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# Concept System and Content of Digital Manufacture

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***Abstract* – Over the last decade, digital manufacturing has been considered as a highly promising set of technologies for reducing product development times and cost as well as for addressing the need for customization, increased product quality, and faster response to the market. In this paper we present the concept and content of digital manufacture. The concept is based on controlling, product design, management and manufacturing. Product design, process planning, factory layout planning, ergonomics, simulation of robot usage, production process simulation, product lifecycle management systems, analysis software, computer aided manufacturing software, time management and business applications are the content of digital manufacture.**

***Keywords* – Concept, Control, Design, Management, Manufacture, Planning.**

## I. Introduction

Product life cycle is becoming shorter and changes that are occurring because of the frequent production program changes, are leading to the necessity of quicker data transfer among the engineers. An application of product lifecycle management software and digital manufacturing concept is enabling transfer of accurate, updated data. Digital manufacturing is a term that is related to wide spectrum of digital models and methods that are dealing with every aspect with product lifecycle management. It is basically integration among different tools used for product design, process planning, time management and business applications, layout planning, ergonomics, simulations of robot work cells, process simulation, product lifecycle management systems, analysis software, computer aided manufacturing software and other applications used for planning and process optimization of a real company.

The changes in the whole product lifecycle should be considered while developing the new products, not just the adjustments related to savings or increasing productivity in order to cut down the production expenses. Thinking about things like design for manufacturing, assembly, reliability, maintenance, disposal should be also considered while thinking about the overall product cost, not just about the ones that actually occur in the shop floor and assembly.

All manufacturing processes in the factory can be supported by the CAD/CAM/CAE systems for receiving orders by digital data and rationalization of design and manufacturing processes.

## II. Concept System of Digital Manufacture

The conception of digital manufacture firstly originated from the technology of numerical control (NC or CNC) and CNC machine tool. Digital design and digital management have fully developed along with the advancement of computer aided design (CAD) and the development of the manufacturing resource planning (MRP) [1].

The Concepts of digital manufacturing (Fig. 1):

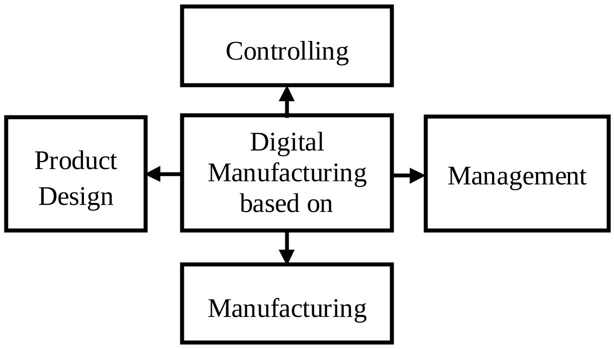


Fig. 1. Concepts of digital manufacturing

### A. *Concept I or the Central Concept based on Controlling*

A Flexible Manufacturing System (FMS) is a manufacturing system in which there is some amount of flexibility that allows the system to react in the case of changes, whether predicted or unpredicted. This flexibility is generally considered to fall into two categories, which both contain numerous subcategories. The first category, machine flexibility, covers the system’s ability to be changed to produce new product types, and ability to change the order of operations executed on a part. The second category is called routing flexibility, which consist of the ability to use multiple machines to perform the same operation on a part, as well as the system’s ability to absorb large-scale changes, such as in volume, capacity, or capability. The work machines which are often automated CNC machines are connected by a material handling system to optimize parts flow and the central control computer which controls material movements and machine flow. The main advantage of an FMS is its high flexibility in managing manufacturing resources like time and effort in order to manufacture a new product. The best application of an FMS is found in the production of small sets of products like those from a mass production.

A flexible Manufacturing Cell (FMC) consists of two or more CNC machines, a cell computer and a robot. The cell computer (typically a Programmable Logic Controller) is interfaced with the microprocessors of the robot and the CNCs. The functions of the cell controller include work load balancing, part scheduling, and material flow control. The supervision and coordination among the various operations in a manufacturing cell is also performed by the cell computer. The software includes features permitting the handling of machine breakdown, tool breakage and other special situations. The cell robot also performs tool changing and housekeeping functions such as chip

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removal, staging of tools in the tool changer, and inspection of tools for breakage or expressive wear. When necessary, the robot can also initiate emergency procedures such as system shut-down. The Flexible Manufacturing System is a configuration of computer-managed numerical work stations where materials are automatically handled and machine loaded. Flexible Manufacturing System components two or more computer managed numerical work stations that perform a series of operations; an integrated material transport system and a computer that controls the flow of materials, tools, and information (e.g. machining data and machine malfunctions) throughout the system; auxiliary work stations for loading and unloading, cleaning, inspection, etc. Flexible Manufacturing System goals reduction in manufacturing cost by lowering direct labor cost and minimizing scrap, re-work, and material wastage.

