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The integral development of products using the DfX approaches and CAx tools

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Abstract: *Approach of integrated design represents the bridge that connects individual stages of the product designing and the technology and has a significant role in the reduction of the overall design time, as well as the production costs. That means that the technological processes design should be connected with production planning as well,, that is the choice of tools, equipment, pressing devices and machine tool. Design for eXcellence is a philosophy that promotes rapid and successful products by encouraging communication and cooperation between the functional departments that are responsible for the design and manufacture of a product. Implementation of a successful DfX programme will decrease product development time, product cost and manufacturing cycle time while increasing product quality, reliability and ultimately, customer satisfaction.*

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Keywords: DfX, CAx, CAD/CAM integration, technological process.

INTRODUCTION

Integrated product and processes design is basically intended to form a competitive product. In the cycle of conceptual design variant and variable product solutions and adopted technologies have a dominant influence on the choice of machine tools for the support in the realization of the adopted technology.

To create a competitive product is an important approach to integrated product design and technology. This approach represents a bridge that connects the individual stages of product design and technology and have a significant influence in reducing overall design time and production costs. Of course, total time and costs can be reduced through the chosen approach in the management of production. This means that the design of technological processes should be linked with production planning, ie. range of tools, accessories, devices for clamping and machine tools [1].

1. DESIGN FOR ‘X’

Design for ‘X’ suggests that the X is used as a variable term that can be substituted with, for example, **A**ssembly, **C**ost, **E**nvironment, **F**abrication, **M**anufacture, **O**bsolescence, **P**rocurement, **R**eliability, **S**erviceability or **T**est.

1.1 DfX and Concurrent Engineering

Figure 1 and Figure 2 show the traditional sequential process of product development and the equivalent concurrent process. The savings in time and money are due to the reduction or elimination of product respins due to changes and corrections to the design from the manufacturing functions upstream. The term ‘respins’ refers to the reworking of a design appears to derive from the record industry and is quite common within the ASIC community.

Concurrent engineering can be viewed as the simultaneous development of the whole design, its components and its assembly process and tooling requirements.

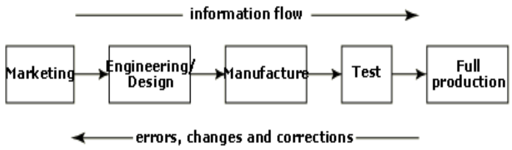

Fig. 1. *Traditional sequential product development*

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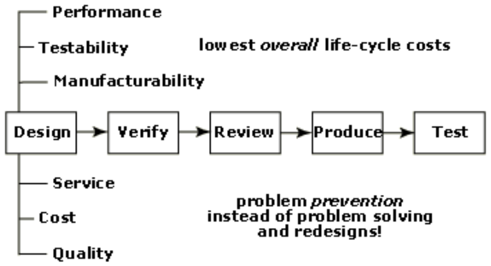

Fig. 2. *Concurrent product development*

DfX is a methodology that involves various groups with knowledge of different parts of the whole lifecycle of a product advising the Design Engineering functions during the design phase. This knowledge can take the form of guidelines that the designer will follow during design, or design review meetings with the field experts [2].

2. CAx-TOOLS

Tasks in the design process were supported by CAx-tools during the last 30 years. Starting with drafting and surfacing also classical mechanical design was replaced by 3D wire frame, solid modeling and parametric and feature based design. Today the complete product creation process, including production preparation, is completely running with CAx-techniques. According to the various application fields different CAx-systems were developed, named by different CAx-methods: Computer Aided Styling (CAS), Computer Aided Aesthetic Design (CAAD), Computer Aided Conceptual Design (CACD). All these technologies are covered by the expression Computer Aided Design (CAD). Two very important CA-fields were historically developed almost independently: Computer Aided Manufacturing (CAM) and Computer Aided Engineering (CAE). The last is mainly used in a limited sense for simulation and Finite Element Analysis.

With the growing integration of these CAx-tools the data and information management became more and more important. Nowadays the complex network of CAx-systems and their various data cannot be handled without Product Data Management Systems (PDMS). They are regarded as the backbone of modern product development and now extended to support the whole product lifecycle. This overall information management leads to the concept of Product Lifecycle Management (PLM).

