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Sadržaj / Contents

VODA / WATER

PROIZVODNE TEHNOLOGIJE / PRODUCTION TECHNOLOGIES

Review of modelling methods and computer models implemented in recent nowadays CAD systems

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Abstract
Design process is intellectual and complex process. Hence, it is difficult to describe him with unique mathematical algorithm, and much difficult with unique computer tool who would give answer on all challenges contained in design process. Therefore, designer is the main actuator of this process in all its stages. Development of computer and computer systems brings implementation in design process. In that sense inevitable and important role in this process obtain CAD systems. In paper is presented brief review of computer models implemented in nowadays CAD systems. Also, basic modelling methods are presented and their implementation in nowadays CAD systems.

Key words: Computer aided design (CAD), design process, modelling methods, CAD models

1. Introduction

When we talk about design, then for the design can say to be a process. According to [1], the process is a set of activities that use the resources to convert input to the output. Activities represent operations, and resources represent the means to which they are performing.
The design process, according to [2], is possible to represent as a transformation system (Fig. 1). Input information are requirements according to the technical system [2]. The result of the transformation system is the solution as a technical system in its entirety. Such a design process consists of the following elements: designer, working environment, information and management.
Product development takes place entirely in the design process. In the second half of the twentieth century, a number of methods and tools have developed which introduce systematics and formalism into the design process. Therefore, the following methods of the design process have developed design process according to VDI 2221, heuristic methods, generalized method, integrated design process, iterative design process, axiomatic design, simultaneous engineering and concurrent engineering [3].

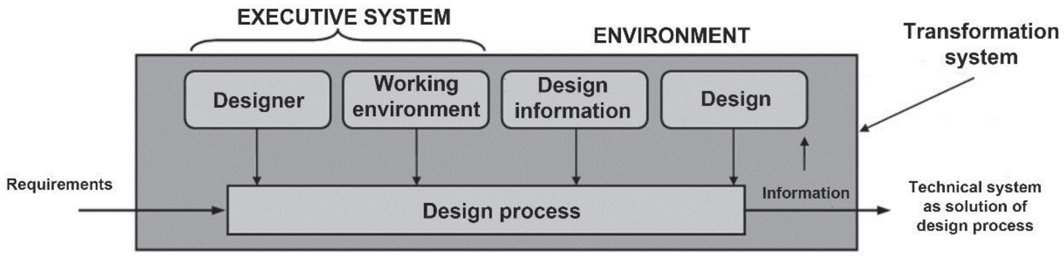

Figure 1. Model of design process [3, 4]

For the purpose of this paper, the design process according to VDI 2221 has accepted, often referred to as the European (German) approach to the design process. Precisely according to the stages of conducting the design process in accordance with VDDI 2221, this paper analyzes the role of the CAD systems in the design process.
According to [5], in the field of design, there is a lack of generally accepted formal representations of no geometric information and product-related data as and design knowledge. Such information and data arise from the conceptual phase, referring to product functions and product's technical requirements. This part of the design process is least automated and covered by computer applications.
When referring to the application of the CAD systems in the design process, according to VDI 2221, their significance is present in the stages of construction realization and detailed design [6]. In these phases, the CAD systems generate the physical (shape) structure of the final product. Technical documentation, parts list, assembly, transport and working documentation have produced. The result of these phases is complete product documentation.

2. Historical development of the capability of CAD systems

The history of the CAD system development and their application from the moment of their creation up to today, it took place systematically as computer capabilities increased.
Computer aided design (CAD) specifies the use of computers in the design process, or in a wider context, in product development process. When this term appeared in the 50s of the last century, it marked the application of computers in the execution of technical calculations. Today it involves the creation of a computer model of construction, different analysis, simulations, optimization and production of technical documentation.
Early modelling systems had modest capabilities and could use only lines for a production of wireframe models. With the development of more modern computers and stronger graphics, there is a better interaction between users and computer programs. At the same time, the automotive and aviation industry have the need to produce forms that are more complex. Thus, surface and solid models have developed that allow faster generation of tool paths and production. CAD systems obtain the more powerful capabilities that make them more involved in product development process and contribute their commercialization (Fig. 2).