### *B. Concept II based on Product Design*

Historically, computer aided design (CAD) was the first to support knowledge in engineering processes and thus incorporates the largest number of knowledge management methods. Computer aided process planning (CAPP) and manufacturing (CAM) have also introduced similar techniques, but knowledge generation and transfer must be carried out separately for each application and specific environmental conditions. One of the most important steps in converting a design concept into a manufactured product is process planning. Such planning determines the manufacturing operations, operation sequence and resources required to manufacture a product based on an engineering drawing or a CAD model. A process plan elaborates the machines, setups, tool specifications, operation time estimates, etc. required to convert raw material into a part [2].

The CAPP problem is complex and is characterized by many interdependent technical and business parameters and variables, no viable off-the-shelf solution is yet available that can be easily or widely implemented in industry. Traditionally, process planning was performed manually from scratch, hence requiring retrieval and manipulation of a great deal of information from many sources, including established standards, machinability data, machine capabilities, tooling inventories, stock availability and existing practice. The process plan is used in production scheduling as well as in machine control; it affects production efficiency, final cost and product quality [3].

### *C. Concept III based on Management*

The products data management system (PDM) is the design and production for businesses to build a concurrent product development environment (from the supply, engineering design, manufacturing, purchasing, sales and marketing, customer mix); the enterprise requirement planning (ERP) is a business and manufacture of all resources and processes for unified management of technology, focusing on manufacturing logistics management. Master production scheduling, material requirements planning (MRP), raw material procurement planning, job shop plans, tooling equipment, management information system (MIS), financial systems management and inventory management are the main management of ERP; the key management of PDM are: electronic storage and document management, workflow and process management, product structure and configuration management, parts classification management, engineering change management and project management.

PDM system to ERP system provides information about product design, ERP system for the PDM system provides the manufacturing cost of the relevant information.

### *D. Concept IV based on Manufacturing*

For the human survival and development the basis is manufacturing. It can be considered that no manufacture, no human survival. In the course of history, manufacturing has gone from craft to a technology and to a science. Manufacturing has not just been a craft or technology, but a manufacturing science including engineering science and organizational science. Manufacture is the process of transforming raw materials into products through the input of energy and information [1].

## III. CONTENT OF DIGITAL MANUFACTURE

Digital manufacturing is an emerging area within product lifecycle management (PLM) that supports collaboration across several phases of product lifecycle. It is based on the current CAM software point solutions that are extended through emerging IT infrastructure to encompass product development, manufacturing and inspection and control. This technology provides numerous benefits including reduced time-to-market and reduced development and manufacturing costs.

Digital Manufacturing content:

### *A. Product Design*

Computer-aided design (CAD) is the use of computer programs to create two- or three-dimensional (2D or 3D) graphical representations of physical objects. CAD software may be specialized for specific applications. CAD is widely used for computer animation and special effects in movies, advertising, and other applications where the graphic design itself is the finished product. CAD is also used to design physicals products in a wide range of industries, where the software performs calculations for determining an optimum shape and size for a variety of product and industrial design applications. In product and industrial design, CAD is used mainly for the creation of detailed 3D solid or surface models, or 2D vector-based drawings of physical components. However, CAD is also used throughout the engineering process from conceptual design and layout of products, through strength and dynamic analysis of assemblies, to the definition of manufacturing methods. This allows an engineer to both interactively and automatically analyze design variants, to find the optimal design for manufacturing while minimizing the use of physical prototypes.

### *B. Process Planning*

Process planning is critical to effective manufacturing operations. Historically, manufacturing process planning was manual, based primarily on the experience and knowledge of individual process planners. They typically developed manufacturing process plans after product

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planning. The failings of this sequential approach contributed to advent of concurrent engineering, where product and process planning could occur in tandem. Most digital manufacturing technology suites are built around this core manufacturing process function. Software tools support process planning in a concurrent engineering environment.

### *C. Time Management and Business Applications*

The act or process of exercising conscious control over the amount of time devoted to specific activities such as increased efficiency or productivity in a given industrial system is called time management. The real-time processing refers to the capability of a system that can respond immediately at the time a transaction occurs. A time management system is a designed combination of processes, tools, techniques and methods. Time management determines the date of completion of any project and the scope of the latter, thus it remains a necessity in any development project. Due to the competitiveness and remain a leader in the market, companies take faster than its competitors products to market quickly and easily communicate with its customers and partners, improve productivity in their organizations, refine and optimize business processes.

