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IMPROVEMENT OF A PRODUCTION PROCESS WITH THE USE OF SIX SIGMA METHODOLOGY

Veža, I. & Grubić, T.

Abstract: Rigid and non-flexible production structures can no longer survive in a turbulent global market since they react on changes with significant time delay. To satisfy the needs and wishes of a customer, regarding the quality, quantity, price and delivery time, it is essential to make leap forward from functional (according to Taylor's principles) to process oriented organizational structures. During the last couple of decades many new approaches has been introduced to help in this leap. One of these approaches is Six sigma. Basics of Six sigma are presented in this paper with and its use in a real production process.

Key words: production process, Six sigma, improvement, Critical-to-quality tree

1. INTRODUCTION

To be a customer oriented means firstly to recognize the customer and then to know what does the customer prefer relevant to either specific product or a service. It means to know wants and wishes of the customer for a product/service. It is not enough only to be a customer oriented. Beside the customer orientation the process and employee orientation equally matters. Essential factor in a process improvement is a process management since without the process management it is no longer important how large is our customer orientation. Bad process management impacts the profit.

There are many Six sigma definitions that could be found in literature:

- Six sigma is a set of procedures with the aim of a process improvement or service delivery (Eckes, 2001).
- Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving towards six standard deviations between the mean and the nearest specification limit) in any process -- from manufacturing to transactional and from product to service (George, 2003).
- Six sigma is a philosophy of doing business with a focus on eliminating defects through fundamental process knowledge. Six sigma methods integrate principles of business, statistics and engineering to achieve tangible results (Green & Dick, 2002).

Based upon before mentioned definitions it can be concluded that Six sigma can be used in diverse improvement processes:

- Six sigma strategic components can be used in a Business Process Management on all levels of a company,
- Process Improvement Methodology (layout of a current process and its improvement recommendations).

Among the first companies in a world that has applied Six sigma is General Electric (Eckes, 2001). Methodology of a production process improvement by using Six sigma is known as DMAIC acronym, and is consisted of the following five steps:

1. **Define.** Define the customer, their requirements, the team charter, and the key process that affects that customer.
2. **Measure.** Identify the key measures, the Data Collection Plan for the process in question, and execute the plan for data collection
3. **Analyse.** Analyse the data collected as well as the process to determine the root causes for why the process is not performing as desired.
4. **Improve.** Generate and determine potential solutions and plot them on a small scale to determine if they positively improve process performance.
5. **Control.** Develop, document, and implement a plan to ensure that performance improvement remains at the desired level.

It has to be emphasised that is equally important to devote resources on the change management. Many change campaigns failed because the strong accent been put on technical changes but none on assuring the acceptance of those changes.

The competitiveness of a company can only be increased if the quality of its products and services is elevated.

2. SIX SIGMA IMPROVEMENT EXAMPLE

The application of Six sigma method is presented on a real production process of a gripping device made by one Croatian company. The production process can be classified as a small lot production type since only 13 pieces of the device were made. The improvement method was applied on one component of the device, prism.

2.1. Define

To apply the proposed improvement method with satisfying results the following prerequisites need to be fulfilled:

1. Project definition;
2. Team establishment.

In the team the company management had been included.
After the team establishment, the special care had been devoted on:

- Team charter;
- Customer identification, their needs and requests;
- Generation of the process map.

The process map included the following elements:

1. technical documentation (drawings, etc.),
2. material (steel Č.4732 according to HRN, composite materials, alloys),
3. machine tools (saw, milling machine, CNC turning machine, grinding machine), cutting tools, machine-processing parameters, subcontractor
4. time of the rough machine-processing,
5. measurements,
6. time of the final machine-processing,
7. final control and assembly.

The customer had been identified with the following requirement: the gripping device needs to be produced which will assure good grip of a profile during its processing (profile is characterized with the length of $70.5^{\pm 0.15}$ mm).

2.2. Measure

In the second step the measurements of input and output information had been conducted, i.e. CTQ (Critical-to quality) tree (Figure 1.) was developed.
The following input information was measured:

- the arrival time of raw material,
- the delivery time to and from the subcontractor,
- part dimensions,
- total production time.

Based on the measurements and analysis of the 13 prisms and their total production times the mean, standard deviation and capability index had been generated. Also, the frequency distributions of the dimensions and the total production times were created.

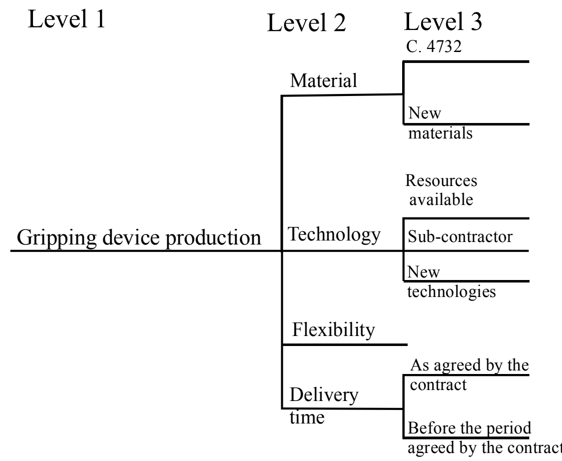

Figure 1. CTQ tree

2.3. Analyse

After the collective table of the analysis has been created it can be approached to root-cause analysis.
The simple question needs to be put: Why did the dimension deviation occur in a first place?
This represents the starting point of root-cause analysis.
As a reasonable answer to the question following answers were synthesised:

1. blunt tool,
2. imprecisely centred and tighten piece work,
3. imprecise measurements,
4. imprecise machine tool,
5. low quality material,
6. environment effect,
7. human factor.

