is neither proactive nor driven by strategic improving of the performance potentials. The results show that technological organizational improvements as well as improvements related to human resources in manufacturing remain to be no more than reactive measures triggered off by new products, changing markets, compulsive cost optimization or changing quality demands.

Keywords: Modernization measures, Performance factors, Planning of manufacturing modernization

1. Introduction

The industry in Germany is facing a phase of aggravation in market and production conditions making changes of directions less and less predictable. To be competitive in such a turbulent environment production is confronted with a great variety of demands. Production has to be able to adapt, react and innovate but at the same time it has to cope with the resulting complexity and has to maintain its stability. To prepare businesses for these demands a continual preoccupation with the analysis of improving performance potentials as well as the deduction of measures and instruments for its successful development has become one of the most important production management tasks. A series of production concepts e.g. „Lean Production", „Total Quality Management", Business Reengineering" etc. which are described in academic specialized literature provides businesses with a collection of instruments to which they can refer and which may help in a turbulent environment. The operationalisation of new production concepts de facto is carried out on the level of measures by means of a selection of possible combinations including carefully tuned measures from the areas Technology, Organization and Personnel (TOP) which collaborate to positively influence one or more performance factors critical for success. For this the transparency of cause and effect, the linkage between improvements measures in all three-action areas (TOP) and substantial performance indicators for production modernization are essential.

By means of a systematic overview as described above this paper aims to illustrate which positive but also negative impacts the modernization measures in particular can have on the crucial performance indicators of the company. Afterwards, based on the empirical results from the German industry the focal points and the systematic of strategic production modernization in practice will be examined.

2. Mapping modernization measures for manufacturing

One necessary step for enabling structured and strategic planning is an overview on instruments and their performance impact. The improvement measures have been structured along the activity fields, application of new technologies, restructuring of the whole value added chain and human resource management. For an evaluation of the impact different modernization measures have in these fields five performance factors have to be differentiated: *productivity/production costs, through-put-times, innovation competence, product and production flexibility*. Whereas company related productivity, for instance measured as value added per employee or through-put-time as an ample performance indicator is acknowledged fact innovation ability, product and production flexibility and product quality will be shortly illustrated in the following.

2.1 Modernization field „technology“

Modernization measures directed towards technological improvement including also the technology equipment applied to the logistics and information technology generally besides manufacturing technology can be collected and grouped according to the following search pattern (Figure 1): Stability, automation, increase in flexibility or performance.

2.1.1 Stability

An increase in technology reliance is feasible by improvement in the utilization time of the machinery; i.e. by a reduction of breakdowns due to organizational failures, technical failures and malfunctions caused by failures of the personnel. Technologies increasing process stability are for instance, the procurement of robust, almost failure-free production systems being easy to handle for the employees. Whereas above all the machine time off and the number of scrap can be thereby reduced the resulting productivity varies from case to case. Also information technological concepts such as supply chain management systems or an integrated production planning and control system (PPC) is contributing to the stability of the production process. Supply Chain Management means the design, integration, planning and control of all the elements of continuous value added chains in partnership – ranging from the procurement of raw materials at the suppliers to the delivery at the end customer. The holistic consideration and information technological support of the logistics chain, beyond its individual participants, i.e. a PPC spanning the whole company and beyond along the value added chain is enabling the coordination of the flow of goods in the whole network.

PPC by means of a reduction of stock and a decrease in capital employed can lead to a faster order processing – i.e. shorter through-put-times leading to an increase in adherence to agreed delivery times without losses in flexibility. (Vahrenkamp 1998, S.28; Dreher 1997, S.191 ff). Support of the production planning and control by information technology can generally lead to an increase in process quality.

2.1.2 Automation

Today process automation in the sense of an adoption of process control and process regulation tasks by automats is applicable in many functions of a company. There are an increasing number of efforts of designing and directing the whole order process ranging from customer order management to the technological-economical-operational production planning including even the order and regulation of goods. Related to this is the whole stream of materials by a system of linked control circuits.

Among the measures being applied in order to increase the degree of automation in companies for instance work piece handling systems and industrial robots are counted. Whereas work piece handling systems do only execute a specific sub-function, such as machines for inlays in assembly and packing industrial robots are universally applicable moving automats with several axes. They are used for the execution of monotone, steadily repeated tasks and in areas which present too much strain for human beings. Thanks to their ability to work under pressure and very swiftly productivity and product quality can be increased and through-put-times can be decreased (Dreher 1997, S. 160; Weck 1996, 493 ff). Although the advantages of industrial robots compared to a more rigid form of automation is its easy ability to adapt, however, they are not so universally applicable as human workforce. Moreover, a necessary reprogramming for executing a new function is rather time consuming. This leads to the application of industrial robots having lower production flexibility for small batch production compared to manual activities.

Modernisation potentials

Moderni-sation fields		Examples of concrete measures	Production costs	Through-put-time	Innovation competence	Product/ manu-facturing flexibility	Product/ process quality
Technologies	Stability	> Robust production systems > PPS/ERP-systems > Process simulation > Supply chain management systems > Geometric data transmission (CAD/CAM) > etc.	+ -	(+)			+
	Automation	> Industrial robots and automated handling systems > Pick-and-place machines > Visual data processing (e.g. quality control, process management) > Automated assembly stations > Automated material flow systems > etc.	+	(+)		-	+
	Flexibility	> Flexible CNC processing centres > Knowledge management via intranet > Rapid Prototyping/Tooling/Manufacturing > Redundant manufacturing capacities > etc.	+ -	+ -		+	(+)
	Performance optimisation	> High-speed machining > Hard machining > Dry processing > Machine tools with linear drives > Computer integrated manufacturing (CIM) > Equipment to manufacture new materials (light alloys, composite materials, etc.) > etc.	+	(+)		-	+ -

+	Improvement is the focus of the measure.
(+)	Improvement as a side effect of the measure is possible
+ -	Ambivalent impact: both improvement and aggraration are possible
-	Negative side effect is possible and/or probable.

Figure 1. Modernization field „technology“

2.1.3 Flexibility

The usage of flexible CNC processing centers belongs to the most frequent technological measures for an increase in production flexibility. CNC processing centers consist of several processing and manufacturing devices integrated into equipment. By means of a control system they are interlinked so that an automated sequence of different processing tasks can be realized. (Dreher 1997, S.149 ff, Weck 1996, S. 182 ff). Its application leads to a flexibility in production as regards the product as well as the process variants. This may have positive but also negative effects on the productivity of the manufacturing processes. These ambivalent consequences the productivity of manufacturing processes and through-put-times can also be characteristically for further listed measures for the increase of flexibility. (Figure 1).

2.1.4 Increase in efficiency

Also the increase in efficiency of the used machinery and equipment belongs to the modernization of technology. Quantitative components of the efficiency measures indicate the quantitative output per time unit, whereas the qualitative component refers to the different horizontal ranges of performance, vertical range and quality. The implications of the measures which are applicable to the increase in efficiency in technology (figure 1) on the company performance are illustrated with the example of the high speed machining (HS-Machining). With its application the cutting speed generally can be increased by the factor 5 to 10. This enables the processing of a significantly higher number of pieces compared to the use of conventional/traditional technologies. As a matter of course the higher output frequency has a positive impact on productivity. However, ambivalent implications do arise with the application of high velocity processing (HS-Machining) as regards the achieved product and process quality. Although with high speed machining an excellent surface quality can be achieved (cf. Krause/Uhlmann 1998) which is to result in a higher quality of the processed product pieces. It can lead to a higher abrasion of machine tools and a more frequent breakdown, which may again result in an increase in produced scrap.

The remarks so far clearly show that selective investment in technological equipment can have a positive impact on all the performance indicators of a company. However, it is worth mentioning that a technology measure can have positive as well as negative impact on the different parameters and therefore they have to be carefully balanced against each other from the start.

2.2 Modernization field „work force improvements“

Measures for improving the personnel management as well as the measures having a (direct) impact on qualitative and quantitative aspects of the production factor personnel offer a traditional field of activity for the optimization efforts of a company (figure 2).

2.2.1 Working structures

In companies increasingly work organizational measures as for instance the introduction of team work, the integration of indirect production tasks into the work spectrum of the machine operators or the creation of cross-departmental development teams are introduced simultaneously demanding and supporting a broader qualificational spectrum of the employees. With group work in production, one of the most discussed measures in Germany is the assignment of a task to a specified group of employees meant. The group is then autonomously preparing and executing the task with regard to the quality requirements or standards in the given cost and time frame. For the work group this implies besides predominantly autonomous organization and coordination of their tasks autonomous decision taking and problem solving. The more "indirect" work tasks such as set up, adjusting, quality control and maintenance ranging even to the dispositive process engineering and organisation into the activity spectrum of the groups (task integration) the more the advantages of this collective work form can be exploited in the company. The systematic consolidation of individual efficiency and experience potentials is increasing the problem solving competence and leads to a better organization and coordination. On the whole, synergy effects of a well functioning group work do secure a better balance between costs on the one hand and customer specific parameters such as quality and product flexibility on the other hand (for instance Senft/Kohlgrüber 1997).

2.2.2 Human resource development and leadership instruments

New work structures with changed tasks and responsibilities of the employees in the manufacturing process do demand additional qualifications and suitable leadership models. In order to meet the increased qualification needs the companies have several measures for increasing the competences of and beyond the professional areas. In addition to extension and intensification of training programmers also measures enhancing competence and motivating the employees as for instance job rotation or staff development talks are gaining importance. The disclosure of company rules and clarification of future job prospects (Becker 1994) do encourage the employees to intensify their commitment and do develop a work climate suitable for innovations. A number of further personnel management instruments such as management by objectives and key performance indicators etc. do have a motivating impact and do enable the employees using their professional options for the sake of the company's success.

Modernisation potentials							
Moderni-sation fields		Examples of concrete measures	Production costs	Through-put-time	Innovation competence	Product/ manu-facturing flexibility	Product/ process quality
work force	Working structures	> Team work > Integration of tasks > Cross departmental development teams > etc.	+ -		(+)	+	+
	Qualification	> Qualification programs > Individual consultation > Job rotation > etc.	+ -		+	+	+
	Leadership	> Management by objectives > Key indicators > Balanced Scorecard (BSC) > Target Costing > Activitiy based costing > Benchmarking > Account for annual working time for flexibilisation of working time > Incentive wages systems > Use of temporary employment > etc.	+	(+)		+	+

Figure 2. Modernization field „work force“

Measures taking into account fluctuations in order capacities thereby enabling flexible personnel assignment do play an important role in the daily business of the company. Against this background particularly these measures which enable an increased adaptation to the manifold demands of the market of lesser costs for instance flexibilisation of working time and employees size do gain attractiveness. On the one hand, for the company the flexibilisation of working time by a better exploitation of the manufacturing resources by means of flexible extensions of working time agreements and a reduction of overtime and personnel costs is linked to economic goals. On the other hand it increases the reaction capacity towards fluctuations in the number of orders and customer changes as regards the delivery times. By introducing leasing personnel companies even go a step further on their way towards flexibilisation of personnel according to actual needs and the order situation. Which flexibilisation and cost reduction potentials these measures do enhance depends in the end on the adjustment of what, integration costs and the accessible work quality of the leasing personnel.

On the whole it can be noted that by an investment in personnel and instruments securing employment almost all economic key figures can be improved, under the assumption that the measures are used targeted.

2.3 Modernization field „Shop-floor organization“

With the activity field organization the measures, which either lead to changes in structure, process design or the activity spectrum of the company, are subsumed (Figure 3).

2.3.1 Organizational structure

The customer or product related division of central departments, production segmentation or decentralization of functions ranks among the organizational measures, which have been dominating company re-organization processes within the last ten years.

Due to the consequent customer orientation the traditionally functional organization principle is substituted by the so-called divisional organization principle. This principle implies that the tasks which have to be fulfilled are no longer subsumed as in the job-shop organization but according to the object principle, i.e. divided into product groups, customer groups or according to geographical differentiations divided into specific divisions, branches or business fields. Due to the "shorter ways" resulting from the reduction of interfaces and the omission of transition times between the production activities and the preliminary and downstream indirect administrative tasks, on the one hand the whole process of order management is definitely shortened. On the other hand this geographical vicinity contributes to the reduction of scrap and production laid downs leading to lower scrap quotes. Finally the direct contact to the target markets does increase the innovation ability and on the whole the reaction ability of the company towards customers' demands (Lay 1997, p.48).

Contrary to the tayloristic organization principle according to which technologically equal machinery in machine shop do stand together, all the machinery belonging to the creation of a product (turning, milling, drilling, grinding etc.) are subsumed under the heading of "cellular layout" or "group-technology principle" (Dreher et al. 1995, S. 16;). This is a means of trying to link the cost and productivity advantages of flow production with the high flexibility of job-shop-manufacturing (Groth/Kammel, 1994, S. 106) thereby producing a higher number of variants in less time.

2.3.2 Process organization

Besides the minimization of through-put-times the increase in processing quality and the reduction of processing costs and partly the improvement of the innovation capacity of the company are in the focus of the organization of value added processes.

As a means of supporting the ability to carry out product development in the company, simultaneous engineering and temporary interdisciplinary product development in particular have been established. Simultaneous engineering is defined as the extensive parallelisation and coordination of all necessary development activities in different sections of a company and its environment in order to achieve an optimization of development time and costs with special regard to the demanded quality of the customers (cf. for instance Lay 1997 S. 49 ff.). Temporary product development teams may aid supporting simultaneous engineering. The consolidation of information from different business fields of the company guaranteed by the two measures mentioned above may help to increase the reaction ability towards constantly changing customer demands and frame conditions.

The biggest and most multifaceted palette of improvement measures in organization is dedicated to the securing of product quality and process quality. New instruments of quality control do care for high quality production and minimization of activities for quality control by means of preventing failure causes. Thanks to a well functioning employee suggestion system (continuous improvement process) besides saving in production costs and production time, above all an increase in the quality and innovation understanding/concept of the employees is feasible (Dreher et al. 1995; Groth/Kammel 1994).

In the course of the realization of new production concepts in order to design material flow in such a way as to optimize production, assembly, transport and storage (Groth/Kammel 1994 S.113), measures for a new organization of the material flow have been realized on the company level and beyond the company level. Kanban is increasingly proliferating as a means of reducing storage of material and semi-manufactured products. This instrument has a remarkable impact on minimizing storage and thereby decreasing capital lock-up. A side effect, which should not go unnoticed, is the elimination of possible counting errors (Dreher et al. 1995, S. 17; Lay 1997, S. 49).

Production synchronous procurement and just in time delivery as the attempt of extending the Kanban system on the level between companies presupposes that vendor parts and assembly groups are being produced according to the estimated demand and are being delivered with a view to fixed delivery dates and demand from the supplier to the producer. Besides the minimization of stock at the supplier as well as at the producer just in time delivery aims at a general reduction of the total put-through times. The reduced production flexibility which may result from production synchronous procurement can be prevented by a careful selection of parts and suppliers suited for just in time procurement (Dreher et al. 1995, S. 18).

Modernisation potentials							
Moderni-sation fields		Examples of concrete measures	Production costs	Through-put-time	Innovation competence	Product/ manu-facturing flexibility	Product/ process quality
Organisation	Organisation structure	> Customer- or product-in-line-oriented decentralisation of central departments > Fragmentation of production into customer or product related segments > Cellular Layout > Dismantling of hierarchical structures > Decentralisation of functions (regional) > etc.	+ -	+	(+)	+	
	Process organisation	> Process orientation > Kanban > One Piece Flow > Just-In-Time with delivery at the customer/ with external supply > Continuous Improvement Process (CIP) > Quality circle > Six Sigma > TQM, Certification, Quality Audit > Environmental Audit > Total Productive Maintenance (TPM) > Customer Relationship Management (CRM) > Simultaneous Engineering > etc.	+ -	+	(+)		+
	make or buy	> Concentration on key competences/ Outsourcing > Building up competences/ Insourcing	+ and -		- and +	- and +	+ -

Figure 3. Modernization field "shop-floor organization"

2.3.3 Make or buy decisions

The adjustment of the vertical range of procurement offers an answer to the question which goods and services are to be produced in at the location and which ones should be procured from suppliers. Outsourcing clearly defined production steps and other value added and indirect areas (for instance EDV activities, customer services, accounting but also R & D, construction, logistics) to other companies is increasingly gaining momentum. Besides focusing on the core competences of the company one of the main reasons for outsourcing is the potential decrease in production costs and the increase in productivity. Unfortunately the neglect of the interface problem between suppliers and service providers often leads to a constraint in production quality and flexibility which may even have a negative impact on the innovation ability of the company. The reverse process in which new or formerly outsourced processes are sourced back because of potential synergy effects is called insourcing.

3. Planning practice of modernization in German manufacturing

The potentials of innovations in manufacturing as mapped in section 2 can, however, they need not necessarily be exploited. With a view to international competition German companies have to clarify:

- to which focal points of innovations in manufacturing they have to assign high priority and
- how the planning of these modernization measures has to be carried out.

The 2001 survey Innovations in Manufacturing of the Fraunhofer ISI may help to answer this question. This survey examines the innovation behavior of companies of the manufacturing sector. The surveyed companies present a representative cross-section of German manufacturing industry including the chemical industry, rubbers and plastics and companies of the metal and electronics industry. 1630 companies of the 13335 addressed companies responded, e.g. a response rate of 12.2 % (Schirrmeister et al. 2003; Lay, Schirrmeister 2004).

3.1 Focal points of innovations in manufacturing

As regards the priorities companies assign to the different fields of innovations in manufacturing the survey shows the following results (cf. figure 4): Although the importance of technology, i.e. investment in machinery, equipment and information technology has increased, compared to figures of former surveys only at 35 per cent of the surveyed companies technological innovation ranks top. At 40 per cent of the surveyed companies organizational measures dominate. Only a quarter of the surveyed companies rank measures concerning human resources as paramount.

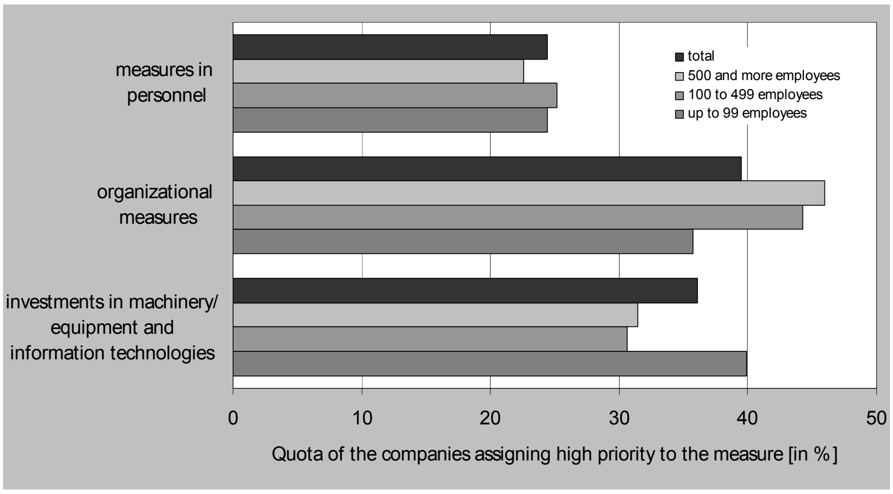

Figure 4. Focal points of innovations in manufacturing

3.2 Planning practice of manufacturing modernization

As regards the evaluation of practical experience of planning innovations in manufacturing questions on the applied resources, the involved company actors and topics and information sources of the companies are in the foreground. The personnel costs for improvements in manufacturing is ten times less the expenditure companies have for product development and research. On average the surveyed companies use one person per year for the strategic innovation planning in manufacturing.

In the planning process all the members of the executive board are in charge. This applies mainly to SMEs. Product planning as well as R&D is more active in bigger companies. Only in huge companies special staff divisions of the operating facilities are responsible for the (strategic) innovation planning. Given the resources mentioned above the integration of experts from other divisions/departments of the company and above all from manufacturing can only be of sporadic nature.

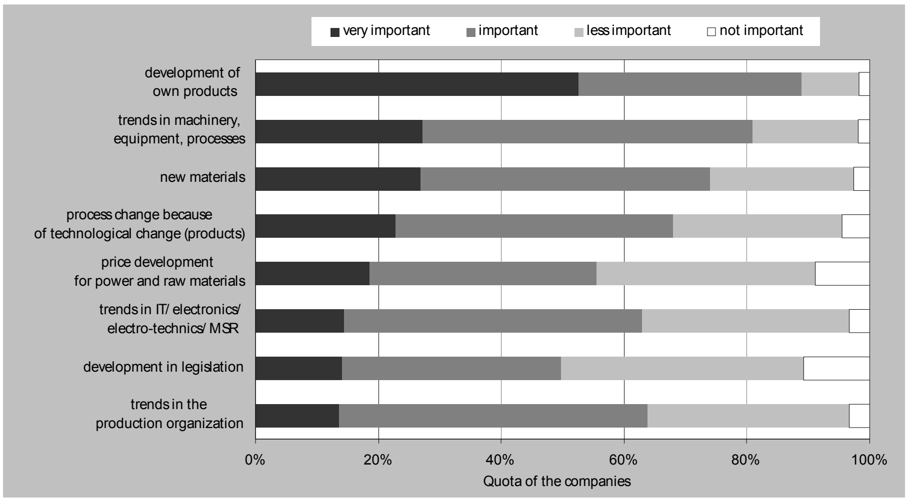

Figure 5. Important factors for production modernization

The (most) crucial aspect in the planning of manufacturing modernization is the market development of own products, i.e. fluctuations in sales figures and changes in batch sizes and variants. Technological change with own products is assigned a less important role. Developments in material are expected to cause more significant changes for manufacturing than new developments in information technology. Generally, companies do focus on market changes in products and incremental technological trends in machinery and equipment. The predominantly short term planning horizon is suitable for the evaluation of these focal aspects. Organizational measures, general opportunities of technological trends as well as the development of prices for energy and raw material do play a rather minor role.

Fairs are the most important information source. Companies do prefer direct information exchange with other companies or suppliers. It is worth mentioning that research institutes and universities do play a more important role than consultants or traditional written information sources.

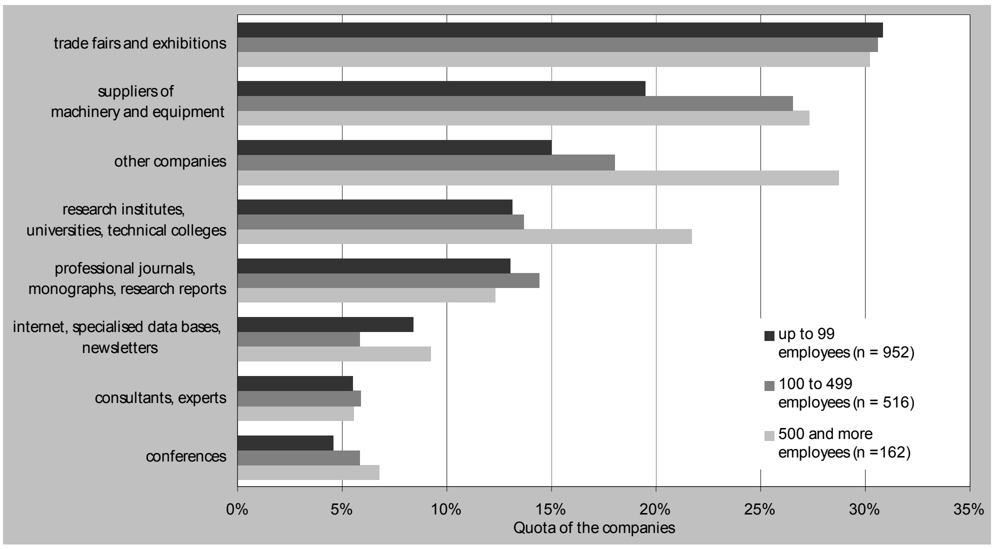

Figure 6. Important information sources for production modernization

4. Conclusion

Given this behavior pattern of the surveyed companies, modernization in manufacturing leading to technological, organizational improvements as well as improvements related to human resources in manufacturing remain to be no more than reactive measures triggered off by new products, changing markets, compulsive cost optimization or changing quality demands. This is somewhat sobering concerning the potentials of strategic behavior in manufacturing planning. Possible potentials and their systematic opening up are not as shown in the mapping of instruments and impacts used and opportunities for manufacturing in Germany are lost.

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INNOVATION MANAGEMENT IN SMALL AND MEDIUM -SIZED ENTERPRISES - THE CASE OF CROATIAN ECONOMY

Ž. Dulčić and D. Bakotić

Abstract

The number of small and medium-sized enterprises (SMEs) in Croatia 2003 was 58 000 companies. The share of small enterprises in total number of enterprises was 93 percent, while the share of medium enterprises was 4 percent. In order to survive in turbulent enviroment characterised by strong competition, SMEs need to develop strong competive advantages. Many Croatian companies are aware of this fact, and in recent years, they extend their effort in this direction. Since the innovations are fundamental factor of competitive advantages development, particularly in SMEs sector, the research about their creation and managing in these companies is conducted. The special questionnaire is developed which covered different aspects of innovation process. Results of this research showed that 60 percent of respondent companies apply some general or some specific instruments for encouragement and promoting innovations. It is also discovered that innovations are specially developed in companies that give a lot of attention on entrepreneurial culture (61 percent). In Croatia only 3 percent of firms use "primary" innovation strategy, while 23 percent apply creative imitation strategy.

Keywords: innovations; innovation management; enterprise; encouragement of innovations; promoting innovation; venture management; open innovation.

1. Introduction

In Croatia, there is a trend of using the concept of "new businesses" and applying the "new venture strategies". Main elements of "new businesses" are: new ideas, innovations and creativity. The new businesses need to be funky, which means different, innovative and unpredictable, surprising and emotional [7]. According to these facts, the development of SMEs sector becomes closely related with innovations.

Innovations may be a result of a specific application of new factors or new methods of production, but they are wide known as introduction of new products or new assortment of products. Innovations tend to be individually motivated, opportunistic, customer responsive, tumultuous, nonlinear and interactive in their development [6].