### *D. Factory Layout Planning*

With market challenges and new global competition, manufacturing companies must dramatically reduce product delivery time from conception to production in order to gain, or even retain, competitiveness. The objective of most projects is to develop options for the layout management to consider, combining the good characteristics of a system and generating a hybrid that provides the most effective result. Layout determines the way in which materials and other inputs (like people and information) flow through the operation. Relatively small changes in the position of a machine in a factory can affect the flow of materials considerably. This in turn can affect the costs and effectiveness of the overall manufacturing operation. Getting it wrong can lead to inefficiency, inflexibility, large volumes of inventory and work in progress, high costs and unhappy customers. Changing a layout can be expensive and difficult, so it is best to get it right first time.

### *E. Ergonomics*

As a discipline it is concerned with the theory and practice of learning about human characteristics and capabilities, then using that understanding to improve people's interaction with the hardware, software and people with which they interact, and with the environments in which they do so [4].

### *F. Simulation of Robot Usage*

An inherent benefit of digital manufacturing is to establish proof of concept and validate processes. By digital modeling and process planning, users can define digital manufacturing operations as a basis for process simulation. With simulation, a user can both visually and analytically verify that a manufacturing operation will perform as planned. Any potential mishaps or inefficiencies can be quickly discerned and corrected.

### *G. Production Process Simulation*

Simulation of production processes can be performed, with the intent to re-use existing knowledge and optimize processes before products are manufactured. Digital manufacturing also allows feedback from actual production operations to be incorporated into the product design process, allowing companies to take advantage of shop floor realities during the planning stage.

Current initiatives in the development of digital manufacturing tools involve improving the user experience, so that information is presented in the context of tasks performed, allowing users to make better decisions faster. Steps are being taken to provide direct connectivity with shop floor hardware, such as programmable logic controllers (PLCs), machine controllers, computer numerically controlled (CNC) machines and others. Unified platforms have also been developed to manage both PLM and manufacturing execution system (MES) information.

### *H. Product Lifecycle Management (PLM) Systems*

Product lifecycle management is a strategic business approach that helps enterprises achieve its business goals of reducing costs, improving quality, shortening time to market, innovating its products, services, and business operations. CIM data defines PLM as: A strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life-integrating people, processes, business systems, and information. PLM software allows companies to manage the entire lifecycle of a product efficiently and cost-effectively, from ideation, design and manufacture, through service and disposal. Computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), product data management (PDM) and digital manufacturing converge through PLM. PLM is unique from other enterprise software solutions because it drives top-line revenue from repeatable processes. By providing the application depth and breadth needed to digitally author, validate and manage the detailed product and process data, PLM supports continuous innovation.

### *I. Analysis Software*

For an example the Tecnomatix is a comprehensive portfolio of digital manufacturing solutions that link all manufacturing disciplines together with product engineering from process layout and design, process simulation and validation, to manufacturing execution [5].

### *J. Computer Aided Manufacturing (CAM) Software*

Computer aided manufacturing commonly refers to the use of numerical control (NC) computer software applications to create detailed instructions (G-code) that drive computer numerically controlled (CNC) machine tools for manufacturing parts. Manufacturers in a variety of industries depend on the capabilities of CAM to produce high-quality parts. A broader definition of CAM can include the use of computer applications to define a manufacturing plan for tooling design, computer-aided design (CAD) model preparation, NC programming,

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coordinate measuring machine (CMM) inspection programming, machine tool simulation, or post-processing. The plan is then executed in a production environment, such as direct numerical control (DNC), tool management, CNC machining, or CMM execution.

## IV. Conclusion

Digital manufacturing is the use of an integrated, computer-based system comprised of simulation, three-dimensional (3D) visualization, analytics and various collaboration tools to create product and manufacturing process definitions simultaneously. Digital manufacturing evolved from manufacturing initiatives such as design for manufacturability, computer-integrated manufacturing, flexible manufacturing, lean manufacturing and others that highlight the need for more collaborative product and process design. Digital manufacturing is utilized in a variety of industries. For example; an automotive original equipment manufacturer can design the entire manufacturing process digitally (tooling, machining, assembly sequencing, and factory layout) at the same time that designers are designing the next vehicle program. Because of this, manufacturing engineers are able to provide immediate feedback to designers, if there are any constraints in the part manufacturability. This type of collaboration between manufacturing engineers and designers creates a holistic view of product and process design. Digital manufacturing can help manufacturing companies improve their productivity in both manufacturing planning and production processes.

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## Author's Profile

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