The upper mentioned answers represent the possible causes of the dimensional deviation.

Main task of this step is to reduce the number of possible causes of the deviation on a reasonable few. This reduction can be conducted by multi-voting method. The answers that remain after the multi-voting are also the possible causes of the deviation not the definite ones (Figure 2.).
The tool that could help in a quest for the most likely cause of the deviation is 5 WHY diagram.
After the multi-voting session the list of potential causes had been reduced to the following causes:

1. imprecise machine tool and blunt tool,
2. imprecisely centred and tighten piece work,
3. imprecise measurements.

Each of the answers from the list had been subjected to the question: Why? For every Why four or five answers were generated.

The results in descending order represent following characteristics:

1. imprecise machine tool
2. blunt tool
3. imprecise centring
4. imprecise measuring
5. low quality material
6. human factor
7. environment effect

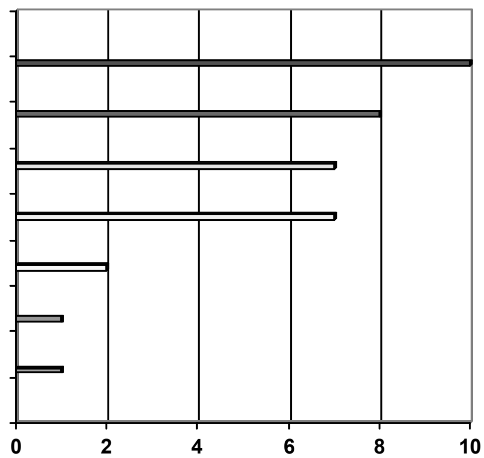

Figure 2. The results of multi-voting session

So, for example by answering on the question: "Why do the imprecise machine tool or blunt tool effect on a dimensional deviation?" we got following answers:

1. imprecise bed,
2. insufficient stiffness of the work table,
3. poorly chip conveying,
4. bad cooling,
5. blunt cutting edge of the tool.

The same procedure is used for other two causes: imprecisely centred and tighten piece work and imprecise measurements.
Next step in a 5 WHY procedure is to take the element that aspires the most likely as the root-cause and subject it again to the 5 WHY procedure.
Among the three potential root-causes the imprecise machine tool or blunt tool represents the most likely root cause.
When the root cause of the dimensional deviation is found we continue the analysis by answering on the following type of questions: "Why do the imprecise bed effect on a dimensional deviation?" The next answers were gathered:

1. badly chosen machine processing parameters,
2. irregular feeds of the work table,
3. irregular tool feeds,
4. shape deviation.

In a same way we can get the answers for the rest of the errors caused by: the imprecise machine tool or blunt tool.

As in a phase of finding the root cause the most likely error caused by the determined root-cause needs to be identified. This identification is also conducted by using the multi-voting.
These steps need to be repeated until the occurrence of repetition of the answers or until we get to the point where no more reasonable questions could be generated.

2.4. Improve

The solutions that lead to six sigma performance were chosen carefully. The improvement of the production process has been obvious after the chosen solutions have been applied. Six sigma method was firstly applied on a pilot project not immediately on the whole production system. After carefully introduction of the method on the pilot project it was possible to apply the method on other areas.

2.5. Control

In the final step of the method the system of constant improvement needed to be assured.
It was recommended to use the calculation of control limits.
During the improvement course all the activities were being continually documented according to response plan. The importance of the response plan is that it creates lasting plan for an action for all participants of a process.

3. CONCLUSION

In this paper the use of Six sigma method in a production process improvement was presented. The idea of this paper was to put accent on the quality of a production process since the effort on the quality in production processes of Croatian enterprises is not significant enough.
The main prerequisite while approaching the improvement campaign is to have the management declaration of its unconditional agreement and involvement in the campaign.
Also the special care during the application of the method needs to be devoted on a co-operation between all involved parties: from the customer, the management and to the project team. It is recommended to give insight, in the improvement documentation, to those who did not participate in the improvement process so they could understand the way in which the improvement was conducted. The generated documentation also indicates the issues which assure that the improved state of the production process continues even after the project team had been dissolved.
It can be concluded that by applying the method in a real production or service processes and by allocating the resources (time and financial) accompanied with the management agreement, the real potential of the method would be determined.

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Authors:

Prof. Dr. sc. Ivica Veža, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, University of Split, R. Boskovica bb, 21000 Split, Croatia Tel. ++385 21 305 777/fax: ++385 21 463 877 E- mail: iveza@fesb.hr

Ass, Tonći Grubić, B.Sc., Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, University of Split, R. Boskovica bb, 21000 Split, Croatia Tel. ++385 21 305 777/fax: ++385 21 463 877 E- mail: tgrubic@fesb.hr