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Stude of Computer Aided Design and Simulation Importance in the Conception and Development Phases of a Product

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Abstract: *The paper presents the importance of computer aided design and simulation in the management of conception phases of a product. In the design process of an industrial product, the analysis and identification of the requirements, the search for solutions, the analysis and comparison of different variants are very important, mostly in the early design phases, when a product needs clarification, understanding of the concept, embodiment design, finding it's place on a concurrential market etc. The whole course and main characteristics of the resulted product development project are guided by these tasks. The work and costs for design changes increase during the progress of a product development project, but in the concept phase when the decisions for the solutions are taken, are much lower. In order to make decisions between different solution variants in an early stage of a project, it is necessary to have access to relevant informations about the viable solutions. To find these solutions and especially to create the informations (knowledge) there are useful to apply CAD/CAM/FEM techniques*

Keywords: computer aided design, conception and development, design phases, reusing the information

1 INTRODUCTION

In order to develop products for concurrential markets with a large number of clients, in the context of high demanding technology development projects, different creative methods are used by the development teams. These teams are able to create a relative high number of concept ideas with specific technical informations. Any ideas could sometimes be valuable for following steps in the project, other projects, or for other project teams.

To support the information generating process, there are several methods and different tools, to analyse product properties in all the stages of the development process. Relevant parameters, which were identified during evaluation, are used as the input values for the selection of suitable analysis methods. By the application of different analysis methods in the early stages of the product development process, relevant information will be compiled and stored, which is very important for further development.

In the field of mechanical engineering and industrial product development, many companies develop complex products in various series and a new design concept may be needed for specific products based on clients demands. This design contains results of working steps, which are similar to the results of the same steps in former design projects. A lot of solutions can be derived from an earlier project or the choice between different solution variants will be based on a similar set of criteria met at another project.

The engineer will make the requirements list, a structure of functions, principle solutions, characteristics, combinations according to criteria derived from the requirements. A methodical procedure in the concept phase produces the information, which is also necessary in following design projects. There is a connection between methodical work in the early design phases and the design knowledge, stored and used from anterior projects. The project team needs special software for supporting systematic work in the early design phases, for compiling design information automatically in a structured way and for providing an easy access to it.

2. COMPUTER SUPPORT IN THE PRODUCT DESIGN PHASES

The structure and assembly of most products is becoming more complex every day. Computer support in engineering design is focused on the modelling of geometry with computer aided design systems and on providing product related data for the following stages of the product life cycle.

In most of cases, engineering designers start their work without an appropriate access to the entire information collected and stored, in former similar projects. Very often this leads to a reinvention of the solutions. The main idea is focused on the solution development by providing solution principles derived from existing patents, finished projects or similar products on the market. Actual CAD systems evolved in their functionality by the integration of feature modelling techniques, parameterization, various simulations capabilities and constraint handling. Under the permanent time pressure, working with the software tool has to speed up the design process. Also, the software tool has to support the designer in creating the design documents (parts, assemblies, draftings, tables, reports etc.) in a comfortable and parametric way.

The main idea is to identify, store and reuse all the important parameters to automatically obtain new and different versions of the designed product. The created documents need to be standardized according to national or international norms and should be demanded by the management in order to fulfil standards such as ISO 9001. Regarding the methodological support, an education in systematic design should be a prerequisite for working with the software tool.

3. REUSING THE INFORMATIONS

Recent studies estimate that almost 80% of industrial design activity is based on variants design and in such a redesign case 70% of the information is re-used from previous succes solutions. The concept of re-using information is inherent within the natural process of design. The origins of formal design re-use are found in the realms of software engineering where it became a realistic solution to problems caused by increasing complexity.

The complexity in design is viewed in such diverse factors: as the product being designed, the design activity itself, the enginners involved, the decision making process, the aspects on the design, knowledge and sources used and generated. Every issue affects each of these factors and has it's complexity. Even the simplest product is associated with a complex array of factors, which model the activity of design and consequently the final product definition, and result in a vast accumulation of related design knowledge. The final product definition is dependent on: the company organisation, the type of design, the chosen design process, designers, tools and external factors out of the designers control. Thus, the design team meet a complex problem in creating knowledge for re-use. The problem is further amplified by the differences in terms of characteristics, types, sources, forms and origins of design related knowledge, which can be considered from many viewpoints such as: functional, structural and behavioural.

