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DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT NOTES

SUBJECT : COMPUTER INTEGRATED MANUFACTURING

SUB CODE : MET-64 **YEAR & SEM : III & VI**

PREPARED BY,

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ASSISTANT PROFESSOR

SVCET

MET64 COMPUTER INTEGRATED MANUFACTURING (4 0 0 4)

UNIT – I

CIM: Introduction to CIM, CIM Wheel, Evolution, Benefits, Trends. Computers in Manufacturing: Factory tasks for Computer Integration – Needs of CIM, CIM Hardware and Software, Workstations. Fundamentals of Communication: Communications Matrix – Types. Representation of data, Coding, Transmission, Medium, Types of Communication Lines and Hardware. Network Architectures: The seven layers – OSI Model, LAN, MAP and Network Topologies. (09 hours)

UNIT – II

Data base: Introduction – Manufacturing data- Data base models, Data base Management – Data base required for a shop floor control (Fundamentals only)

Product Design: Design Process, Design for Manufacturability, CAD – areas of Application, Benefits, CAD to CAM, CAE (Fundamentals only) (09 hours)

UNIT – III

Concurrent / Simultaneous engineering: Introduction, Design for manufacturing and assembly, and other product design objectives. Advanced Manufacturing Planning.

Introduction to Reverse Engineering.

Process Planning: CAPP – Retrieval and Generative Model. (09 hours)

UNIT – IV

Production Planning and Control: Computerized PPL, Aggregate Production Planning, MPS, MRP, MRP II, ERP and JIT.

Automated Data Collection – Bar Codes, OCR, Image Processing, RF Identification, Magnetic Identification, Voice Technology, Comparison, Control Types. (09 hours)

UNIT – V

Quality: Modern Concepts, TQM, TPM – ISO Standards, CAQC – Contact & Non – Contact type, Introduction to CMM – Types

Inspection: Description, Working Principle and Application of Various Techniques and Equipments. Interfacing inspection with CAD/CAM. (09 hours)

Text Books

1. Mikell. P. Groover, Automation, Production Systems and computer integrated manufacturing, Prentice Hall of India, New Delhi, 2007.

2. P. Radhakrishnan , S. Subramanyan and V. Raju, CAD/CAM/CIM, New Age International (P) Ltd., New Delhi, 2000.

References

1. S. Kant Vajpayee, Principles of Computer Integrated Manufacturing, Prentice Hall of India, 2003.

2. Roger Hanman, Computer Intergrated Manufacturing, Addison – Wesley, 1995.

Web reference

1. www.cimlearningzone.co.uk/

2. http://nptel.ac.in/courses/112102101/

3. http://nptel.ac.in/courses/112102103/

4. http://elearning.vtu.ac.in/06ME72.html

Unit – I

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COMPUTER INTEGRATED MANUFACTURING

Computer Integrated Manufacturing (CIM) encompasses the entire range of product development and manufacturing activities with all the functions being carried out with the help of dedicated software packages. The data required for various functions are passed from one application software to another in a seamless manner. For example, the product data is created during design. This data has to be transferred from the modeling software to manufacturing software without any loss of data. CIM uses a common database wherever feasible and communication technologies to integrate design, manufacturing and associated business functions that combine the automated segments of a factory or a manufacturing facility. CIM reduces the human component of manufacturing and thereby relieves the process of its slow, expensive and error-prone component. CIM stands for a holistic and methodological approach to the activities of the manufacturing enterprise in order to achieve vast improvement in its performance.

This methodological approach is applied to all activities from the design of the product to customer support in an integrated way, using various methods, means and techniques in order to achieve production improvement, cost reduction, fulfillment of scheduled delivery dates, quality improvement and total flexibility in the manufacturing system. CIM requires all those associated with a company to involve totally in the process of product development and manufacture. In such a holistic approach, economic, social and human aspects have the same importance as technical aspects. CIM also encompasses the whole lot of enabling technologies including total quality management, business process reengineering, concurrent engineering, workflow automation, enterprise resource planning and flexible manufacturing.