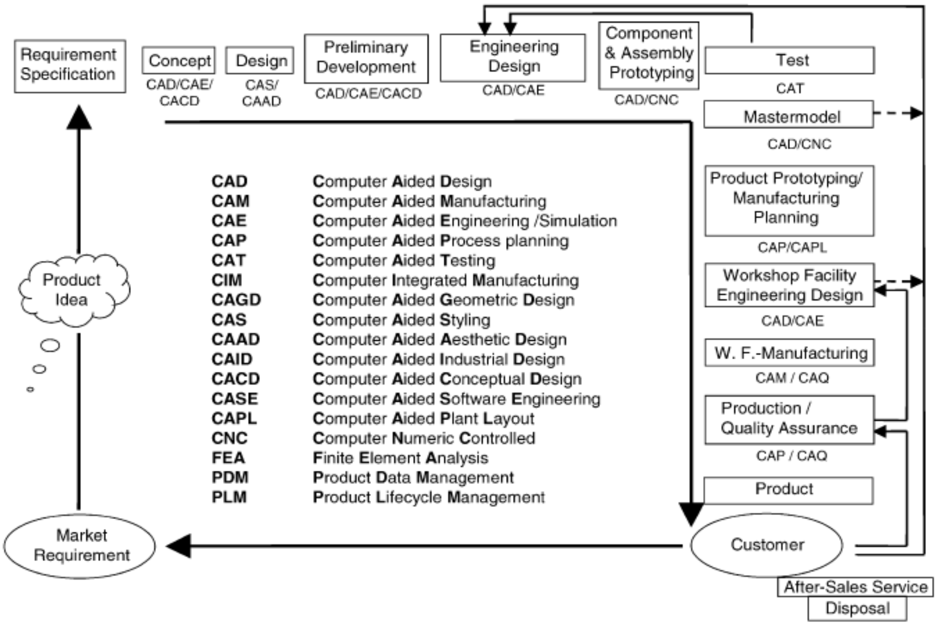

Fig. 3 *General process chain of product development*

In an exemplary simplified process chain (Fig. 3) it is shown that CAD is only a part of the product development process. This process begins with an idea, requirements and specifications for the product and ends with the serial production, customer after sales service, recycling, scrapping and disposal. CAD is embedded in the development process together with many other CAx technologies. In order to avoid unnecessary loops the engineer has to have knowledge of the surrounding process steps as well as the kind and quality of data, respectively information, they produce or require. The knowledge about the previous process steps is to maintain the design intend, the knowledge about the following process steps is to guarantee their feasibility. In addition to this economical aspect the quality of the product describing information has to be taken into account [3].

3. CAD/CAPP/CAM INTEGRATION

CAD / CAPP / CAM integration is aimed at improving the process of product design and technology significantly reduce production costs, and provide conditions for easy and economical technology of processing and assembly. Since installation costs are a significant part (25-65%) production cost, design for assembly DFA (Design for Assembly) along with the technological design of assembly processes CAAPP (Computer Aided Assembly Process Planning), close interaction in the process of product design, processing technology and assembly.

In relation to the modeling of the component domain, makes more complex the problem is significant in research approaches and ways of modeling the assembly structure and executive functions and processes, in this case to model assembly structures of machine tools. Defining the prefabricated structure of machine tools based on the principles of design for assembly DFA as the main strategy of simultaneous projects, and is considered the key to successful design in a competitive environment.

Taking into consideration criteria of product design and technology, the goal is to make technological advancement, reduction of production time, reducing the preparatory and the operational time, reliable technical support and increase production efficiency.

3.1 Basic features of CAD/CAM system

Computer-aided design (CAD - Computer Aided Design) is the process of product design by computer and includes activities that take place between the electronic drawing and work on software systems that support automatic product design. CAD can be defined as the use of computers and graphics software to assist in the development or improvement of product design from conception to documentation.

CAD is a series of methods and tools to assist the design process in creating a geometric presentation of what is constructed, dimensioning and tolerances, changes in construction management, archiving (saving), exchange of information on parts and assemblies, with the help of computers. CAD model of the input for the next step in the design manufacturing (CAM), and analysis (CAE).

The application of CAD / CAM system provides many benefits to users, so it is now practically no question whether they should be used but that the optimal solution for a specific product or a development company. The basic advantages of CAD system are:

- Increase productivity (speed)
- Support changes in the structure
- Communication
- Some basic analysis

3.2 Development of products in CAD systems

The rapid development of information technology products has led to revolutionary changes in the planning, execution and control of engineering and business processes, and integrated logistics support process in which the role integration just take information technology. It can be said that the transition to digital technology, as holders of the integration process in modern business, the condition of surviving and growing company in a competitive environment. In this sense, considering integration processes in product design and technology, CAD/CAM to the concept of concurrent engineering as a framework for the globalization of business companies, detailed consideration are the basic approaches in the process of engineering design.