Differences between the average and successful companies can be explained through the difference between the level of creativity, which generate innovations, and promptness in their implementation. It can be related with a new product or new services, improvements in quality, modern design, or more efficient process of production. But generally, innovations are correlated with all aspects of human living not only with the business activities. In recent years, the development of IT technologies turns the innovations at the first place as fundamental development drivers of small and medium enterprises, and their establishment at the market.

The key role of innovations is detected in creation of added value, so the companies tend to develop and exploit innovations as their enterpreneurial culture and strategy attribute [4]. In process of creation, encouragement and promoting innovations, the human component is dominant. It is reflected on process of creation and innovations developing, but also in the innovation mangement. Innovation management is a high-risk and potentially rewarding process, so it demands great attention in all aspects.

2. Research Methodology and Characteristics of the Research Sample

The questionnaire consisted of four groups of questions, related to the perception and nature of innovations, ways of encouragement and promoting innovations, creation of added values as one of the important element of enterprenerial culture, and strategies for innovation development and innovation management.

It has been distributed to 120 randomly selected SMEs, located in five Croatian counties: Splitsko-dalmatinska, Dubrovačko-neretvanska, Varaždinska, Primorsko-goranska and the city of Zagreb. Figure 1 illustrates the distribution of enterprises from the sample, according to the counties in which they are located.

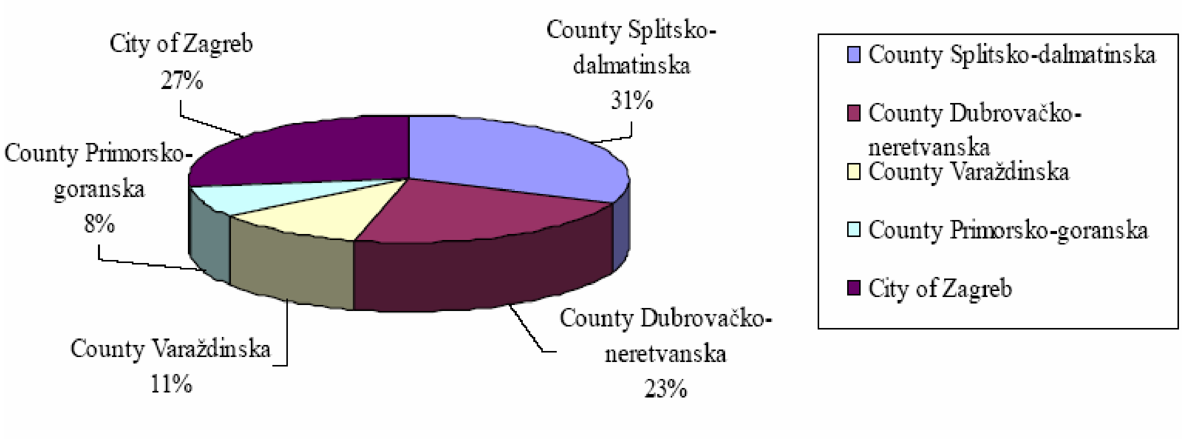

Figure 1. Distribution of respondents according to their location
(Source: Research documentation)

Of the 120 questionnaires, 80 were filled in and returned, bringing the response rate up to almost 67 percent, which can be considered very satisfactory. Of the questionnaires received, 75 were correctly filled in, representing the sample for this study, which represents 0.15 percent of the entire population. The study has included the company from different industries, as shown by Table 1.

Table 1. Distribution of respondents according to the industry

Industry	Amount of enterprises in the sample
Trade	39%
Hotels, restaurants and tourism	24%
Crafts and personal services	16%
Financial, technical and business services	11%
Manufacturing and mining	10%

This survey has concentrated on the small and medium-sized enterprises, as defined by the Croatian commercial law. Namely, in Croatia, the SME business sector, according to the official definition consists of:

- small enterprises, with less than 50 employees,
- medium-sized enterprise, with more than 50, but less then 250 employees,
- crafts and freelancing professions and
- cooperatives.

However, crafts, freelancing professions and cooperatives have not been considered in this research.

3. Research Results

Some of the most important issues covered by the questionnaire were vision, business philosophy and the entrepreneurial strategy of respondents. More than 80% of respondents have stated that they posses a complete **vision of their business**. However, only a few could reliably describe how their company would look like in ten years.

The essence of the ruling **business philosophy** in Croatian SMEs can be reduce to three main points: "to survive in the market", "to be better than the others" and "to earn as much and possible and expand the business" [5]. The questions concerning entrepreneurial strategy have elicited different responses, which lead to the overall conclusion that strategy is still perceived as a specific manner of conducting business.

The research shows that companies, which generate ideas and apply continued innovations (31 percent), have gradual process of creating and applying innovations. The phases in that process are as follows:

1. Generating ideas
2. Maturing of idea
3. Creation of concept or prototype
4. Promotion and commercialization of the innovation

The results of the research also show that four factors have a huge influence on encouragement of innovations creation and also on development an enterprenerial culture, which can be great support for continuity of innovations in the Croatian small and medium enterprises. These factors are:

- relations among employees
- organizational goals
- degree of stimulating innovations
- type of organizational structure

They are based on dominant characteristics of employees as well as on the management features.

But according to the respondents the main components in process of creation, development and application of innovations are **entrepreneurial culture** and applied **entrepreneurial strategy**.

Individual characteristics of the entrepreneurs are directly related to the kind of **entrepreneurial culture**, being the presupposition for the implementation of the entrepreneurial strategy. In this research, a typology differentiating four different kinds of the entrepreneurial culture **(indifferent, caring, strict and integrative)** has been used.

The **indifferent entrepreneurial culture**, although occurring relatively rarely (usually in the cases of declining enterprises), is characterised by indifference both to the people's needs and their results. At the other hand, the **caring culture** features a considerable attention to the needs of individuals, as well as to their education, career progress, cooperation, teamwork and the workplace security. **Strict culture** is directed toward the achievement and the realisation of enterprise objectives. It emphasizes efficiency and views people as means required to meet the objectives. **Integrative culture** is as much directed toward the result (efficiency), as to the people's needs. It puts emphasis on the unity and the strength of the collective [2].

Figure 2 illustrates the types of the entrepreneurial culture found in the analysed enterprises, i.e. their relative frequencies (in percentages).

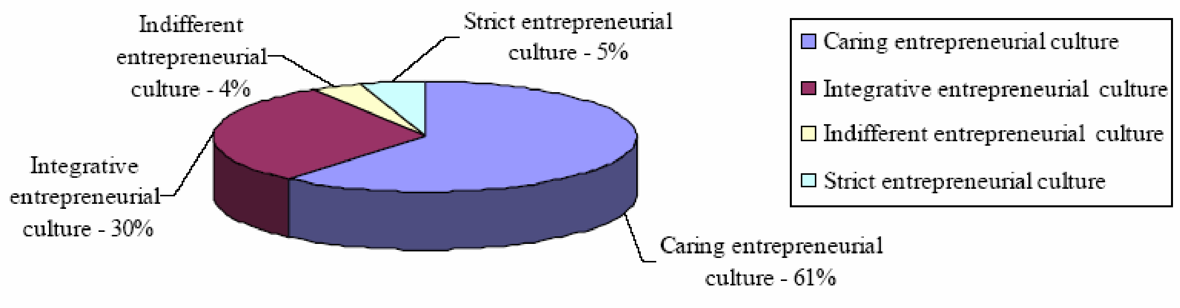

Figure 2. Relative frequencies of the types of entrepreneurial culture in surveyed enterprises

Another set of questions looked into the **type of the entrepreneurial strategy** used by the respondents. The research results show that the majority of entrepreneurs utilise the **market adaptation strategy**, followed by the creative imitation and focusing strategies.

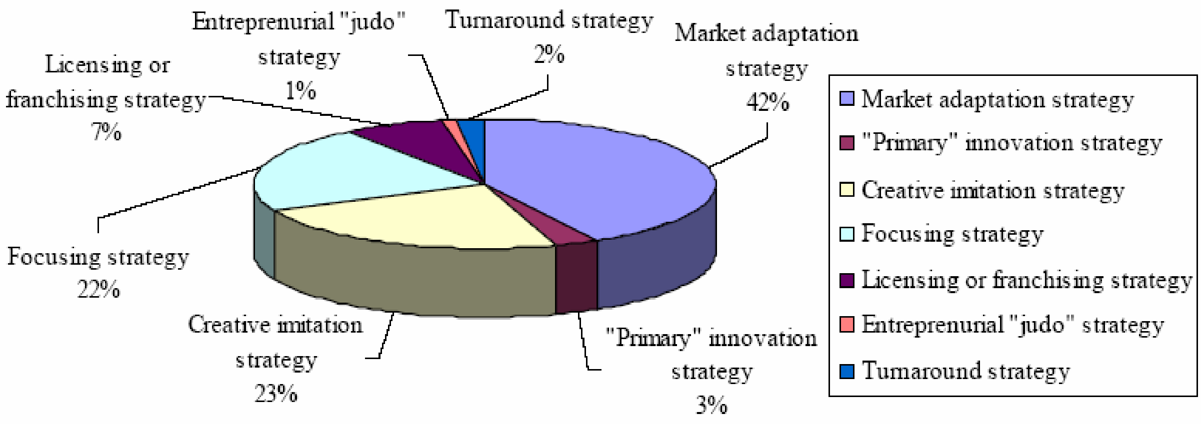

Figure 3. Entrepreneurial strategies implemented by the small and middle-sized Croatian enterprises (Source: Research documentation)

The ("primary") innovation strategy, used by a mere 3% of respondents, can be described in terms of P. F. Drucker: **"achieve faster, achieve more"**. It, basically, represents an attempt either to take the position of the leader in an industry, or to monopolise an industry (a new market). This strategy is associated with a high degree of risk, as well as with extensive organisational (and other) changes in the context of strategic implementation. **Creative imitation strategy**, implemented by 23% of the surveyed entrepreneurial firms, is founded on the modification of the existing product, service, or a process, in order to meet the market demand (i.e. to meet the demand in a more appropriate manner, as it is already served by the existing competitors). Entrepreneurs opting for such a strategy pay more attention to the modification process than to the development of new products (services). While the **("primary") innovation strategy** can be described in terms of **creating new consumer needs**, the **creative imitation strategy** strives to find feasible solutions to those needs [1].

Analysis of the questionnaires demonstrates that SMEs sector in Croatia use some general and some specific instruments in order to encourage and promote innovations. **General instruments** cover some techniques of collecting and generating ideas, and also some techniques for analysing and development of ideas. Only 16 percent respondent companies use project management as tool for encouragement and innovations promotion.

The most often used techniques of collecting and generating new ideas are: **employee suggestion scheme, quality circles, and different creative techniques** such as brainstorming and brainwriting. The most accepted techniques for analysing and development of ideas are: **value analysis** and **cost-benefit analysis**.

Among special instruments of encouragement and promoting innovations, the special role of **R&D organizational units** has to be pointed out. Over than 70 percent of respondents have some kind of units for innovation development. Most respondent companies have just one working place dedicated to these activities (61 percent); in some others, there is a special organizational section (23 percent) and in 16 percent of responding companies these activities are organised in special department.

Others special instruments are protection of patents, brand names and copyrights. These techniques use only 37 percent of SMEs in Croatia.

From claims mentioned above it can be pointed out that **small and medium-sized enterprises in Croatia do not use enough volume of instruments for encouragement and promoting innovations**. The reasons for this lies in financial obstacles and insufficient financial resources, so small and medium-sized companies should enter into partnerships or some cooperative relationships, and make use of synergy to obtain successful effect in innovation management, especially in the area of businesses linked with patents and licences.

4. Conclusions

The results of research show that **innovation management** is one of the essential precondition for surviving and than development of small and medium-sized companies in Croatia. Implementation of innovations in these companies depends firstly on managers and their management style, but also on characteristics of employees. These factors influence development of entrepreneurial culture and formation of stimulating creativity, and build up supportive organizational climate. In many companies the willingness for innovations is evident, because of awareness that innovations are basics for creating competitive advantages.

This research suggests deficient implementation of modern concepts of innovation management, such as concept of **"open innovation"**. The main idea of this concept is promptness and readiness of companies for their future development and growth, which is based on innovations, not only their internal, but also on external sources of innovations [9].

Venture management is new concepts of management, with a role of generating innovations and new ideas, strengthening organizational development and creation of competitive advantages [8]. The most important aspect of venture management is formation of cooperation relationships among small and medium sized enterprises. Mature and established companies, with the main goal to found new organizational units, which take responsibility for innovative and high risky tasks, mostly accept this concept. These units offer a possibility for approaching new technologies.

There are **different types of venture management organizational existence**, but the most important ones are internal and external type. Internal variant of venture management is the case when one organizational unit is established inside the company. At the other side, the external type of venture management represents a new firm with legal and economic independence [8].

The acceptance of venture management is significant for innovation creation, as well as for progress and expansion of SMEs. Concerning financial barriers and deficit of financial funds, it offers a spectrum of different opportunities, with the accent on organizational benefits, costs reducing, enhanced utilization of human resources, and diminishing the risk.

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THE GERMAN INNOREGIO-PROGRAM AS A NEW WAY TO PROMOTE REGIONAL INNOVATIVE NETWORKS - LESSONS FOR TRANSFORMING COUNTRIES

A. Eickelpasch

Abstract

In this paper the German InnoRegio-program is presented, a new way to promote regional innovative networks. The program is oriented to eastern Germany, a less favoured region in Germany which is still suffering from its heritage from the former socialist economy. First, the concept and implementation of the program are presented. Second, some preliminary experiences and their possible application for regions in transforming countries are discussed.

Keywords: Innovation, regional networks.

1. Introduction: The situation in eastern Germany

More than ten years after German reunification the economic situation in eastern Germany is still unsatisfactory. Since the end of the 1990's the catching up process in eastern Germany has been faltering. Macroeconomic growth is lagging behind the west German rate, while registered unemployment is still very much higher than in the old Länder and is hardly changing. Despite the massive support by the government and the successes in modernization the economy, industry is still very small and too much oriented towards local or regional markets. Companies are mostly small and medium companies (SME) with weak financial fundaments [1]. Thus, eastern Germany can be classified as a region with substantial economic structural problems which are partly explained by its heritage from the former socialist economic system.

New approaches were being sought in promotional policy so that the weaknesses that are known or suspected can be better targeted and removed. One of these weaknesses is insufficient research activities, and the consequent shortage of innovation by companies. Another is inadequate regional cohesion between companies and related facilities. Formal and informal co-operation between the various regional protagonists is regarded as essential to strengthen innovation and exploit the regional economic potential, and that means networking companies, research facilities, universities, the administration and politicians.

2. The InnoRegio program

2.1 Aim of the program

The InnoRegio Initiative from the Ministry of Research and Education has been designed to tackle this. Its aim is to make companies more innovative by promoting network formation and so indirectly stimulate growth and employment in the regions of eastern Germany. In this approach building up viable cooperation between companies and between them and related establishments like research and educational facilities and technology transfer offices in the various regions is the main focus.

In addition to promoting specific associative projects in innovative fields proposed by the participants themselves, social innovation is also to be stimulated. In particular, new institutional arrangements like forms of organization and steering patterns of communication and interaction, are to be tried out and established. Interested participants were free to choose the field of activity and themes themselves.

In deviation from the traditional promotion policy this offer is not addressed to individual companies but to regional groupings that have formed for specific projects. The recipients of the promotional funds were chosen in competition.

2.2 Conceptual framework

The concept is based on the interrelation between networking and innovation that is founded in theory and has been proved empirically. The theoretical basis of the InnoRegio concept can be sketched as follows (figure 1):

- Innovations are based an the production and exchange of knowledge. They are particularly accelerated by handing on tacit knowledge.
- Common interests and complementary competencies are essential, and confidence is the basis of the process. Geographical proximity helps to create common experience, which in turn helps to build up confidence and cooperation.
- Regional networks defined as a system of potential partners such as companies, universities, research facilities or intermediate institutions are a vehicle to speed up innovations or make them easier and are thus essential for successful co-operations.
- Strengthening innovativeness makes the individual protagonists more economically efficient, it creates spill-over effects and externalities that over the medium to long term help other protagonists in the region in their value creation and competitiveness.
- The networking of regional protagonists in the innovation process - or regional innovation systems, as they are also called - should in principle evolve spontaneously from the interests and needs of those involved, and be self-steering. But in view of the many obstacles, like high start-up costs, lack of confidence and the 'free rider' problems associated with this, state promotion can be helpful in the initial phase. It is then also reconcilable with policy on the general order.

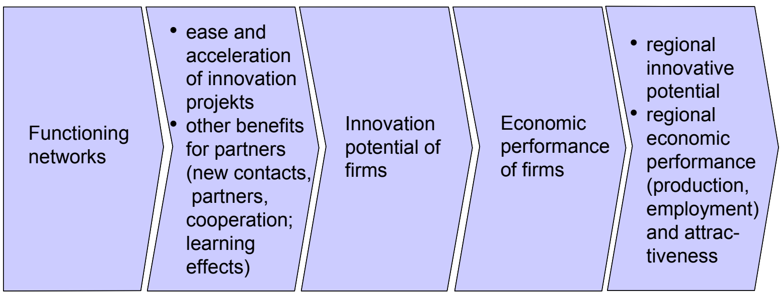

Figure 1: A Simple Model of the Impact of the Promotion of Innovative Regional Networks

2.3 Program Implementation

The networks involved in this promotion were chosen in a three-tier procedure (figure 2). The initial qualification phase ran from April 1999 to October 1999, when participants from the regions put forward their first concepts for promotion for their project associations. Out of 444 applicants 25 networks were selected in November 1999 for the next so-called development phase, by an independent jury. Main criteria were criteria like importance for the region, how well the participants complement each other and the innovative quality of the approach. The applicants were awarded up to about € 153,400 in promotional funds to draw up a more detailed version of their concept. In this phase the InnoRegios were also given immaterial support from the project sponsors through moderators who monitored the communication and organization process and through consultancy on subject areas and technical aspects of the promotion.

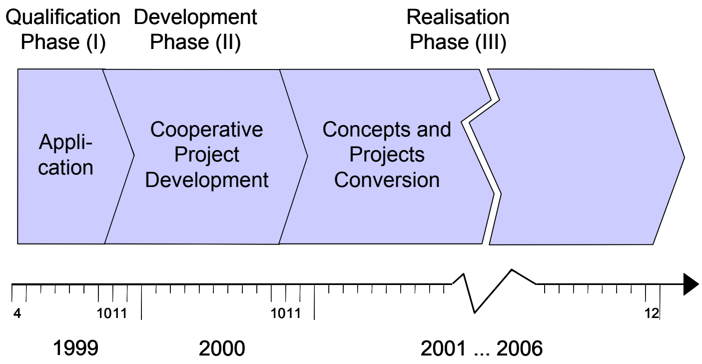

Figure 2: The InnoRegio Process

The concepts had to be handed in by 30 June 2000. In October 2000 the jury initially recommended 19 InnoRegios for promotion in the so-called realization phase. Another six InnoRegios were given the possibility of developing their concepts in more detail by June 2001. Four of them were successful, so that all over all 23 initiatives were selected for promotion for a period of five years (from the end of 2000 to the end of 2006). Activities eligible for funding are R&D projects, qualification measures as well as services for the improvement of the network infrastructure. The projects are conducted by private firms, universities and other public research institutes jointly or on their own. It is emphasized that in addition, the management of the network is supported financially for the whole realization phase [2]. The BMBF is providing a total of € 255 million for this program. Thus, the InnoRegio Initiative is the most important pillar of the ministry's innovation policy for eastern Germany.

The InnoRegio program does not specify objectives, topics, or composition of the networks in concrete terms. The 23 InnoRegio networks that received support thus cover a broad spectrum of activities and differ significantly among themselves in terms of the individual participants involved. The networks are active in the areas of medical technology, renewable resources, biotechnology, micro-system technology, mechanical engineering, manufacturing technology, circular-flow economics, environmental technology, and automotive technology. Various branches of the service industry may also be included here, such as those offering travel and tourism for disabled people, or establishing consultation and treatment services for people with diabetes. Restriction to one strictly limited technological field is the exception rather than the rule: usually, each network includes more than one field. The differences in the choice of topic are reflected in the structure of participation. The share of manufacturing industry, service enterprises, universities and scientific facilities differs widely among the groups of actors in the individual networks.

The size of the networks is very different as well. Taking as a yardstick the support volume given by the ministry we can classify twelve as small networks (less than € 10 mill.), six networks as medium-sized (€ 10 mill. up to € 15 mill.) and five networks as large (more than € 15 mill.).

According to the InnoRegio approach to mobilize regional economic potential wherever in eastern Germany, there were also no restrictions concerning the location of the participants' network. Thus, the networks involved are spread all over eastern Germany, Berlin, Brandenburg, Saxony, Saxony-Anhalt, Mecklenburg-Western Pomeranian and Thuringia (map). Measured by density we can identify seven networks in agglomerations (mainly Berlin, Dresden), nine networks in medium dense regions and seven networks in rural areas (like the northern parts).

Map: Geographical Allocation of the InnoRegio-Networks in Eastern Germany
- Site of the Coordinators' Office -

3. Experiences so far

In order to evaluate the program the following questions are central:

- Has InnoRegio led to the formation of a network of regional protagonists that is permanently viable? In other words, what factors determine the process of network formation generally and specifically in the case of InnoRegio?
- Has the networking initiated the formation of efficient regional innovation systems, or have existing systems been strengthened? To put it differently: Is the network making the expected contribution to form or strengthen regional innovation systems?
- What effects are to be expected by changes in the innovative ability of the network participants on value creation, competitiveness and employment in the region as a whole?
- What can we learn for the improvement of the economic situation in countries and regions with comparable economic situation as they can be found in transforming countries?

In this paper only a selection of the question raised can be discussed not only because this would go beyond the scope of this paper but also because some of effects especially those on the economic performance of companies will take time and thus can be realized only in the future. The results presented here are based on the experiences made until the year 2003 and results from the complementary research conducted by the DIW Berlin [3].

In the course of time from the beginning of the realization phase until the end of 2003 the network infrastructure is in most of the networks established: The formal and legal organization is in power, and the networks are - taking the most important determinants - functioning: The networks are mostly “complete” which means, that according to the assessment by the participants, only in few cases partners which are needed for cooperation are not (yet) integrated into the network. The competences of partners are complementary to each other. In addition, the organizational efficiency, the possibilities for the exchange of information and climate of confidence are well developed. Last, but not least, the network management as the backbone of the network infrastructure is broadly accepted by the partners involved.

But the entry into the realization phase of InnoRegio also brought some initial difficulties. The participants complained in particular that the approval process was too complicated and took too long. These problems were mainly due to the complexity of the promotional approach, to which all partners involved first had to adjust. Some measures introduced helped to accelerate the procedure, e.g. more intensive consultancy for applicants and close cooperation of all involved in the so called promotion management team.

In the course of the improvement of the promotion more and more of the envisaged projects were approved by the ministry and their realization could start. In summer 2003 about 550 promoted innovation projects were in the phase of realization or already finished. Most of the projects are research projects (87 %), some of them aim at the improvement of vocational training (6 %) and some are services for the function ability of the network concerned (7 %). Examples for the latter are the two projects presented at this conference from the InnoRegio called RIO, one project dealing with the “Increasing production capabilities by network enabling strategies” the other one with the “Secure order data management in supplier networks”. As main results most of the projects are highly innovative, are finished or still worked on successfully and are (or had been) using the knowledge potential which is offered by the network and its members by intense exchange of information.

To sum up, the InnoRegio program is in the meantime accepted widely by the participants. In the course of the realization the satisfaction concerning the program has increased. This is not surprisingly first because of all the immediate benefits which result from the financial aids for projects but secondly also because of other advantages connected to the membership in the network, as the chances to get into touch with potential partners, to find partner and to realize new co operations (figure 3).

An open question remains concerning the conversion of the results of the InnoRegio projects into new products and its introduction into the market. Although most of the firms concerned are engaged in dynamic markets and are competitive the introduction of the new products will demand considerable efforts of the firms at least because of the high costs of market introduction. This process is not without risk especially when the profitability of companies is insufficient which can be observed for companies involved.

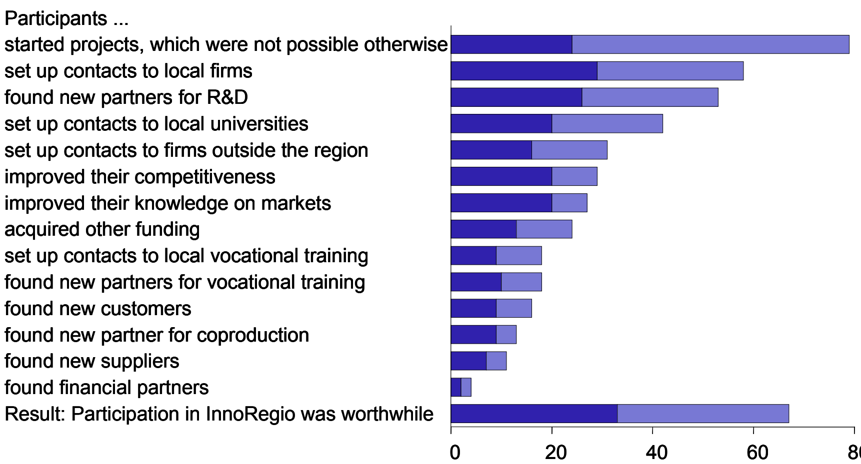

Figure 3: Assessment of InnoRegio by Participants, 2003 (in %)

4. Lessons to be learnt

As a result the experiences made so far in the InnoRegio process can be summed up as follows:

1. First of all functioning networks have been created. As shown, some of the success factors for functioning are the completeness of a network, the complementarities of competences, the efficient and transparent organizational structure, the positive climate of confidence (including openness for new members) and the efficient network management. One open question concerning the stability of networks remains, as it is not clear what happens to the network when the financial support comes to an end.
2. Networks must not become an end at itself. They are vehicles to ease or to accelerate the innovation potential of firms. Thus, the economic success of the promotion of networks also significantly depends on firms involved, on their absorption capacities and their ability to convert research an development into new products, their market power, their presence at dynamic markets and last but not least on their financial capabilities to introduce new products into the markets successfully. As shown, firms engaged in functioning networks use the benefits of the networks. One main question – which is may be one of the key factors – is the economic potential of the companies involved.
3. The advantages of networks for the innovative and economic potential of regions are obvious. But it has to take into account that founding and implementation of regional innovative networks as well as the conversion into economic impacts need time. The effects cannot be expected in short period of time.

