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GEOMETRIC MODELLING AND ENGINEERING ANALYSIS

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ABSTRACT:
To engineers, design means creating something new by enhancing existing designs, altering them to perform new functions, or simply introducing new concepts. Design is driven by the consumers, shaped by the users, and priced by the market. Computer – Aided Design (CAD) has revolutionized the procedures used in conceptualizing and designing mechanical parts, electrical networks, and architectural designs among others. The computers graphics capability and computing power allow designers to fashion and test their ideas interactively in real time without having to create real prototypes as in conventional approaches to design. How the use of the CAD system enhances designs can be demonstrated by analyzing each design step. To explain the advantages which CAD has brought to these fields, this work presents review the classical approach to design and study how it is done in the context of the computer-assisted approach with special emphasis on the geometric modelling and engineering analyses.
Key words: CAD, geometric modelling, engineering analysis,

1. INTRODUCTION

The designer, as a technical problem solver has the main responsibility for function and costs, and plays a central role in the application of techniques concerning the development of machines, plants and equipment. The development and design step is only one phase of the product life cycle and must be seen in connection with other work steps of the product planning, forming, production, introduction and up to recycling. The technical product is the result of a series of analysis, synthesis and test processes. The design methodology helps to structure these individual steps and to evaluate the products according to different features. The tool CAD (Computer Aided Design) gives an important assistance in this process. This computer support should, in general, raise the information level of the designer and decrease the, at the moment, considerable time required for obtaining information. The use of the CAD systems focuses on automation of the creation of the CAD geometry, the engineering analysis, and generation of the support information. In order to have an useful system, and demonstrate its functionality, the system will have to operate within an integrated design environment. The designer usually have to decide on the type of modeling technique based on the ease of using the technique during the construction phase and on expected utilization of the resulting database later in the design and manufacturing processes. Regardless of the chosen technique, the user constructs a geometric model of an object on a CAD/CAM system by inputting the object data as required by the modeling technique via the user interface provided by the software. The software then converts such data into a mathematical representation, which it stores in the model database for later use. The user may retrieve and/or modify the model during the design and/or manufacturing processes.

2. DESIGN PROCESS

The creative phases of design are based upon the human ability to conceptualize or abstract ideas from physical observations of the real world. Such ability comes from experience, based on experiment: discerning patterns of behavior in particular sets of observations.The steps in design are defined here according to VDI: problem definition, conceptualization (conceptual design), synthesis (embodiment design), Detail Design, Analyses.

The **Problem Definition** serves for information about requirements set to the solution as well as to existing conditions and their significance. The result of these work steps is the requirements list.

Conceptual Design is a part of the design that establishes the principle solution after clarification of the problem definition through taking the essentials of the problem, setting up of function structures and through searching for appropriate effective principles and their combination in an effective structure. Conceptual designing is the principle establishment of a solution. The form of presentation of a solution principle can be very different. With established structural elements, block presentation of a function structure, circuit diagram or a flow diagram suffices.

Synthesis is a part of the design that elaborates, starting from the concept, the layout and forms, and develops a technical product or system according to technical and economic aspects. The synthesis is the structural establishment of a solution. It is often necessary to produce several layouts to scale simultaneously or successively in order to obtain more information about the advantages and disadvantages of the different variants. To achieve a viable synthesis decision, all the elements affecting the design, including product configuration, cost, and labor must be considered.

Detail Design is a part of the design that supplements the constructive structure of a technical object through final regulations for form, dimensioning and surface quality of all separate parts, selection of materials, checking of the production possibilities as well as the final costs. It also creates the compulsory drawings and other documents needed for its realization.

Analyses are concerned with the mathematical or experimental testing of the design to make sure it meets the criteria set in the problem definition. The engineer must test all possible factors important to the design. For instance, the engineer divides the design problem into categories such as stress analysis, vibration, thermodynamics, heat transfer, and fluid mechanics. In each category, the design as a whole or parts of the design is tested for the ability to serve their particular function. A safety factor is usually added to make sure the design works within certain safety limits.

3. COMPUTER AIDED DESIGN

CAD is becoming a necessary tool for any engineering task. The computers graphics capability and computing power allow designers to fashion and test their ideas interactively in real time without having to create real prototypes as in conventional approaches to design. A typical CAD system involves both design and manufacturing operations (CATIA V5). Complex geometries are handled easily on CAD workstation, allowing the user to spend more time on the design aspect of the problem. The various design advantages CAD offers can be grouped in two areas: drafting and design, and geometric modeling.

