© OCT 2018 | IRE Journals | Volume 2 Issue 4 | ISSN: 2456-8880

Computer Aided Design in the Field of Mechanical Fabrication

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Abstract -- The Computer-aided design (CAD) involves creating computer models defined by geometrical parameters. These models typically appear on a computer monitor as a three-dimensional representation of a part or a system of parts, which can be readily altered by changing relevant parameters. CAD systems enable designers to view objects under a wide variety of representations and to test these objects by simulating real-world conditions. Computer aided design is a complex process. There are many specialized tools that can speed up your design, minimize errors and improve your results. In this article will discuss following, Familiarize with terms used in CAD industry, the general idea of design process stages and available software tools.

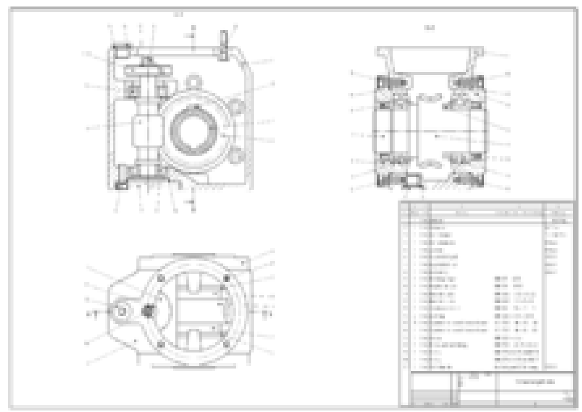
Indexed Terms: Mechanical Engineering design in CAD, CAM software.

I. INTRODUCTION

The mechanical engineering field requires an understanding of core areas including mechanics, dynamics, thermodynamics, materials science, structural analysis, and electricity. In addition to these core principles, mechanical engineers use tools such as computer-aided design (CAD), computer-aided manufacturing (CAM), and product life cycle management to design and analyze manufacturing plants, industrial equipment and machinery, heating and cooling systems, transport systems, aircraft, watercraft, robotics, medical devices, weapons, and others. In that computer-aided design and manufacturing helped industry growth in competitive market.

II. COMPUTER AIDED DESIGN

Computer-Aided Design (CAD) is software that is used by architects, engineers, drafters, artists, and others to create precision drawings or technical illustrations. CAD software can be used to create two-dimensional (2-D) drawings or three-dimensional (3-D) models.



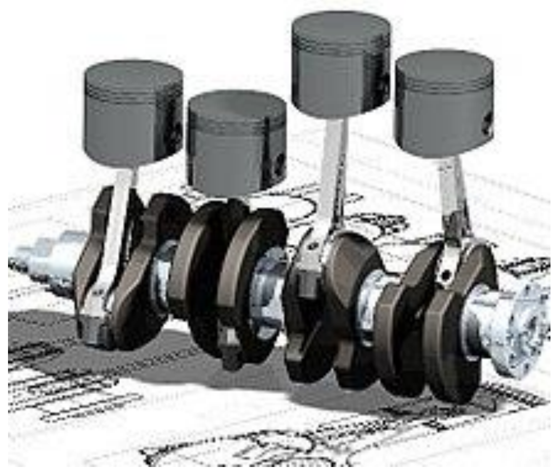


Fig 1: CAD design

CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used. Its use in designing electronic systems is known as electronic design automation

(EDA). In mechanical design it is known as mechanical design automation (MDA) or computer-aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software. CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions. CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space. CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

III. COMPUTER AIDED MANUFACTURE

Computer-aided manufacturing (CAM) uses geometrical design data to control automated machinery. CAM systems are associated with computer numerical control (CNC) or direct numerical control (DNC) systems. These systems differ from older forms of numerical control (NC) in that geometrical data are encoded mechanically. Since both CAD and CAM use computer-based methods for encoding geometrical data, it is possible for the processes of design and manufacture to be highly integrated. Computer-aided design and manufacturing systems are commonly referred to as CAD/CAM.

IV. IMPLEMENTATION

Computer-aided design is one of the many tools used by engineers and designers and is used in many ways depending on the profession of the user and the type of software in question[1].CAD is one part of the whole Digital Product Development (DPD) activity within the Product Lifecycle Management (PLM) processes, and as such is used together with other tools, which are either integrated modules or stand-alone products, such as:

- Computer-aided engineering (CAE) and Finite element analysis (FEA)
- Computer-aided manufacturing (CAM) including instructions to Computer Numerical Control (CNC) machines
- Photorealistic rendering and Motion Simulation.
- Document management and revision control using Product Data Management (PDM)

CAD is also used for the accurate creation of photo simulations that are often required in the preparation of Environmental Impact Reports, in which computer-aided designs of intended buildings are superimposed into photographs of existing environments to represent what that locale will be like, where the proposed facilities are allowed to be built. Potential blockage of view corridors and shadow studies are also frequently analyzed through the use of CAD.CAD has been proven to be useful to engineers as well. Using four properties which are history, features, parameterization, and high-level constraints. The construction history can be used to look back into the model's personal features and work on the single area rather than the whole model. Parameters and constraints can be used to determine the size, shape, and other properties of the different modeling elements. The features in the CAD system can be used for the variety of tools for measurement such as tensile strength yield strength, electrical or electromagnetic properties. Also its stress, strain, timing or how the element gets affected in certain temperatures, etc.