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SUPPLY CHAIN DESIGN WITH THE USE OF TAGUCHI METHOD

T. Grubić and I. Veža

Abstract

The process of supply chain design that will efficiently respond to emerging market demands is of great importance for enterprise competitiveness. Development of methods for the use during the supply chain design process is a research topic not only in scientific community but in industrial also. A method that could be efficiently used during this process has to posses many features. Some of those features are: the appropriateness of the method in order to use it on each of the three supply chain management levels (strategic, tactical and operational), applicability of the method in diverse industrial sectors and maybe the most important feature of all the ability to built-in business environment effects in a supply chain design. In this paper the potential of Taguchi (also known as Robust Design) method in a supply chain design process as well as the modelling of a supply chain with the use of method is presented. Modelling is carried out with the use of discrete event simulation and presented on the practical example.

Keywords: Taguchi method, supply chain, discrete event simulation

1. Introduction

Today's enterprises are faced with the situation that can be characterized by competition and uncertainty. It is no longer acceptable to assume that good products will sell for ″them selves″ or that present market success ensures future success. To ensure the success of an enterprise on the market, it is common practise for enterprises to set some form of business alliances. In the last decade of the past century many new organizational concepts emerged. Those concepts focused on the closer relationship between the involved parties. One of those concepts is Supply Chain Management (SCM). The purpose of SCM is an integration of all involved parties and their respective processes and strategies, from sourcing to delivering. Implementation of such organization, which will efficiently accomplish the integration, is rather complex task.

To survive on today's global market; enterprises can no longer optimise their businesses isolated from their business partners, because a sum of sub optimal solutions does not have to present global optimal solution. An optimal supply chain is one that can respond with the shortest order-lead time and the minimal overall cost. Identification of non-controllable factors that affect a supply chain is of essential importance. Building those effects, in the optimal supply chain configuration, it is possible to design a system that is insensitive, or at least less sensitive, on those effects. In this paper the design and optimisation of a supply chain, which has built-in insensitivity on variations caused by the non-controllable factors, is presented.

2. Taguchi method

To design a product, and also the process that generates a product, which will efficiently respond in multiple customer environments is decisive factor for success or the failure of an enterprise. Important role in such a process has the design of experiments (DoE). Prof. Genichi Taguchi tried to eliminate the major drawbacks of classical DoE (large number of experiments and elimination approach of so-called nuisance factors [1]). Taguchi method adds a new dimension to statistical experimental design explicitly addressing the following concerns faced by product and process designers:

- How to reduce economically the variation of a product's function in the customer's environment (achieving a product's function consistently on target maximizes customer satisfaction).
- How to ensure that decisions found to be optimum during laboratory experiments will prove to be so in manufacturing and in customer environments.

The essence of Taguchi method is quality and how the customer perceives it. The product/process quality improvement is achieved by reducing the effects of variation but without its elimination. Every product/process can be described by using P-diagram, Fig. 1 [2].

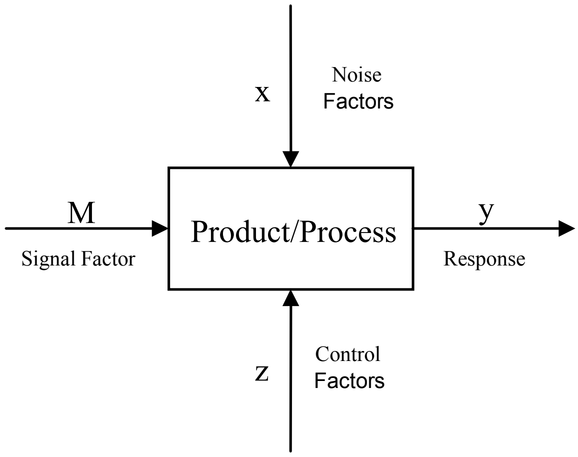

Figure 1. P-diagram [2]

Fig. 1 represents factors that influence a product/process. These factors are:

- **Signal Factor (*M*)** is the factor whose value is directly set by the user or the operator of the product to express the intended value for the response of the product (precisely signal factor is what the user of a product expects of it, e.g. selection of tolerances for a component).
- **Noise Factors (*x*)** are factors whose values are either difficult to control, impossible to control or too expensive to control in the field of use. The noise factors cause the response **(*y*)** to deviate from the target specified by the signal factor **(*M*)** and lead to quality loss.
- **Control Factors (*z*)** are the factors whose values can be specified freely by the designer. In fact, it is the designer's responsibility to determine the best values of these factors.
- **Response (*y*)** represents the actual value of the product's/process' quality or, in other words, response of the product's/process' function.

Each of these factors can take different values, so-called levels.

As it is previously said, the goal of Taguchi method is to reduce the effects of product/process variation without their elimination. The metric of product/process insensitivity to variation is signal-to-noise (S/N) ratio. The S/N represents the ratio between the signal of a product/process and noises in its environment (Fig. 1). By increasing the S/N ratio a product/process becomes more insensitive to variations in its environment. In simple words, it is a measure of functionality of a process' to improve product performance (quality). The expression used to calculate the S/N ratio depends on chosen QC (Quality Characteristic) and it is expressed in dB (decibels), Table 1.

Table 1. S/N ratios [2]

Quality Characteristic QC	S/N ratio (dB)
Smaller-the-better	$-10 \cdot log_{10}\left(\frac{1}{n}\sum_{i=1}^{n} y_i^2\right)$
Nominal-the-best	$10 \cdot log_{10}\left(\frac{\mu^2}{\sigma^2}\right)$
Larger-the-better	$-10 \cdot log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y_i^2}\right)$

The terms used in Table I, can be described:

n - number of observations,
y_i - the QC value of the observation "i",
μ - the average value of a sample.
σ - standard deviation of the sample.

3. Optimisation of a supply chain with Taguchi method

In this section the application of Taguchi method is illustrated on a supply chain model. The supply chain was modelled and simulated using eM-Plant™ software package for the discrete event simulation [3].

The supply chain is consisted of four producers (P1-P4), four distributors (D1-D4) and two wholesalers (W1 and W2), Figure 2.

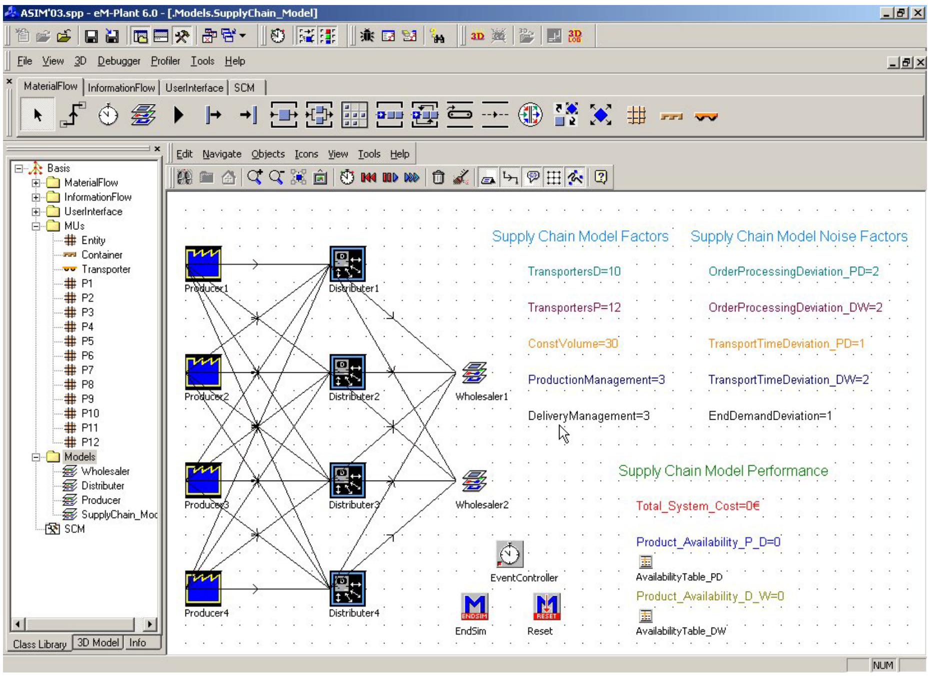

Figure 2. The model of supply chain

The producers produce 12 different kinds of product that are ordered by the distributors. Two wholesalers order from the distributors. Each of the four producers produces only six of the before mentioned products that are characterized with different specifications (product volume and production time). Transport times between different tiers in the supply chain are presented in table 2 and are expressed in hours.

Table 2. Transport times

	P1	P2	P3	P4	W1	W2
D1	14	20	20	12	8	12
D2	18	16	13	19	10	11
D3	14	16	20	17	14	6
D4	20	12	14	20	16	8

The supply chain model is characterized as:

- Wholesalers W1 and W2 place an order at the ninth day of simulation where the quantity of ordered products follows the uniform distribution U (1, 5). A wholesaler randomly chooses the distributor and this is also modelled as uniform distribution U (1, 4). The time between two consecutive orders of a wholesaler is described with the negative exponential distribution NegExp (4), where 4, expressed in hours, represent an average time between two orders.
- The distributors hold at their storages some amount of products (each of the 12 products). At the eighth day of simulation the distributors forward the orders of 50 pieces of each product to producers. If the ordered amount can be shipped, which depends of current storage capacity of product and transporters availability, it is shipped, and if not only the part of the order is shipped and the rest is backordered. An order is defined as realized only if it the whole quantity of products ordered is shipped.
- The producers make products for seven days until the first order of a distributor. The P1 and P3 make products 1-6 and P2 and P4 products 7-12. The D1 and D2 order products at P1 and P2, while D3 and D4 order at P3 and P4. If a producer can deliver the whole amount of products ordered by a distributor (that depends of current product and transporters availability) it delivers it and if not it delivers only the amount that can be delivered at the moment. An order is defined as realized only if it the whole amount of products ordered is shipped.
- The performance metrics of the supply chain are: the total system cost and average product availability (number of realized orders/total number of orders) between the two tiers, i.e. between the producers and distributors (P-D) and distributors and wholesalers (D-W).
- Total system cost consists of: storage and transport costs, of producers and distributors, and penalty costs due to backorders between the involved tiers in the supply chain.
- The simulation time of the model is three months.

The response of the model is already defined in the model characteristics: total system cost and average product availability and they are smaller-the-better and larger-the better type respectively. The control **(*z*)** and noise factors **(*x*)** of the model are represented in tables 2 and 3.

Table 3. The control factors of the supply chain model

Factor	Level		
A - Num. of distributors' transporters	10	12	14
B - Num. of producers' transporters	8	10	12
C - The order of distributor	10pcs.	20 pcs.	30 pcs.
D - Production volume	5 pcs.	10 pcs.	20 pcs.
E - Accumulation of orders	9h	6h	3h

Table 4. The noise factors of the supply chain model

Factor	Level	
Order time deviation P-D	1h	2h
Order time deviation D-W	30min.	1h
Transport time deviation P-D	3h	5h
Transport time deviation D-W	2h	4h
End demand deviation	30% lower	30% higher

Design of experiments for the model is determined by choosing the orthogonal arrays, among the standard ones [2] that could accommodate the control and noise factors. The L_{18} standard array and L_8 standard array has been chosen for the control and noise factors respectively. By knowing the orthogonal array the plan of experiments is explicitly defined. The experiments are conducted according to L_{18} array on which the effects of noise factors are simulated by L_8 array. In this specific situation this means that for every of 18 control factor combinations the effect of noise factors is simulated through 8 noises factor combinations. Also, every control/noise factor combination is replicated 3 times so the total number of experiments resulted in: $432 = 18 \cdot 8 \cdot 3$.

Table 5 presents the relative effects of control factors, according to the results of experiments, expressed in the system's metrics (total system cost and product availability).

Table 5. The relative effects of control factors

Factor	Level	Total cost (S/N)	Total cost	P-D availability (S/N)	P-D availability	D-W availability (S/N)	D-W availability
A	10	-131.92	3651648.25	-5.28	0.68	-24.81	0.23
	12	-132.02	3675747.00	-2.44	0.78	-24.88	0.23
	14	-131.91	3649622.00	-2.62	0.77	-25.66	0.24
B	8	-132.02	3676580.75	-4.69	0.68	-26.88	0.23
	10	-131.94	3655807.00	-2.20	0.80	-24.28	0.24
	12	-131.89	3644629.00	-3.46	0.75	-24.20	0.22
C	10pcs.	-133.88	4224864.50	-0.12	0.99	-34.78	0.05
	20pcs.	-128.06	1937987.00	-1.67	0.83	-24.40	0.36
	30pcs.	-133.91	4814165.50	-8.56	0.41	-16.18	0.28
D	5pcs.	-131.93	3656292.75	-2.44	0.78	-24.64	0.24
	10pcs.	-131.92	3652803.25	-2.39	0.79	-24.62	0.22
	20pcs.	-132.00	3667921.75	-5.51	0.66	-26.10	0.24
E	9h	-131.96	3654499.25	-2.44	0.78	-26.54	0.19
	6h	-131.90	3653938.00	-3.98	0.74	-25.39	0.23
	3h	-131.99	3668580.00	-3.92	0.71	-23.42	0.28

The optimal combination of control factors can be found by observing their relative effects. Generally for the S/N metric the larger value is desired (not absolutely larger value). By analyzing the relative effects from table 5 the optimal combination of control factors that should result in the greatest insensitivity to noises is: $\mathbf{A_2\ B_2\ C_2\ D_2\ E_1}$.

The optimal combination is verified by comparing it with the randomly chosen control factor combination: $\mathbf{A_2\ B_1\ C_3\ D_3\ E_3}$. The results of this comparison are presented in table 6.

Table 6. Optimal vs. random control factor combination

Combination	Total cost (S/N)	Total cost	P-D availability (S/N)	P-D availability	D-W availability (S/N)	D-W availability
$\mathbf{A_2\ B_1\ C_3\ D_3\ E_3}$	-133.43	4847914.43	-16.03	0.158	-11.84	0.32
$\mathbf{A_2\ B_2\ C_2\ D_2\ E_1}$	-120.39	1919121.49	-1.2	0.87	-16.45	0.29

4. Conclusion

In the paper the use of Taguchi method for supply chain optimization has been presented. The efficiency of the method was presented on a supply chain model that consists of four producers, four distributors and two wholesalers. Even the presented model is relatively complex one, real potential of the method could be observed on a more complex model, e.g. model in which more entities are involved that on the other hand results in larger number of relevant control and noise factors. Results in table 6 present enough evidence about the appropriateness of the method for supply chain optimization.

The major benefit of Taguchi method is its ability to implement the effects of a supply chain environment while searching for optimal configuration. In this way the resulted supply chain is insensitive on variations generated in its internal and external environment.

Taguchi method is conducted in two stages: parameter and tolerance design. Former has been presented in the paper. The parameter design is conducted until the greatest insensitivity on variations in achieved. So it is an iterative process. On the other hand the reason of tolerance design study is to identify which noise factors are the largest drivers of decrease of a system's variation insensitivity. By identifying those noise factors the appropriate activities (or boundaries in which the noise factors are controlled) for the reduction or elimination of their effects could be set. The future research of the use of Taguchi method in a supply chain optimization will involve the application of tolerance design.

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APPLICATION OF THE SWOT ANALYSIS AND THE SYSTEM DYNAMICS METHODOLOGY TO THE STRATEGIC PLANNING OF THE MARKET DEVELOPMENT OF A HIGHER EDUCATION INSTITUTION

M. Hell, E. Marušić and J. Bubić

Abstract

According to the theoretical model which links the SWOT analysis and the system dynamics methodology, this paper is presenting the application of a new system in the strategic development planning of a higher education institution. On the basis of the overall business system model for a higher education institution shown in this paper, which also includes the microenvironment's relevant factors and the results of a case study, we will show a possible development scenario by introducing a new "product," which is on-line teaching.

Keywords: SWOT analysis, system dynamics, higher education institution, development strategy

1. Introduction

The development of any organization, as well of institutions of higher education, should be based on their development plans. The theoretical model of synthesizing system dynamics methodology and the SWOT analysis [4], enables us to combine static and dynamic methods for development planning.

The SWOT analysis (Strengths, Weaknesses, Opportunities and Threats), used to analyze all external and internal development factors and supplemented with the system dynamics methodology, ensures the prediction of possible deviation from the set goals caused by feedback loops (FBL).

This paper will present the possibilities of applying this new approach to the strategic development planning of a specific higher education institution (the Institution). Based on the results of the market research, using a questionnaire as the basic means of research, the paper will present a possible development scenario of the Institution by introducing a new "product," which is on-line teaching.

Therefore, the questionnaire has evaluated all the relevant factors, i.e. the internal strengths and weaknesses of the Institution and the external opportunities and threats. On the basis of these findings, a SWOT analysis has been made through the appropriate adaptation to the specific case. This analysis has identified, among other things, the possibility of introducing on-line teaching into the Institution's education system as the new "product" (new product launch strategy) that would reap numerous beneficial effects.

By exploiting the aforementioned opportunities, a new model of the Institution's development planning strategy is suggested in this paper through application of the suggested methodology. Part 2 defines the Institution's business system of and shows its hierarchic diagram. Part 3 presents a structural model of the suggested development strategy in accordance with the results of the research mentioned. Part 4 depicts a simulation scenario which displays the development and reciprocal influence of the Institution's observed SWOT elements.

The above-mentioned goal of this work is achieved in the described manner, proving the possibility of applying the synthesis of SWOT analysis and system dynamics in the strategic development planning of the higher education institution.

2. Definition of the Institution's Business System

Every educational institution can be viewed as a company that produces and sells knowledge. Its goal, as with any other company, is to market goods and services in the best possible way and to achieve the highest possible level of consumer satisfaction. Without analyzing the economic justification of education and the personnel training in a relevant profession, the paper defines, as a basic standpoint for the analysis, the increase in the "production" of the Institution by the increase in the total number of graduates. Pursuant to the already-mentioned standpoint, an observation of all relevant internal and external factors is needed; i.e. a definition of the entire Institution's business system, which calls for a more systematic approach.

Breaking the Institution's business system down into its basic levels, while taking into account the relevant factors of the microenvironment, we can notice its fundamental elements, which are shown in the hierarchical diagram in Figure 1.

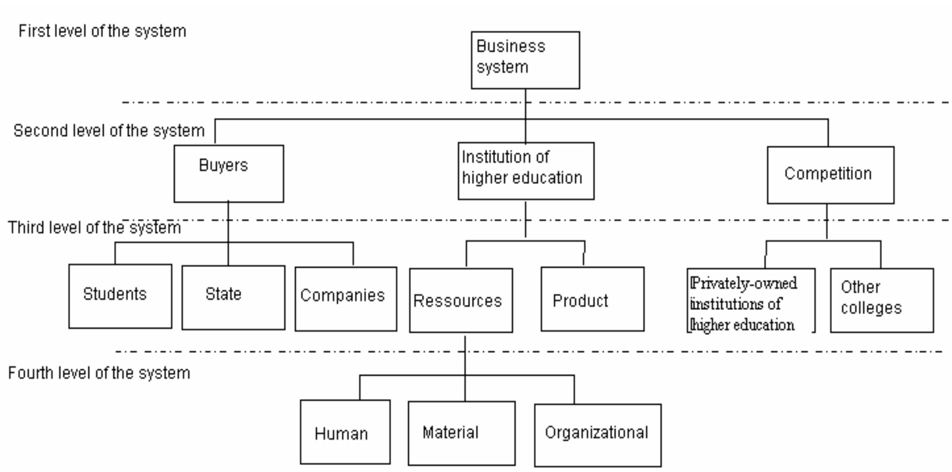

Figure 1. Hierarchical diagram of the Institution's business system

Observing the second level of the hierarchical diagram in Figure 1., we can see three basic parts of the Institution's business system as follows:

1. Buyers – all legal entities and natural persons who use the services of the Institution;
2. The Institution – the observed higher education institution;
3. Competition – all the higher education institutions that engage in similar activities and strive to attract the same buyers, i.e. the target markets of the observed Institution.

For the purpose of the analysis, the said three components will be divided into two groups: external environmental factors which include buyers and competition as the first group, and the internal environmental factors of the Institution as the second group. The third level of the diagram divides the said three components into their basic elements.

There are three basic groups of buyers: the first one is the State by giving grants to students and by ordering different studies and projects, the second group represents students, and the third group of buyers represents different companies, because of the need to train further their personnel.

This basic division of the Institution is done according to available resources and to the products offered. On the basis of the resources, which are on the forth level divided into human, organizational, and material, an overall supply of the Institution is created - a range of products (including the quality); i.e. curriculums that are actualized through the teaching process, and the services of the Institution such as conducting different studies and projects.

Human resources, whose division was not included in the hierarchical diagram in Figure 1, in order to simplify the model, falls into several groups according to the jobs they perform – teaching staff, clerical workers and administrative staff. The organizational resources represent the

Institution's management and other organizational staff. Material resources represent the Institution's physical assets such as premises, teaching equipment and the overall level of equipment in lecture-rooms, including computer equipment.

Considering the rapid development of science and the need for an interdisciplinary approach to deal with business problems, apart form the higher education institutions that offer the same or similar programs as direct competition, we point out the existence of indirect competition as well. Those are all other institutions of higher education where potential students can enroll. Besides, the competition includes all private institutions which educate through highly specialized courses, meeting only the basic criteria of the education needed for a specific line of work.

We need to evaluate the thus defined components, i.e. subjects of the high education market - single out strengths and opportunities and minimize weaknesses and threats in order to achieve the more effective overall business.

3. Modeling the development strategy of the Institution

On the basis of the verbal model, a structural model of the Institution's development strategy will be presented in this Part. The modeling is based on research results which were used to assess the importance of the SWOT analysis elements. The aim of this strategy is to introduce on-line teaching as a new "product" in the overall offer of the Institution. In respect of possible changes in higher education, such a form of teaching represents an important factor in the education process development.

3.1 Verbal model

The importance of the described strategy (a new product launch – on-line teaching) in the Institution's development is followed up with the "on-line teaching" variable. The development of the Institution triggered by the implementation of on-line teaching in relation to the competition is followed up by the variable bearing the same name and representing the difference between the importance of the strategy application (+) and the importance of the competition influence on the Institution's development (–).

The research has established the following advantages of the Institution /having positive impact (+) on the implementation of the strategy/: the short duration of studding, the computer literacy of teachers (+) and students (+) and the quality of computer facilities at the Institution (+). The utilization of this opportunity (the implementation of on-line teaching) has a positive impact (+) on teachers' and students' experience, on the reduction of the study duration, and on improving the Institution's quality of computer facilities. All in all, it is easy to see a positive feedback loop (+)FBL1

By taking this opportunity, the field of the Institution's activities would spread from regional to global market. The market expansion reduces the importance, i.e. is it has a negative (–) impact on the identified weaknesses: unfavorable market position (–), poor facilities (–) and unfavorable image (–). As these weaknesses have a negative effect on the utilization of the opportunity (–), the final result is thus the positive circle of the feedback loop (+)FBL2.

By reducing weaknesses (unfavorable market position, poor facilities, unfavorable image), the significance of the competition is reduced (+) as well. As the impact of the competition's threat decreases, the importance of the mentioned weaknesses is also reduced (+). This is represented with a positive feedback loop (+)FBL3. The time needed to eliminate the weakness will depend on the speed of the utilization of the mentioned opportunity.

Reduced threats allow more space for the Institution's strengths, which also represents the negative consecutive link (–). Growing strengths minimize threats which also represents another negative consecutive link (–). This has defined yet another positive feedback loop (+)FBL 4.

Observing the overall relationship system among the observed SWOT elements, we can notice another positive feedback loop: (+)FBL5. The accumulative character of the (+)FBL5 was determined by the positive sign of the feedback loop. In accordance with the discussion on comparing development and orientation of the feedback loop among SWOT elements [4], it can be noticed that by implementing the suggested strategy of introducing new "product", the direction of

FBL5 will be a positive one (counter-clock-wise), which represents success in the Institution development. On the basis of these two statements, we can conclude that the Institution's development is achieved through accumulating successes.

3.2 Structural model

The previous verbal method can be presented with a structural diagram. In order to simplify the model, not all causal-consecutive links are shown, but only the causal-consecutive links between the observed SWOT elements.