The challenge before the manufacturing engineers is illustrated in Figure. 1.1

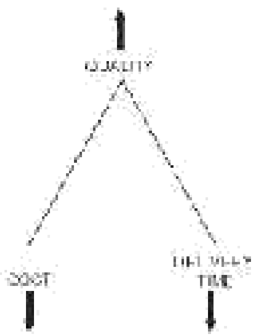


Figure 1.1. - Challenges in manufacturing

Manufacturing industries strive to reduce the cost of the product continuously to remain competitive in the face of global competition. In addition, there is the need to improve the quality and performance levels on a continuing basis. Another important requirement is on time delivery. In the context of global outsourcing and long supply chains cutting across several international borders, the task of continuously reducing delivery times is really an arduous task. CIM has several software tools to address the above needs.

Manufacturing engineers are required to achieve the following objectives to be competitive in a global context.

- Reduction in inventory
- Lower the cost of the product
- Reduce waste
- Improve quality
- Increase flexibility in manufacturing to achieve immediate and rapid response to:
- Product changes
- Production changes
- Process change
- Equipment change
- Change of personnel

CIM technology is an enabling technology to meet the above challenges to the manufacturing.

The advances in automation have enabled industries to develop islands of automation. Examples are flexible manufacturing cells, robotized work cells, flexible inspection cells etc. One of the objectives of CIM is to achieve the consolidation and integration of these islands of automation. This requires sharing of information among different applications or sections of a factory, accessing incompatible and heterogeneous data and devices. The ultimate objective is to meet the competition by improved customer satisfaction through reduction in cost, improvement in quality and reduction in product development time.

CIM makes full use of the capabilities of the digital computer to improve manufacturing. Two of them are:

i. Variable and Programmable automation
ii. Real time optimization

The computer has the capability to accomplish the above for hardware components of manufacturing (the manufacturing machinery and equipment) and software component of manufacturing (the application software, the information flow, database and so on).

The capabilities of the computer are thus exploited not only for the various bits and pieces of manufacturing activity but also for the entire system of manufacturing. Computers have the tremendous potential needed to integrate the entire manufacturing system and thereby evolve the computer integrated manufacturing system.

Definition of CIM

Joel Goldhar, Dean, Illinois Institute of Technology gives CIM as a computer system in which the peripherals are robots, machine tools and other processing equipment.

Dan Appleton, President, DACOM, Inc. defines CIM is a management philosophy, not a turnkey product.

Jack Conaway, CIM Marketing manager, DEC, defines CIM is nothing but a data management and networking problem.

The computer and automated systems association of the society of Manufacturing Engineers (CASA/SEM) defines CIM is the integration of total manufacturing enterprise by using integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency. CIM is recognized as Islands of Automation. They are