V. CAD MERITS AND DEMERITS

Merits:

- Reduced storage space
- Corrections can be made easily
- Repetitive parts of the drawing can be saved and imported as part of a "CAD library"
- CAD systems can be linked with CAM machines to produce objects straight from the drawings
- 3D CAD designs can be made to look realistic by using the material library for clients to see
- CAD designs can be easily shared between companies or department using email
- CAD can be used to create simulated environments to show the client

Demerits:

- Work can be lost if the computer crashes
- Work could be corrupted by viruses
- Work could be stolen or "hacked"
- Time taken to learn how to use the software
- Initial costs of buying a computer system are high.
- Time and cost of training staff
- Continual need for updating software or operating systems
- CAD/CAM systems mean less people need to be Employed

VI. TYPES OF CAD

There are several different types of CAD, each requiring the operator to think differently about how to use them and design their virtual components in a different manner for each [1].There are many producers of the lower-end 2D systems, including a number of free and open-source programs. These provide an approach to the drawing process without all the fuss over scale and placement on the drawing sheet that accompanied hand drafting since these can be adjusted as required during the creation of the final draft.3D wireframe is basically an extension of 2D drafting (not often used today). Each line has to be manually inserted into the drawing. The final product has no mass properties associated with it and cannot have features directly added to it, such as holes. The operator approaches these in a similar fashion to the 2D systems, although many 3D systems allow using the wireframe model to make the final engineering drawing views.3D "dumb" solids are created in a way analogous to manipulations of real-world objects (not often used today). Basic three-dimensional geometric forms (prisms, cylinders, spheres, and so on) have solid volumes added or subtracted from them as if assembling or cutting real-world objects. Two-dimensional projected views can easily be generated from the models. Basic 3D solids don't usually include tools to easily allow motion of components, set limits to their motion, or identify interference between components.

There are two types of 3D Solid Modeling

I) parametric modeling allows the operator to use what is referred to as "design intent". The objects and features created are modifiable. Any future modifications can be made by changing how the original part was created. If a feature was intended to be located from the center of the part, the operator should locate it from the center of the model. The feature could be located using any geometric object already available in the part, but this random placement would defeat the design intent. If the operator designs the part as it functions the parametric modeler is able to make changes to the part while maintaining geometric and functional relationships.

II) Direct or Explicit modeling provide the ability to edit geometry without a history tree. With direct modeling, once a sketch is used to create geometry the sketch is incorporated into the new geometry and the designer just modifies the geometry without needing the original sketch. As with parametric modeling, direct modeling has the ability to include relationships between selected geometry (e.g., tangency, concentricity).

Top end systems offer the capabilities to incorporate more organic, aesthetics and ergonomic features into designs. Freeform surface modeling is often combined with solids to allow the designer to create products that fit the human form and visual requirements as well as they interface with the machine.

VII. FREE SOFTWARE

CAD software enables engineers and architects to design, inspect and manage engineering projects within an integrated graphical user interface (GUI) on a personal computer system [3]. Most applications support solid modeling with boundary representation (B-Rep) and NURBS geometry, and enable the same to be published in a variety of formats. A geometric modeling kernel is a software component that provides solid modeling and surface modeling features to CAD applications. Based on market statistics, commercial software from Autodesk, Dassault Systems, Siemens PLM Software, and PTC dominate the CAD industry. The following is a list of major CAD applications, grouped by usage statistics

Freeware and open source software,

- BRL-CAD
- FreeCAD
- LibreCAD
- OpenSCAD
- QCad
- SolveSpace
- 123D

VIII. MECHANICAL CAD STANDARDS

CAD Standards are a set of guidelines for the way Computer-aided drafting (CAD), or (CADD) Computer Aided Design and Drawing, drawings should appear, to improve productivity and interchange of CAD documents between different offices and CAD programs, especially in architecture and engineering [2].

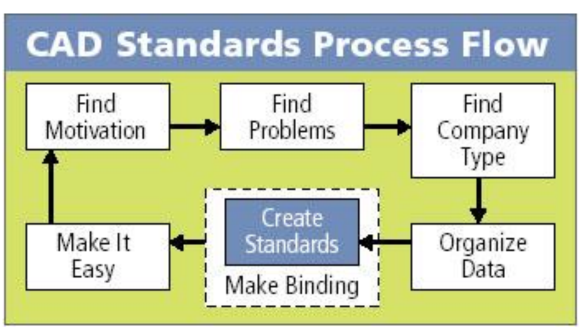


Fig 2: CAD Standards process flow

Model-based definition (MBD) is a method of product specification using elements within 3D models as defined by ASME Y14.41-2012. ASME Y14.41-2012 is based upon ASME Y14.5-2009 symbols and definition methods, such as Geometry Dimensioning and Tolerance (GD&T).Subscribers of International Organization for Standardization (ISO) have the standards ISO 1101 and ISO 16792 for model-based definition.

