Computer Aided Manufacturing

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Contents

• Manufacturing
• Use of Computers
• Computer Applications (CAD, CAM, CAPP etc.)
• Design Process involved
• Manufacturing Systems and types
• Introduction to CIM
• Sub-systems of CIM
• Present Scenario
• Future Prospects
Manufacturing

• **Manufacturing** is the process of converting raw materials, components or parts into finished goods that meet a customer's expectations or specifications.

• Manufacturing is a value-adding process allowing businesses to sell finished products at a premium over the value of the raw materials used.

• It is a series of interrelated activities and operations involving design, material selection, planning, production, quality assurance, management, and marketing of discrete consumer and durable goods.
Manufacturing
Use of Computers

1. A **computer** is a machine that can be instructed to carry out sequences of arithmetic or logical operations automatically via computer programming.

2. Modern computers have the ability to follow generalized sets of operations, called *programs*.

3. These programs enable computers to perform an extremely wide range of tasks.

Evaluation of Technology

Human evolution

Now

[Images of human evolution and modern technology]
Evaluation of Technology
• CAD - computer aided design. The use of computer methods to develop the geometric model of the product in three-dimensional form, such that the geometric and manufacturing requirements can be examined.

• CADD - computer aided design and drafting. Combining the CAD function with drafting to generate the production drawings of the part for the purpose of downstream processing.

• CAE - computer aided engineering. The use of computer methods to support basic error checking, analysis, optimisation, manufacturability, etc., of a product design.
Computer Applications

• CAM - computer aided manufacturing. Generally refers to the computer software used to develop the Computer Numerical Control part programs for machining and other processing applications.

• CAPP - computer aided process planning. The use of computer to generate the process plans for the complete manufacture of products and parts.

• CATD - computer aided tool design. Computer assistance to be used for developing the tools for manufacture such as jigs and fixtures, dies, and moulds.
Computer Applications

• CAP - computer aided planning. The use of computer for many of the planning functions such as material requirement planning, computer aided scheduling, etc.

• CAQ – Computer Aided Quality assurance. The use of computers and computer controlled equipment for assessing the inspection methods and developing the quality control and assurance functions.

• CAT – Computer aided testing refers to the software tools that can take a system through its various phases of operations and examine the response against the expected results.
Computer-aided technologies

Design Process

- Design is an activity that needs to be well organised and should take into account all influences that are likely to be responsible for the success of the product under development.
Design Process

• **Product Engineering**
  • Product functions
  • Product Specifications
  • Conceptual design
  • Ergonomics and Aesthetics
  • Standards
  • Detailed Design
  • Prototype development
  • Testing
  • Simulation
  • Analysis
Design Process

• Manufacturing Engineering
  • Process planning
  • Process sheets
  • Route sheets
  • Tooling
  • Cutting tools
  • Jigs and Fixtures
  • Dies and Moulds
  • Manufacturing Information Generation
  • CNC Part programmes
  • Robot Programmes
  • Inspection (CMM) programmes
Stages of Design Process

1. Problem identification and recognition of need
2. Problem definition and conceptualisation
3. Geometric modelling and spatial analysis
4. Engineering analysis and optimisation
5. Prototype development
6. Manufacturing process development
7. Manufacturing Implementation
Computer assisted Design Process

Problem identification and recognition of need

Problem definition and conceptualisation

Geometric modelling and spatial analysis

Engineering analysis and optimisation

Prototype development

Manufacturing process development

Manufacturing implementation

Computer assisted operations

Computer aided design

Finite element analysis

Rapid prototyping

Computer aided manufacturing

CNC/Raabts/ASRS CIM/ERP
Manufacturing Systems

- Manufacturing systems is a collection of integrated equipment and human resources, whose function is to perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts.

- It is a logical groupings of equipment and workers in the factory.

- Components of a Manufacturing System are:-
  1. Production machines
  2. Material handling system
  3. Computer system to coordinate and/or control the preceding components
  4. Human workers to operate and manage the system
Categories of Manufacturing Systems

- It is classified in three categories in terms of the human participation in the processes performed by the manufacturing system:

1. Manual work system - a worker performing one or more tasks without the aid of powered tools, but sometimes using hand tools

2. Worker-machine system - a worker operating powered equipment

3. Automated system - a process performed by a machine without direct participation of a human
Categories of Manufacturing Systems

(a) Manual work system, (b) worker-machine system, and (c) fully automated system
Manufacturing Support Systems

Manufacturing support involves a sequence of activities that consists of four functions:

1. **Business functions** - sales and marketing, order entry, cost accounting, customer billing

2. **Product design** - research and development, design engineering, prototype shop

3. **Manufacturing planning** - process planning, production planning, MRP, capacity planning

4. **Manufacturing control** - shop floor control, inventory control, quality control
Manufacturing Support Systems
Sequence of Information-Processing Activities in a Manufacturing Firm

Order to produce → Business functions → Product design → Manufacturing planning → Manufacturing control

Starting materials → Factory operations → Product to customer
Automation in Production Systems

• Automation is technology associated with the applications of Mechanical, electrical and computer based systems to operate and control production

• Two categories of automation in the production system:

  1. Automation of manufacturing systems in the factory

  2. Computerization of the manufacturing support systems

• The two categories overlap because manufacturing support systems are connected to the factory manufacturing systems.
Automated Manufacturing Systems

Examples:

- Automated machine tools
- Transfer lines
- Automated assembly systems
- Industrial robots that perform processing or assembly operations
- Automated material handling and storage systems to integrate manufacturing operations
- Automatic inspection systems for quality control
Automated Manufacturing Systems

Car Manufacturing System

https://gfycat.com/occasionaljampackedglobefish
CAD + CAM = CIM
What is CIM?