1. CAD/CAM/CAE/GT
2. Manufacturing Planning and Control.
3. Factory Automation
4. General Business Management

CIM wheel

CASA/SME's CIM Wheel is as shown in Figure 1.2

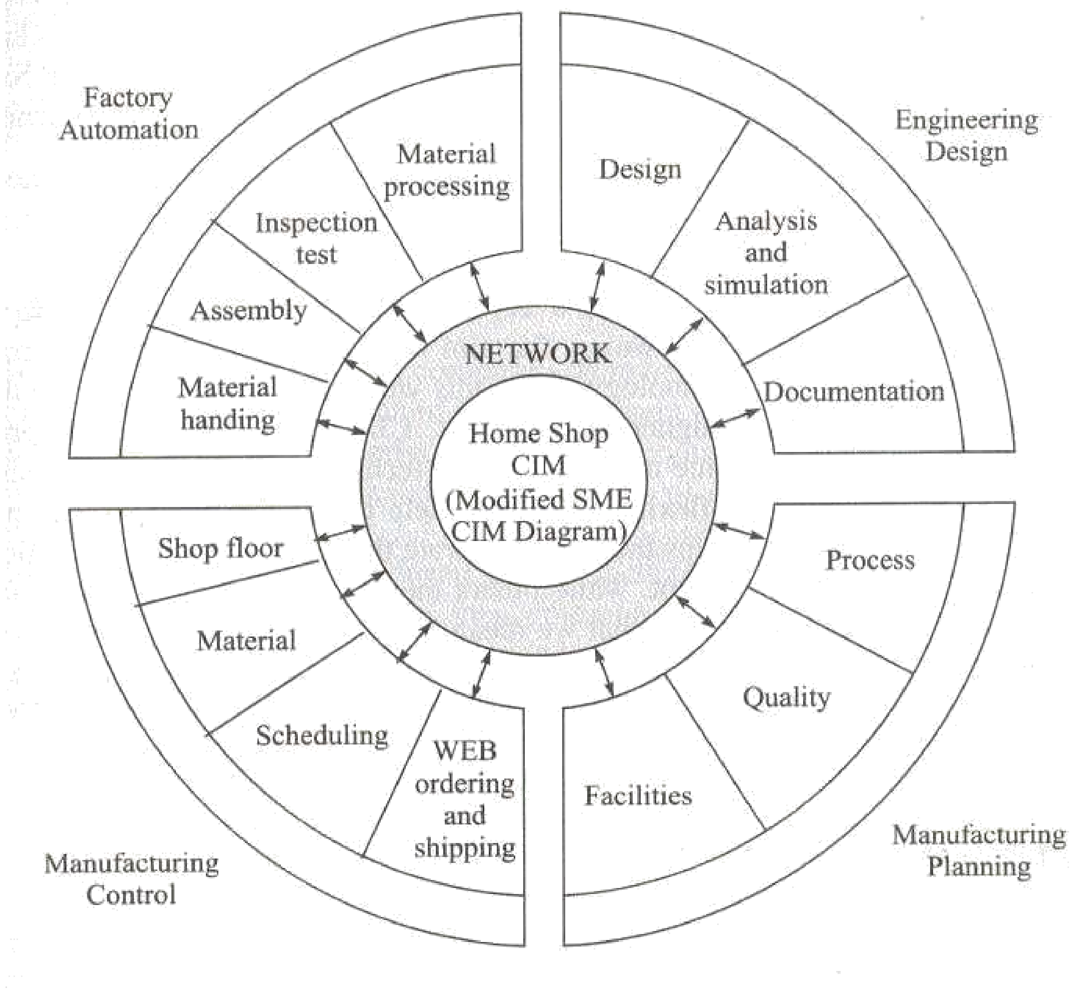


Figure 1.2- CASA/SME's CIM Wheel

Conceptual model of manufacturing

The computer has had and continues to have a dramatic impact on the development of production automation technologies. Nearly all modern production systems are implemented today using computer systems. The term computer integrated manufacturing (CIM) has been coined to denote the pervasive use of computers to design the products, plan the production, control the operations, and perform the various business related functions needed in a manufacturing firm. *CAD/CAM* (computer-aided design and computer-aided manufacturing) is another term that is used almost synonymously with CIM.

Let us attempt to define the relationship between automation and CIM by developing a conceptual model of manufacturing. In a manufacturing firm, the physical activities related to production that take place in the factory can be distinguished from the information-processing activities, such as product design and production planning, that usually occur in an office environment. The physical activities include all of the manufacturing processing, assembly, material handling, and inspections that are performed on the product. These operations come in direct contact with the product during manufacture. They touch the product. The relationship between the physical activities and the information- processing activities in our model is depicted in Figure 3. Raw materials flow in one end of the factory and finished products flow out the other end. The physical activities (processing, handling, etc.) take place inside the factory. The information-processing functions form a ring that surrounds the factory, providing the data and knowledge required to produce the product successfully. These information-processing functions include (1) certain business activities (e.g., marketing and sales, order entry, customer billing, etc.), (2) product design, (3) manufacturing planning, and (4) manufacturing control. These four functions form a cycle of events that must accompany the physical production activities but which do not directly touch the product.

Now consider the difference between automation and CIM. Automation is concerned with the physical activities in manufacturing. Automated production systems are designed to accomplish the processing, assembly, material handling, and inspecting activities with little or no human participation.