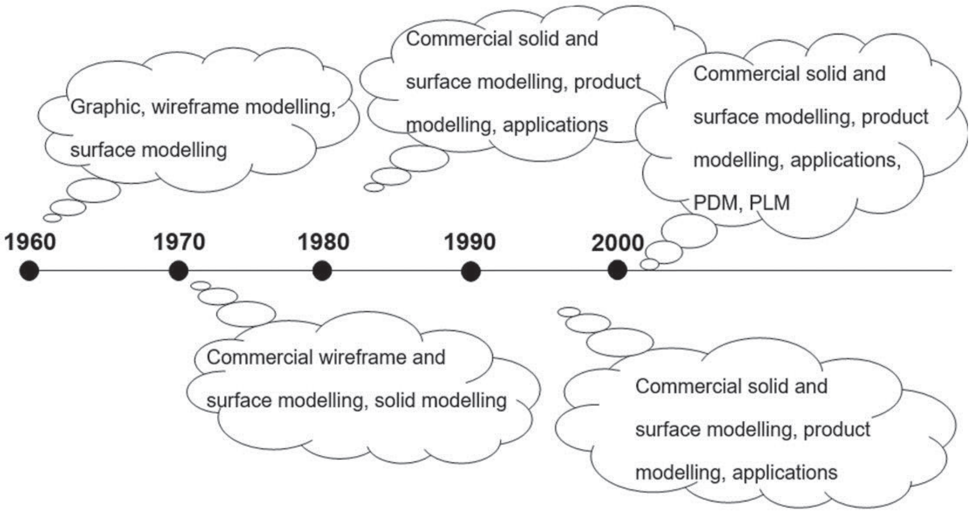

Figure 2. History of CAD and its capabilities [7]

Today's benefits of using CAD technology in product development can systematized into three segments: productivity increase, management flow of technical information and the impact of CAD systems implementation on increasing quality. The impact of CAD systems implementation on increasing quality that has reflected in the quality of drawings that no longer depends on the skill and experience of the drawer, drawings are of better quality, the possibility of associative quote, standardization of procedures and symbols, rationalization of the product development process and quality of design.

3. Types of space models implemented in CAD systems

The first computer programs designed for drawing have based on two basic topological elements, point and line. These programs have designed exclusively for 2D drawing. By moving to 3D space, other topological elements have also used [7]. As the computers developed and became more powerful, so the computer programs designed for drawing got more and more opportunities. The development of these features also leads to the development of graphic representation of space models.

3.1. Wireframe model

A wireframe space model is one of the first modes of space description on computer screen (Fig. 3). It represents the simplest view of the object in space. Some of the following simple objects such as line, circle, arc, describe this model.
The lack of wireframe models has reflected in ambiguity. This disadvantage derives from the representation of the models by means of edges (Fig. 4). These models are not suitable for numerical analysis because it is not possible to calculate the size such as the surface and volume of the model.

3.2. Surface model

Surface model mathematically is described by edges and surfaces between edges (Fig. 5). In this way, ambiguity of the model has achieved. Models are suitable for visualization by hiding invisible edges. The lack of these models is reflected in the inability of numerical analysis, because they do not have the interior, apropos they are described by surfaces and edges. They are suitable for NC tooling machines and surfaces for the design of tools and molds.

