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Title: **VIRTUAL MANUFACTURING: DESIGN AND MANUFACTURING TOOLS**

Volume 06, Issue 07, Pages: 156– 161.

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VIRTUAL MANUFACTURING: DESIGN AND MANUFACTURING TOOLS

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ABSTRACT: Virtual manufacturing (VM) is a key concept that summarizes computerized design, manufacturing activities dealing with models and simulation of digital file instead of objects and their operation in the real world. Virtual manufacturing concept is more safety, relevant and cost effective than physical one. This paper explains briefly about design and manufacturing tools used in virtual manufacturing.

Key Words: Virtual manufacturing, Digital file, Design, Manufacturing

1. Introduction:

The main aim of this paper is explains briefly about the design and manufacturing tools used in Virtual Manufacturing. Design tools utilized to drafting 3D models in the form of digital file. Drafting papers and pens had been replaced with computer aided design (CAD) system. Digitally designed 3D model file get transferred to manufacturing tool computer aided manufacturing (CAM) system. The main objective is accomplished through the innovative integration of design and production solid models with advanced simulation technology. The use of simulation software to achieve the objectives of virtual manufacturing has been rapidly increasing throughout industry. The potential for these tools to significantly improve affordability and reduce cycle times is widely accepted, but the potential has not been fully achieved. [1] The use of VirtualManufacturing by

multi-functional Integrated Product Teams, enables these teams to dramatically improve the quality of their products through accurate cost, schedule, and risk analyses prior to commitment to product manufacture.[2]

2. History

The term Virtual Manufacturing first came into prominence in the early 1990s, in part as a result of the U.S. Department of Defense Virtual Manufacturing Initiative. Both the concept and the term have now gained wide international acceptance and have some what broadened in scope. For the first half of the 1990s, pioneering work in this field has been done by a handful of major organizations, mainly in the aerospace, earthmoving equipment, and automobile industries, plus a few specialized academic research groups. Recently accelerating worldwide market interest has become evident, fueled by

price and performance improvements in the hardware and software technologies required and by increased awareness of the huge potential of virtual manufacturing. Virtual manufacturing can be considered one of the enabling technologies for the rapidly developing information technology infrastructure. The most advanced current form of the Computer Aided Manufacturing is Virtual Manufacturing (VM) based on Virtual Reality (VR). The concept of Artificial Reality appeared already in the 1970s (Miron KRUEGER) and the notion of Virtual Reality was introduced by Jaron Lanier (1989). In 1990 the concepts of Virtual World and Virtual Environments appeared. Virtual reality is defined as a computer generated interactive and immersive 3D environment simulating reality. Let us have a short glimpse at the last three decades of research in virtual reality and its highlights [3]

- Sensorama - in years 1960-1962 Morton Heilig created a multi-sensory simulator. A prerecorded film in color and stereo, was augmented by binaural sound, scent, wind and vibration experiences. This was the first approach to create a virtual reality system and it had all the features of such an environment, but it was not interactive.
- The Ultimate Display – in 1965 Ivan Sutherland proposed the ultimate solution of virtual reality: an artificial world construction concept that included interactive graphics, force-feedback, sound, smell and taste.
- The Sword of Damocles - the first virtual reality system realized in hardware, not in concept. Ivan Sutherland constructs a device considered as the first Head Mounted display (HMD), with appropriate

head tracking. It supported a stereo view that was updated correctly according to the user's head position and orientation.

- GROPE - the first prototype of a force-feedback system realized at the University of North Carolina (UNC) in 1971.
- VIDEOPLACE - Artificial Reality created in 1975 by Myron Krueger - “a conceptual environment, with no existence”. In this system the silhouettes of the users grabbed by the cameras were projected on a large screen. The participants were able to interact one with the other thanks to the image processing techniques that determined their positions in 2D screen's space.
- VCASS - Thomas Furness at the US Air Force's Armstrong Medical Research Laboratories developed in 1982 the Visually Coupled Airborne Systems Simulator – an advanced flight simulator. The fighter pilot wore a HMD that augmented the out-the-window view by the graphics describing targeting or optimal flight path information.
- VIVED - Virtual Visual Environment Display – constructed at the NASA Ames in 1984 with off-the-shelf technology a stereoscopic monochrome HMD.
- VPL - the VPL company manufactures the popular Data- Glove (1985) and the Eyephone HMD (1988) - the first commercially available VR devices.
- BOOM - commercialized in 1989 by the Fake Space Labs. BOOM is a small box containing two CRT monitors that can be viewed through the eye holes. The user can grab the box, keep it by the eyes and move through the virtual world, as the mechanical arm measures the position and orientation of the box.

- UNC Walkthrough project - in the second half of 1980s at the University of North Carolina an architectural walkthrough application was developed. Several VR devices were constructed to improve the quality of this system like: HMDs, optical trackers and the Pixel-Plane graphics engine.
- Virtual Wind Tunnel - developed in early 1990s at the NASA Ames application that allowed the observation and investigation of flow-fields with the help of BOOM and DataGlove.
- CAVE - presented in 1992 CAVE (CAVE Automatic Virtual Environment) is a virtual reality and scientific visualization system. Instead of using a HMD it projects stereoscopic images on the walls of room (user must wear LCD shutter glasses). This approach assures superior quality and resolution of viewed images, and wider field of view in comparison to HMD based systems.
- Augmented Reality (AR) - a technology that “presents a virtual world that enriches, rather than replaces the real world”. This is achieved by means of see-through HMD that superimposes virtual three-dimensional objects on real ones. This technology was previously used to enrich fighter pilot’s view with additional flight information (VCASS). Thanks to its great potential – the enhancement of human vision – augmented reality became a focus of many research projects in early 1990s. Advanced engineering environments are integrated computational systems and tools that facilitate design and production activities within and across organizations. may include the following elements:

3. Design Tools

Design tools such as 3-Dimensional computer-aided design (CAD) models, computer-aided engineering (CAE), Design for Manufacturing & Assembly .