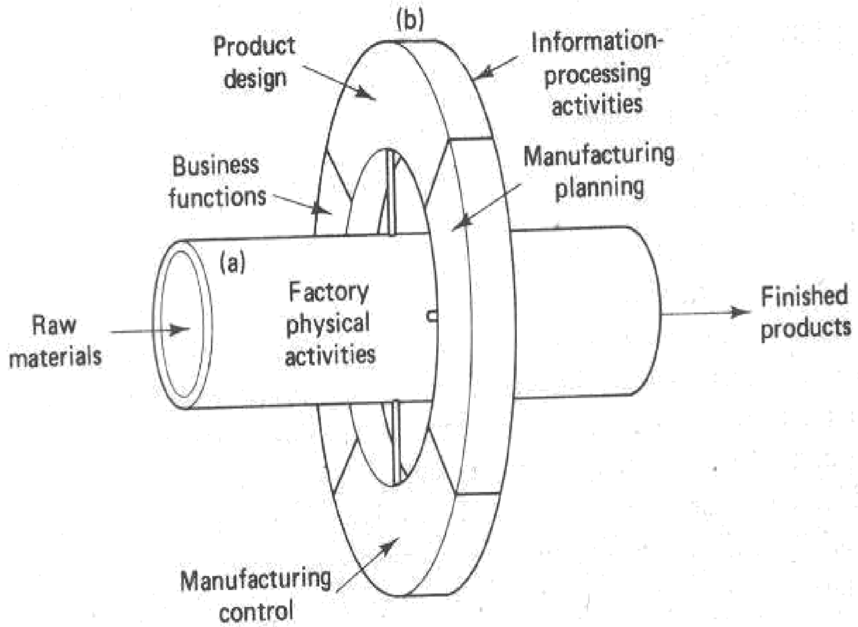


Figure.1.3. Model of manufacturing

In the above Figure1.3 Model of manufacturing, showing (a] the factory as a processing pipeline where the physical manufacturing activities are performed, and (b) the information-processing activities that support manufacturing as a ring that surrounds the factory concerned more with the information-processing functions that are required to support the production operations. CIM involves the use of computer systems to perform the four types of information-processing functions. Just as automation deals with the physical activities, CIM deals with automating the information-processing activities in manufacturing.

EVOLUTION OF COMPUTER INTEGRATED MANUFACTURING

Computer Integrated Manufacturing (CIM) is considered a natural evolution of the technology of CAD/CAM which by itself evolved by the integration of CAD and CAM. Massachusetts Institute of Technology (MIT, USA) is credited with pioneering the development in both CAD and CAM. The need to meet the design and manufacturing requirements of aerospace industries after the Second World War necessitated the development these technologies.

The manufacturing technology available during late 40's and early 50's could not meet the design and manufacturing challenges arising out of the need to develop sophisticated aircraft and satellite launch vehicles. This prompted the US Air Force to approach MIT to develop suitable control systems, drives and programming techniques for machine tools using electronic control.

The first major innovation in machine control is the Numerical Control (NC), demonstrated at MIT in 1952. Early Numerical Control Systems were all basically hardwired systems, since these were built with discrete systems or with later first generation integrated chips. Early NC machines used paper tape as an input medium. Every NC machine was fitted with a tape reader to read paper tape and transfer the program to the memory of the machine tool block by block. Mainframe computers were used to control a group of NC machines by mid-*60.* This arrangement was then called Direct Numerical Control (DNC) as the computer bypassed the tape reader to transfer the program data to the machine controller. By late 60's mini computers were being commonly used to control NC machines.

At this stage NC became truly soft wired with the facilities of mass program storage, offline editing and software logic control and processing. This development is called Computer Numerical Control (CNC). Since 70's, numerical controllers are being designed around microprocessors, resulting in compact CNC systems. A further development to this technology is the distributed numerical control (also called DNC) in which processing of NC program is carried out in different computers operating at different hierarchical levels - typically from mainframe host computers to plant computers to the machine controller. Today the CNC systems are built around powerful 32 bit and 64 bit microprocessors. PC based systems are also becoming increasingly popular.

Manufacturing engineers also started using computers for such tasks like inventory control, demand forecasting, production planning and control etc. CNC technology was adapted in the development of co-ordinate measuring machine's (CMMs) which automated inspection. Robots were introduced to automate several tasks like machine loading, materials handling, welding, painting and assembly. All these developments led to the evolution of flexible manufacturing cells and flexible manufacturing systems in late 70's.

Evolution of Computer Aided Design (CAD), on the other hand was to cater to the geometric modeling needs of automobile and aeronautical industries. The developments in computers, design workstations, graphic cards, display devices and graphic input and output devices during the last ten years have been phenomenal. This coupled with the development of operating system with graphic user interfaces and powerful interactive (user friendly) software packages for modeling, drafting, analysis and optimization provides the necessary tools to automate the design process.

CAD in fact owes its development to the APT language project at MIT in early 50's.

Several clones of APT were introduced in 80's to automatically develop NC codes from the geometric model of the component. Now, one can model, draft, analyze, simulate, modify, optimize and create the NC code to manufacture a component and simulate the machining operation sitting at a computer workstation.