Cycles in engineering proces planing represent the backbone of the analysis process where the design as a thinking process associated with the two characteristics of the human mind: originality and skill.

Another characteristic of the adopted design process is the objectification of computer aided design products and technologies. Uncertain consideration are elements of the design process based on knowledge. Then presents the main factors of formation of knowledge in engineering design as a condition for entering the field of expertise [2], [4].

4. SOME EXAMPLES OF INEGRATION

This work shows the process of the design on the example of hydro engine back lid on the hydraulic motor. Within the process of forming a competative product, special attention is paid to the elements, that is the parameters of the technological process which significantly reduce production costs, e.g. choice of tools and the way of tightening and positioning of the part. By the technological analysis of the object it has been established that the tightening device of the working pieces presents a predominant factor in the production realization. For that reason special attention was paid to the modelling of the machine tool with the special tightening device which in this case represents an additional fourth control axis [5].

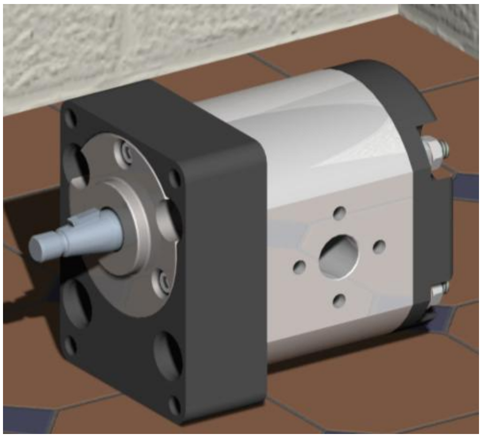

Fig. 4. *Hydro engine*

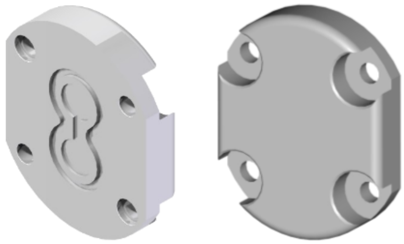

Fig. 4. *Prepared and finished part*

The processing of a mechanically correct part requires qualitative prepared part, its correct pressing and location definition (of the position and orientation) in the space. As an addition to the definition of spesific surface positioning, it is necessary to design the way of firmly holding the part in the given position under the influence of outer forces like gravitation force, cutting force, vibrations, centrifugal forces, etc. It must not influence the previously determined function of positioning, but it has the function of providing stability of the part. The pressing devices must have the appropriate pressing force so as not to damage the part in the points of contact with its excessive pressure.

4.1 Types of pressing in cases of miling and drilling

Pressing tools design and devices for pressing the working part on the machine design are realized by the application of contemporary CAD/CAM programme packages. The position of pressing, previously described, has to follow the rules of the precision of the production and respect the relation between the segments of the part. It also has to ensure that the part doesn't move during the processing, that the parts of the pressing equipment don't interrupt the movements of the tools or cause increase in the tool operation and that it is easy to remove filing [7].

4.2 Modelling of the installation structure of the machine tool

The concept of the machine tool in the narrower sense is defined to support the adopted production process. In order to perform the necessary operations while processing the back lid of the hydro engine, machine variants have to have the appropriate movements which provide independent wholes – modules. For every movement, whether main or additional, there has to be the right module that provides such a movement. In order to press the processing part it is necessary to design a pressing device. Thus modular analysis is done based on which the pressing device design is done with certain modifications in relation to the already existing vices, and in particular pressing prism. From the available modules CIRPP those that meet the given demands are chosen.