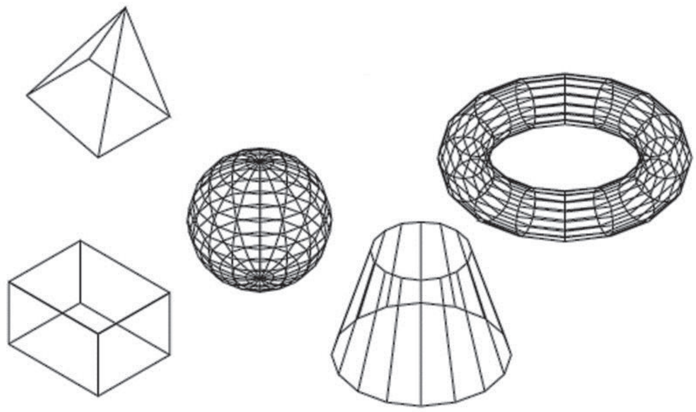

Figure 3. Examples of wireframe models

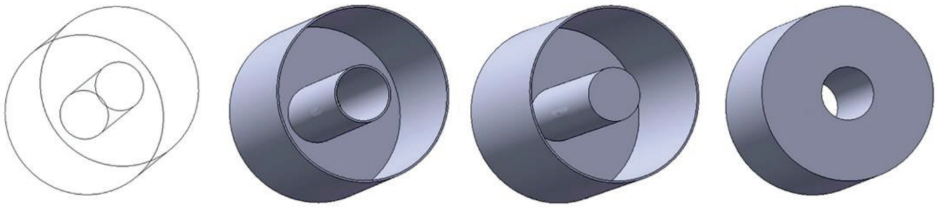

Figure 4. Ambiguity of wireframe model

Surfaces that border the surface model can be surface planes. Surfaces that are more complex is possible to construct by projecting a set of curves per bearing, linear interpolation between two curves or moving one curve to another. Designed surfaces are generating with the set of curves. They can be cubic and space nonanalytic curves (spline curves and NURBS curves).

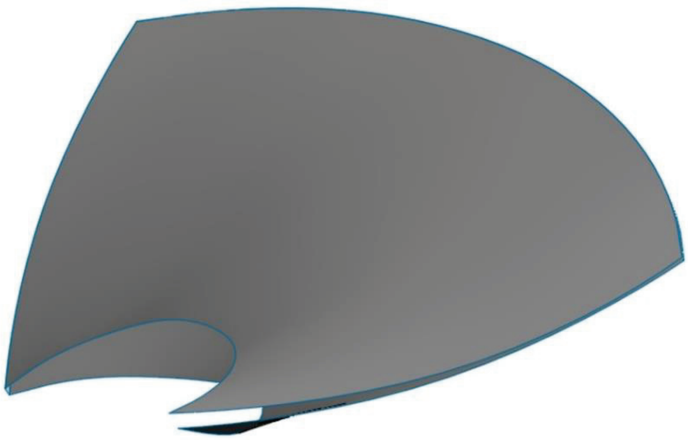

Figure 5. Surface model

3.3. Solid model

The solid model describes the edges, surfaces and volume within edges and surfaces (Fig. 6). Compared to surface models, these models do not have open surfaces and free edges because all surfaces are close and connect. When showing solid models, the physical object divides the 3D Euclid space into two areas. One area is external and the other is internal. The areas are separated by a solid body border [8]. Solid models have a border, they are homogenous and final. Solid models are suitable for numerical analysis and application in CAM systems to generate NC programs.

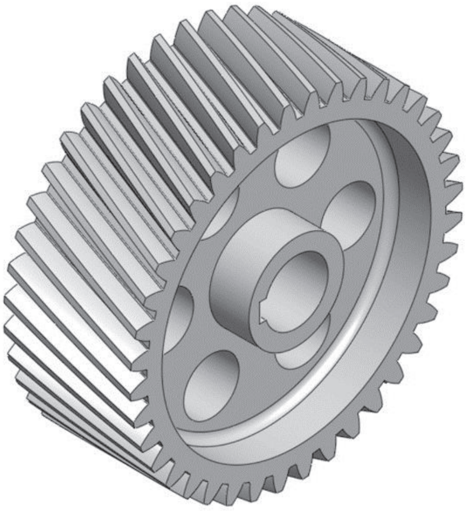

Figure 6. Solid model

3.4. Assembly model

Integrating product information over the entire lifecycle implies an overview of the construction from a rough model to a model that contains detailed information such as product structure, technological process, technical reports, material specification, transport documentation, use and maintenance. Parts and subassemblies represent "building blocks", the structures of a product assembly [9].