VDA-FS is a CAD data exchange format for the transfer of surface models from one CAD system to another. Its name is an abbreviation of "Verband der Automobilindustrie - Flächenschnittstelle", which translates to the "automotive industry association - surface data interface". Standard was specified by the German organization VDA. VDA-FS has been superseded by STEP, ISO 10303.

IX. DESIGN PROCESS

The below charts given generalized design, validation and manufacturing process [2]. Each stage requires specific knowledge and skills, and often requires the use of specific software.

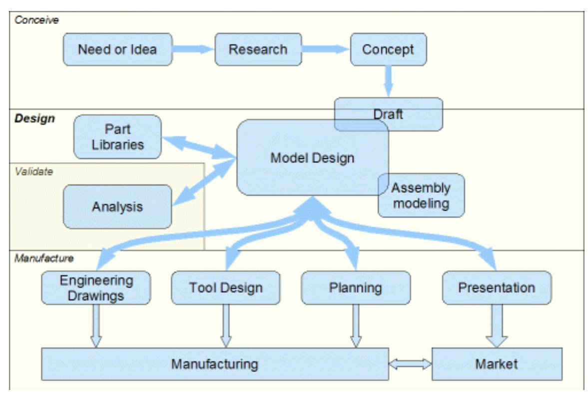


Fig 3: CAD Design Process

Need or Idea -Usually the design process starts with a defined need. The need can be defined by market research, by the requirements of a larger body of work (for example airplane part). Sometimes, the design process is begun with a new idea or invention. At any rate, a needs analysis should precede any decision to undertake a project. This includes defining the need in a highly detailed way, in writing.

This is similar to the requirements specification process in software engineering. Research - Professionals tend to research available solutions before beginning their work. There is no need to "reinvent the wheel". This is to study existing solutions and concepts, evaluating their weaknesses and strengths. The research should also cover available parts that can use as a part of the design. It is obvious, that Internet and search engines like Google are very helpful for this task. There are also many libraries of standardized parts which import into the project. Concept - Based on the research, start with a high level concept. Also specify the main principles and major parts. For example it can consider Diesel or Stirling engines for stationary electric generators. Draft - choose to create a draft by pen and paper. Some prefer to use simple vector graphics programs, others even simple CAD (for example Smart Sketch), yet others prefer to start directly in their main CAD system. Model Design - 2D and 3D modelling in CAD. The designer creates a model with details, and this is the key part of the design process, and often the most time consuming. This will be described in greater detail in further lessons. Part Libraries - Standard parts, or parts created by other team members, can be used in the model. Files representing a part can be downloaded from the Internet, or local networks. They are also distributed on CD ROMs or together with CAD as and extension (library). By putting these predefined parts into the project, ensure that they are correct and save a lot of time and effort. When working on a large project, this becomes a requirement to ensure the parts operate together, swap out equivalent parts, and coordinate distributed teams' work. This was, a standard part can be inserted into the project by one team member. Assembly modelling - Parts are assembled into a machine or mechanism. Parts are put together using mating conditions such as alignment of the axis of two holes. More about how to do this in further lessons. Analysis - Specialized programs (CAE -- Computer Aided Engineering) aid in analysis of 3D model robustness and performance. Many software tools are used for this task. Most notably FEM (Finite Element Method) and Kinematics. Some CAD programs include these tools built in. Engineering Drawings - From the 3D models, generate a set of engineering drawings for manufacturing. These drawings are then distributed to the departments and individuals responsible for producing that work. Also these drawings must be tolerance for proper manufacturing. Tool Design - can use CAM software to simulate, optimize and prepare manufacturing. Generated NC (Numeric Control) code is then executed by manufacturing machines like lathes or milling cutters. Planning - Critical Path Method, Gantt chart and other methods and tools are used by project managers to plan and optimize manufacturing. Project management and ERP systems are used. Presentation - It should create photo realistic images and/or animations to present the design. This allows to get customer feedback even before the product is actually manufactured. it can also consider using rapid prototyping techniques to present a physical 3D model. Major CAD/CAE/CAM software companies develop and sell tools that cover the whole cycle. These complex software tools support change management, teamwork, versioning and resource planning.

X. CONCLUSION

Upon understand the CAD, it will be useful for designing of mechanical components. The focused learning gives an overview about available tools and their producers. This would become familiar with industry lingo and terminology. After successfully learning of CAD will be able to initialize the CAD software selection process for a specific industry.

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