3.1. Geometric modeling

There are three types of geometric models: wire frames, surfaces and solids.

Wireframe models: Many CAD systems use the wireframe method to define object geometry. In this method, user enters vertices as (x, y, z) triples. Joining the vertices creates an object called a wireframe. This representation contains only points and lines (usually straight lines). The user can inquire about the coordinates of the vertices and the length, in three dimensions, of the edge. Wireframes are not complete and surface geometries are not present which may be important for later manufacturing processing and other analyses. The model contains only the points and edges (Fig.1).

Surface models: Wireframes contain no information about the surfaces themselves, nor do they differentiate between the inside and the outside of objects. Surfaces models overcome many ambiguities of wireframe models. They define part geometries precisely and help produce numerically controlled (NC) machining instruction, in which the definition of structural boundaries is difficult. Connecting various types of surface elements to user-specified lines creates surface models (Figure 2).

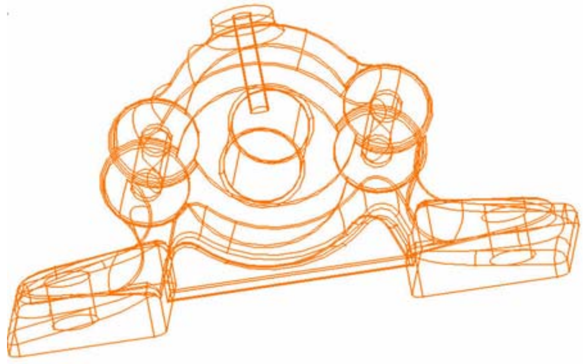

Figure 1. A wireframe model - CATIA V5

Figure 2. A surface model - CATIA V5

Solid models: Solid modeling is used to define geometry and volume unambiguously; it provides the ultimate way to describe mechanical parts using computer. Unlike wireframe and surfaces modeling, solid modeling provides the accuracy needed for precise mechanical design. It has the potential to create a database that provides a complete description of the part to downstream applications. Solid models are constructed in two ways: with primitives or with boundary definition. Both of these methods develop complex geometries from successive combinations of simple geometric operations. Most industrial parts with planar, cylindrical, and other simple shapes can be modeled with primitives, but complex contoured components such as automobile exhaust manifolds and turbine blades are easier to model using the boundary-definition method. An example of a solid model using CATIA V5 software is sown in figure 3.

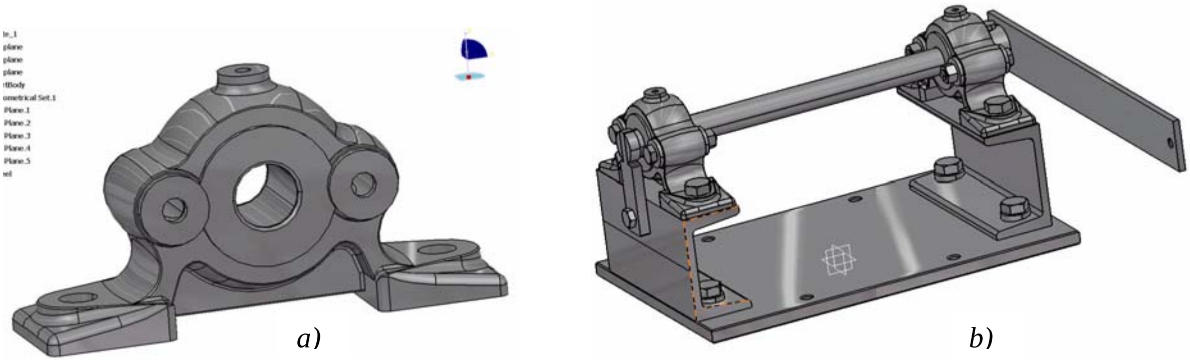

Figure 3. Examples of solid modeling - CATIA V5: a) part design, b) assembly design

3.2. Engineering Analyses and CAD

There are two types of analysis: analytical and experimental. Both are performed to assess product performance. In the **analytical** approach, different types of analyses can be carried out using various softwares in Computer Aided Design. These include Finite Element Analysis, kinematical analysis and synthesis, and static and dynamic analysis. Finite Element Analysis (FEA) is a computer-assisted technique for determining stresses and deflections in a structure (Figure 4). In most cases, finite-element models are developed for prototype designs for which experimental data exist so that FEA results can be crosschecked and design modifications can be made. Modifications are also tested for actual prototypes. The second aspect of analysis deals with **experimental methods** in which testing is conducted on prototypes and models either to extract material properties or to validate performance characteristics of a particular design. Initial testing can be done on prototype or on different components to understand the mode's response to certain loading conditions. Experimental data are extremely useful in the analysis of models for which analytical solutions are not reliable. Additional experimental analyses include fatigue testing to estimate part life from strain gauge measurements (Figure 5).