3.1. Computer-aided design (CAD):

Computer-aided design is the use of [computer systems](#) (or [workstations](#)) to aid in the creation, modification, analysis, or optimization of a [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.[4]

3.2. Computer-aided engineering (CAE):

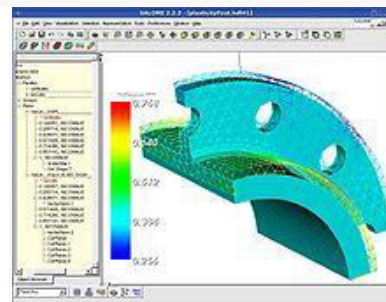


Fig.1.CAE Model

Computer-aided engineering is the broad usage of [computer software](#) to aid in [engineering](#) analysis tasks. It includes [finite element analysis](#) (FEA), [computational fluid dynamics](#) (CFD), [multi body dynamics](#) (MBD), and [optimization](#).

3.3. Design for Manufacturing & Assembly :

DFM is the method of design for ease of manufacturing of the collection of parts that will form the product after assembly. DFA is a tool used to select the most cost effective material and process to be used in

the production in the early stages of product design.

4. Manufacturing Tools:

Manufacturing tools such as computer-aided manufacturing(CAM), Distributed Interactive Simulation(DIS), Integrated Product and Process Development (IPPD),Just In Time(JIT),Material Requirement Planning(MRP).

4.1. Computer aided manufacturing (CAM):

Computer aided manufacturing has been considered as software converts three dimensions (3D) models generated in CAD into a numerical control 2 programming tools to generate computer numerical control (CNC) code, set of basic operating instructions written in G-Code to drive numerically controlled machines. The code is a programming language that can be understood by numerical controlled machine tools and essentially industrial robots. The code can instruct the machine tool to manufacture a large number of items with perfect precision and faith to the CAD design while the stage at which conceptual designs for new products can be made entirely within the framework of CAD software. The computer Aided Manufacturing takes a step further by bridging the gap between the conceptual design and the manufacturing of the finished product.

4.2. Distributed Interactive Simulation(DIS):

DIS is a network protocol. It describes the exact layout of a few dozen Protocol Data Units (PDUs) that contain information about the position and orientation of entities in the world, and much else. The are PDUs that describe electronic warfare,

logistics, collisions, and simulation management

4.3. Integrated Product and Process Development (IPPD):

Integrated Product and Process Development is the DoD management technique that simultaneously integrates all essential acquisition activities through the use of [Integrated Product Teams \(IPT\)](#) to optimize design, manufacturing, and supportability processes. IPPD facilitates meeting cost and performance objectives from product concept through production, including field support. It evolved in industry as an outgrowth of efforts such as Concurrent Engineering to improve customer satisfaction and competitiveness in a global economy.[5]

4.4. Computer Integrated Manufacturing(CIM):

The digital manufacturing tools very well integrates the product design with manufacturing processes. This helps in creating a virtual manufacturing environment with different simulation applications such as plant layout, workstation layout, material and work flows, design automation. The virtual approach follows the concurrent engineering principles, for parallel development of product design and manufacturing process. Thus virtual collaborative platform has forwarded concurrent engineering principle with product design data as an input for validating production process. Thus manufacturing process simulation of virtually designed products, forms a closed loop within engineering design function thereby providing optimized DfM (Design for Manufacturing).

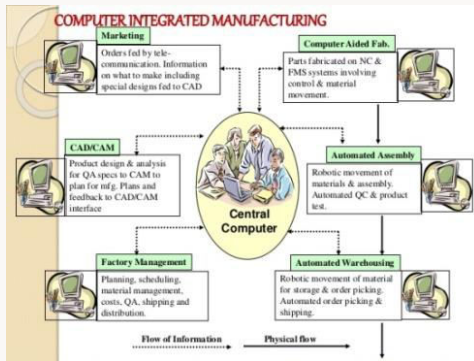


Fig.2. Computer Integrated Manufacturing



Fig.3. Digital-manufacturing-virtual-factory

4.5. Just In Time(JIT):

The principle of Just in Time (JIT) is to eliminate sources of manufacturing waste by getting right quantity of raw material and processing the right quantity of products in the right place at the right time. Just-in-Time (JIT) theory has been operating widely in the Japanese automobile industry and the electronics industry, though more and more applications can be found in many industries over the world.[6]

4.6. Material Requirement Planning(MRP) :

MRP technique- is used to explode bills of material, to calculate net material requirements and for production planning. The master production schedule and bill of materials indicates the materials to be demanded, order scheduling, cycle time production and supplier lead times then

these all factors jointly determine when orders should be placed. It is a time phased priority-planning technique that calculates material requirements and schedules supply to meet demand across all products and parts in one or more plants and used to optimize the inventory. It controls the system that attempts to keep adequate inventory levels to assure that required materials are available when needed.[7]

5. Conclusion:

It appears that VM will stimulate the need to design both for manufacturability and manufacturing efficiency. Virtual Manufacturing to become a standard tool for the design to manufacturing process: computer technology is widely used and accepted, the concept of virtual prototyping is widely accepted, companies need faster solutions for cost / time saving, for more accurate simulations, leading companies are already demonstrating the successful use of virtual manufacturing techniques.

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