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Computer-aided Design in Manufacturing Process Management

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Abstract

Computer-aided design (CAD) is powerful tool, which helps designers and constructors with the designs of new products in all areas of industrial manufacturing. CAD is one of many inputs of manufacturing process management (MPM). MPM defines "how" a product is to be produced. It is a summary of inputs which help by production. CAD is divided to 2D and 3D modeling. There are many free and paid software applications which can be used by designing a product. 3D CAD applications with ability to create both 3D and 2D designs are widely used among the designers. This article gives an overview over history of 2D and 3D CAD software and their division.

Keywords: 2D CAD, 3D CAD, computer modelling.

Introduction

Nowadays, the biggest milestone of successful product placing on market is time reduction, therefore the production of any product should be very quick. Customers are very impatient and market is overloaded with similar products which differ in quality and design. It is up to manufacturing companies if they choose the way of quality and design attractive product, which leads to higher costs of material and components and at the end to higher cost of final product. Or they choose the way of average quality and design, where the production costs and final price of the product are lower.

Customers consider the usage of product. Some of them are using products daily and in that case, they usually pick product of higher quality and price. Those who are using products occasionally will pick product with lower quality and price.

All processes which influence product production are connected to manufacturing process management (MPM). MPM defines "how" a product is to be produced. MPM receives the digital product definition from engineering, considers the capabilities and capacities of internal plants and external suppliers, and delivers the set of manufacturing plans required to produce the product. MPM also entails giving early feedback from

manufacturing to engineering based on preliminary versions of the manufacturing processes. Additionally, the MPM process communicates with production systems (ERP/MES), delivering optimized routings, as well as manufacturing bills-of-materials (mBOMs) and work instructions, including all supporting documents needed by production operators to build the product. [1]

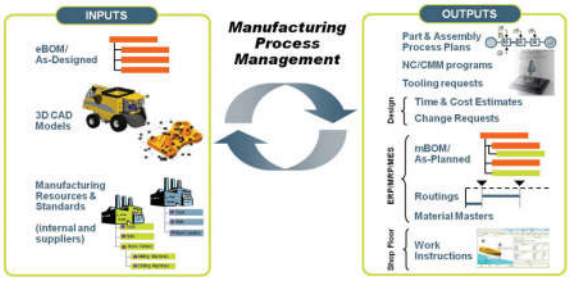

Fig. 3. Process of defining and managing the manufacturing processes used to fabricate parts, assemble final products, and perform inspection [2]

Computer-aided design

The digital product definition comes from one of the most powerful tools in MPM, which is called computer-aided design (CAD). CAD is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software helps to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. Its output is often in the form of electronic files for print, machining, or other manufacturing operations. [3]

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. 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 [4].

Invention of CAD is attributed to a French engineer, Pierre Bézier (Arts et Métiers ParisTech, Renault). After his mathematical work concerning surfaces, he developed UNISURF, between 1966 and 1968, to ease the design of parts and tools for the automotive industry. Then, UNISURF became the working base for the following generations of CAD software. As computers became more affordable, the application areas have gradually expanded. The development of CAD software for personal desktop computers was the impetus for almost universal application in all areas of construction. Key products for 1981 were the solid modeling packages - Romulus (ShapeData) and Uni-Solid (Unigraphics) based on PADL-2 and the release of the surface modeler CATIA (Dassault Systemes). Autodesk was founded 1982 by John Walker, which led to the 2D system AutoCAD. The next milestone was the release of Pro/Engineer (now PTC Creo) in 1987, which heralded greater usage of feature-based modeling methods and parametric linking of the parameters of features. Also of importance to the development of CAD was the development of the B-rep solid modeling kernels (engines for manipulating geometrically and topologically consistent 3D objects) Parasolid (ShapeData) and ACIS (Spatial Technology Inc.) at the end of the 1980s and beginning of the 1990s, both inspired by the work of Ian Braid. This led to the release of mid-range packages such as SolidWorks and TriSpective (later known as IRONCAD) in 1995, Solid Edge (then Intergraph) in 1996 and Autodesk Inventor in 1999. An independent geometric modeling kernel has been evolving in Russia since the 1990s. [3] CAD software can create 2D and 3D designs.

2D CAD

2D CAD is commonly used to design vector-based layouts. For example, architects use CAD software to create overhead views of building floor plans and outdoor landscapes. These layouts, which contain vector graphics, can be scaled to different sizes, which may be used for proposals or blueprints. 2D CAD also includes drawings, such as sketches and mockups, which are common at the beginning of the design process. [5]

There are many 2D CAD software applications which can be used for creation of design intent. Some of them are paid, some free. Paid versions mostly provide greater functionality and direct connection to 3D CAD applications. Below are mentioned some of free and paid software applications.

Table 1. Examples of free and paid 2D CAD applications

Free	Paid
DraftSight	AutoCAD
QCAD	ArchiCAD
LibreCAD	VisualARQ
Draft IT	PowerCAD

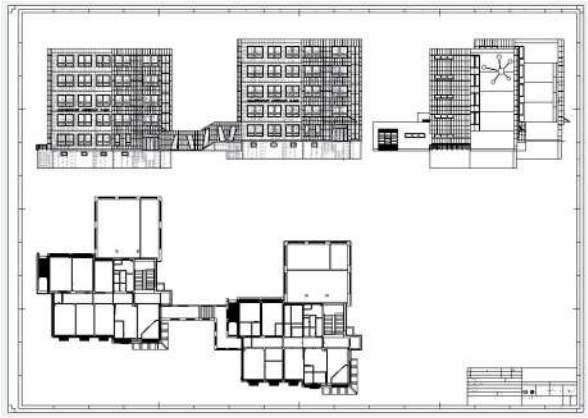

Fig. 4. Example of 2D design

3D CAD

3D CAD models are typically vector-based, but the vectors include three dimensions. This allows designers to create complex 3D shapes that can be moved, rotated, enlarged, and modified. Some 3D models are created exclusively of polygons, while others may include Bézier curves and other rounded surfaces. When creating a 3D model, a CAD designer may first construct the basic shape of the object, or "wireframe." Once the shape is complete, surfaces can be added that may include colors, gradients, or designs that can be applied using a process called texture mapping. Many CAD programs include the ability to adjust lighting, which affects the shadows and reflections of the object. Some programs also include a timeline that can be used to create 3D animations. 3D CAD includes computer-aided manufacturing (CAM), which involves the actual manufacturing of three-dimensional objects. [5]

There are many 3D CAD software applications which can be used for creation of design intent. Some of them are paid, some free. Paid versions mostly provide greater functionality as simulations, optimization, mechanism design, sheet metal design, human factor design and more. Below are mentioned some of free and paid applications.

Table 22. Examples of free and paid 3D CAD applications

Free	Paid
123D Design	3DS Max
Blender	Autodesk Inventor
FreeCAD	CATIA
OpenSCAD	PTC Creo
SketchUp	SolidWorks
TinkerCAD	Rhino

Fig. 5. Example of 3D design

As mentioned before 3D CAD programs provide 3D models. Basically, is creation of 3D models called solid modeling. There are 2 types of 3D solid modelling in 3D CAD applications: parametric modeling and explicit (direct) modeling. Specifications for parametric and explicit modeling are very comprehensive and are not the intention of this paper.

Conclusion

This paper gives an overview about history of creation of CAD applications, their division to 2D and 3D. Also provides an overview on free and paid applications.

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