1. Computer-integrated manufacturing (CIM) is the manufacturing approach of using computers to control entire production process. This integration allows individual processes to exchange information with each other and initiate actions.

2. Computer-integrated manufacturing (CIM) makes the use of computer-controlled machineries and automation systems in manufacturing products. CIM combines various technologies like CAD and CAM to provide an error-free manufacturing process that reduces manual labor and automates repetitive tasks.
Introduction to CIM

1. The term "computer-integrated manufacturing" is both a method of manufacturing and the name of a computer-automated system in which individual engineering, production, marketing, and support functions of a manufacturing enterprise are organized.

2. In a CIM system functional areas such as design, analysis, planning, purchasing, cost accounting, inventory control, and distribution are linked through the computer with factory floor functions such as materials handling and management, providing direct control and monitoring of all the operations.
Computer Assistance

- Financial management
- Costing
- Sales and marketing
- Purchase Order Control
- Vendors
- Subcontracting
- Personnel

- Factory Level Production planning
- Production management
- MPS, MRP, MRP II, JIT, OPT
- Bill of materials
- Capacity Planning
- Inventory Control

- Key CIM Technologies
  - Computer networks
  - System Design & Analysis
  - Distributed Processing
  - Database Management
  - Modelling and Simulation
  - Expert Systems
  - Quality Engineering

- Computer Aided Design (CAD)
  - Feature and Solid Modelling
  - Variational and Parametric Modelling
  - Computer Graphics
  - Graphic Standards
  - IGES, DXF, STEP, etc.
  - Design analysis tools
  - FEM, FEA, Simulation
  - Test and Analysis
  - Design Tools Mechanical
  - Hydraulic, Electronics, etc.

- Computer Aided Manufacturing (CAM)
  - Manufacturing Information Generation
  - Process Planning
  - Production Planning
  - CNC Part programming
  - Robot Programming
  - CMM programming

- Business Data Processing System
  - Mechanisms
  - Production Activity
  - Machining, Assembly
  - Material handling, Storage
  - Production Control
  - Loading, Scheduling, Balancing
  - Capacity Planning
  - Quality Control

- Manufacturing Systems
Data flow in CIM

Yu et al., Manufacturing letters (2015)
The various processes involved in a CIM are listed as follows:

• Computer-aided design
• Prototype manufacture
• Determining the efficient method for manufacturing by calculating the costs and considering the production methods, volume of products, storage and distribution
• Ordering of the necessary materials needed for the manufacturing process
• Computer-aided manufacturing of the products with the help of computer numerical controllers
The various processes involved in a CIM are listed as follows:

• Quality controls at each phase of the development.
• Product assembly with the help of robots
• Quality check and automated storage
• Automatic distribution of products from the storage areas to awaiting lorries/trucks
• Automatic updating of logs, financial data and bills in the computer system.
Advantages of CIM

1. Error Reduction
2. Speed
3. Flexibility
4. Integration
Advantages of CIM

1. Error Reduction
   Elimination of human error in many assignment and reporting functions on factory floor operations drastically reduces the error rate.

2. Speed
   CIM environments reduce the time it takes to perform manufacturing fabrication and assembly, allowing quicker flow of product to customers and increased capacity.
3. Flexibility

With CIM companies quickly react to market conditions and then return to previous settings when market conditions change.

4. Integration

CIM offers a degree of integration that enables the flexibility, speed and error reduction required to compete and lead markets. Integrating factory floor operations with enterprise software enables employees to do higher value functions for their companies.

https://youroffice.com/4-simple-steps-to-practice-flexibility-in-your-business/
Usages of CIM

1. Industrial and Production Engineering

2. Mechanical Engineering

3. Electronic Design Automation
   1) Printed Circuit Board design
   2) Integrated Circuit design

https://www.123rf.com/profile_macrovector
Challenges

1. Integration of components from different suppliers

2. Data Integrity

3. Process Control
1. Integration of components from different suppliers:

When different machines, such as CNC, conveyors and robots, are using different communications protocols (In the case of AGVs, even differing lengths of time for charging the batteries) may cause problems.