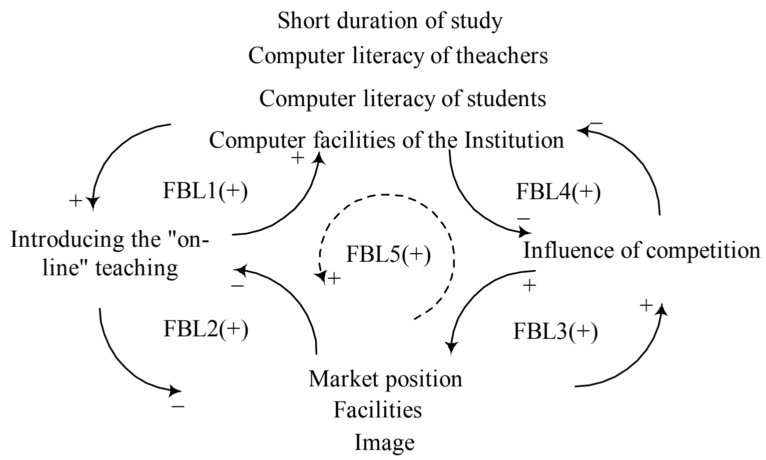

Figure 2. Structural diagram of the Institution's development by introducing the on-line teaching

3.3 Mathematical computational model

The following code represents the mathematical computational model of the Institution's development by introducing the on-line teaching. In order to simplify the model, the importance of the components is not shown as the functions of time, but represented by their average values, and can be changed during simulation. The simulation scenario of this mathematical computational model is graphically presented in the next section.

```
init    Competition = 3.38/6
flow    Competition = +dt* Influence_of_weakness_on_increasing_of_threat
        -dt* Influence_of_strenghts_on_decreasing_of_threat
init    On_line_ teaching = 4.13/6
flow    On_line_ teaching = +dt* Influence_of_ strenghts _on_taking_opportunity
        -dt* Influence_of_weakness_on_taking_opportunity
init    Level_of_computer_equipment_at_the Institution = (3.67+3.81+3.20+3.25+3.83)/30-0.5
flow    Level_of_computer_equipment_at_ the Institution = -dt* Rate_of_fall_of_level_ of_computer_equipment
        +dt* Rate_of_growth_of_level_of_computer_equipment
init    Computer_literacy_of_teachers = 1-0.5
flow    Computer_literacy_teachers = -dt* Rate_of_fall_of_computer_literacy_of_teachers
        +dt* Rate_of_growth_of_computer_literacy_of_teachers
init    Computer_literacy_of_students = 1-0.5
flow    Computer_literacy_of_students = -dt* Rate_of_fall_of_computer_literacy_of_students
        +dt* Rate_of_growth_of_computer_literacy_of_students
init    Facilities = 0.5-(1.79+2.22+1.70+1.315+2)/30
flow    Facilities = -dt* Rate_of_fall_of_importance_of_facilities
        +dt* Rate_of_growth_ of_importance_of_ facilities
init    DEVELOPMENT_OF_THE
INSTITUTION_COMPARED_TO_COMPETITION_APPLYING_ON_LINE_TEACHING = 0
flow  DEVELOPMENT_OF_THE
INSTITUTION_COMPARED_TO_COMPETITION_APPLYING_ON_LINE_TEACHING
= -dt* Competition
        +dt*On_line_teaching
```

init	Market_position = 0.5-2.81/6
flow	Market_positioning = -dt* Rate_of_fall_of_importance_of_m_p
+dt* Rate_of_growth_ of_importance_of_m_p
init	Importance_of_duration_of_study = (3.57+3.30+3.33)/18-0.5
flow	Importance_of_duration_of_study =
-dt*Rate_of_fall_of_importance_of_duration_of_study
+dt* Rate_of_growth_of_importance_of_duration_of_study
init	Importance_of_image = 0.5-0.65+0.6857+0.4286+3.21/6
flow	Importance_of_image = +dt* Rate_of_growth_of_i
-dt* Rate_of_fall_of_i
aux	Rate_of_fall_of_level_of_computer_equipment = DELAYMTR(Competition, 1 ,3,0)*0.1
aux	Rate_of_fall_of_computer_literacy_of_teachers = Competition *0.001
aux	Rate_of_fall_of_ computer_literacy_of_students = Competition *0.02
aux	Rate_of_fall_of_duration_of_study = Competition *0.02
aux	Rate_of_fall_of_f = DELAYMTR(On_line_teaching, 3 ,5,0)
aux	Rate_of_fall_of_m_p = DELAYMTR(On_line_ teaching, 1 ,3,0)
aux	Rate_of_fall_of_i = On_line_ teaching *0.5
aux	Rate_of_growth_of_level_of_computer_equipment = On_line_ teaching *0.02
aux	Rate_of_growth_of_computer_literacy_of_teachers = On_line_ teaching *0.1
aux	Rate_of_growth_of_computer_literacy_of_students = On_line_ teaching *0.1
aux	Rate_of_growth_of_duration_of_study = On_line_teaching *0.005
aux	Rate_of_growth_of_f = 0* Competition
aux	Rate_of_growth_of_m_p = Competition *0.5
aux	Rate_of_growth_of _i = Competition *0.7
aux	Influence_of_weakness_on_taking_opportunity = Facilities*0.2+Market_positioning*0.2+ Importance_of_ image *0.2
aux	Influence_of_weakness_on_increasing_of_threat = Facilities *0+Market_positioning*0.6+Importance_of_image*0.6
aux	Influence_of_strengths_on_taking_opportunity = Level_of_computer_equipment_of_the Institution + Computer_literacy_of_teachers + Computer_literacy_of_students + importance_of_duration_of_study *0
aux	Influence_of_ strengths_on_decreasing_of_threats = importance_of_duration_of_study *0.01+_Level_of_computer_equipment_of_ the Institution *0.1+ Computer_literacy_of_teachers*0.1+ Computer_literacy_of_students *0.2

4. Simulation scenario of the Institution development strategy

This simulation scenario shows the development of the Institution, i.e. the observed SWOT elements when applying the strategy of introducing the new product, i.e. on-line teaching. The model does not include the impacts of other possible strategies. The Institution development is projected for the period of eight years.

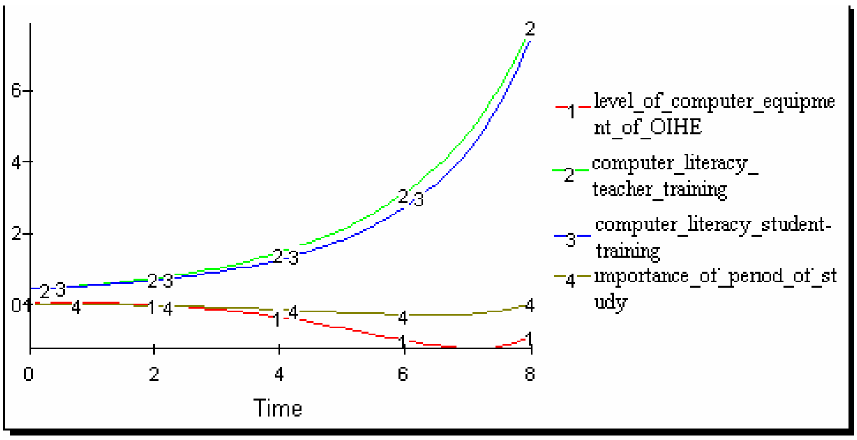

Figure 3. Development of the Institution’s strengths influenced by the suggested strategy [4]

We can see in the Figure 3. the development of the Institution's internal strengths and their dependence on other development factors. The existing computer equipment, as the Institution's strength will gradually become outdated in comparison to the competitors that will, in order to strengthen their own competitiveness, invest in new equipment. However, in certain time the newer equipment of the competition will become out-of-date, so that the difference in its quality as compared to the quality of the observed Institution will decline. For this reason, and because of other development factors, it is expected that in the seventh observed year the importance of the level of the Institution's computer equipment will grow again. Computer literacy of students and teachers will likewise grow due to their active involvement in the described form of teaching and studying.

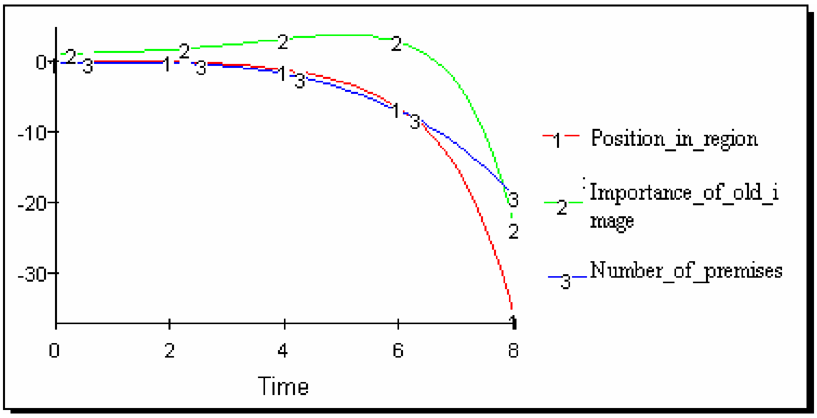

Figure 4. Decline of the Institution's weaknesses under the influence of the suggested strategy [4]

Figure 4 shows the behavior dynamics of the existing Institution's weaknesses. In the fourth year after the new product strategy implementation, when the first generation of graduated students is expected, apart from other positive effects that will be achieved, the Institution's image will rise exponentially. Developing from positive into negative values, SWOT elements are from weaknesses turning into the strengths. The success of implementing the suggested strategy will result in an increase in the number of enrolled students. The acceptance of the described new way of studying on the part of the students lessens the importance of the Institution's poor facilities.

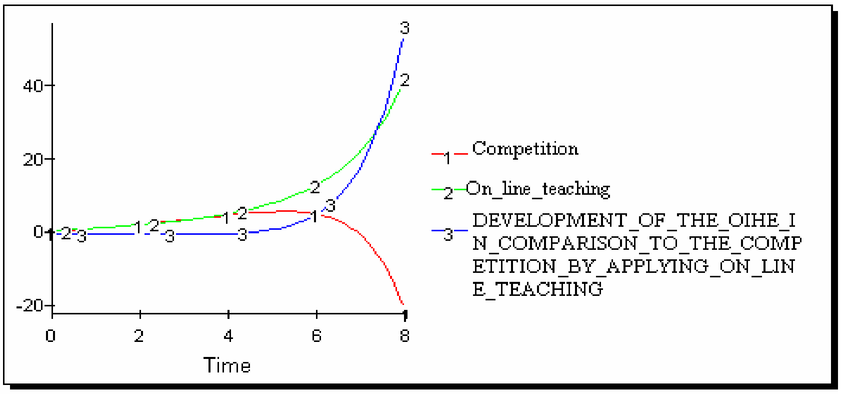

Figure 5. Market development of the Institution by applying the suggested strategy [4]

Market trends indicate that competitors, in order to strengthen their market position, will most certainly copy the described Institution's strategy, which is to introduce on-line teaching (Figure 5). Considering the specific characteristics of the Institution's students, after the first generation of graduated students, an increase in the number of newly-enrolled students is expected.

5. Conclusion

Factors which determine the strategic (lack of) success of any organization are identified in the context of SWOT analysis, thus it can be considered to be an inseparable part of the strategic analysis of any higher education institution.

Taking into consideration the time flux of the strategy of the observed Institution's development, it was also necessary to observe the time flux of the SWOT factors (Strengths, Weaknesses, Opportunities and Threats), which was done successfully by a "synthesis" with system dynamics methodology. In that way, by creating simulation scenarios, it became possible to predict the transformation of opportunities into threats, strengths into weaknesses and vice versa. On the basis of such a developed dynamic model, in the case of a new threat or an opportunity in the external environment that could not be foreseen during the previous SWOT analysis, by changing the parameters or adding to the model, we can run through a new simulation scenario and introduce changes needed in business with the aim of avoiding/reducing the newly created threats or utilizing opportunities.

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GA MODEL OF ON-LINE OPTIMIZATIONS OF PRODUCTION COSTS OF CONTINUOUS PROCESSES

A. Korošec, J. Balič and F. Čuš

Abstract

In modern industry, which consists of many different computer-aided processes, there is almost lack of integration between different subsystems. Manufacturers continue to refine how they plan the production to meet the demands and manage fast growing dynamics. In this regard, we have seen the evolution to MRP, MRP II and ERP. However, even those with extremely sophisticated planning systems often have major difficulties in executing in the plant in a way that meets market demands cost-effectively. Planning system in major commercial ERP solutions such as SAP, Baan, Oracle, PeopleSoft consists of many small special parts of software for planning of different resources: material requirement, capacity usage, human resources, cash flow and time management.

In modern production plants where complexity is soaring, very highly trained personnel are needed. The new methods enforce new kind of skills and special knowledge. Through optimizations and decision support, it leverages investment in plant equipment and information systems.

Keywords: Genetic Algorithm, Constraint Planning, Material Requirement Planning, Master Production Scheduling, Capacity Planning, Enterprise Resource Planning

1. Problem description

Concurrent pressures from stockholders, customers, and market competition are squeezing manufacturing plants in terms of efficiency and profitability. Such time pressure leads to new challenges; production on demand which has increased the number of products; as a result, smaller order quantity must gear up to handle extra loads, customers are now penalizing the suppliers not only for deliveries that are late, but also for those that are too early or incomplete.

The production cycle must be shrinked but is just one small time interval in the whole customer order life cycle as was reported by Jezernik [8] and many others [13, 16].

Most of decisions at different business stages must be served by accurate data because the wrong decision can have a great impact on the whole business in one time period. Typically, at the moment of customer's demand without the view on capacity utilization, material requirement and inventory, acceptance of order and delivery date cannot be handled in a proper way.

Realistic systems are rarely deterministic if either the dependencies or boundary conditions are well known. Mathematical models [10, 11, 17] have a great degree of uncertainty with numerous parameters with questionable dependencies.

Aluminium processing is a typical mass not interrupts industry with great dependency on small changes in the whole process because the rules of changes and algorithms are mostly unknown to the conventional mathematical methods and there are not the best methods for solving complex tasks in real production system.

Controlling the material flow, capacity usage, and production cycle time can be of special advantage in case of malfunction. Production process it self is complex enough without all co-processes, which are obviously part of one business process.

What does the shortest operation time mean when we have a long set-up time? What are worthy the high efficiency of capacity usage with constantly long supplier's delivery times and unpredictable delays in the supply chain?

Synchronizing tasks for closely connected processes can be a great opportunity for gaining business at higher efficiency. At the crisis time we need a different scenario for immediate use ever changing conditions and with major parameter – speed. Polajnar et al. [12] reported that only speed could bring a company predominant position on the market.

ERP or MRP II systems provide planning based on current transaction from the market and purchasing, manufacturing execution systems, shop floor control, and data collection system track actually happening at the point of production. Optimizing engine is needed to synchronize customer's expectation and company environment with production execution system.

MPS system can be used for planning and forecasting the future trends on the market and in production process as well. The real situation with many dynamic changes of plan cannot be planned correctly with the system like MPS. The methods of operational research come in place, which provide a search mechanism for reaching contradictory business goals and the best economic results with minimal costs.

2. Modelling aluminium production with genetic algorithm

Genetic Algorithm (GA) is optimization method with great power when a large space of solutions must be discovered. The main problem areas for GA so far are non-deterministic problems which means that way to the optimal solution is not known which is especially true in complexity of production and business processes [6].

The main goal of these models is to reach optimal production plan with consideration of dynamic conditions such as customer orders, inventory, capacity utilization and quality of raw material and products [9, 15]. For easier representation of results and clear model representation it consists of four optimizing phases:

- Data preparation and initial of global variables,
- searching for optimal production plan on bases of customer orders,
- Time scheduling and costs optimization,
- Inventory optimization,
- costing capacity optimization with consideration of raw material quality.

The optimization process is managed with decision tree logic where each optimization task is one node with different attributes. Al-Attar [1] reported about model, which transforms the resource optimization problem into a sequence optimization problem. These attributes help us to control process with particularly rules to rich most accurate goal at different time. Because of lack of time we can execute different phases of optimization out of job time and save the phase optimization results, which can be used as, input when the time for decision is very limited. Values of attributes can be changed on global level and used in particular tasks, which provides a great possibility of various simulations.

2.1 Data preparation and modelling

The purpose data modelling is to provide fast integration path to the operational data from enterprise resource planning system and convert them in proper format. Data in genetic algorithm must be converted into numerical ones, which are used as genes composed in string of them called chromosomes.

The model must describe the characteristics of plant, how the various resources work, time frames, rules, or conditions. There are two different types of data; static data that does not change often (technology, machine parameters, etc.) and dynamic data which changes frequently (orders, customer requirements, market constraints, etc.) [14].

Static data includes all plant data that does not change very often, such as information about the resources (machines, tools, people, materials), as well as basic production processes (routing and operation definitions). Static data also include calendars of work shifts and Bills of Materials.

Dynamic data changes frequently, based on customers, suppliers, orders, shop floor transactions, inventory, due dates, etc. Dynamic data is acquired in enterprise software and imported frequently in scheduler system. The connection between those systems is very important and time consuming.

2.2 Definition of cost function

Decision either we are looking for maximum, minimum or target value of specific function is crucial and must be accepted at the very beginning of modelling a problem case. The whole model can be built from different perspective e.g. the profit can be defined by function based on minimum costs or by searching for maximum incomes [4, 5].

In our case we decide that major goal function will be searching for maximum income based on production plan, available capacity and customer orders. The main cost function is to find optimal production program which can be realized with regard to fixed customer order amount constrained with aluminium metal quantity, capacity availability and order delivery dates. Cost function for reaching maximal profit can be defined as follow:

$$\max(\sum_j (c_j - b_j).Q_j - C \tag{1}$$

c_j - Net selling price product or family products

b_j - Production costs of product or family of products

Q_j - produced quantity of product or family of products

C - fixed costs of operation.

In such a way we simulate environment where numerous combinations of selling prices (c_j), production costs (b_j) and quantities (Q_j) are explored with genetic algorithm and optimal solution is proposed.

3. Analysis of optimisation results

With good scheduling program it is possible to handle much more load than it was before, instead of investing in expensive new equipment [7]. The plant was able to leverage greater productivity and higher throughput from existing resources.

Model for reaching greater productivity is based on operational data and must be verified with different methods. The optimization phases have been simplified with the sense to provide the clear model where results of optimization can be easy interpreted. Other reason is the possibility to solve the same optimization problem with different methods.

In general the evolution engine of genetic algorithm is much more time consuming process when small problem space must be discovered for optimal solution but is very efficient to find up the near to optimal solution in second or third generation. The real power becomes obvious when the complexity of model gets out of control i.e. when the cost functions can no more be expressed with mathematical equations or when the number of variables is very large [3].

Variable non-sequence chromosomes were used for testing another variation of problem model the system with hundred equations and four hundred unknowns. Calculation of cost variable and constraints in each generation evaluates the generated genes and gives us best results. In this model the cost prices of products become variable, and the evolution engine finds itself the relation between the quantity of product and it price:

Method	Simplex Algorithm	GA 1 Chromosome	GA 4 Chromosome
Results	173.320.000	157.486.079	190.331.241

Figure 1. The results of searching the optimal production plan in specific point of time and production stage, which was achieved with different searching method

4. Conclusion

Leading ERP systems already have integrated planning systems such as MRP, MPS, CRP, which give us the powerful tool for planning different resources in different time intervals, from strategic to operational level [2, 4, 9]. Almost all have some simulating tools included.

But the way that we can simulate the whole business behaviour is maybe more important than most precisely predicted states – too late. First of all, we are looking for reason, which can cause bad business results, or opportunities, which can give more value at same price.

With one kind of modelling and with one way of thinking we can easy miss the real cause or opportunity. Modelling and searching for different solutions using evolution methods can give us totally new view on existing state and show up the reason for bad results. This is a way of learning and collecting knowledge.

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SCHEDULING – THE WEAKNESS LINK CAN BE IMPROVED THROUGH APPLYING OF GENETIC ALGORITHM

R. Lujić, T. Šarić, G. Šimunović and G. Matičević

Abstract

Today are well known basic enterprise tasks, those are: how to satisfy customer demands, how to fulfil due dates, low prices and undoubted quality. The most of Croatian enterprises are not able to fulfil obligations according to customer demands in a way of due dates and that is fact that is based on engineers experiences.
So, it can be concluded that the weakness link in Croatian ERP system is inappropriate scheduling model. Usually, scheduling model has not possibility to make plan variants (according to cost, time or both). The article has intention to show how applying of 3-tournament steady-state selection genetic algorithm can improve scheduling process through comparison of different plan variants according to set parameters.

Keywords: scheduling, genetic algorithm, Enterprise Resource Planning (ERP).

1. Introduction

Only the opportune information provides privilege on the market so the meaning of the Information system in the World becomes more significant. The aim of Information System has been changing: from separate programs called information islands, to package programmes of universal application and Management Integrated Information System - MIIS to Computer Integrated Manufacturing - CIM [1].

Table 1 shows what was before and after appearing of ERP system [2].

Table 1. With and without ERP systems

Before ERP	With ERP
Islands of information	Consolidated "Big Picture"
No real-time data	Real-time data
Low accuracy of information	High accuracy of information
Manual collation of information	Instant reporting

Problems before ERP system existed are: delays, lost orders, keying into different computer systems invites.

ERP is integration of data and processes which enables business process optimisation and standardisation, business process documentation and measuring of business process performance.

ERP attempts to integrate all departments and functions across a company onto a single computer system that can serve all those different departments' particular needs. ERP automates the tasks involved in performing a business process. If installed correctly, it can have a tremendous payback. The basic ERP functions show figure 1 [3].

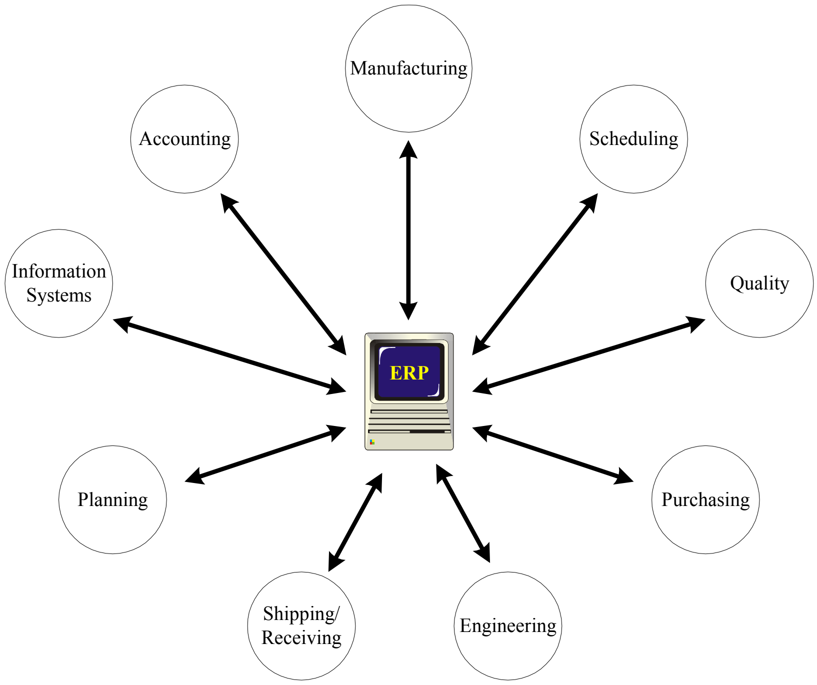

Figure 1. ERP functions

Figure 2 shows relationships between mentioned functions [3].

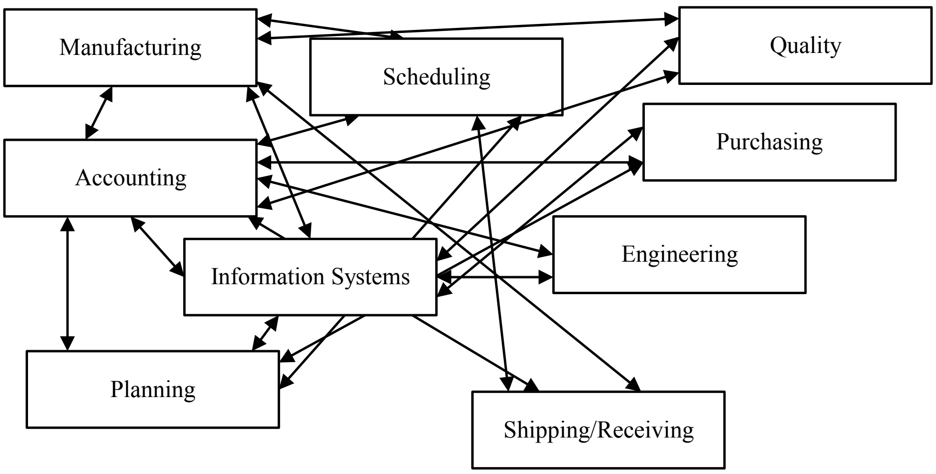

Figure 2. Relationships between ERP functions

2. Planning and Scheduling

Planning and scheduling are very distinct. Planning defines what have to be finished and restrictions that are connected with jobs; in the same time scheduling defines how and when that will be done. Scheduling refers on temporary defining of necessary activities and operation for actual plan [4].

Production planning figures out which products to produce, when to produce them, how to produce, and how many of each with the goal how to meet delivery and keep costs low.

General postulates of scheduling problem can be defined through: set of activities that have to be done, set of resources that can be used on activities, set of restrictions that have to be satisfied, set of goals that define efficacy of scheduling which is the best way for resources joining to activities in required time, so all restrictions can be satisfied and goals fulfil.

Figure 3. shows stages in production planning and scheduling

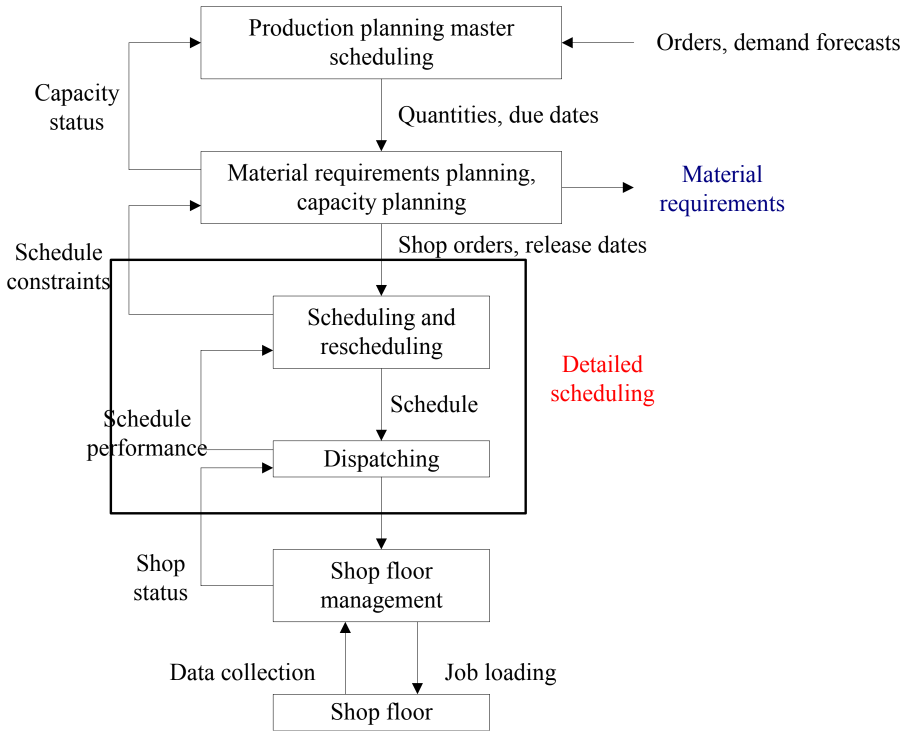

Figure3. Stages in Production Planning and Scheduling

Usually, planning means generating of production tasks together with forecasting of prices and market demands for longer period. Scheduling means joining of resources to activities, defining of priorities and staring times of activities for shorter period [5].