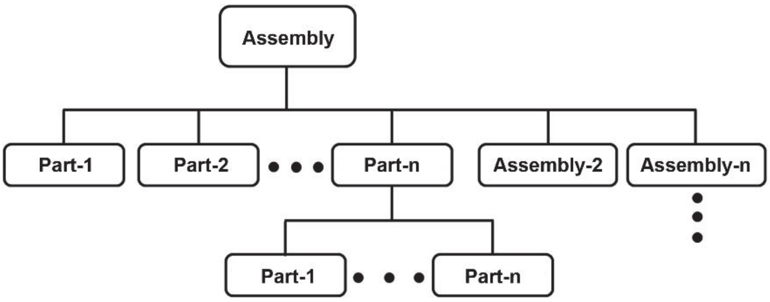

Figure 7. Simplified assembly scheme [9]

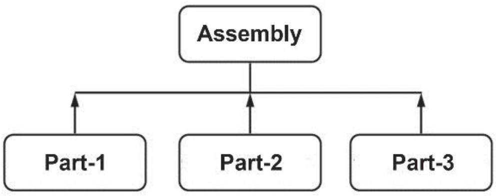

Figure 8. Bottom-up method

Through the product structure is possible to see geometrical and dimensional relations between parts (Fig. 7). Also is possible to see functional relations (binding function) [10]. Through tem is established shape structure of product. Hence, assembly model has important role in design process, because he presents final aim of this process, a product.

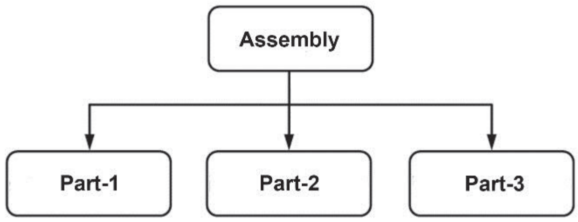

Figure 9. Top-down method

There are two techniques for generation assembly models: bottom-up technique (Fig. 8) and top-down technique (Fig. 9). Figure 10 shows the assembly model of friction unit according to [11].

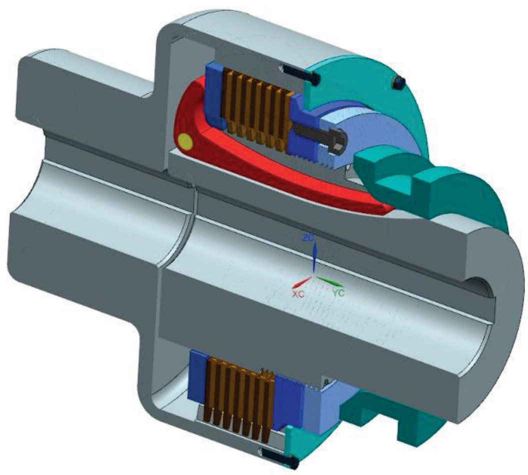

Figure 10. Assembly model of friction unit

4. Methods of modelling space models

Modelling of solid body models in modern CAD systems is accomplished by two following methods: Boundary Representation (B-Rep) and Constructive Solid Geometry (CSG). These two approaches are not the only ones to make solid body models. In [8] there are also four approaches: spatial enumeration, cell decomposition, sweep method and primitive instancing method. Most of today's modern CAD systems use combinations of B-rep and CSG methods. These methods are implemented in feature based modelling method [8]. In this paper, the B-Rep and CSG modelling methods will explain in more detail.

4.1. Boundary representation (B-Rep)

In the B-Rep method, equations of surfaces, curves, and coordinates of points, that define the boundaries of the model, form information about model geometry (Figure 11). The combination of information on geometry and their connection is the basis of the B-Rep approach. This approach is implemented in all CAD systems and is used to display space models. B-Rep method consists of topology and geometry [7]. Topology defines the structure of the model, and geometry its shape. The basic topology elements of the model are the face, edge and tip. Beside of basic elements, there are derived elements such as shell and ring.