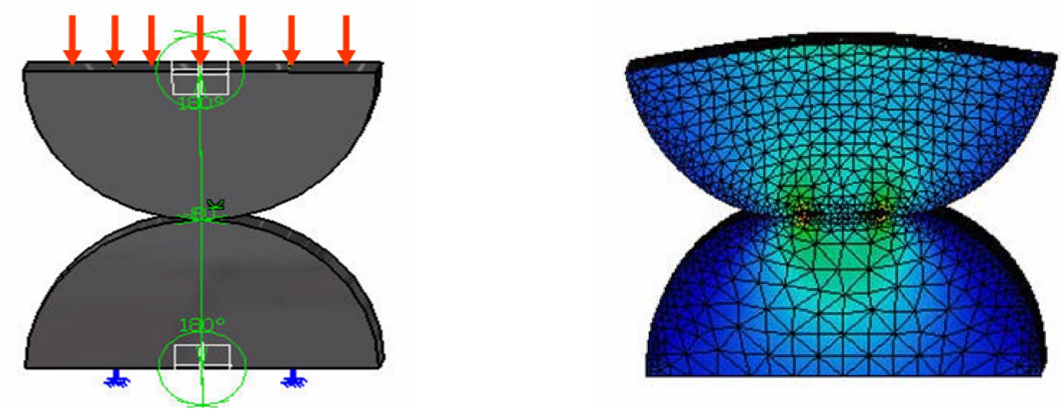

Figure 4. Analytical analyses (Finite Element Aanalysis -CATIA V5)

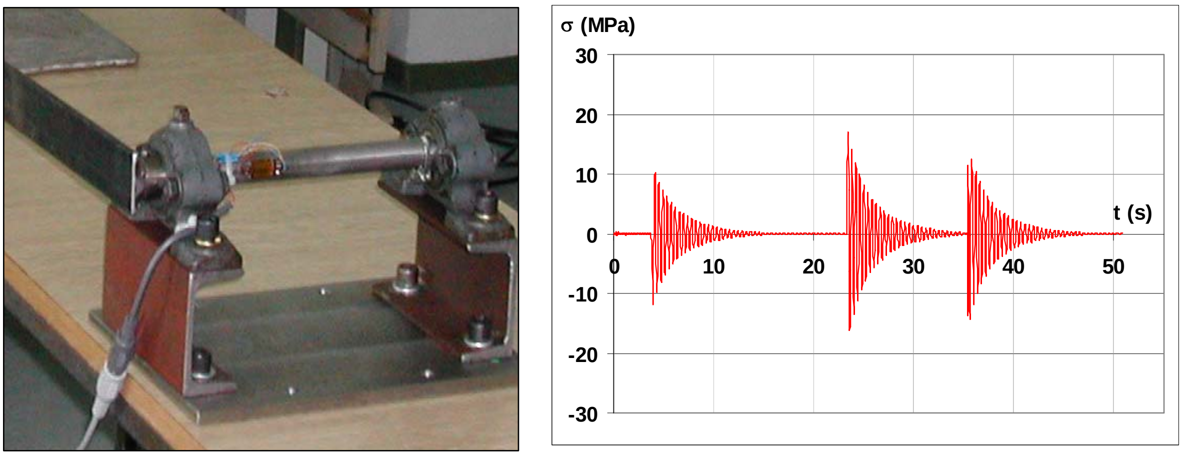

Figure 5. Experimental analyses (strain gauge measurements)

4. CONCLUSIONS

The integration of experimental testing and analytical tools results in more efficient engineering analysis. Computer Aided Design provides the ultimate tool for combining such methods with graphics capabilities to allow the designer to arrive at realistic and effective designs in minimum of time. There are many advantages in using a CAD system for geometric modelling and analysis such as:

· Increases the productivity of the designer. CAD systems aid the designer to conceptualize the product more easily thus reducing the time needed for synthesizing.
· Improves the quality of the design by enabling the designer to perform more complicate engineering analysis and consider a larger number of design alternatives.
· Improves design documentation.
· Creates a manufacturing database. During the creation of the product design documentation such as dimensions, materials etc. much of the required database to manufacture the product is also created.

5. REFERENCES

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