Figure 4. shows plan creating, which requires process models, defining relations between activities and resources, set the goals, evaluation of human resources, data structure and algorithm that all these things can be realised. Scheduling provides resources per operations according to required time. Activities can be everything from technological operations till development of software modules.

Resources are human beings, machines and row material. Typical goals are minimizing of overall project time, minimizing of products due dates overrun [4].

Scheduling problem includes many restriction types such as temporary, depends on position, according to possibilities and combination.

Scheduling is activity with lot of important tasks [6]:

- to fulfil due dates according to customer demands,
- to minimise of due date overrun,
- to minimise of preparation time,
- to increase utilisation of resources,
- to decrease of idling,
- to decrease of stores in process.

Naturally, all these goals are in confrontation. So, the scheduling goal is not to fulfil just one criteria (etc. due date), more often is junction of different requirements. The only way is to find balance between opposite criteria.

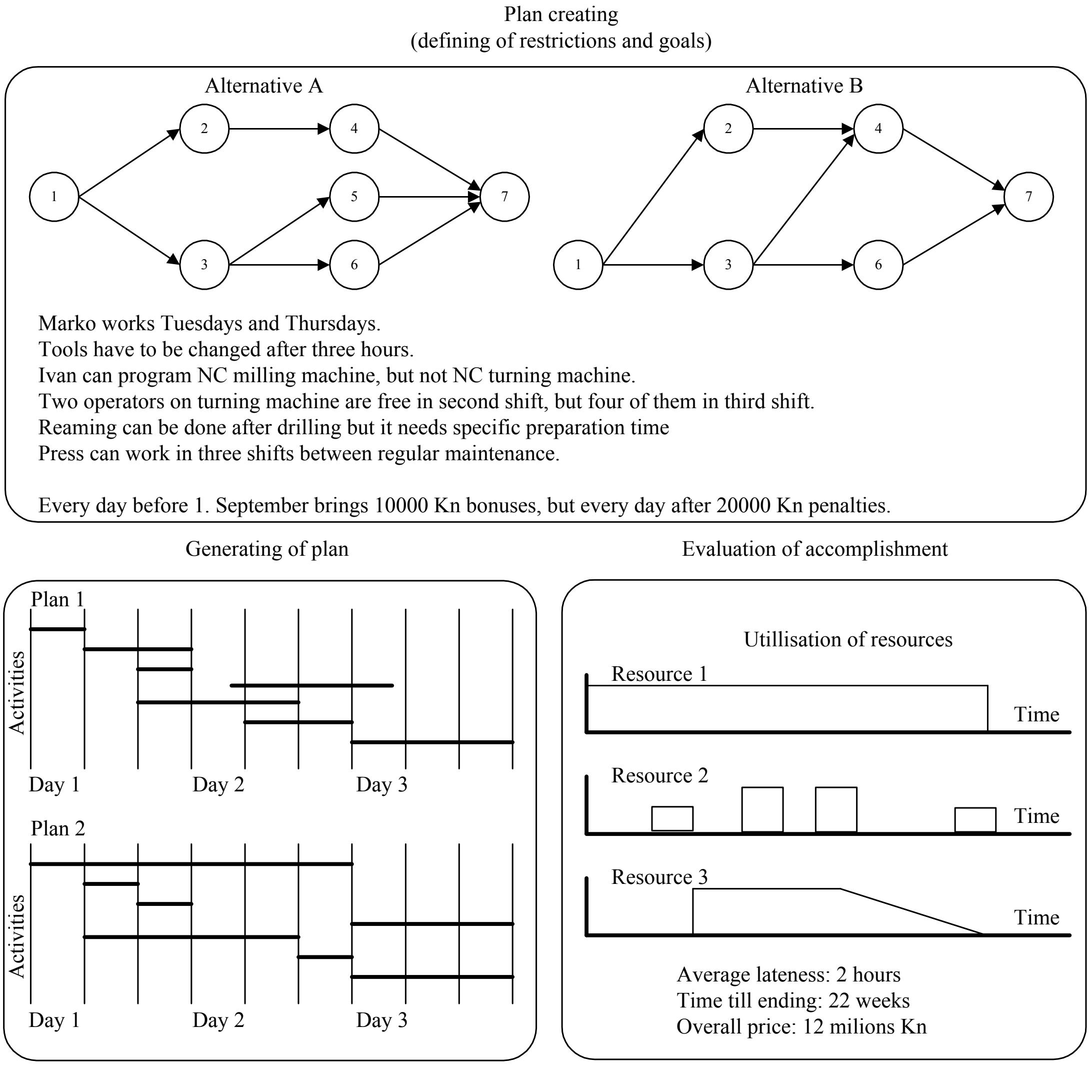

Figure 4. Review of creating, generating and plan evaluation

3. Genetic Algorithm (GA) and Scheduling

Today exists a lot of models and methods (based on mathematical techniques, AI techniques etc.) that can be used in problem of plan variants determination. Despite efficiency of mentioned techniques it can be very hard to find optimal solution (there are lot of different influence factors) in real time so the better way is to find sub-optimal or near optimum solution which is acceptable in time frame. One of applicable solutions can be achieved through the applying of Genetic Algorithms.

Genetic Algorithms are stochastic search and optimisation algorithms based on the mechanics of evolution and natural genetics.

The main goal is to achieve decreasing of manufacturing time through the prediction of GA parameters (population size, selection types, crossover and mutation factors, GA stopping conditions and other technological and non-technological parameters) which will allow efficient dynamic scheduling and term plan variants. The problem is to find optimal order of operation in production.

3-tournament steady-state selection genetic algorithm is chosen in this case.

Tournament selection can be divided according to number of chromosomes that are involved into tournament: 2-tournament, 3-tournament etc. K-tournament selection (k=2,3,4,...,N) with the same probability chooses k chromosomes and between them the best and the worst chromosomes will be selected [7].

Characteristic of 3-tournament steady-state selection without duplicates is to choose randomly three different chromosomes from the population and after that the worst chromosomes will be eliminated according to fitness function [8].

The task is to schedule *i* products with *j* operations in quantity of *n* pieces on *k* machines. So, table 2. shows necessary input and output variables of suggested GA

Table 2. Input and output variables of suggested GA

INPUT VARIABLES		OUTPUT VARIABLES
Setup time	Population size	Term plan variant
Machining time	Selection type	
Due date	Crossover factor	
Price	Mutation factor	
Number of pieces	Inversion factor	
Machines availability	Condition to stop GA	
Starting manufacturing date	Weight factors	

Through the initialisation the starting population will be generated usually randomly from the range of possible solutions. After that the selection process will be started where according to fitness function the best chromosomes will be chosen, and whose genetic materials will be transfer through the reproduction process in the next generation, and worst chromosomes will be eliminated. The next step is crossover where the attribute will be transferred from parents to children. Following is mutation that presents random changing of attributes. It means that genes in chromosome will be changed. In such a way attributes are better and better from the generation to the generation.

Experimental results that are realised through the applying of GA in a few attempts are shown through table 3. The GA characteristics are: the size of starting population is 50, number of iteration is 5000 and mutation factor is 0,1%. The GA was programmed in combination of C and C++.

In verification process except GA the following rules are used: FCFS (First Come First Served), EDD (Earliest Due Date), SLACK (minimum SLACK), CR (Critical Ratio), SPT (Shortest Processing Time) and LPT (Longest Processing Time).

The results that are achieved through applying of mentioned rules and GA and comparison is given in table 4.

Table 3. Experimental results through the applying of GA

Attempts	Values of fitness function	Average lateness
1.	5.313267289519	179,6
2.	5.473354095074	185,1
3.	5.697977937667	204,1
4.	5.716704789519	270,6
5.	5.857144604334	292,3
6.	5.881434170962	299
7.	5.993419124666	388,1

Table 4. Display of comparative results of testing rules

	Results	
	Average finishing time	Average lateness
FCFS	2753,8	472,2
EDD	2779,8	267
SLACK	2884,3	267
CR	2862,3	267
SPT	2729,8	371
LPT	3009,7	543,8
GA	2588,5	179,7

4. Conclusion

Modern manufacturing has lot of complex problems that require development of new methods, models and systems not just on planning level but also on scheduling level. Through applying of genetic algorithm the term plan variant can be realised. It is necessary to emphasize that realised plan cannot be optimal. From the comparison results can be seen that all rules except GA define only one possible solution (term plan). GA compares lot of plans according to fitness function and specified number of iterations. Between these solutions can be expected that some of these solutions will have better results than other rules.

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TECHNOLOGY PARK (TP) MOSTAR – THE PLACE FOR DESIGN AND DEVELOPMENT OF SMALL AND MEDIUM ENTERPRISES

V. Majstorović, V.Višekruna and D. Petković

Abstract

Before the last war, the city of Mostar and the region of Herzegovina stood for one of the most significant economical centers of the former Yugoslavia. Developed base industry, high level of finalization of valuable and sophisticated products from the metal-working industries, developed agricultural sector and food industry were just some of the basics of its previous economical state. Unfortunately, the consequences of war and world economical changes in the course of the last 15 years resulted in fully different economical state.

This paper deals with problem issues of setting up a technological park as a foundation for the economical reconstruction. It would try to build up a net of successful SMEs that would lead to big business systems.

The question we ask is if this is possible in our conditions, as some countries, today stabile members of EU (Spain, Portugal, Ireland) have just undergone such a process, being some 20-30 years ago basically of the same economical status as the region of the former Yugoslavia. The paper elaborates the basic conditions of setting up such a TP.

Keywords: technology park, technology transfer, SME, human resource, entrepreneurial.

1. Basic problem issues

Before the last war, the city of Mostar and the region of Herzegovina stood for one of the most significant economical centers of the former Yugoslavia. Developed base industry, high level of finalisation of valuable and sophisticated products from the metal-working industries, developed agricultural sector and food industry were just some of the basics of its previous economical state. Giant factories as ALUMINIJ, SOKO, HEPOK etc. were significant and very well known names in the business field outside the country as well. Unfortunately, the consequences of war and world economical changes in the course of the last 15 years resulted in fully different economical state. It is without question that the Western Balkans' countries, as well as many others in the vicinity, will have to find their way towards the world's economical relations through the development of small and medium companies (SME). In the developed systems of the capitalist economy these companies started as "suppliers" of the big systems.

Unfortunately, in our case, such a chance was not taken during the arrangement economy period, so now we must take the other way. Parallelly forming a net of successful SMEs, which are to become large business systems, is not impossible. Some countries, today stabile members of EU, like Spain, Portugal or Ireland, have just undergone such a process, and some 20-30 years ago they were basically of the same economical status as the region of the former Yugoslavia.

Of course, every large production system that managed to survive all the problems of the last decade of the last century and with the help of the foreign partners managed to start fresh, can be very helpful for the SME net formation. As foreign experiences show us, one of the key roles for the formation of such a net, is the role of technology parks.

2. Technology parks

“Technology park” stands for a more or less wide notion, used to describe various attempts to encourage the development of the “undertaking spirit through knowledge-based small and medium companies“ within one state. It has many synonyms, the most frequent are “science park (SP)”, “science-technology park (STP)”, “research park”, “technopolis” or “technopol”.

Let us take a look at the definition of TP given by IASP – International Association of Science Parks (www.iasp.org):

“SP/TP is an organization governed by specialized professionals whose main task is to increase the life-standard of the community by promoting the culture of innovations and competition of associated undertakers and research institutions. To achieve these goals, TP stimulates and manages the knowledge and technology exchange between universities, I&R institutions, SMEs and the market; it helps creating and developing innovations-based companies through incubation and spin-off processes and provides with services for increasing the added value along with the services of high-quality ambiance and equipment in TP.”

As we see, there are more definitions of TP, but the fact is that it represents an SME agglomeration with the following features:

- It is connected to the educational and research institutions,
- It ensures the infrastructure and services for the activities of associated SMEs, in the first row: the real estate and the business space,
- Helps the process of technology transfer,
- Helps the economical development of the region it is located in.

It should be pointed out that technology parks are not merely an SME agglomeration in the field of metal-working and related activities. According to the preferences of the depicted region, technology parks may consist of agricultural, chemical, ecological or metallurgical activities. Their name may also have another determination, as ecology park, agriculture park or bio-park, e.g. Ecology-techno park in Turin, Biomedical Research Department of Technology park in Barcelona or Wood-processing Sector of TP in Jonseu in Finland. Basically, these are all technology parks, because every section of human earning activity has its technological laws.

We witness the formation of local and regional development agencies, stakeholder forums, one-stop shops, incubators and similar forms. It should be pointed out that the formation of TP does not mean duplicating the capacity of the same task. The work field is the same, but the activities of TP are much more sophisticated and complex than the previously mentioned organizational forms. Surely, this is one of the basic reasons for non-existence of a single TP in Bosnia and Herzegovina. TP Ljubljana is the only member of the International Association of the Science Parks, from a considerably wide region of West Balkans. Very different from our region is the region of Spain, here taken as an example of comparison, with over than 70 technology parks of various profiles (Petkovic, 2003).

3. Key tasks and aims of TP

The introductory part shows clearly that the expectations of a TP are great, especially today, when the economy of an entire region is going through a difficult phase, and where every TP could be a generator of SME development and the foundation of this region’s future. It should be the place where the following would be created:

- Motivation and climate for the development of a skill-based company,
- Promotion of self-employment as a modern social trend
- Making a positive image of an undertaker
- Providing employed people with detail information and solutions
- Opening of the new work-places and jobs in the region
- Help when turning the regional potential into commercial companies
- Providing a profile at the market for the high technological company in the region, through foreign partners and international contacts
- Help when creating cluster-formed companies as an aimed group for an international competitive approach

TP should help the home industry become competitive in these times of the global process called the globalization. The economy of the Western Balkans region is at the moment highly incapable of meeting the challenges of this kind, and defining and financing the projects that would help it. For this reason, the aims of TP formation must be somewhat different: the maintenance of the most creative potential in the country, enabling the standard close to that in the western countries, along with the challengeable jobs like those in the West. The same maintained potential, probed in difficult market conditions, would, in ten years, be capable of constructing a totally new industry of the region, based on new assumptions. The primary task of each TP is the growth of SME profit, attributing to the further growth and development of every TP (Tihi, 2003).

If we put it mathematically, the best definition of TP would be:

TECHNOLOGY PARK = PLOT OF GROUND + FACILITIES + EXPERTS' KNOWLEDGE

Every state, region, town or county district may have their reasons for forming a TP, but still the main aim is increasing the number of knowledge-based SMEs. They are the spines of the private sector, because they help develop economy's heterogeneousness. Developing countries lacking the up-to-date high technology knowledge may use a TP to attract foreign investment, arrange business and increase the state budget. Our aim is, as well, preventing the best young scientists to leave the country, by offering them attractive jobs and good profit here. But this must be accompanied by the transformation of University, from mere tuition to undertaking. The next important factor is encouraging the technology transfer from research institutions to the economy (Lesjak, 2002).

4. The main premises for development of TP Mostar

As we see from the previous chapters, the role, place and significance of every TP can be estimated. When it comes to the region of Herzegovina, for which TP Mostar would be built, profiled and developed, various options of its foundation and development are possible. The qualitative Study should decide which solution comes as the most acceptable and valuable one. Various disciplines would lighten up all the sides of foundation of TP Mostar.

Technology park should be a creative environment for commercial research and work of the companies involved in research and development. It should be an association of SMEs, engaged in works dealing with research and University. From the legal point of view, TP is a kind of contract, binding SME to the University and regional or central government, as founders of university. University guaranties these company's business activities, some work space and equipment, as well as administrational help, while the companies are expected to engage university's personnel into these activities, and offer stronger technological basis for including the students into practical work (e.g. vacation praxis etc.).

TP founders can be the University or certain individual faculties, county districts, regions, cantonal government and individual firms, the modality of which should be discussed in detail in the qualitative Study. The work of TP would be based on the continual generation of the new research personnel from the University. TP is a flexible structure consisted of small relatively independent parts. Along with the development of TP, this structure is dynamically changing and adjusting to the market's demands.

In our conditions, TP must provide the University and local economy with development component, as well as small expenses for the founders (University, Town, Canton, District), at least at first, until the situation improves. Consequently, its organization cannot copy those in the developed countries, nor shall its business character be as exclusive as in the West.

Out of defined aims of TP, its primary tasks are visible as well (Petkovic, 2003):

- To absorb the latest scientific achievements from Europe and the world and turn them into production technologies available to the undertakers,
- Application of the knowledge useful for the development of the community,

- Active participation of the large number of university's personnel, not only research-based, but also through practical application of the knowledge, in order to gain profit, which is the primary interest of the undertakers,
- To spread scientific thoughts to the other fields, like marketing, management, law, financing etc. and make the work of SME complete and comprehensive.

It should be pointed out that the preferential technologies of the future TP Mostar are to be chosen by the qualitative Study. Its development profile should be made after taking into account what was before, what the world is seeking at the moment, and what the anticipations for the future are. Considering all the previous assumptions, conditions of micro and macro location, international trends etc., the profile of this TP is very wide, moving from food and drinks production and manufacturing, over metal-working and machine-building Sector, towards rational use of natural resources for ecological production and energy resources exploitation (Petkovic, 2004).

5. Conclusion

We see TP Mostar as a generator of SME development in the region of Herzegovina. In the developed countries, it is an optimal solution for SME development. Of course, we cannot expect any conclusions to come up "over night", because forming a TP is not a "piece of cake" for any government in the world. TP project should give the key answers on viability of such a project and define the concept of regional economical development as well as its connection to SME. Other questions require answers as well, as: what is the structure of SMEs, compatible with the work of TP? How are the private undertakers within one TP connected and how can a TP influence the development of undertaking? How to participate and how to leave a TP? What is the undertakers' interest when participating? What is a cluster and how to run a cluster policy? What is the role of universities/ faculties in joining the resources for forming a TP?

One of the most important questions of every TP is the question of its legal registration, organization and structure of the potential ownership relations.

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A GENETIC ALGORITHM APPROACH FOR MANUFACTURING CELL DESIGN

T. Mikac, M. Perinić and S. Vuković

Abstract

Group technology (GT) is a manufacturing philosophy, which determines and divides the parts into some families and the machines into some cells by taking advantage of part similarity. Cellular manufacturing (CM) is the implementation of GT to the manufacturing process. To solve that problem usually known as the cell-formation problem, a lot of approaches have been developed. In this paper, a genetic algorithm approach for designing independent manufacturing cells in cellular manufacturing with alternative process plans is proposed. Several manufacturing parameters, such as production volume, machine capacity, processing time and number of cells, are considered. The problem is formulated through adequate mathematical model and solved using genetic algorithm that determines the machine cell, part family and process plan for each part simultaneously.

Keywords: group technology, cellular manufacturing, cell formation, genetic algorithm.

1. Introduction

In a cellular manufacturing environment, the application of group technology (GT) is one of the main works. Group technology is a manufacturing philosophy, which determines and divides the parts into some families and the machines into some cells by taking advantage of part similarity. Cellular manufacturing (CM) is the implementation of GT to the manufacturing process. The advantages derived from CM include reducing the number of setups and material handling costs, decreasing work-in-process inventories, improving space utilization, and simplifying planning and scheduling. The fundamental problem in CM is to identify and create machine cells and associate part families.

The procedure of the machines and parts to form cells in CM is called a manufacturing cell design. The manufacturing cell design is an important step in the development and implementation of cellular manufacturing systems. Standard cell formation models ignore many manufacturing factors and only consider machining operations of parts, so manufacturing system is presented by a binary machine-part incidence matrix A where 1 is number when part j is processed on machine i and 0 otherwise. For the successful implementation of CM, the identification of independent manufacturing cells is necessary in the design phase of cellular manufacturing [1].

Generally, the design of independent manufacturing cells may not be possible without duplication of bottleneck machines. Although the design of independent manufacturing cells requires additional capital investment, the more simplified production planning and scheduling functions might provide enough savings to justify them. Considering that a part has two or more process plans and each operation associated with a part can be processed on alternative machines, it may be possible to design independent manufacturing cells without much additional investment. Also, consideration of alternative process plans may greatly enhance the efficiency of grouping [2].

To solve that problem usually known as the cell-formation problem, a lot of approaches have been developed. Among them, GA approaches have been used to reduce the computational complexity [3, 4]. Genetic algorithms are heuristic search techniques that utilize analogies to natural selection and survival of the fittest. They employ a population of solutions, combining the solutions in specific way in attempt to form better solutions. In this paper, a genetic algorithm approach for designing independent manufacturing cells in cellular manufacturing with alternative process plans is proposed. Several manufacturing parameters, such as production volume, machine capacity, processing time and number of cells, are considered. The problem is formulated through adequate mathematical model and solved using genetic algorithm that determines the machine cell, part family and process plan for each part simultaneously. We coded a computer program in Visual C^{++} and used an IBM compatible Pentium computer to perform the computations. Final results show the effectiveness of the proposed algorithm.

2. Problem formulation

Cell formation is an assignment-type problem and can be summarized as follows: given n items and m resources, the problem is to determine an assignment of the items to the resources optimizing an objective function and satisfying a stated set of additional side constrains. An objective function provides the basis for evaluating the machine groupings arrived at by a genetic algorithm searching method. In this work, objective function model combining the minimization of cell workload variation [5] and minimization of duplication amortization costs is developed to determine the process plan for parts, part family and machine cell simultaneously.

2.1 Assumption

(1) Alternative process plan for each part are known.
(2) Number of cells for configuration and upper limits of the number of parts in each cell are known.
(3) Only one same type machine within each cell exist.

2.2 Notation

i machine index (i = 1, 2, 3,…, nm)
j part index (j = 1, 2, 3,…, np)
k process plan index (k = 1, 2, 3,…, npp_j)
c cell index (c = 1, 2, 3,…, nc)
p_{jk} process plan k for part j
t_{ijk} processing time on machine i for part j under process plan k
ac_i duplication amortization costs of machine type i
uc upper limit of the number of parts in cell c
cam_i capacity of machine type i
pv_j production volumes for part j

$$x_{jkc} = \begin{cases} 1, & \text{if part } j \text{ processed under process plan } k \text{ belongs to cell } c \\ 0. & \text{otherwise} \end{cases}$$

$$y_{ic} = \begin{cases} 1, & \text{if machine type } i \text{ belongs to cell } c \\ 0. & \text{otherwise} \end{cases}$$

$W = [w_{ij}]$ machine-part incidence matrix where w_{ij} is the workload on machine i induced by part j under process plan k
$Y = [y_{ic}]$ cell membership matrix
$M = [mc_j]$ matrix of average cell load where mc_j is the quotient of total load of cell c induced by part j with number of machines in cell c

2.3 Model

The mathematical programming formulation of the grouping problem through proposed model is as follows:

$$\text{Minimize } WC = \sum_i \sum_j \sum_k \sum_c (W - M)^2 \cdot x_{jkc} + \sum_c \sum_i ac_i \cdot y_{ic} \quad (1)$$

where is:

$$w_{ij} = pv_j \cdot t_{ijk} \tag{2}$$

$$mc_j = \frac{\sum_i y_{ic} \cdot w_{cj}}{\sum_i y_{ic}} \tag{3}$$

subject to:

$$\sum_k \sum_c x_{jkc} = 1, \forall j \tag{4}$$

$$\sum_j \sum_k x_{jkc} \le uc, \forall c \tag{5}$$

$$\sum_j \sum_k pv_j \cdot t_{ijk} \cdot x_{jkc} \le cam_i, \forall (i,c) \tag{6}$$

$$x_{jkc}, y_{ic} \in \{0,1\}, \forall (i,j,k,c) \tag{7}$$

$$\sum_c y_{ic} = 1, \forall i \tag{8}$$

$$\sum_i y_{ic} \ge 1, \forall c \tag{9}$$

Constraint (4) ensures that only one process plan is selected for each part, and that a part belongs to only one cell. Constraint (5) imposes the restriction on the maximum number of parts in a cell in order to have easy planning and control. Constraint (6) implies that total workload for a machine type are less than or equal to one's available capacity. Constraint (7) indicates the 0-1 integer variables. Constraint (8) ensures that particular machine is assigned to one cell only. Constraint (9) ensures that no cell is empty.

3. Genetic algorithm approach

GA is a meta-heuristic for solving combinatorial optimization problems [6]. But because the variables are constrained to integer values, the model is difficult to solve for a large number of parts and machines due to the computational complexity. Proposed approach using genetic algorithms is developed to solve the simultaneous process plans selection and independent manufacturing cell design problem.

3.1 Representation and initialization

Representation is first step in applying genetic algorithm for solving machine cell design problem where each gene represents a process plan number and cell number for each part. A candidate solution is represented by a string of numbers known as a chromosome, where length of the chromosome represents the number of parts considered in the problem. If the number of parts is np, a chromosome C can be represented as follows:

$$C_i = [g_1\ g_2\ g_3\ \ldots\ g_f\ \ldots\ g_{np}] \tag{10}$$

where, C_i is the ith chromosome and g_f is the fth gene within the C_i.

In this chromosome, let the number of process plans for each part be npp_j and upper limit on number of cells be nc, the range of g_f be $[1, npp_j \bullet nc]$. If d is a g_f from C_i, the process plan number for the part j and the cell number can be calculated by the following equations:

$$k \leftarrow (d-1) \setminus nc + 1 \tag{11}$$

$$c \leftarrow (d-1) \bmod nc + 1 \tag{12}$$

By Eq. (11) and (12), C_i can be represented as follows:

$$CC_i = [(k_1, c_1), (k_2, c_2), (k_3, c_3), \ldots (k_f, c_f), \ldots (k_{np}, c_{np})] \quad (13)$$

For instance, let $np = 6$, $npp_1 = 2$, $npp_2 = 2$, $npp_3 = 3$, $npp_4 = 1$, $npp_5 = 2$, $npp_6 = 3$, and $nc = 3$, we have the following chromosome:

$$C_1 = [\ 4\ \ 3\ \ 6\ \ 2\ \ 5\ \ 7\ ] \quad (14)$$

By Eq. (11) and (12), C_i calculates that the process plan number and cell number for each part. The result values of the above chromosome are shown as follows:

$$CC_1 = [\ (2,1)\ (1,3)\ (2,3)\ (1,2)\ (2,2)\ (3,1)\ ] \quad (15)$$

The second step in genetic algorithm is to initialize the population of chromosomes. In this model initialization of the population of chromosomes is generated randomly.