4.2.1Vice module

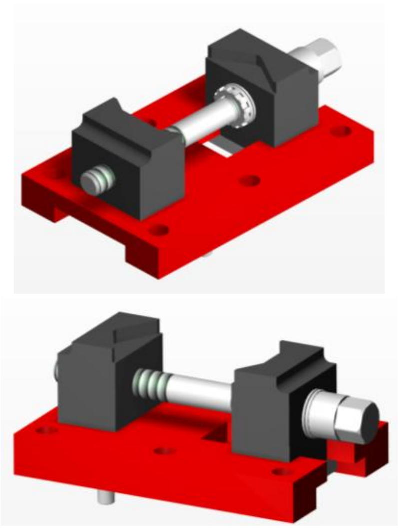

Fig. 5. *Vice module*

Vice module assembled with the holder, bearing and rotation desk represents an additional axis on the tool machines. For the processing of the back lid of the hydro engine, three-axis verticall drill/miling machine and three-axis horizontal drill/miling machine are chosen, so that the assembly of the vice represents the fourth additional axis. This additional axis increases the productivity, in one pressing, 16 back lids and housing of hydroengine are processed. The number of simultaneously processed lids is conditioned by maximum tool stability, so that the tool can process all 16 lids, without changing the tool in the meantime. After the processing, the changing of tools and working objects is done. The vice is modelled parametrically and variantly so that it can be used for pressing of the hydro engine's back lid of different dimensions and for the appropriate number of parts that can be accepted [6].

4.2.2Realization of the adopted technological process on variantly chosen machine tools

The prepared part for the production of the back lid of the hydroengine is an extradited aluminium pole and it's shown in fig. 4. Based on the technology that represents a way out of the matrix of following, the process of the hydroengine's back lid production is done in two pressing moves. In the first pressing move the prepared parts are put into the vice, one by one, and the look of the prepared parts [2].

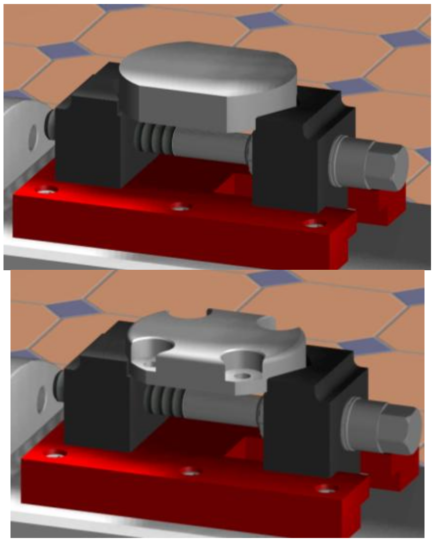

Fig. 6. *Vice module*

Tightening device, together with the girder, sinking and rotary table presents an additional axis on machine tools. In this and the next variant triaxial horizontal driller/cutter, and the triaxial vertical driller/cutter are chosen, so that the structure of the tightening device presents the fourth additional axis. By this additional axis productivity is increased, within one tightening 16 hydraulic motor back lids are processed. The number of the back lids that are processed at the same time is conditioned by the maximum stability of the tools, so that tools can process all 16 back lids, without having to change the tools in the meantime. The process having been done, the tools and working objects are changed. In the next picture we can see what the tightening device looks like, this one is modelled parametrically and variantly so that it can be used for tightening of the hydraulic motor back lids of different dimensions and for the right number of pieces that are acceptable [6].

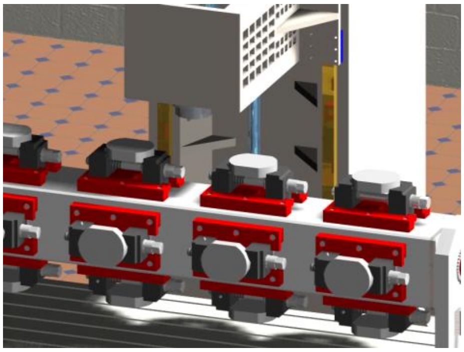

Fig. 7. *Hydro engine*

One variant machine tool used to process hydraulic motor housings and back lids is a vertical drilling/cutter fig.8. This machine tool has two translations and one rotation of the working object, one translatory and one rotary movement of the tools. On this machine 4 axis- X',Y',Z, and A' are numerically controlled [6].

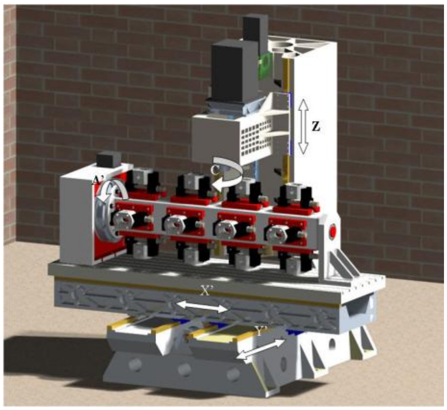

Fig. 8. *Vertical driller/cutter*

5. CONCLUSION

Achieved results in this work are reflections of the research of variant option in the technological production process of the hydro engine back lid using already existing tool machines.

The results of the research come from a very large theoretical analysis of the individual parametres which directly influence generating of technological process.

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