CONSIDERATIONS ABOUT OPTIMIZED CAD DESIGN APPLICATION FOR THE AUTOMOTIVE AND ENGINE'S MECHANICAL STRUCTURES

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ABSTRACT - The CAD and FEM tools are the most usual instruments in order to design and optimize mechanical structures today. Previously, those tools were not redily accesible for every one, but only for a limited number of research centers and big companies. The software applications for design and optimization regarding structural mechanical structures, and specially those in the automotive engineering area, provide a wide range of possibilities in order to improve the results. Almost all design engineers are able today to use these tools in their design activities. In addition, a structured way for design will allow a better application of finite analysis method (FEM). Previously it was less important how a mechanical component was designed in a CAD tool. Today, it is very important how the mechanical component will be designed, if it is easy to be modified, if the design method is „user-friendly". Today the designed part will be generated in a design office, but will be analysed in another office located in another place (country), by other design engineers. After that, the FEM-analyses may take place in another office. This paper considers some possibilities for optimization and improvements in CAD design for the automotive and engine's mechanical structures in order to increase the designer work's efficiency and to allow a more structured way to create 3D parts.

INTRODUCTION

Overview CAD / FEM construction in automotive engineering

The complexity of research and development activities in the automotive and engines area have increased extremely. As a consequence, all the research and development steps are based on computer-based methods. For parametric-associative CAD construction, there are several different applications, shown in the following examples. Parametric-associative CAD construction: The basic procedure is developed as far as possible. There are a few efficent methods in the concept development. The most frequent problems are concerned with the increased complexity of the CAD models (complex surfaces and solids, complex assemblies, sheet metal, drawings and other output files). Another problem is the new trend of multinational companies, which supose a simultaneously processed computer aided design. This enables design engineers to work simultaneously on the same assembly in different locations alternatively the CAD model can be processed in a design office, and then passed on to the next design office (in a different place). Additionally, the optimization process can take place at all levels: the creation of a CAD model (as a parametric construction), sheet metal, drawings, FEM analyse. The research and development process can be improved, under the above mentioned circumstances, in order to get a convenient, user-friendly and modification-friendly parametric-associative CAD construction, and is very helpfully in making quick decisions.

PREPARATION WORK TO CREATE A MODIFICATION-FRIENDLY PARAMETRIC-ASSOCIATIVE CAD CONSTRUCTION

At the beginning it is helpful to try to establish a strategy of how the constructions steps should follow. It is necessary to differentiate between two different types of CAD constructions:

a) existing CAD construction (based on existing examples);
b) new CAD construction (never done before);

The first one is very convenient because the existing example can be followed. The second option will be discussed as follows. The first step is to collect as much information as possible about the part which will be modeled and to decide what is most important for the CAD construction. A list of assertive information will be created. After that the information has to be analysed and transformed into input variables.

The next step is to separate the more significant variables from the less significant variables. The first significant variable will constrain the relevant geometrical properties of the CAD model while the second significant variable will control the less decisive. If it is necessary, another lower placed level of input variables can be created.

A separate list with boolean input variables can be created. Those variables can control the occurance or not for some particulary CAD construction details. These details may appear or not in the CAD model.

Another important step is to establish the references. The most important reference is the coordinate system. It will serve as the basic reference for the CAD model. Other references, such as planes, axis, curves and points may be created if necessary. Thay may be associated to the input variable or not.

Defining the modeling strategy is the next step. It can be diferentiated between simple CAD modelling, skeleton method (Pro/Engineer) and parametric method based on Excel input sheet (Unigraphics). The last one will serve as practical example.

Optimized design process will take place using a self configurated modification-friendly user interface based on a Unigraphics Excel sheet. The next presentation is an adapted version for a mechanical part of an internal combustion engine. The end result, a finalised CAD design version, will be delivered to the FEM program. After the FEM-Analyse, other design modifications could be be performed if necessary. The modification-friendly user interface will allow the modification to be done and the resulting CAD model will be prepared for a new FEM computation. A sumarized list of these preparation steps based on that method is presented as follows:

- information about product $\Rightarrow$ input variable list;
- input variable list $\Rightarrow$ first level significant variables / second level significant variables;
- input variables list $\Rightarrow$ boolean input variables;
- establish the references $\Rightarrow$ main coordinate system, planes, axis, curves, points;
- define the modelling strategy;
- optimize/modify the CAD design through the modification-friendly user interface.

BRIEFLY PRESENTATION OF UNIGRAPHICS SOFTWARE

Unigraphics (NX) is one of the world's most advanced and tightly integrated CAD/CAM/CAE product development solutions. Spanning the entire range of product development, NX delivers immens value to enterprises of all sizes. It simplifies complex product designs, thus speeding up the process of introducing products to the market. The NX software integrates knowledge-based principles, industrial design, geometric modeling, advanced analysis, graphic simulation, and concurrent engineering. The software has powerful hybrid modeling capabilities by integrating constraint-based feature modeling and explicit geometric modeling. In addition to modeling standard geometry parts, it allows the user to design complex free-form shapes such as airfoils and manifolds. It also merges solid and surface modeling techniques into one powerful tool set.