3.2 Evaluation

The goal of optimization problems is to minimize some cost function. The objective function for the cell design model in this paper is formulated in order to minimize the sum of the cell workload variation (machining costs) and machine amortization costs (duplication costs). GA procedure computes fitness value based on the original objective function for each string of the solution space so string with the maximum score function is determined.

Fit-fun (n) = max { const / WC }

3.3 Crossover and mutation

Crossover is aimed at exchanging bit strings between two parent chromosomes. In this model two cut-point crossover method is used. For example, the parent chromosomes are randomly selected and the cut points are then randomly selected as follows:

two cut points

↓ ↓

[4 3 6 2 5 7]

[3 5 7 1 1 5]

Offsprings formed by exchanging the end parts of their parents are as follows:

[4 3 7 1 1 7]

[3 5 6 2 5 5]

Mutation is performed as random perturbation. The mutation operator for cell design problem is designed to perform random exchange. For a selected gene g_f, it will be replaced by a random integer with [1, $npp_j \bullet nc$]. An example is given as follows:

selected gene

↓

[3 5 6 2 5 5]

In this chromosome, the third gene is selected for mutation. The value of the gene is replaced by a random integer value [6]. If the value is 4, then the offspring after mutation is:

[3 5 4 2 5 5]

3.4 Selection

Selection strategy means sort of parents and offsprings on ascending order and selection of the first pop-size chromosomes as a new population. This strategy deletes all duplicates among parents and offspring.

4. Numerical example

In order to demonstrate the efficiency of the proposed methodology, an example of manufacturing system with 10 machines, 7 parts, 3 cells, and 200 duplication amortization costs for each machine is considered. The set of process plans, production volumes for each part, processing times per unit in minutes and machine capacity are given in Table 1., and the maximum number of parts in each cell is restricted to five as in literature example [3].

The genetic parameters for example problem are as follows: crossover rate $p_c = 0.6$, mutation rate $p_m = 0.2$, maximum generation *max-gen* = 500, and population size *pop-size* = 100. We coded a computer program in Visual C^{++} and used an IBM compatible Pentium computer to perform the computations. The initial data matrix similar to example from literature [3] is shown in the Table1.

Table 1. Data of the machine-part processing

Part	Process plan	Machine										pv_j
		1	2	3	4	5	6	7	8	9	10	
1	1	2		3							2	80
2	1					2				3	1	80
	2	4		5		4				7		
	3	6		5		7				5		
3	1	6				5		6				80
	2					3		3				
4	1			4		5					7	80
	2		4			7					6	
	3					3				4	3	
5	1			4	2					5	2	80
6	1	5	6				4		8			80
	2	2	4				2			4		
7	1			5	7					3		80
cam_i		2500	2300	2000	2200	2000	2500	2500	2000	2000	2000	

With constancy const = 10^8 only one optimal solution is obtained, and this result is listed in Table 2. If we compare this solution to results from literature [3] where two alternative solutions are obtained, it is clear that with our objective function that results are not alternative solutions with equal fitness value. That comparison is shown in Table 3.

Table 2. Optimal solution

Solutions	Cell number	Part (plan)	Machine	Fitness value
Optimal solution	1 2 3	2(1) 3(2) 4(3) 1(1) 5(1) 7(1) 6(2)	5 7 9 10 1 3 4 9 10 1 2 6 9	7 998

Table 3. Values of alternative solutions from literature [3]

Solutions	Cell number	Part (plan)	Machine	Fitness value
Alternative solution 1 from literature [3]	1 2 3	1(1) 5(1) 7(1) 2(1) 3(2) 4(3) 6(2)	1 3 4 9 10 5 7 9 10 1 2 6 9	7 998
Alternative solution 2 from literature [3]	1 2 3	3(2) 2(1) 4(3) 6(2) 1(1) 5(1) 7(1)	5 7 1 2 5 6 9 10 1 3 4 9 10	7 751

In this example, the genetic algorithm based approach is able to find an optimal solution within a satisfactory execution time.

5. Conclusion

We studied a problem of independent manufacturing cells design considering alternative process plans and machines duplications with the objective of minimizing total workload and machine amortization costs. The problem is formulated as a 0-1 integer programming model, and a genetic algorithm based approach is developed to solve the problem. The model identifies part families and machine cells simultaneously, and it also specifies the process plan for each part. Proposed approach is demonstrated by using appropriate example. From the result of examples, the proposed approach is very effective to solve cell formation problems as well as methods from the literature [3]. The results obtained using the proposed approach is optimal solution.

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THE REENGINEERING METHODOLOGY OF BUSINESS PROCESSES

Z. Milanović, I. Veža and N. Letilović

Abstract

The influence of IT technology has resulted in a modification in the way of businesses are being done. According to this influence the new paradigms for products and services has been set. The newly established paradigms must comply with: the end user requests, the employees' requests and above all the systems that generate those products and services. If a company wants to survive on a modern market it needs to reorganize its production systems. One of the possibilities lies in a business process reengineering.

1. Introduction

Real-life organizations structure into a large company and corporation hardly may do with consumer satisfied, and slowly reaction on their desire and change which are occur on the market, and that mean to are biggest and nethermost change of course necessarily into a area manipulation and management on all level.

To satisfied request customer for some the product or service organization must be execute consequent activities in order to create that product (service) with minimum expense commerce, with large profit, on satisfied workers. Then, commercial process must be in-depth elaboration, stable, adaptive each request customer, i.e. must be effective.

For resumption such target necessarily is into a company know flow business process, theirs internal rule and validity, and way on which be exactly that may describe accept all detail which influence on flow business process, over wherefore we have accept about often presence dual business orientation company in which with one side do we have core business on at the same time outsourcing of all possible rest activities for which is company favourably to buy of company which produce that like us core business.

Essential, it very important to have wholly clear conception business process in some company, whereby via unquestionably graphically languages escape obstruction toward obviously one business process. Obstruction result mostly because of the various aspect view on the same process, and because of the various adeptly segment. Scheer [2] sets new standard for the action control business process which contain the following segment:

- constantly method enhancements,
- initiation calculation efficiency and profitably for standard software,
- hasten process in relation with opposition,
- analysis weakly points in the case present to the view tight throttle into a process work,
- initiation control into a work process,
- collecting information for estimation cost work process.

Tool expression exactly real-time for which yourself may somewhat create without separately effort. Adaptability valuetion and target this approach give ideally solution for all company which work agreeably with process and which want constantly improve standard servisne equipped.

2. Reengineering business process

Notion business process reengineering (BPR) is first set in year 1990. in one article write from Michael Hammer [1] and publish in Harvard Business Review. Into a year 1993. Michael Hammer and James Champy [1] publish the book with caption: ”Reengineering the Corporation – A Manifesto for Business Review" where method BPR define on the following way:"Reengineering business process is change thinking and remodel business process with target improvement key parameter of business like us: product quality, services hasten and business expenses”.

Method BPR occur like mood solving problem into a organization like logical answer on difficulties which sets modern market, his dynamic and acquiring. Modification into a company never come without reason and mostly are cause crisis situation whether format (crisis liquidness, crisis result, negative trend reality in relation with expectance profit, strategic crisis and similar). Minimum visible crisis is strategic crisis, whereby in despite of currently good situation with profit can indication crisis which we have be capable recognize and eliminate duly. These indication are recognizable over dissatisfaction clients, decline interest on the market, low quality the products, and into a business process over frequently mistakes, over overdue reactions, over making tight throttles, over indefinitely flow over business process. Elaborate and implementation project method BPR can obtain the following enhancements:

- enhancement quality proizvoda/service,
- shorten time from entry to exit,
- bigger satisfaction kupaca/client,
- bigger satisfaction employees,
- priority in relation with opposition,
- bigger profit company,
- decrease expense operate.

Fundamental target reengineering each commercial process is obtain high-quality finally products (services) on less expenses, and capital notion which ties on method BPR are processes and modifications.

2.1 Basis starting-point and main features reengineering business process

Basic starting-point reengineering business process is process access, i.e evolution process orientation into a company whose are attribute the following:

- transaction phase into a process naturally, logical and rationalization precedence,
- knowledge to process have more ways in which can execute,
- transaction business where for it has a mostly meaning,
- attempt to more businesses make one business,
- include all employees into a process decision,
- decrease classic format control.

The following basic starting-point of method BPR is orientation on base – main function and setting highly target which reengineering business process want realize.

Basic features of method BPR are the following:

- basis variation way thinking
  Understand return to basis thinking about process which lead into a some company.
- completly or total new define business process
  In this case not practice improve established business process than him totally leave and evolution modern process organization.
- drastic change
  Here understand change result by method BPR on established business process, which are such character to expect big improve into a business result area.
- orientation toward process, and not toward structure or function

Method BPR starting from thinking that are men basis organizations and hers most important resource, and that their knowledge and experience is necessarily into a new design business process. Process does watch entirely and leave individually view on the product which accrue like result all process into a company. Method BPR set-off significance team work, good communications, and significance change into a way thinking all employees into a meaning an unlimited into a review full process.

2.2 Phase reengineering business process

Reengineering business process does lead into a few phase [3] (figure 1.):

1. Define vision and strategy:
   - define process which is necessarily redesign,
   - define priority and order redesign,
   - define targets method BPR .

   In this phase must be completely clearly define which does improve want obtain with method BPR (shorten time from entry to exit, new the product, decrease expense business…)
2. Conceptual shema of development method BPR:
   - elaborate business process organizations (AS – IS analysis),
   - consider possibility solve,
   - TO – BE conception,
   - simulation AS – IS and TO – BE conception.

   After elaborate AS – IS analysis, in this phase is very easy practicable comparison with other business organizations (benchmarking) which does to work at same function. Also can exactly define our finally set up targets and wishes.
3. Implementation method BPR:
   - preparation and lesson employees on future state,
   - presentation redesign business process,
   - adaptation modifications,
   - feedback information about result modification.
4. Watch redesign business process:
   - measurement organizations modification,
   - analysis organizations modification.

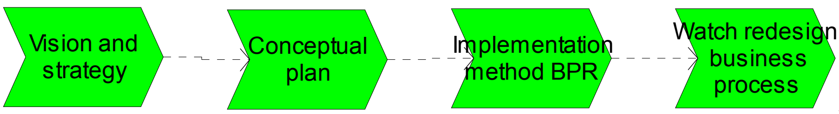

Figure 1. Show phase reenginering business process

Presentation method BPR in company often is necessary modify or totally leave traditional vertical hierarchical structure. Reengineering business process execute redesign established or presentation completely new business process with target enhancements of all possible component business, on exact information which may obtain and watch in each moment simulation really business process.

2.3 Business process

In each present-day company does have to manipulate business process on way to with easiness can see problem, to duly can reaction on mistake, and to can presentation necessarily enhancements. To make this we have completely clear review business process and completely control over their manipulation, i.e. necessarily would be necessarily:

- exactly define process,
- constantly manage process,
- improve noneffective process,
- provide realization modification.

As they in all business organization not exist on all level identical consciousness about totality process, often do we have presence nonflexibility in certain segment business process, and as result this phenomenon and aggravating adoption certain modification which give answer on the following question:

- about feature business process,
- about tight throttle business process,
- about potentially for improve,
- about necessarily personal resource,
- about uniformity load between personal resource,
- about conection between whole database.

Prerequisite for obtain quality answer on mentioned question is initiation simply, and for all obvious model for description business process. Essentially, necessarily is leave traditionally vertical – hierarchy structure and substitute is with process organization which insist horizontality connection activities which execute whereby represent figure 2.

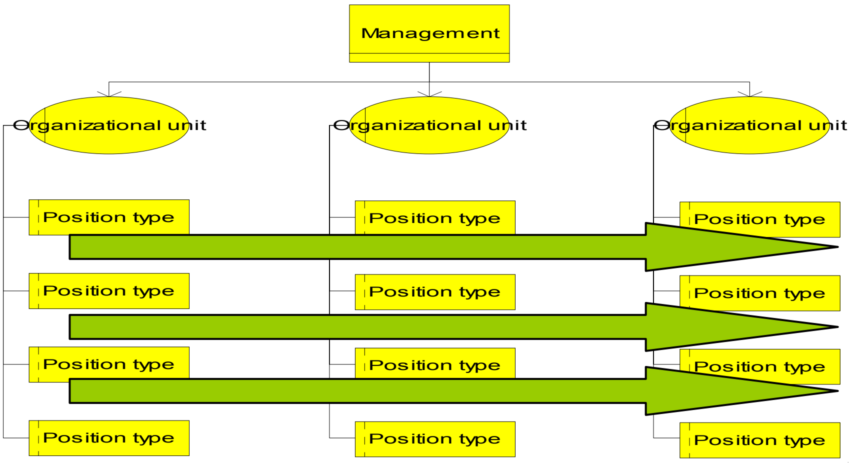

Figure 2. Represent process through section

Process organization does base on following working or business process as a criterion for forming organization unit or working team, instead on business function. On this way employees unite according to process until function hierarchy care for untroubled flow over process. For operation process responsible is master process, and employees from certain business function exceed in process teams which execute concrete business function in a particular business process.

Process organization structure personify process and team orientate organization inside which does show great number simple processes that are focusing on unite execute function particular business process.

2.4 Modeling business process

First step at manipulate production process is their document, and choice work methodology, medium and tool which would it execute. Here will it be apply tool under name ARIS [2,3], and modeling will it be performance into a few phase thus:

- reconsideration and modeling organization structure,
- reconsideration and modeling business process (AS - IS).
  Method top down lowering to level smallest detail model business process.
- versification business process,
- see tight throttle by simulation,
- modeling improve business process (TO - BE).

Model established state necessary have to be really, clearly and easily to be surveyed, because thus may see and decline much illogicality and previous any reorganization company, i.e can improve established state, and such improve model does can define in phase make model established state. After to establish good database business process and visual assign weak point in process, necessarily is realize analysis business process on way to proceed certain measurement. Exactly answer about efficiency process, its weak point and tight throttle, and about expense operate, load employee and similar, give would us simulation which will it be really if we are detailed elaborate business process.

2.5 Kind description business process

Such as already mention, to understand business process necessarily is describe and document them precision and simply. Have more possibilities expression business process and it thus:

- text expression,
- cybernetics expression,
- network diagram,
- process diagram (flowchart).

Text expression is with complexly process and very impractical,vast and complicated in practice. Often does use in combination with process diagram at detailed description certain function and event in business process.

Cybernetics expression is figurative expression in which each process has a its input and exit, and between them occur certain activities which work men to use some method and equipment.

Network diagram is similar Gantt chart and expression movement business process and lengthening all operation. Today is often in apply with large and complexly project.

Process diagram (*flowchart*) is diagram commercially activities and consist chain interconnection logical symbol that are not standard then each software or any other tool has a its prescribe symbol which represent process (figure 3).

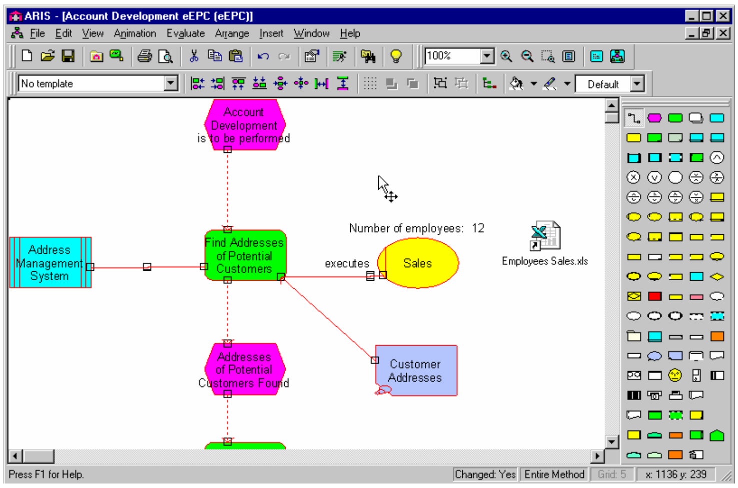

Figure 3. Show model process diagram (flowchart)

Usual is that process diagram (because of the complicated business process) show in more level on way that we work separation process. If one process consist more process under level, make new process diagram to complete show wholle system on simple way, and that can describe own notion business need on efficient way. Flowchart is tehnique which is today used very often by manufacturing project, show business process, and from reengineering business process. Scheer [3] is develop model flowchart using software tool under caption ARIS [2,3] (figure 2.). Characteristically for this model is that we can on very lucid, precise and simply way describe business process through prism event which following after certain function for which obtain exacatly executors.

3. Conclusion

Reengineering of business processes is a need that results as the reaction to many different influences. Some of them are: bigger opposition on the market, constant trend of extending the assortment of products and services, shortening the time from claim to realization (from input to output in business process), constant stress for creation the bigger profit, etc. The basic model of commerce is such, there must exist a process which does occur, and men and technology which support it. If in a company traditionally vertical organization structure dominates that is based on function and structure, redesigning it in a process orientated way, it could answer to those needs.

By using ARIS [2,3] tool it is possible to reengineer a business process in way so that one database of the business process exists, to do simulations of different business scenarios, to recognize weak points in established business system and to establish an optimal one. This approach does empty footstep and tight throttle in company decrease on negliglible small value, expense operate does reduce on minimum, and following all important parameter commerce is simply and quality with probability to duly to see problem whether kind.

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INNOVATIONS IN MANUFACTURING

N. Osmanagić-Bedenik, J. Preister and N. Podrug

Abstract

In cooperation with Fraunhofer Institut, Graduate School of Economics and Business Zagreb and Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (University of Split) are conducting a survey with aim of monitoring technological and organizational modernization of production in Croatian manufacturing companies as well as achieved performance. The purpose of this study is to collect in-depth information about the innovativeness of Croatian manufacturing company, to provide basis for practitioners, policy makers and educators.

Keywords: manufacturing companies, innovations, technical and organizational modernization

1. Introduction

In today's global and increasingly knowledge-based economy, for company's competitiveness is not enough to optimize performances relative to costs, delays and quality criteria. Innovation, defined as the capacity to apply knowledge in improving productivity and creating new products and services, represent crucial element for long-run competitiveness. A synthesis of academic and industrial view on importance of innovation is presented in Tomala and Seneschal's paper (2004). Innovations result in:

- meeting new consumer needs,
- offering a wider range of products and services,
- increasing the quality and the reliability of existing products,
- winning new markets,
- reducing environmental damage,
- satisfying legislation, regulation and standards,
- increasing production flexibility,
- reducing costs (including wages, raw material, energy consumption),
- improving the performance of the various product-linked services.

Innovation must be constant corporate activity because those that do not innovate or fail in the process, disappear irremediably. Although all of such activities do not lead inevitable to radical innovation that completely modify the usual references, it is necessary to emphasize importance of relatively small, incremental innovation meaning slight modifications of existing services and product characteristics.

Competitiveness in transition countries is mostly attained by low prices and less by new design, product innovation or new manufacturing methods (Bastič, 2004). A common characteristic of transition countries including Croatia is that value added is stagnating at a level which is only a fraction of that in the EU, return on capital is low and does not allow investment in new technologies. One of the reasons for low value added is the technological gap between the transition countries and their counterparts in the EU. After gaining independence in 1991, Croatian economic system that was based on social self-management and on the social ownership of production factors turned into market-driven economy and caused considerable number of structural changes. These have been characterized by the shift from social to private ownership, from large to small companies, from industrial to service economy, as well as redirection towards developed European markets and shift from a supply-driven economy into a demand-led one. The aim of this research and paper is to provide an in-depth view into Croatian manufacturing companies and in order to get a clear overview of strengths and weaknesses of a particular company as well as opportunities and threats that arise from external environment. Focus is defining specific organizational and technological answers to ensure a stable and competitive manufacturing base.

2. Towards a European Manufacturing Innovation Survey

In cooperation with Fraunhofer Institut (ISI – Institut Systemtechnik und Innovationforschung), Graduate School of Economics and Business Zagreb and Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (University of Split) are conducting a survey with aim of monitoring technological and organizational modernization of production in Croatian manufacturing companies as well as achieved performance.

The institute has seven scientific departments which concentrate on particularly innovative technology fields, respectively innovation dynamics, at regional, national and international levels. Department *Innovation in Production* in its work covers the following aspects:

- development and realization of technical-organizational concepts (structuring of work systems, moderation of teams, creation of networks, technology-structuring)
- analysis of the distribution of production concepts (survey, case studies, benchmarking, scenario technique)
- impact analysis (economic efficiency, environmental and social acceptability)
- consulting for technology and economic policy.

The survey *Innovation in Manufacturing* on a biennial basis has been conducted since 1993 in Germany and is well known among experts, policy makers and managers. In 2001 the survey included 1630 company establishments, meaning metal and electronics industry, chemical and plastic processing industry. The data are used to advice industry, research, intermediaries and policy on the diffusion patterns and impact of new organizational, managerial and technical concepts (process innovations). Also, the data serves as benchmarks for companies as well as for programme development and evaluation in the area of manufacturing innovation.

Benefits from this survey have been recognized by other countries. Globalization and need for sound international comparison of manufacturing competence, stresses the need for reliable, comprehensive and compatible data on the status of modernization of manufacturing at a European and OECD level. For the 1999 Georgia Manufacturing Survey in the USA parts of the questionnaires were harmonized. In 2001, Belgium and Switzerland joined the survey using the identical questionnaire and in 2003 Austria joined. Idea of gathering partner around on existing infrastructure and questionnaire has been very successful and besides Croatia, France, Italy, Slovenia, Sweden and Turkey agreed on participating and their surveys are in preparation. Australia, Japan, Korea, Netherlands, Norway, United Kingdom and USA are strongly interested. This procedure will ensure not only national data source for scientific purposes and research in the respective national context, but provide the chance to join bilateral and multilateral consortia and research programmes.

Concerning time perspective, the survey runs every two years and underlying philosophy is to keep set of questions constant over time, change others according to changing issues in manufacturing innovation and leave some space for related new or country-specific topics. Partner are given the possibility to keep to the core set of questions in order to limit burden on respondents and heighten response rates, replace/skip questions or adopt the full questionnaire. Several sections are focusing on usage of new information and manufacturing technologies, on innovative organizational concepts and managerial practices, but the questionnaire also comprises company and manufacturing characteristics as well as different performance indicators.

The questionnaire is to be answered by the manufacturing or (in smaller firms) the responsible general manager. It refers to establishments/workplaces with 20 or more employees at a certain location which represents a homogeneous manufacturing unit (and therefore does not necessarily address companies as a whole). Minimum total responses should be between 60 (small) and 300 (big countries). Fraunhofer ISI acts as co-ordinator and offers its expertise in the analysis of such data and helps with implementation of the survey (in particular automated data entry and consistently check applying a common procedure for all countries). Also, Fraunhofer ISI provides first international analysis of the data and proactively promotes usage of the results for international comparisons in co-operative projects of the partners to be funded by the appropriate national or international bodies.

3. Innovation in Croatian manufacturing firms

The focus of the survey is on technical, organizational, and managerial manufacturing innovation in manufacturing firms. The manufacturing sectors to be surveyed where chosen by Fraunhofer institute. Since the questionnaire is limited only to manufacturing companies NACE codes were used to choose manufacturing companies. The sample includes NACE codes 25, 28-35, which can be characterized as discontinuous or piece good manufacturing. Translated to Croatian national codes these industries are:

Table1. Sectors included in the survey

NACE	Croatian code	Description
25	DH	Manufacturing of rubber and plastics products
28	DJ	Fabrication of fabricated metal products
29	DK	Manufacturing of machinery and equipment
30	DL30	Manufacturing of office machinery and computers
31	DL31	Manufacturing of electrical machinery and apparatus
32	DL32	Manufacture of radio, television and communication equipment
33	DL33	Manufacture of medical, precision and optical instruments
34	DM34	Manufacture of motor vehicles, trailers and semi-trailers
35	DM35	Manufacture of other transport equipment

This sample does not cover the whole manufacturing industry but it covers discontinuous or piece good manufacturing where innovations are more important and submitted to faster changes then continuous flow production (Meredith, Shafer, 2003, p. 210).

One of the aims of the paper is to compare Croatian innovation strategies with those of well developed countries. In those developed countries such as Germany this survey is made every two years. Therefore our questionnaire adopted in part the Frauenhofer institute questionnaire. Another part of the questionnaire is devoted to modern concepts in operations management which we found not covered by the Frauenhofer questionnaire. In this part we briefly discuss the aims of the questions. The questionnaire has 18 sections with 14 mandatory sections. These 14 sections are mandatory for the reason of comparison with the results of studies in other countries. Altogether we adopted 16 sections from the original Fraunhofer Institute questionnaire for the reason of better comparison and added two more sections which cover supply chain management and a part describing responding manager and his functions and activities in the company.

The first section covers modern concepts of factory modernization such as virtual company, integrated production system, kaizen, digital factory and so on. The aim of this question is to find out the level of managers knowledge about this modern concepts. The next question in this section covered the competitive advantages of the firm. The responders were asked to rate the importance of a particular competitive priority such as customization, quality, delivery… This is a strategic question with the aim to find the dominant competitive priority in Croatian companies. We believe that our results will significantly differ from the surveys in developed countries because of specific Croatian conditions. For example in America and Europe quality is self evident while some preliminary results show that in Croatia quality is in second place.

Section two is devoted to modernization activities such as the importance of modernization, specific measures of modernization, modernization planning, new product launch and process modernization to detailed resources used in modernization (in person months and €). This is a highly interesting part since it reveals the actual level of investment in modernization.

In section three the responders are asked to identify actual and planned activities in modernization for the next period of three years.

Part four is completely devoted to manufacturing technologies. It covers in depth existing technologies, the level of their usage and reasons why some technologies are not used. This part of the questionnaire is very complex and necessitates high knowledge of production technologies used in the responding firm. Since this part was a mandatory question it will enable us to evaluate the technological discrepancies from the firms in highly developed countries. The lack of financial resources and expensive debt unable most Croatian companies to purchase this modern technology, although this has to be left for later proof.