2. Data Integrity

The higher the degree of automation, the more critical is the integrity of the data used to control the machines. While the CIM system saves on labor of operating the machines, it requires extra human labor in ensuring that there are proper safeguards for the data signals that are used to control the machines.
3. Process Control

Computers may be used to assist the human operators of the manufacturing facility, but there must always be a competent engineer on hand to handle circumstances which could not be foreseen by the designers of the control software.

http://www.technologystudent.com/rmprp07/intman1.html
Sub-Systems in CIM:

Some or all of the following subsystems may be found in a CIM operation:

1. Computer-aided techniques

2. Devices and equipments required

3. Technologies
Sub-Systems in CIM:

**Computer Integrated Manufacturing**

- Computer Aided Design (CAD)
- Computer Aided Manufacturing (CAM)
- Flexible Manufacturing Systems (FMS)
- Computer Aided Process Planning (CAPP)
- Computer Aided Engineering (CAE)
- Computer-Aided Quality Assurance (CAQ)
- Production Planning and Control (PPC)
- Enterprise Resource Planning (ERP)
Sub-Systems in CIM:

Devices and equipment required:

• CNC, Computer numerical controlled machine tools
• DNC, Direct numerical control machine tools
• PLCs, Programmable logic controllers
• Robotics
• Computers
• Software
• Controllers
• Networks
• Interfacing
• Monitoring equipment
Sub-Systems in CIM:

Technologies:

- FMS, (flexible manufacturing system)
- ASRS, automated storage and retrieval system
- AGV, automated guided vehicle
- Robotics
- Automated conveyance systems

https://gfycat.com/gifs/search/agvs
Product cycle in Computerized Manufacturing environment

CIM
- Need forecast
- Product concept
- Customer feedback
- Marketing

CAD
- Geometric modelling
- Finite element analysis
- Computer aided design
- Product proving (simulation)
- Computer aided drafting

CAM
- Computer aided CNC part program generation
- Computer aided tool design
- Tool manuf. and tryout

CAM
- Computer inspection and quality control
- Actual production
- Robots and other material handling equipment

Material requirement planning
- Order new equipment
- Computer aided process planning
- Computer aided tool design
The common databases various for computerized applications
Present scenario

1. Smart manufacturing

2. Digital manufacturing

3. Internet Of Things (IOT)

4. Artificial Intelligence (AI)
1. Smart manufacturing:

   **Smart manufacturing** is a broad category of manufacturing that employs computer-integrated manufacturing, high levels of adaptability and rapid design changes, digital information technology, and more flexible technical workforce training. Other goals sometimes include fast changes in production levels based on demand, optimization of the supply chain, efficient production and recyclability.

2. Digital Manufacturing:

**Digital manufacturing** is the use of an integrated, computer-based system comprised of simulation, 3D visualization, analytics and collaboration tools to create product and manufacturing process definitions simultaneously.

**Digital manufacturing** evolved from manufacturing initiatives such as design for manufacturability (DFM), computer-integrated manufacturing (CIM), flexible manufacturing and lean manufacturing that highlight the need for collaborative product and process design.

Present scenario

2. Digital Manufacturing:

https://www.intelizign.com/blog/2019/01/10/industry-4-0-with-digital-manufacturing/
3. Internet Of Things (IOT):

1. There are essentially two different roles that the IOT can play in manufacturing. It can connect the “things” that make your product—machines and equipment—to potentially make your manufacturing processes run more smoothly.

2. Or you can tap into data collected or generated by your products, making them “smart” products.

3. IOT has multitudes of applications in manufacturing plants. It can facilitate the production flow in a manufacturing plant, as IOT devices automatically monitor development cycles, and manage warehouses as well as inventories.
Present scenario

3. Internet Of Things (IOT):

IOT in manufacturing

https://www.scnsoft.com/blog/iot-in-manufacturing
4. Artificial Intelligence (AI):

Artificial intelligence technology is now making its way into manufacturing.

“AI will perform manufacturing, quality control, shorten design time, and reduce materials waste, improve production reuse, perform predictive maintenance, and more,” says Andrew Ng, the creator of the deep-learning Google Brain project and an adjunct professor of computer science at Stanford University.

Present scenario

4. Artificial Intelligence (AI):

https://www.asme.org/engineering-topics/articles/manufacturing-design/artificial-intelligence-transforms-manufacturing
Cloud based manufacturing:

- Cloud models come as infrastructure, platform, and services. Manufacturers can opt for the solution of choice and strategize migration in stages. This makes cloud a flexible and convenient choice.
- Cloud allows the synchronization of data from multiple sources into a single dashboard. Hence it relieves executives from the burden of manually transferring data from one system to another.
Future Prospects

Cloud based manufacturing: 

https://www.researchgate.net/figure/Cloud-manufacturing-abstract-from-20_fig8_236671408
Overall cycle of development
Summary

• What is Manufacturing?
• What is the Use of Computers and there evaluation?
• Various Computer Applications (CAD, CAM, CAPP etc.)?
• Design Process involved with computers assistance?
• What is Manufacturing Systems and its types?
• What is CIM?
• Sub-systems of CIM
• What is Present Scenario?
• What are Future Prospects?
Thank You