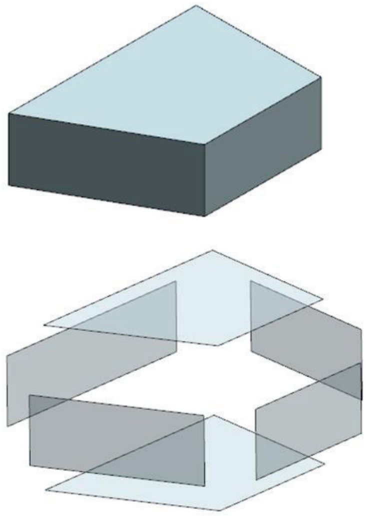

Figure 11. B-Rep modelling method

Topology allows the connection of the structure. For example, if it is a face, then all the edges round the face are interconnected and make a unique structure. Each face is part of the surface, each edge is part of the curve, and the tip lies at the point in the space. This is a precise geometric description, which does not only include the outer surfaces surrounding the space model but also its internal structure.

4.2. Constructive solid geometry (CSG)

During the 60s and early 1970s, were introduced requirements for extending the 2D CAD system with the third dimension [12]. During modelling, the user uses full body primitives. The method of connecting solid bodies is based on the assumption that each physical body is created by combining elemental (primitive) forms. The most used elementary forms are: cube, roller, cone and sphere (Fig. 12). Besides these forms, prism and torus are using as elementary forms.

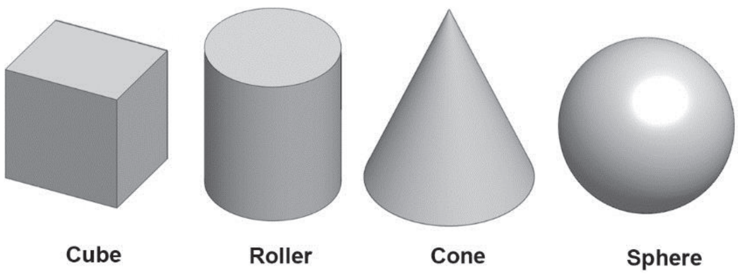

Figure 12. Basic elementary forms

The basement of CSG approach is theory of sets, where by composing primitive forms with Boolean operators they form new bodies. Boolean operators that are used within CSG approach are union, distinction and intersection. Mathematically, this operation is possible to write in the following way. Let *U* is a set, *A* and *B* are his subsets:

- **Union** (Fig. 13) of *A set* and *B* set ($A \cup B$) is a set $A \cup B = \{x \in U : x \in A \vee x \in B\}$. Union of *A* set and *B* set is a new set $U = A \cup B$ where all elements of *A* set and all elements of *B* set, are elements of *U* set.

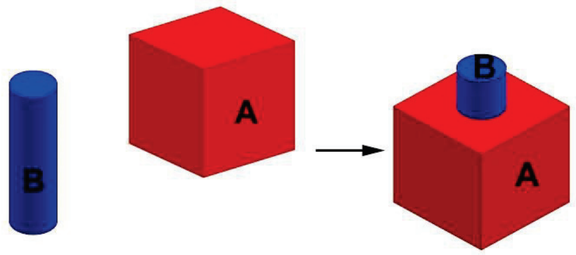

Figure 13. Union $A \cup B$

- **Distinction** (Fig. 14) of *A* set and *B* set ($A-B$) is a set $A-B=\{x \in U : x \in A \wedge x \notin B\}$. Distinction of *A* set and *B* set is a new set $U=A-B$ where all elements of *A* set are in this set, but elements of *B* set are not in this set.