MODIFICATION-FRIENDLY USER INTERFACE BASED ON UNIGRAPHICS EXCEL SHEET – PRACTICAL EXAMPLE

A practical example of a mechanical component of an internal combustion engine is presented here. A piston pin was chosen.

Collecting informations about the analysed modell and return the input variable list: The piston pin is used to transmit force generated after the combustion process from the piston to the connection rod. After pre-dimensioning, the input variable list consists of length, outer radius, thickness, longitudinal and radial chamfer dimensions. *First level significant variables* are stated as follows (Fig. 1, Fig.2):

- length[mm];
- outer radius [mm];
- thickness [mm];

The second level significant variables are stated as follows (Fig. 1, Fig. 3):

- the longitudinal chamfer dimensions [mm];
- the radial chamfer dimension [mm];

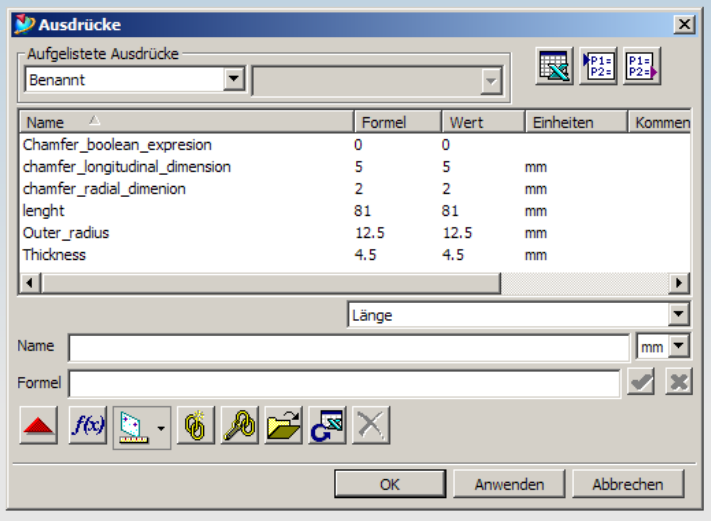

Fig. 1

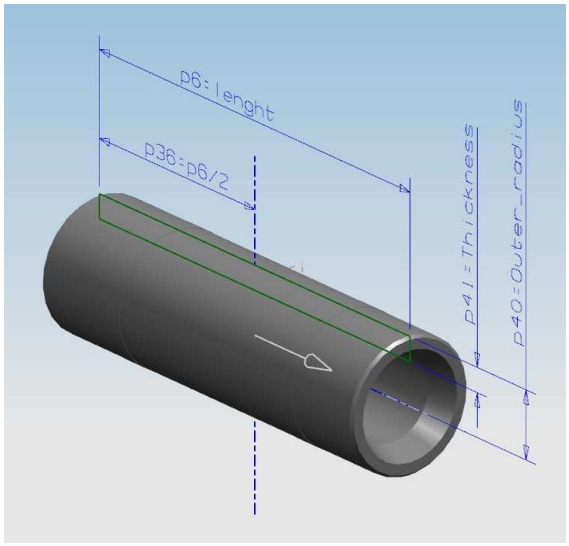

Fig. 2

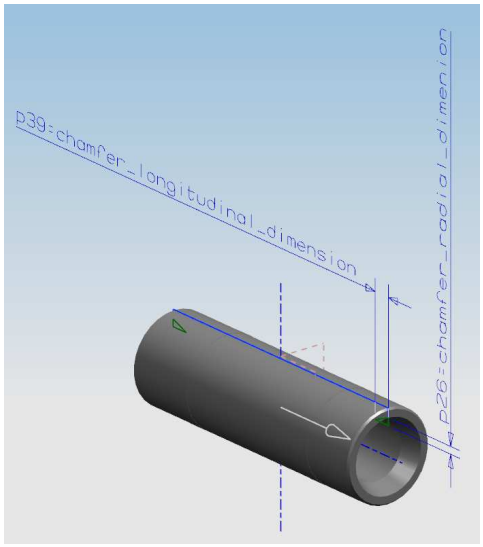

Fig. 3

Boolean input variable: 0 or 1. That input variable can activate (1) or deactivate (0) the chamfer (Fig. 1).

Establish the references: here is the reference system in the middle of the part (Fig. 4).