Design by re-use relies on the availability of appropriate knowledge sources. This require a suitable knowledge modelling mechanism to support design for re-use which would capture knowledge from many sources at different stages and represent an evolution through the design activity. Formal knowledge modelling mechanisms which adequately support design for re-use must be capable to define knowledge elements. This will facilitate a better understanding on how and why design knowledge was developed into the final product definition and provide the designer with a greater knowledge resource to utilise in future projects.

4. KNOWLEDGE IN PRODUCTION PROCESS

Several information has to be handled for the manufacturing of a specific product. This information is represented by three important models: product model, resource model and process model (fig. 1). The amount of information provides a higher product complexity and an increasing number of variants. Improvements in the field of manufacturing processes lead to complex manufacturing knowledge. Thus, efficient information management is very important in the conception and development phases of a product.

The information flow can be separated into two major flows: one flow focusing on technological details of the product and another one preserving economical or administrative informations. These two separated flows corespond to the differences between process planning, production control and scheduling systems. The traditional approach of separating planning activities (e.g. process planning) from implementing activities (e.g. production control and scheduling) results in a gap between the involved systems.

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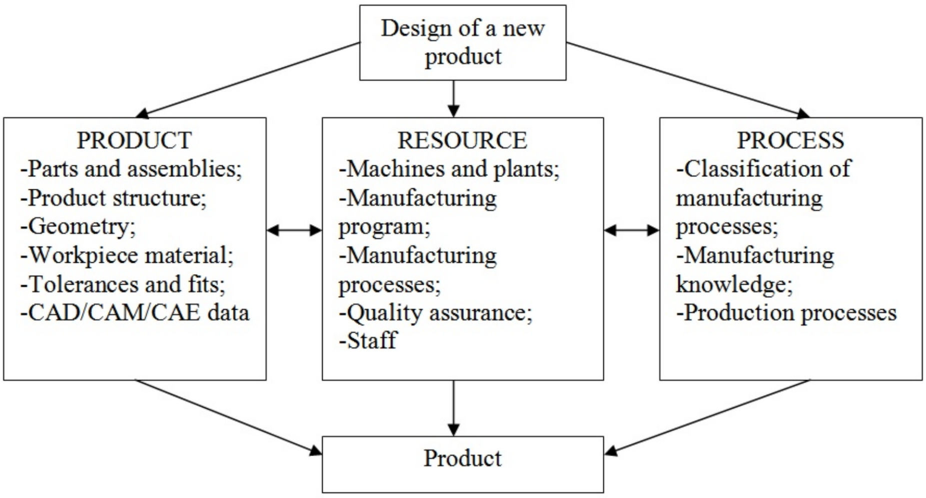

Fig. 1. Information models in the production engineering domain

It implies loss of time, of information and, in consequence, loss of quality and prolonged time-to-market.

5. A CASE STUDY

The aim of this short case study is to design a cylindrical gear pump manufactured by a romanian company in a large number of constructive variants. It was identified the need to model the pump’s assembly with the CATIA v5 software, having parametric abilities, so the pump should cover a domain of flows demanded by the company customers. The following steps were analyzed: it was identified the pump functional role and its components, dimensions and assembly conditions, then, in a very important step, the pump's model was created in a complex parametric manner establishing the dimensional and functional relations between the components’ dimensions. Finally, a FEM analysis of the pump gear in some imposed conditions exposed the most stressed components.

The designed pump works with an external involute gear, it is one of the most usual types, used in many installations, functioning at different pressure levels. In principle, this kind of pump is composed of impeller rotors mounted on transmission shafts or being one part with them, a body, a compensator, a casing cover, different sealing elements, fittings, screws and set pins.

The gear volumes (cups) represent the gashes between two consecutive teeth that pass one after another through the aspiration chamber. These gashes are filled with fluid which is then transported and delivered under pressure in the recession chamber.

Usually, the pumps’ flows vary between 2 and 1000 l/min, driving power up to 30-40 kW and rotative speed between 700 and 7000 rpm. The flow variation may be obtained in different constructive variants using the same rotating speed or by changing it while keeping a certain variant.

To obtain these variants it was necessary to parametrize the pump's assembly after it's flow parameter. The flow is obtained from one of the fundamental pump's characteristic, geometrical volume *Vg*, expressed by the equation (1):

$$V_g = 2 \cdot z \cdot b \cdot A \cdot 10^{-3} \text{, [cm3/rot].} \quad (1)$$

where: *z* – number of teeth, *b* – gears width and *A* – area of the gash profile between two consecutive teeth. The gash profile area decreases with an increase of the teeth number which determines an increase of the interior pump gauge. Further, the pump flow *Qp* is calculated with the equation (2):

$$Q_p = \frac{V_g \cdot n}{10^3} \cdot \eta_v \text{, [l/min]} \quad (2)$$

where: *n* – rotational speed of the driving shaft and η*v* – volumetric efficiency. In this case, *n*= 3000 rpm and η*v*= 93%, but these values may be different due to the pumps large diversity. In the company specifications, the standard and first value of this *Vg* parameter is 2.11 cm3/rot.