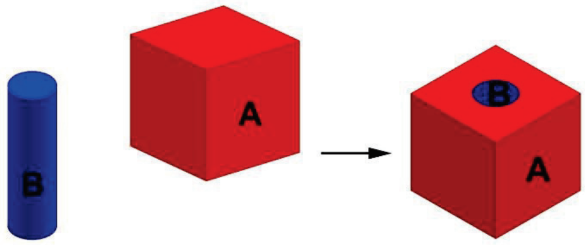

Figure 14. Distinction $A-B$

- **Intersection** (Fig. 15) of *A* set and *B* *set* ($A \cap B$) is a set $A \cap B=\{x \in U : x \in A \wedge x \in B\}$. Intersection of *A* set and *B* set represents set of elements that belong *A* set and *B* set.

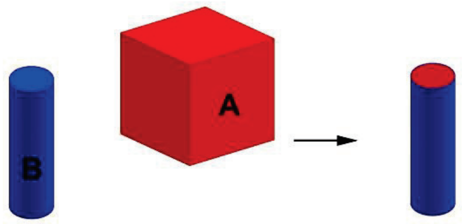

Figure 15. Intersection $A \cap B$

5. Conclusion

In a design process, and wider–in product development process, the implementation of 3D CAD systems today is very significant. It is possible to say that it becomes one of the basic conditions for survival of companies in the global market.

In the 2D CAD system, almost everything was done, so their stagnation began, and emphasis was put on 3D CAD systems. These systems are quality enough today, fast and cost-effective (mid-range CAD systems), and are increasingly used in companies.

3D CAD systems today offer great features such as clear display of models, standardization, space models parametrization, automation of making technical drawings, integrated product development, associativity, generation of NC codes, calculations using the finite element method, etc. Most of the data is stored in a space model. This makes them different in relation to 2D CAD systems whose data are limited to a technical drawing.
The industry in Croatia still has a large share of the 2D system, and the reason is out of date the program and machine equipment. But nowadays a recent rise in the 3D CAD systems, as well as higher quality computer, software and machine equipment.

6. References

[1] ISO 9000: 2000, Quality management systems-Fundamentals and vocabulary, 2000
[2] Hubka, Vladimir; Eder, W.E. Theory of Technical Systems. Berlin: Springer-Verlag, 1988.
[3] Duhovnik, Jože; Tavčar, Jože. Elektronsko poslovanje in tehnični informacijski sistemi. Ljubljana: LECAD, Univerza v Ljubljani, Fakulteta za strojništvo, 2000.
[4] Hubka, Vladimir. Theorie der Konstruktionsprocesse. Berlin: Springer-Verlag, 1976.
[5] Štorga, Mario. Model rječnika za računalnu razmjenu informacija u distribuiranom razvoju proizvoda. Doktorska disertacija, Zagreb, Fakultet strojarstva i brodogradnje, 2005.
[6] Hlebanja, Jože. Metodika konstruiranja. Ljubljana: Univerza v Ljubljani, Fakulteta za strojništvo, 2003.
[7] Stroud, Ian; Hildegarde, Nagy. Solid Modelling and CAD Systems: How to Survive a CAD Systems. Springer-Verlag, London, 2011.
[8] Radhakrishnan, P.; Subramanyam, S; Raju, V. CAD/CAM/CIM. New Age International Publisher, Third edition, 2005.
[9] Duhovnik, Jože; Demšar, Ivan; Drešar, Primož. Modeliranje z značilkami na osnovi SolidWorks. Univerza v Ljubljani, Fakulteta za strojništvo, 2014.
[10] Karakašić, Mirko. Model povezivanja funkcija proizvoda, parametara i interval njihovih vrijednosti kod razvoja proizvoda, primjenom matrice funkcije i funkcionalnosti. Doktorski rad, Strojarski fakultet, Slavonski Brod, 2010.
[11] Kljajin, Milan. Tarna lamelna spojka. Strojarski fakultet, Slavonski Brod, 1998.
[12] Kyran, M.D. The CRC Handbook of Mechanical Engineering. New York, 1997.