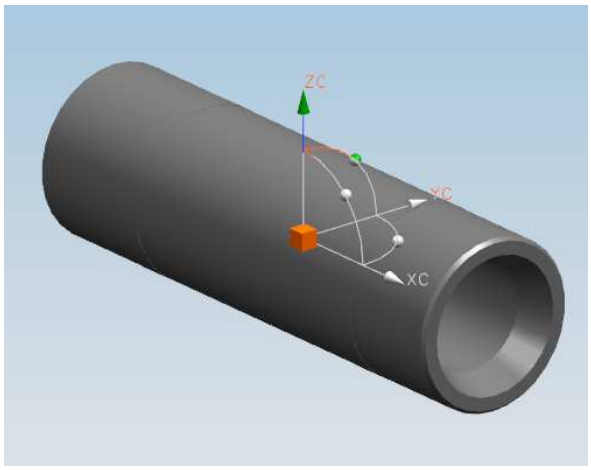

Fig. 4

Define the modelling strategy:

- simple CAD modelling;
- parametric method based on Excel input sheet (Unigraphics);

The modification-friendly user interface is a powerful tool wich allow the design engineer to modify/optimize the design variables. That means that instead of altering the model's sketch to change the dimensions the values themselves can simply be altered in the Excel sheet. After regeneration, the entire model will be automatically redesigned. After that it can be exported to the integrated (or not integrated) FEM tool and analysed. Should new modification occur, the entire process can easily be repeated.

The modification-friendly self-featured interface is presented in the Fig. 5:

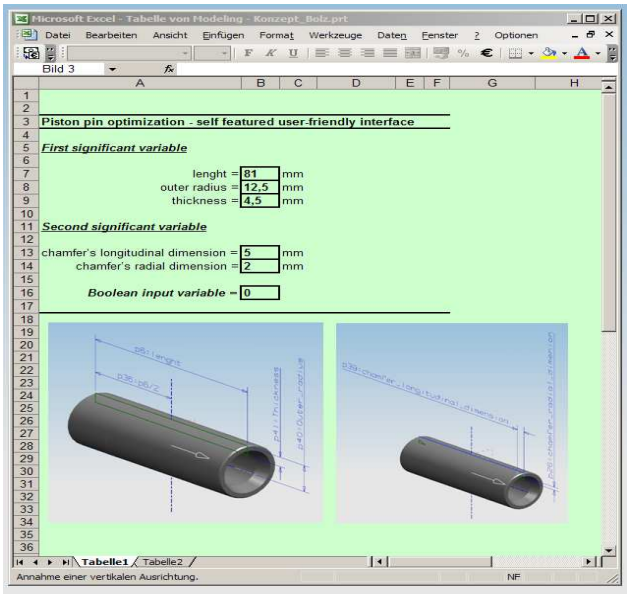

Fig. 5

CONCLUSIONS

The modification-friendly self-featured interface on Unigraphics is a very useful and powerful tool. The design engineer has the possibility to design, to optimize and to export the optimized / modified model to the FEM software, for example. After that, through this self-featured tool, it can be modifying and optimized continuously until a satisfying result is achieved. Variability is another strong characteristic, the interface can be a adapted at any time according to the new requirements. Despite this simple demonstrative example, this application can be used for very complex assemblies, where the usual modifying sketches procedure delayed the response. This optimization procedure can be used to produce fully automatically generated drawings. The drawings will be modified automatically each time when the interface will be regenerated, together with the CAD model. The main advantage for the FEM analysis is the repetitive computation caracteristics, which allow the same prescribed load distribution over the new optimized lenght. This simple and user-friendly self-made powerful interface allows CAD modifications an FEM analysis in a simple & effective way.

REFERENCES

[1] Bobescu, G. s.a. (1998) *Motoare pentru automobile si tractoare, Vol. II*, Editura “Tehnica”, Chisinau

[2] Singiresu S. Rao (1996) *Engineering Optimization: Theory and Practice*, 3rd Edition, John Wiley & Sons, Inc.

[3] Grünwald, B. (1980) *Teoria, calculul si constructia motoarelor pentru autovehicule rutiere*, Editia a II-a, Editura Didactica si pedagogica, Bucuresti

[4] Untaru, M. s.a. (1982) *Calculul si constructia automobilelor*, Editura Didactica si pedagogica, Bucuresti

[5] Colectiv de autori (1995) *HÜTTE – Manualul inginerului – Fundamente*, Editura tehnica, Bucuresti

[6] Köller, E. s.a. (2006) *Verbrennungsmotoren – Motormechanik, Brechnung und Auslegung des Hubkolbenmotors – 4 Auflage*, Friedr. Vieweg & Sohn Verlag | GWV Fachverlage GmbH, Wiesbaden

[7] Schumacher, A. (2005) *Optimierung mechanischer Strukturen - Grundlagen und industrielle Anwendungen*, Springer Verlag Berlin, Heidelberg

[8] VISAN, A. s.a. *Modelarea matematica a proceselor neconventionale*, *Cap. 1. Metodologia generala a modelarii proceselor neconventionale de prelucrare – Rezumat*, Curs, Universitatea Politehnica din Bucuresti

[9] Buede, D. (2009) *The engineering design of systems*, John Wiley & Sons