Section five covers organizational concepts. Organizational concepts evolve as the production and process evolve and innovate (Swamidass, 2001, p. 195). It comprises separate sections that cover organizational structure, organization structure for product development. The responders are asked to what percent they use particular organizational element. They are also asked if they plan to adopt these organizational elements in next two years. They were also asked to reveal why they do not use modern organizational elements as knowledge balances or balanced scorecards. The possible answers are lack of technological and commercial solutions or lack of applicability in the company. Organizational structure for product development in comprises Simultaneous Engineering and cross functional temporary development teams. Responders had to rate the usage of this concepts in new product launch. Special part in this section is devoted to quality and environmental protection. It covers ISO certificates, 6 sigma quality program, and continuous improvement. In this section a great part is devoted to organization of production. It covers topics as fragmentation in production, the level of integration tasks, kanban, JIT, special contracts with equipment manufacturers, life cycle costing.

Section six covers team work in production. Questions cover the level of worker involvement in manufacturing teams and how many workers make a team. This question allows regression analysis on firm's profit. We hypothesize that higher team involvement has impact on firm's profit. It also covers the questions whether the quality controls is lowered to the employee level and are all team members qualified for all tasks.

Part seven is devoted to how specific production tasks are carried out. Specifically it asks how task scheduling, detailed planning of shop floor orders are carried out, CNC program set-up and programming, set-up of machines, machine maintenance and quality assurance. The responders could choose four different answers for each question: done centrally by specialists, done by shopfloor specialists, shopfloor machine operators or not applicable. Indirectly this questions show the empowerment of the shopfloor specialists and operators.

Section eight is devoted to the qualification of the staff and how they are spread among fields such as R&D, logistics, manufacture, sales and distribution, services and general administration. The responders had to indicate the appropriate percentage for each question. Such numerical answers will enable us to do the regression analysis on number of workers to see the efficiency of each field. For example a large percentage of general administration staff will reveal either the inefficiency or the low level of IT usage (therefore higher percentage of worker needed for administration). Low percentage of R&D personnel will mean lower possibility of innovation.

Section nine is indirectly connected with supply chain management. It covers to what extent and with whom companies cooperate in various research and cooperation arrangements. Specifically it covers topics of worker education, R&D with suppliers and customers, research and design with companies from the same market, cooperation in services, purchasing and production. Preliminary analysis shows high level of cooperation in these fields.

Section ten covers the topics of relocation of parts of production. In the first part of the question we ask if relocation took place and to where. Possible answers were Europe, North and South America or Asia. Specifically we ask if the companies have relocated their production, repatriation of production from abroad or relocation of some foreign production to the answering company. This question was added because it is more common in Croatia that foreign companies come to Croatia then Croatian production moving abroad. In the second part of the question we ask the reasons for relocation or repatriation. Among the possible answers were cost of production factors, taxes, communication costs, capacity bottlenecks, availability of qualified staff, infrastructure, opening up the markets, access to technologies, vicinity of important customers, presence of competitors, flexibility or quality.

Section eleven asks to describe the industry and the main product or group of products. The responders had to indicate the NACE class, main product and how much is the share of this product in total revenues. According to this main product, the responders had to answer are they predominantly a supplier or producer of finished goods. If they are predominantly a supplier they had to indicate to which branch (Mechanical engineering, Electrical engineering, and Automotive engineering) they predominantly supply.

In section twelve the responders were asked to describe their main product in the following terms: product development, size of series, production and product complexity. In the part product development the question is how much customers participate in final product production. Size of series varies from unique product to large series of more then 1000 pieces per month. Production part is the question how much is made according to order receipt to make to stock. Product complexity finally investigate are the product one-piece product to complex systems like manufacturing systems. Next part of this section is devoted to lead and delivery time. In this section the percentage of reworked products or semi-products are also asked. The third part of this section is devoted to main changes that happened with the main product in last three years. Responders are asked to respond on a 5 point Likert scale did the product size change, is the demand for accuracy changed, is there a reduction in number of applied materials, functions, components and offered variants.

In section thirteen the responders are asked to have they launched a new product in last three years, which share of turnover did this new product generate and how long did it take to develop this new product in months. They were also asked if this new product is new to the market and not only to the company.

Section fourteen covers the topic of products which are offered more then ten years. The responders are asked which part of the share these products generated.

Section fifteen is devoted to the very detailed description of the company. It asks how many employees the company has in year 2003 and 2001, turnover for these two years. On a three point Likert scale they had to indicate did the purchased volume, amortization, cost of waste disposal, share of staff costs, share of R&D expenditure, degree of capacity utilization, general administrative costs, return on sales raise, decreased or stayed on an unchanged level for this two years. The next part of this question asks how large changes in classical mechanical components, electronics, software and services were. The ratings had to be stated in percentages and how much of the changes were internal labor. Also on three point Likert scale they had to indicate whether this changes decreased, remained the same or increased in this last two years, separately for the total share and of the part that involved internal labor. Finally, they were asked from where they purchase their inputs and where they place their final products.

Section sixteen asks about knowledge and usefulness of governmental measures for research, development and innovation. Three programs exist in Croatia and the web addresses were given to the responders. Apart from these three programs responders could answer on an open end question if they know of any other program.

Section seventeen is about supply chain management integration and practices. It covers several topics. How do firms communicate with their suppliers, what are the supplier selection criteria. They were also asked whether they communicate with the suppliers of their suppliers and do they have any knowledge about them. The upstream side of the supply chain management is also investigated. They are asked if they communicate with their customers and what is their source of information about them. Finally they are asked if in their company exist someone who promotes supply chain management and do they know of companies that have adopted supply chain management.

Section eighteen covers two topics: General information about the manager that answered the questionnaire and general information about the company. General information about the manager in comprised education degree, the level of management, job name, and formal organizational structure. General information about the firm comprised the name of the firm, date it was established, is it a subsidiary of some company, the ownership structure and finally business results in year 2003 (Revenue, export, assets and base capital).

So far we received 30 completely filled questionnaires out of 500, which represents 6% response rate. With additional calls we expect to heighten this response rate to minimum 60 ones. The questionnaire is very lengthy and very detailed therefore the response rate is low. The analysis of data will be done in cooperation with Fraunhofer Institute and will provide immediate comparison with the countries that already made the field study. We expect somewhat lower innovation in Croatia than in developed countries mainly because very expensive capital in Croatia. Some preliminary analysis shows that R&D departments are present in surveyed firms, which is very important perquisite for innovation and staying competitive (Tomala, Senechal, 2004, p. 281). R&D budget is around 3% of turnover which is quite good for Croatian environment. Our prognosis is that around 15% of surveyed companies have adopted innovative manufacturing and organisation. That is a low percentage and should be heightened by various governmental activities and better cooperation of banks with manufacturing companies. One has to bear in mind that entering the European Union in 2007. Croatian companies will have to compete with word class manufactures.

This study forms a base for exploring current practices of Croatian companies regarding innovations in manufacturing and will also form a base for a longitudinal study of innovation management in Croatia. We expect to publish our results on the web pages as well as on upcoming conferences on innovations in manufacturing.

4. Conclusion

This work is a description of work in progress that explores innovations in manufacturing. We thoroughly describe the questionnaire and the purpose of the questions. Innovations in manufacturing are essential for staying competitive (Tomala, Senechal, 2004, p. 281). With the entering in European Union in year 2007, Croatian companies will have to compete on an equal basis with best European players. Therefore innovations in manufacturing are an essential prerequisite. With this research we aim to explore the innovation practices in Croatian companies, identify the differences from the companies in developed countries, and actions which should be made in order to influence innovation in Croatian companies. Some preliminary results are given and the direction of future research is established.

The results are aimed to be a help to practitioners, educators and policy makers as well.

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LOGISTICS AS COMPETITIVENESS FACTOR OF ENTERPRISES IN COUNTRIES IN TRANSITION ON A GLOBAL MARKET

J. Šamanović

Abstract

Enterprises in transition operate in a very uncertain and changeable environment and therefore have to develop the ability to compete and adjust to these conditions. The abilities to compete and adapt are mainly related to a relatively new function of enterprises - logistics.

The process globalisation has significantly influenced the implementation of logistics activities. At the same time, it has also influenced the development of theoretical approaches to the logistics system as well as the management of the activities of such a system.

This paper points out the necessity of enterprise in transition to organise contemporary logistics systems and create efficient logistics strategies. Only the enterprises which recognise the importance of implementation of logistics strategies on international market can improve the quality of logistics and in that way create their competitive advantage.

Keywords: globalisation, transition, logistics strategy, supply chain, logistics team.

1. Introduction

Major challenge which enterprises in transition had to face is competition. Conditions under which they operate had changed so much that many of the enterprises have shifted from the monopolistic position on the domestic market to the exposure to severe competition of global market. Besides, enterprises in transition are present on the global market with raw materials and semi-manufactures, and enterprises from developed countries with high technology products, and therefore the exchange of goods is not equally useful for each. Enterprises in transition find it difficult to achieve competitiveness in the field of production due to the level of technology, the price of capital and organisational level, which are inferior to those of the enterprises in developed countries. Consequently, they should focus on spatial and time transformation of goods, i.e. business logistics. Enterprises in transition should create logistics systems based on their comparative advantages. That will enable them to gain relevant comparative advantages in business ventures over their competition. The need for greater competitiveness is not an imperative only for ambitious enterprises in transition, which want to penetrate foreign markets, but also for those, which are oriented to the domestic market, because it is getting more difficult to protect that market from foreign competition by administrative government measures. According to that, the following working hypothesis has been made: in order to enter the global market enterprises in transition should organise contemporary logistics systems and create relevant logistics strategies as soon as possible. To prove the above stated hypothesis the following methods have been used: analysis, synthesis, deduction and comparison.

1.1 Necessity of implementing logistics in business of enterprises in transition and level of logistics infrastructure

Economics processes with global features and the increase in competition on the global market are conditioned by development of transport infrastructure and means of transport, achievements in information technology, deregulation and standardisation in transport, dislocation of production and expansion of distribution costs (According to the researches the costs of the international distribution range between 25% and 35% of the selling price of the goods, while they range between 8 and 10% within a particular country.).Affirmation of such processes in terms of economy would not be possible without the development of complex logistics systems. Logistics systems contribute to the increased efficiency and speed of the process of flow of goods, ideas, people and information, within and between various national economies. Enterprises in transition should begin creating strategic logistics systems, which will aim at exploiting available resources and comparative advantages, in agreement with the potentials of demand on the domestic and world market. Logistics systems of enterprises in transition are characterised by: undeveloped transport and communication infrastructure, incorrectly located (balanced development of a country) and technically outdated production and storage facilities, the lack of qualified logistics personnel on all levels of management, low degree of utilisation of packaging waste and the lack of environmental protection.

Before shifting to market economy, countries in transition had an expensive and inefficient logistics system. It lagged behind logistics systems of the developed countries for 20 to 30 years (concerning roads infrastructure) (Waters , 1999). For a long time logistics expertise and other management techniques were not appreciated. Quality of products and logistics services was poor and customers' satisfaction was completely neglected. Investing in consumers' services was not treated as a source of progress but unnecessary expense. It caused uncompetitive ness of their enterprises on the international market and overall economic lag. The only exceptions were the enterprises that specialised in the export to the developed countries. The other enterprises operated on "the quasi market" which was dominated by the monopoly of government-owned enterprises. Systems of supply, sales and storage in Bulgaria were made up of 27 logistics subjects, in Hungary 133 specialised enterprises operated on the domestic market and 30 on the foreign market, in Poland 64 enterprises dealt with wholesaling and supplying. In countries members of the Council for Mutual Economic Assistance shipping enterprises had a monopolistic position. Each country had only one shipping enterprise, which was responsible for all foreign trade shipping operations. In Hungary MASPED, in Czechoslovakia CECHOFRACHT, in Romania ROMTRANS, in Poland C. HARTWIG, while Yugoslavia had more government-owned shipping enterprises such as TRANSJUG, JADRANTRANS, CROATIA.TRANSPORT etc (Zelenika, R i Pupovac, D, 2001).

Due to underdeveloped transport infrastructure, incorrectly located production and storage facilities (criterion for investing was an even development and not location factors), outdated transportation means, manipulative technology and large supplies, logistics costs in all countries in transition were very high. They averaged between 20% and 30% of a country's GDP, which is twice as much as in the countries of EU and other developed countries (Waters, 1999). When the enterprises in transition entered international market complexity of logistics activities grew progressively and logistics costs increased.

Lack of logistics support in the countries in transition is compensated by: relatively low cost of labour, low cost of building land for industrial facilities, favourable geographic position in relation to the EU market, relatively high market potential considering the number of inhabitants and the expected economic growth.

Despite similarity of logistics systems in countries in transition some differences exist because of differences in competitiveness of their enterprises on the international market and the possibility to join the EU. The differences are evident in: development of economy (GDP per capita), structure of import and export, balance of payment and balance-of-payments current account, level of indebtedness, size of territory and quality of logistics system, cultural-historical differences, roads, decisions and effects of achieved reforms and the progress made towards integration in the EU. According to the GDP per capita Albania, Bosnia and Herzegovina, Bulgaria, Macedonia and Romania are at the lowest level of development (below 2,000 US $) while Czech Republic, Hungary, Croatia, Poland and Slovakia make between 3,500 and 5,200 US $. Slovenia is ahead of all the countries in transition with a GDP of 9,800 US $ (National Bureau of Statistics, 1988). Balance of trade and balance-of-payments current account in all the countries are more or less negative. It all refers to the uncompetitive ness of their enterprises of the global market. Countries in transition mostly import from and export to the EU market. The import and export consist of mainly agricultural products, industrial products of a lower level of processing and products of labour intensive activities (textile, footwear, clothing, wood, iron, steel). This structure is particularly unfavourable for the southeastern European countries. The EU imposes stricter import regulations on these than on some other products. Such concentration is mostly present in Albania (84 %) and it is the least in Croatia (51 %) (Group of authors, 2001 / Rusthon, A. & J. Oxley, 1993).

2. Models of organisation of a logistics system

Logistics activities can be carried out in the framework of the organisational structure of the enterprise or they can be entrusted to specialised logistics enterprises. The organisation of logistics activities within an enterprise makes sense in larger enterprises in which they are present to such an extent that it is worth organising an own logistics service. In case of a smaller range of logistics activities there is no need for organisation of business logistics within an enterprise because it is much more reasonable to entrust the logistics activities to specialised logistics enterprises.

2.1 Carrying out logistics activities outside an enterprise

Entrusting logistics activities to outside specialised logistics enterprises is justified in small, medium and sometimes big enterprises. Specialised logistics enterprises are equipped with the necessary means and they have adequate personnel and facilities (warehouses, motor fleet, logistics managers etc) for carrying out logistics tasks. Logistics services offered by specialised logistics enterprises vary from transport to complete distribution including loading, discharge, reloading, collecting, orders, home delivery, packaging of the goods, management, storing the goods, management and control of stocks. According to the researches carried out in Great Britain logistics enterprises offer 49 different kinds of logistics services which the clients can be charged for in different ways (Rusthon, A. & J. Oxley, 1993). Benefits that derive from entrusting logistics activities to specialised logistics enterprises are manifested in reduced costs of transport and storage, and in a higher quality of logistics services and less organisational problems. An enterprise in transition orientated to export to overseas countries should, for example, entrust its logistics to a specialised logistics enterprise, which would transport the goods of the enterprise in question along with the goods of some other enterprises and would therefore, making a better use of the ship capacity lower the cost of transport. Besides, a specialised logistics enterprise has a better knowledge of transportation routes, customs and administrative regulations, circumstances in particular ports and terminals, which is a prerequisite for a more efficient execution of logistics activities and tasks. In the recent years the importance of enterprises which offer worldwide express logistics services has increased (Federal Express, Worldwide express, DHL, Exel Logistics, P&O Trans European, Mc Gregor Cory, Wincanton Logistics and other). In the European Union and the USA more and more enterprises make contracts with specialised logistics enterprises. According to the researches, in recent years the number of the enterprises, which do not have a permanent contract with specialised logistics enterprises, has been constantly decreasing. Therefore, in the period from 1990 to 1996 the share of British enterprises without a permanent logistics contract has decreased from 37% in 1990 to under 20% in 1996. An average contract length in that period was three years (Waters, 1999).

There's reason to believe that the development of specialised logistics enterprises in the countries in transition will be based on the appearance of foreign logistics enterprises (they will either open their branches or take over small domestic distribution enterprises) (Austrian post took over the Croatian distribution enterprise "Overseas Express" at the beginning of 2004) and the transformation of the existing domestic shipping and transportation enterprises into logistics enterprises. The relationship between the enterprises using the logistics services and the provider of the logistics services (logistics enterprises) can take the following forms: 1) Logistics enterprise buys up the complete logistics system of the user of logistics services (vehicles, warehouses, equipment, and takes over majority of the workers) and makes a contract with the user about the execution of logistics activities; 2) Joint-venture between the user and the logistics enterprise; 3) Managerial contract between the users of logistics services and the logistics experts; 4) Purchase and sale of logistics services between the enterprises which use them and those which provide them.

2.2 Organisation of logistics within the organisational structure of an enterprise

The position of business logistics in the organisational structure of an enterprise and its internal organisation depend on more factors. The most relevant are: the size of an enterprise, the size and location of particular plants, organisational structure of an enterprise, product range and the size of particular orders, customer profile and number of customers, technical equipment for carrying out logistics tasks (means of transport, pallets, containers, machinery for transport of goods and data processing), logistics software, regularity in placing orders, system of logistics planning, business policy and similar. The process of designing the organisational structure of an enterprise as well as of its logistics system is based on certain goals. It is carried out by breaking down the logistics task into particular activities and tasks, and by entrusting them, with the help of the established coordination mechanisms, to particular organisational units or individuals for execution.

So far the logistics activities and tasks have been most frequently performed within the framework of more classic organisational units, and rarely within a separate service or department. Classical or traditional model of organisation is based on functional organisational structure and hierarchical management (from top positions to the lower ones). Logistics system cannot easily fit in such an organisational structure because it is not function-oriented but process-oriented. Communication between departments is hindered which jeopardises the execution of logistics processes.

Contemporary organisational reorganisation is heading towards specialisation and differentiation of organisational structures, which is based on the specific quality of different activities and tasks of an enterprise. The purpose of these changes is carrying out of particular tasks and projects by expert working teams, as a unique team, which is formed out of several departments. It particularly refers to larger companies with complex organisational structure. In order to improve planning, organisation and control of logistics management a large number of world famous companies uses matrix model of organisation which proved successful (Hilton, Boeing, Shell Oil, Dow Chemical, Chase Manhattan Bank, Procter & Gamble, Lockheed Aircraft and others). The essence of matrix organisational structure is the fact that in the process of designing the organisation of an enterprise it keeps the functional principal, i.e. vertical line of authority and at the same time establishes a relatively permanent horizontal organisational structure based on the information system. Through traditional functional borders of the functional organisational structure of an enterprise, an informal organisational unit in form of a special team is formed (board, commission, committee and similar).

Matrix model of organisation of logistics system presents a good organisational solution for larger enterprises in transition. Informal logistics organisational unit in form of a logistics team can be set up within an enterprise and among more enterprises participating in a supply chain. Planning and control of logistics activities and tasks is carried out by a logistics team closely collaborating with other functional organisational units (supply, production, sales, finance, marketing and similar). Authorised and responsible person within the team (informal logistics organisational unit) is the logistics manager. Member of the team are experts in particular fields of logistics activities, and are recruited from personnel from different functional organisational units such as transport, storage, purchasing, information system and similar.

The team solves disputes, suggests compromise solutions, manages logistics processes but does not make orders. Logistics manager is the chairman of the team and his main task is to encourage the team to fulfil the logistics plan and programme. Contrary to a traditional managers who gave orders to his employees to carry out certain tasks, logistics manager teaches and delegates authority to the team members who take initiative to perform certain tasks in the best possible way. Logistics manager has the role of a teacher, a coach and a team organiser. The ability of the team leader or logistics manager to use the knowledge and creativity of the team members to the full is essential for successful fulfilment of logistics activities and tasks. The biggest advantage of the matrix modelling of logistics system is the fact that it enables a high level of creativity and organisational adaptability, and it is suitable for solving conflict situations, which emerge from different interests and competence conflicts between particular organisational units of an enterprise.

3. New logistics strategies in function of competitiveness of an enterprise on the global market

The business environment of a contemporary enterprise can be described with a single word - globalisation (The beginning of globalisation is connected to the efforts of the big multinational companies to establish domicile companies in different countries because in that way they avoided different tax, customs and administrative limitations in export. Besides, multinational corporations make effort not only to launch their products on foreign markets, but also to expand their impact on raw material resources and cheaper labour in underdeveloped countries.). It presents the most complex market condition, which should not be opposed but approached as a challenge. Namely, the positive effects of globalisation should be increased and the negative ones decreased. Its importance for the development and survival of the enterprises on the market is best proved by the fact that the world export increased by 75% in the last decade (Vukić, 20/03) and that nowadays even 40% of the products on the British market are imported (Zelenika, 2001).

Logistics strategies are implemented through strategic decisions which refer to: improvement of customer service, stocks planning and control (MRP, DRP JT), integration of participants in supply chain, expanding of information technology and dislocation of production. A classic approach to forming a logistics strategy was based on the belief that logistics, as other functions in an enterprise (marketing planning, supply, sales, production), is a part of a business system of an enterprise, and therefore the logistics strategy has to be an integral part of the general enterprise strategy.

Because of the changed business conditions, i.e. influence of the environment on contemporary enterprise operations, an approach different from is needed to form new logistics strategies. Logistics strategy stops being just a part of the general strategy, but is a powerful support to all individual strategies of an enterprise (especially marketing strategy). It supports and integrates (connects) all the other strategies in order to achieve the goals of the company. It makes the logistics strategy an integrating power and the key factor in the enterprise performance on the market.

Logistics strategies of enterprises in transition should aim at: developing a system of supply chain management, shortening of the time needed for the flow of goods (compression of the time cycle) through logistics system, a more flexible production based on the market demands, quality logistics package arrangements (establishing specialised logistics enterprises) and a reduction of logistics costs.

Competitiveness of enterprises in transition would benefit from their joining together with domestic and foreign companies. More companies from transition countries joining multinational supply chains would further increase it. That would increase their competitiveness in relation to the companies from the developed countries, which had already gone through such a transformation.

By shortening the time needed for the flow of goods with the help of logistics system, logistics costs would be reduced and at the same time the quality of logistics services increased. According to the research the turnover period in the developed countries is 30-40 days, and in Croatia it is 140-150 days. George Stalk and Thomas Hout, the authors of "Race against Time", are right when they say: "The ways in which a company manages the time of development, advertising, production, sales and distribution is the most powerful source of competitive advantage." Logistics managers recognised the importance of shortening the turnover period with the help of logistics system a long time ago. Many leading companies in the world make efforts to reduce the period from designing a product to its delivery to the customers. Shortening of the turnover period can be achieved through the suitable implementation of the contemporary systems of stock control and management. For that purpose the following are most frequently used: Materials Requirement Planning (MRP), Distribution Requirement Planning (DRP) and Just in Time (JIT).

It is of great importance that the logistics strategies of enterprises as well as the development policies of transition countries are based on the principle of "economy of sustainable development" and not on profit at any cost. Such orientation would jeopardise the resources and endanger healthy environment for future generations.

All of these strategies require simultaneous implementation in order to achieve better results with less risk. Every improvement made in this direction can help enterprises in transition become strong, reliable and attractive partners to the enterprises of the EU and other countries. Every deviation from the above stated can jeopardise past investments in transition processes and cause legging behind in the future development.

4. Conclusion

Globalisation of the market, opening of borders, liberalisation, deregulation and standardisation in transport, development of transport infrastructure, achievements in information technology, environmental protection, fluctuation in exchange rates, risk of dumping prices and antidumping regulations reveal the important issues concerning the use of actual and potential capabilities of the enterprises in transition as well as their ability to retain the existing and conquer the new markets. Each in its own way these factors are responsible for organising logistics and for creating logistics strategies essential for survival of the enterprises in transition and their development.

Designing of the organisation of the logistics system requires special attention because it significantly influences the business results and competitiveness of an enterprise on the market. Nowadays, business logistics faces many specific tasks and that is why the traditional model of organisational structure is not suitable, and new organisational models are required. Matrix model of organisation of logistics system presents a good organisational solution. The essence of this model is forming an informal organisational unit in form of a special logistics team or board within the functional organisational structure of an enterprise.

Due to the underdeveloped logistics systems and fragmented national economies enterprises in transition do not have the strength to compete successfully on the global market with the enterprises from the EU, USA and Japan. This is why they should form new logistics strategies such as: management of supply chain on the regional level, systems of stocks management and control (DRT; MRT and JIT) and development of logistics package arrangements.

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INCREASING PRODUCTION CAPABILITIES BY NETWORK ENABLING STRATEGIES

B. Schallock

Abstract

This paper presents approaches and solutions that help small and medium sized enterprises in Europe to gain better market access. Networking and sharing efforts in marketing, jointly offering complete modules or services and sharing the cost for a central office and ICT platform, reach this. The author is aware of the fact that the East European entrepreneurs dislike such a «collective approach». His proposals are based on various experiences in Germany (RIO, AMTECH) and in Europe (Virtuelle Fabrik Westschweiz) and he recommends a triple effort consisting of a regional strategy (as InnoRegio), a business approach (as ProNetz) and a set of management and software tools (as VIENTO and Xchain).

Keywords: Tender management, network manager, communication platform, regional development, public private partnership

1. Introduction and challenge of restructuring economies

Our institute Fraunhofer IPK in Berlin experienced a long series of discussions with Prof. Veza from Split as well as with own staff members from Macedonia and project partners from Poland. This makes us confident that the methodological and practical proposals in this paper are suitable for developing countries and those in economic transition. We learned even that there were very similar problems for enterprises in Croatia/Macedonia than for those in East Germany after reunification. In all these countries big state economy units were cut into small units and in most cases the former customers in the country or abroad were in financial crises.