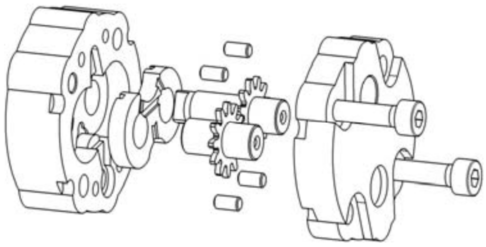

Fig. 2. The gear pump assembly model

Figure 2 presents the gear pump model in an exploded 3D visualization.

All the pump components were designed and then assembled in the CATIA Assembly Design module by applying various geometrical and dimensional constraints: coincidence (between the gears' shafts axes and the body and casing cover's holes axes, etc.), surface contact (between the lateral surfaces of the gears and the compensator's appropriate surface, respectively of the casing cover etc.). The parametric assembly was built with parametric designed parts, the pump components, involving many constraints, relations, conditions, verifications, messages etc. written in the Visual Basic language using a specific sintax. The design engineer (which can be also the programmer) is now able to vary a value and the whole assembly is immediately re-created. Figure 3 contains a small fragment of the parametrization code used in updating the pump's dimensions depending on the flow's variation.

```
if `Pump flow Qp (l/min)` ==2.11
        {`gear1\ gear \Pad.1\FirstLimit\Length`=2.3mm
        body\PartBody\Pad.1\FirstLimit\Length =25mm
        body\PartBody\Pocket.6\FirstLimit\Depth =10mm
        compensator\PartBody\Pad.1\FirstLimit\Length =7.7mm
        ` gear1\gear\Pad.3\FirstLimit\Length`=23mm+1.7mm
        ` gear2\gear\Pad.3\FirstLimit\Length` =15mm+1.7mm
        body\PartBody\Pad.3\FirstLimit\Length=2mm
        body\PartBody\Pad.8\FirstLimit\Length=2mm
        `efficiency`=0.88}
else if `Pump flow Qp (l/min)` ==10.6
        {` gear1\ gear\Pad.1\FirstLimit\Length`=10mm
        body\PartBody\Pad.1\FirstLimit\Length =35mm
        body\PartBody\Pocket.6\FirstLimit\Depth =20mm
        compensator\PartBody\Pad.1\FirstLimit\Length =10mm
        ` gear1\gear\Pad.3\FirstLimit\Length`=23mm-6mm+10mm
        ` gear2\gear\Pad.3\FirstLimit\Length` =15mm-6mm+10mm
        body\PartBody\Pad.3\FirstLimit\Length=4mm
        body\PartBody\Pad.8\FirstLimit\Length=4mm
        `efficiency`=0.93}
```

Fig. 3. The parametrization code

Based on this parametrized model, on the simulations performed, a new family of pumps may be produced. A real pump variant is shown in figure 4.

Fig. 4. A gear pump variant

6. CONCLUSIONS

The implementation of methodical and parametric design procedures is a very important step in computer aided design. The management has to ask for informations and CAD data for tracking the work in the determining early design phases. Today, a link is needed between data/ knowledge management in the early design phases and future product functionalities in the embodiment and detail design.

REFERENCES

[1]. Bernard, R. (1999). Early evaluation of product properties within the integrated product development, *Shaker Verlag*: Aachen 1999.
[2]. Brown, S.L., K.L. Eisenhardt (1995). Product development: past research, present findings, and future directions, *Academy of Management Review*.
[3]. Chung, A. Ch., (2004), Simulation, modeling. handbook. A practical approach. industrial and manufacturing engineering series. *CRC Press LLC*, ISBN 0-8493-1241-8, Boca Raton London.
[4]. Culley, S.J. (2008). Design re-use of standard parts, keynote paper, in proceedings of design reuse - *Engineering design Conference*, Brunel University, UK.
[5]. Ghionea, I. (2010), Researches on optimization by simulation of the industrial products design. *Phd. thesis*, University Politehnica of Bucharest.
[6]. Tollenaere, M., (1998). Conception de produits mécaniques. Méthodes, modèls et outils. *Editions Hermes*, ISBN 2-86601-694-7, Paris.
[7]. ***, (2009), Pompe cu roți dințate. Product Catalog HESPER.

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