The challenge that we are facing could be expressed like: How can smaller enterprises be part of a regional or international value chain (access to customers)? How can the minds of managers of small enterprises be opened for new structures and management procedures? How can work be made efficient and how can information exchange of SMEs meet expectations of Western customers? The answers to these challenges are given in three papers at this conference. The first by Eickelpasch [1] describes macro economic view of innovation cluster. The second by Schallock [3 and this article] describes micro economic reasons for SMEs of being part of production networks and the third by Zeeb [2] a practical low cost solution of effective data exchange.

One of the sad experiences with SMEs when we propose a more structured way of management is that they reply: "Don't explain concepts, methods or benchmarking figures, just bring to me customers and all my problems are solved". This sounds right at the first glance but is not true and shows that the problem is not understood. The real goal is to reach a level of performance, responsiveness and visibility to potential customers so that those find it worth to include this company into their suppliers list. Performance is reachable by methodological management processes.

This means that SMEs face structural and mental problems at the same time.

2. Deficits of SMEs

The deficits of SMEs can be summarized by the following list:

- Lack of capital for marketing campaigns,
- Lack of product development capacity,
- Lack of sales representatives in other countries,
- Lower wages make it more difficult to attract well educated workforce and
- They are too small to create a niche market.

Figure 1 shows hierarchical supplier relationships, which are still dominant with, rather fix relationships. Although there are trends of sourcing from new supplier countries such as Spain, Portugal or Czech Republic, it is still very difficult for SMEs from East European Countries to “break into” such a rigid supplier relationships in West European Countries.

The proposed form of networking is an away to share the effort of approaching new customers and fulfilling high expectations such as completeness of product (system or subsystem) and services, level of performance and interconnectivity of order management systems [2].

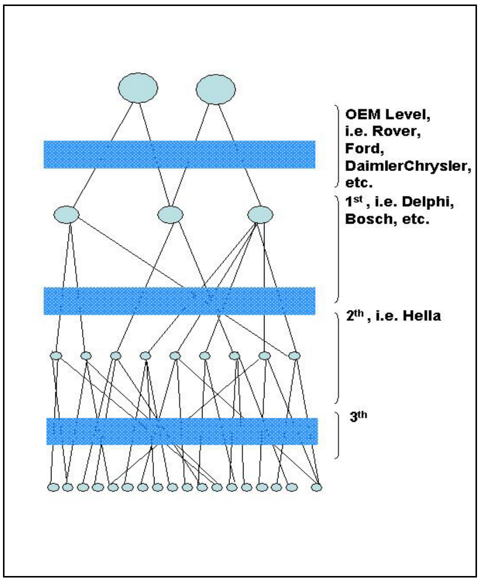

Figure 1. Traditional supplier customer structure

3. Increased production capabilities by networking

The personal involvement of the author in networking of enterprises started in 1996 and was caused by depressing incidents in the Berlin Brandenburg industry. Although several global manufacturers -BMW, Rolls Royce, Bombardier- are presents in the region, they source primarily from system suppliers in Western Europe while neglecting the numerous small suppliers of the region. This did lead to the establishment of the Enterprise Network Berlin Brandenburg (www.pronetz-online.de) with the aim to jointly offer subsystems. The database and production profiles rose up to 850 enterprises. Six Virtual Eenterprises were coached. All restructuring methods were oriented to define possible subsystem delivery to gather with the customers. It became obvious out of practical limitations that more software support should be provided [3]. One of the most prominent promoters of the concept of enterprise networks was Prof. Schuh [4]. His “Virtuelle Fabrik Bodensee” turned out to be so successful that further groups of enterprises did develop the same structures [5]. A real case of a joint customers offer and delivery from “Virtuelle Fabrik Westschweiz” as shown in figure 3.

Also the aspect of interregional cooperation beyond country borders was not only exercised by IPK [6] with Spanish and Portuguese partners but also worked out as a specific concept by McGregory and Shi - Cambridge University [7].

Next to production clusters a big advantage of networking is joint product development with new link of industry to public research organization [1]. One of the twenty three innovation networks in East Germany is RIO, devoted to develop vehicle parts from renewable materials and metal foam. The Network was coached by a coordination office of three persons and uses an ICT platform (see Figure 2).

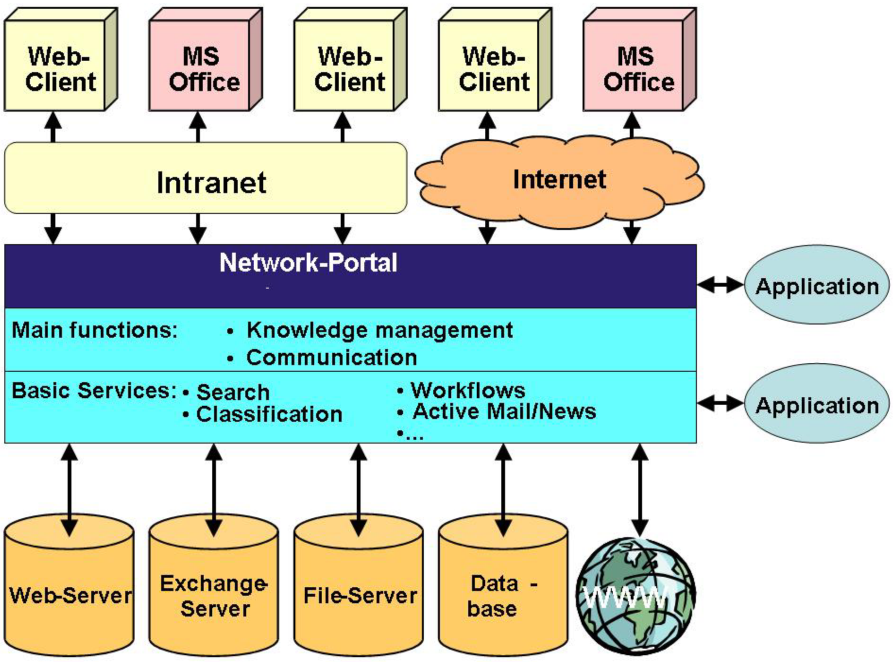

Figure 2 Structure of RIO ICT platform

The material database for renewable materials like hemp and foams from potato starch is a unique feature of the RIO ICT platform, but all other features of this web based solution are transferable and useful for any regional network:

- Document management system,
- Process and information flow modelling,
- Model based cost calculation,
- XML-based data transfer tool (xchain) [2],
- Project management tools,
- Competence and product descriptions for marketing, transfer to individual home pages and ordering systems,
- Public home page,
- Network management features as address book, mails and news.

It is very obvious that the kind of product innovation that is handled in RIO and in other InnoRegio projects could not be managed by any typical small East German production enterprise without joining a network.

America is well known for the philosophy of not interfering into any private business with public money except for military research. Nevertheless there are federal and state initiatives as US net under the name of regional technology strategies who's publications [8] give cases and profit increase figures after networking activities in order to encourage more US companies to follow networking strategies. This can be taken as a proof for the high value of this management strategy. Although the national interest in networking in the US decreased, we could experience recently a very interesting public-private approach in West Massachusetts (Regional Technology Alliance) with full support from enterprises and universities to selected sectoral clusters.

Although enterprise cooperation is not new, the author argues that organisational and cultural aspects, visible in mental and emotional hesitations of shop owners to join networks represent a major research challenge. The numerous developed support systems are not the key drivers for success, but the services provided to the network members.

One of the features of the RIO ICT Platform and one service of the coordination office is to work out offers to customers and use models of the complete value chain (see Figure 3). When the network manager becomes aware of a tender. He creates a file including the bill of material of the required subsystem. For the system he searches off-the-shelf parts from e-markets as well as for manufacturing partners in his network according to manufacturing skills. It allows to model the manufacturing sequence and all involved partners as well as to analyse process cost. This enables the Virtual Enterprise to hand in an offer within hours instead of weeks.

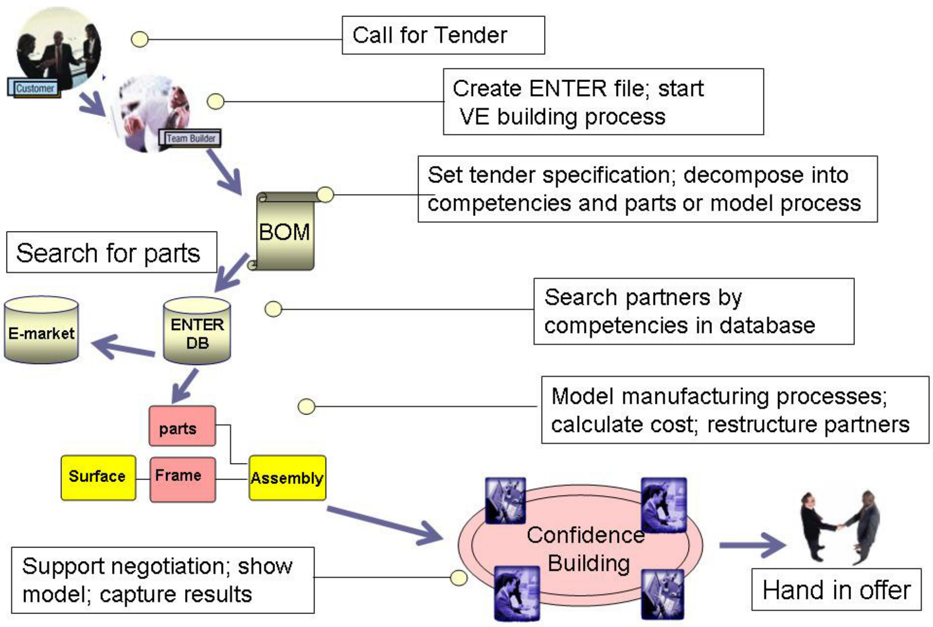

Figure 3. Tender management procedures

For SMEs an extended access to customers is often more important, than a reduction of costs. A new concept of the Fraunhofer IPK offers therefore enterprise networks as partner for system suppliers and e-Markets. More and more not only suppliers compete against each other by supplier regions. Here, competitive costs, responsiveness and the ability of design and deliver complete solutions (System or Subsystem) are crucial factors for competitiveness.

Figure 4. Example of a joint bid of complex equipment by a network [5]

4. Individual enterprises strategies combined with regional approaches

It is recommended that small enterprises think strategically, which future customers should be approached and which partners or sub-suppliers are of long term interest. Then a group of SMEs can form an own network if they are willing to invest several years of networking work (building trust and agree on rules of conduct).

The second option is to create these networks in a public private partnership (PPP), where regional agencies pay for network managers or information systems and effort to build prototypes and market them. The InnoRegio program is one of the most ambitious but there are much smaller funding programs in Germany as well as "Wachstumskerne" or NEMO (Network management East).

A network study in Saxony (ca. 6 Mio inhabitants) was able to list 300 networks of different sizes and level of intention.

5. Summary and offer to Croatia

This paper about methods and tools of networking should be seen as part of a set of several papers in this conference. Eickelpasch [1] transferred the basic message that it is more than worth to stimulate innovation by publicly supported networks (as InnoRegio Process in Germany). This paper refers to network management support being coaching as well as marketing support, business process improvement and using ICT platforms [6] [3]. In the third paper of this set, Zeeb [2] shows a practical and low cost solution for exchanging order management data, which is a module of the RIO network platform. The paper intends to get across the knowledge to SMEs about the possibilities and requirements of E-Business.

The Fraunhofer Association is the largest organization in Europe for applied research with 11.000 employees in total. Out of 50 institutes, about ten are dealing with production technology and about 60% of all consulting contracts are devoted to SMEs. This knowledge can be available to Croatian industry. The other experience of Fraunhofer IPK related to production networks, regional industrial strategies, transregional cooperation to Western and Eastern Europe and benchmarking seem even more important to support an innovation strategy in Croatia.

All these issues: technical expertise, management strategies and regional economy restructuring skills of IPK and partners can be embedded in an framework of projects in Croatia that are devoted to particular sectors. As it was reported in this paper about the ProNetz approach from Berlin, it is proposed to analyze potential customers for Croatian enterprises first and then design productivity improvement measures in particular enterprises and the ICT support according to the branch and customer expectations. This strategy requires multifunctional teams from Germany (benchmarking, business process restructuring, quality management, management skills and training, application specialists) and teams in Croatia and a time span of three years minimum. Croatian Engineers, managers and students should have access to special tutorials [9] on using methods and tools in production management, network management and other topics as well as case descriptions of restructuring projects in their own country.

The strategy can well be combined with public regional restructuring efforts (basic and further education, transport, language skills, staff exchange programs, economic development agencies, European funds, export and investment support measures, information platforms for enterprises).

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SECURE ORDER DATA MANAGEMENT IN SUPPLIER NETWORKS

S. Zeeb

Abstract

The article characterizes the necessity and the requirement needed for an electronic data interchange and process integration within company networks. It shows general methods of resolution and recommendations of action for supplier networks within SMEs. An example taken from the Berlin-Brandenburg area shows the actual implementation within an InnoRegio Network.

Keywords: data interchange, process integration, E-business standards, supplier networks

1. Introduction

Enterprises will improve their market chance, if they are able to provide process relating information networks with their customers and suppliers. The trend to system suppliers existing within many industry sectors (e.g. the automotive industry) requires new ways of corporation from SMEs in the form of supplier networks. In order to be able to react readily and flexibly, solutions from information technologies are needed. Due to the heterogeneous and largely functional oriented application systems in some enterprises as well as a variety of existing standards, it is not possible to present a „ready-made“ solution of a software or organizational integration of supplier networks (customer-supplier-process chains). This lecture offers general methods of resolution and gives an example of an implementation within an existing company network.

2. Integration is sensible and necessary

The actual advantage for partners of an electronic supply-chain not only evolves from the electronic data interchange, but also through the integration of the business processes. A significant acceleration of the processes and improvement of the data quality can only be achieved if processes are being integrated on both sides. For this reason, big companies more and more demand the provision of system integrations from their suppliers and sub-suppliers. (Statements by VW: „We therefore want the integration of EDI in our as well as our supplier's processes.“ „We also expect from our JiT suppliers that they will link the pre-suppliers recommended by VW/Audi similarly to EDI like VW/Audi observing the recommendations by VDA (Association of German Automobile Manufacturers).“ [1]

3. E-Business standards

The agreement on standards is fundamental for the integration. Within the E-Business standards define data formats that underlie the information exchange within and between the companies. Generally, it is possible to distinct between professional and technical standards.

As an abstract, standards can be pictured as correlating stacks [2].

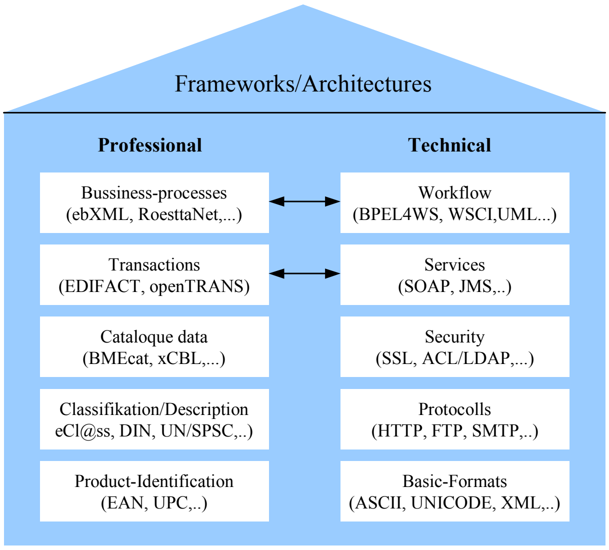

Figure 1. Standard Stack

The agreement on standards (especially in functional areas) is impeded by various factors: Firstly, it isn't clear at all what constitutes a standard. Technicians rather tend to protrude the specification and the standardization process, while for economists the actual distribution is more important. Secondly, if specifications are taken as norm, the sheer number of standards alone becomes so overwhelming and confusing, which prompted the computer scientist S. Tannenbaum to the much quoted statement „The nice thing about standards is that there are so many to choose from." And lastly, standards often cover different combinations of areas so that they can describe addition as well as competition at the same time. To achieve transparency all three factors are not beneficial.

Additionally, one needs to keep in mind that standards are very complex regulators and often subject to change, which requires further quite considerable amounts of maintenance. This situation within companies can be improved accordingly by implementing corresponding conventions. For instance, standards will be implemented only after a thorough cost-benefit calculation. This proceeding will have its limits as soon as corporations between the companies start.

4. Special problems within small enterprises

Other than the mentioned key aspects for the integration of existing systems as well as the variety and complexity of standards, it becomes clear that small enterprises often do not meet the technical and organizational requirements needed for the integration of processes. It often occurs, for example, that no suitable software exists which can provide the corresponding data and sequential data processing for partners. MS-Office products – such as Excel - or simple order management systems are used. An electronic data interchange is processed unstructured for example via an E-Mail attachment. Fundamental IT skills and the knowledge about significant standards only exist to a minor extent in many small enterprises. In addition, networks and their connection with the provision of operational data cause suspicions.

5. General methods of resolution

Generally, we can distinct between two different kinds of technical and organizational solutions: The centralized and the decentralized solution.

The centralized solution uses a central server for the data control of the network, which means that each company connected to the network will be registered centrally and will send / receive data via the central server. The processes needed for the network control will be saved onto the server and executed. It is possible to save the data both locally with the companies as well as centrally on the server. It is necessary to use this solution, if a centralized pool of master data in needed. From an organizational point of view this can be considered a closed, fixed solution. If the server will be supervised and controlled by a neutral position (e.g. a network manager) it is considered to be a corporative solution. In contrast it is also possible to entrust a company of the network (corporation leader) with the supervision and control. With this solution it is generally possible to offer control mechanisms through a partner as information are available from a central location. Advantages: Synchronization of master data with all partners, simple administration. Disadvantages: Corporate financing/operating of the central server (alternative: operation via an external provider).

Decentralized solution: Direct communication and integration of the companies. Each company will use a local infrastructure/software, allowing the integration of their own software into an electronic value chain. Each company will consequently provide transparency to certain processes and data for others. Advantages: Flexibly adjustable to the individual needs of the companies - individual, flexible solution. Disadvantage: Technical infrastructure and knowledge must exist within the company.

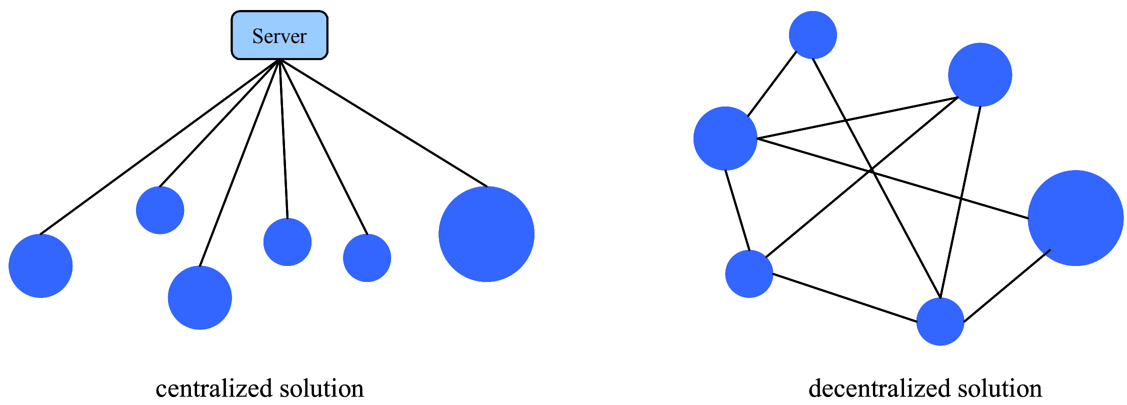

Figure 2. Centralized and decentralized architecture

6. Recommendations of action for the use of standards

The study „E-Business standards in Germany"[2] recommends for a simple start of SMEs to use simple standards and consequently diminish the obstacles for the enterprises. The author recommends a practical approach in order to avoid difficulties for projects in SMEs caused by the use of complex document standards concerning the contents. This, above all, applies to the use of process standards as they are very complex and many standardization procedures have not been completed. As inter-company business relations (especially within networks) are normally arranged for a longer period, networking via the use of converters will be possible even for only moderately standardized environments.

The use of standards concerning the contents within a specific project strongly depends on the industry sector and the objectives to be accomplished. A universal recommendation of action for the use of a standard is therefore not very sensible.

A crucial point is to get across the knowledge to SMEs about the possibilities and requirements of E-Business. They include, among other things, awareness for the need to maintain and update master data, as this is the key requirement for a successful E-Business and also to have a basic knowledge about existing standards.

7. Security

Other than the security of data, which must be provided during transfer through technical measures (encoding), the trust of the companies in the security and the confidentiality of their own data is a key issue. For this reason, if a centralized server is used, it is recommended not to permanently save internal data of the companies onto the server. Only data needed to comprehend processes should be saved there.

8. Example RIO

The RIO e.V. (Regional Innovation Alliance Oberhavel) is a supplier network for automobile components made of alternative and sustainable materials. The network wants to build a bridge between automobile manufacturers and SMEs in the Berlin/Brandenburg area. At present the sub-project “production support” is realized within the InnoRegio alliance project called “Information and communication platform RIO”. The objective of this sub-project is the automatic exchange of production and contract data between the companies of the network.

During analysis it became clear that most of the companies within the network have no internal application, which could provide the data needed for data transaction and process integration.

For the process integration, it was necessary therefore, to provide a local software solution for the companies. It was designed to fit to the centralized solution.

The companies process data in the local software and are able to de-allocate master data for certain partners. The de-allocation of a master data (e.g. a product for a certain partner) is the precondition for the data transfer and consequently the updating and maintenance of the master data within the company network is ensured.

The data transfer is carried out via a server application (xChain-Server) installed on the server of the RIO network alliance. This Server synchronizes master data and takes on the routing of documents to be exchanged.

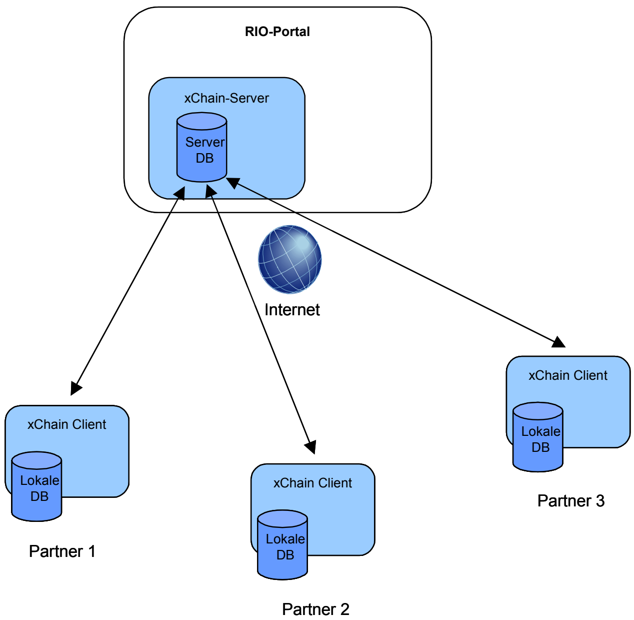

Figure 3. RIO Architecture

The client application (xChain-Client) runs as a stand-alone application. An offline-processing is therefore possible. The user is able to define which data he wants to process and when he wants it to be transferred. The data will be transferred in XML. The technical transmission will be carried out via Web Services (SOAP). An internal RIO format was designed for the description of the content of the data to be exchanged.

The transfer of data and documents is distinguished between the exchanges of master or transaction data. The master data is the basis for the actual transfer of transaction data (orders, dispatch advice, invoices).

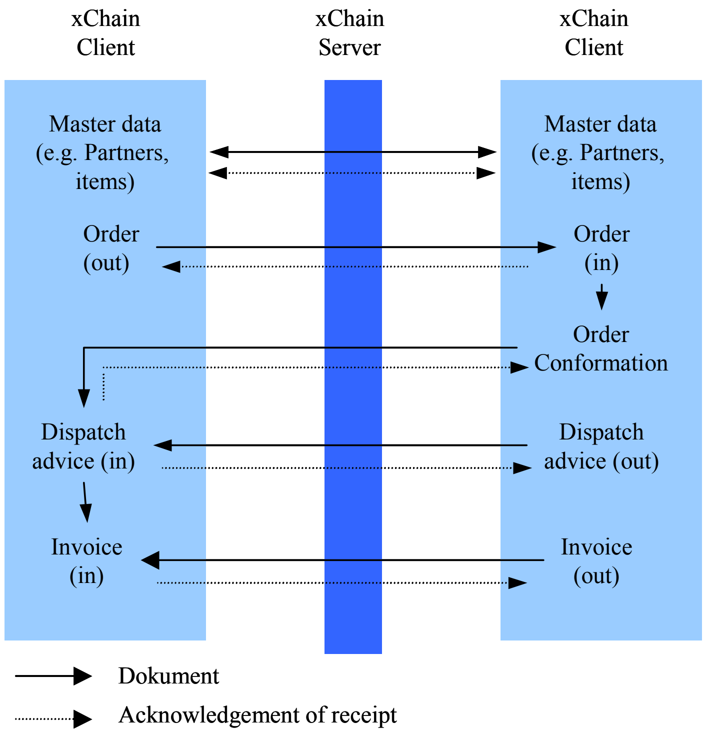

Figure 4. Processes within the RIO Supply Chain

With this systematic the data transfer can be carried out via many levels of the value chain. Data needed for the process of planning can be saved onto the server and are consequently available for cost planning and scheduling for the entire value chain.

Local updating and maintenance of data using the offline-processing is an advantage for small enterprises, as they normally do not have leased lines. Using the sequentially automated data transfer significantly accelerates the processes of the network. You will achieve cost-efficiency by reducing manual tasks such as data input, printing and distribution via fax/post. Towards mutual customers the network will be able to present itself as virtual enterprise. In general it is planned that orders from the network placed within a corporation can directly be handled via the RIO server.

9. Conclusion

SMEs will improve their market chance if they operate together within supplier networks. To be able to react readily and flexibly within such networks an electronic data exchange as well as process integration will be necessary. For this purpose E-Business standards concerning the technology and the contents exist. A practical approach to this problem with the objective to qualify SMEs for the E-Business is recommended.

References

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