If we review the manufacturing scenario during 80's we will find that the manufacturing is characterized by a few islands of automation. In the case of design, the task is well automated. In the case of manufacture, CNC machines, DNC systems, FMC, FMS etc provide tightly controlled automation systems. Similarly computer control has been implemented in several areas like manufacturing resource planning, accounting, sales, marketing and purchase. Yet the full potential of computerization could not be obtained.

Potential benefits of CIM

i. Improved customer service
ii. Improved quality
iii. Shorter time to market with new products
iv. Shorter flow time
v. Shorter vendor lead time
vi. Reduced inventory levels
vii. Improved schedule performance
viii. Greater flexibility and responsiveness
ix. Improved competitiveness
x. Lower total cost
xi. Shorter customer lead time
xii. Increase in manufacturing productivity
xiii. Decrease in work-in process inventory

COMPUTER-INTEGRATED MANUFACTURING CONCEPT

There are three major challenges to development of a smoothly operating computer-integrated manufacturing system:

- **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.
- **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.
- **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.

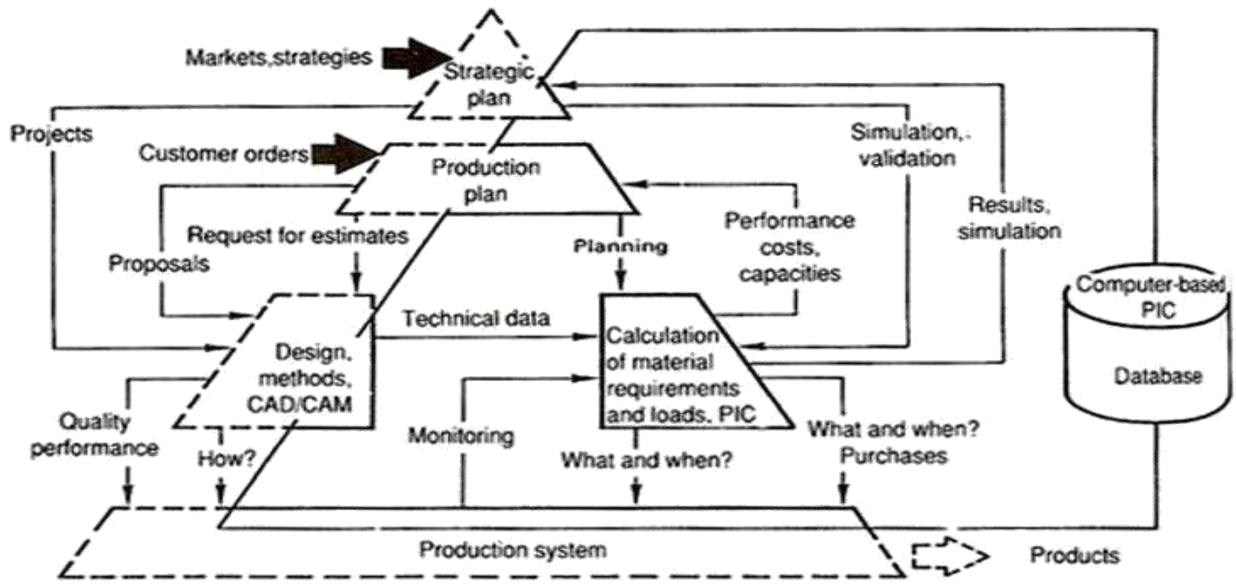


Figure 1.4. Computer Integrated Manufacturing control system **Subsystems in computer-integrated manufacturing**

A computer-integrated manufacturing system is not the same as a *"lights-out" factory*, which would run completely independent of human intervention, although it is a big step in that direction.

Part of the system involves flexible manufacturing, where the factory can be quickly modified to produce different products, or where the volume of products can be changed quickly with the aid of computers. Some or all of the following subsystems may be found in a CIM operation:

Computer-aided techniques:

- CAD (computer-aided design)
- CAE (computer-aided engineering)
- CAM (computer-aided manufacturing)
- CAPP (computer-aided process planning)
- CAQ (computer-aided quality assurance)
- PPC (production planning and control)
- ERP (enterprise resource planning)

- A business system integrated by a common database. 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

Technologies:

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

Others:

- Lean manufacturing

CIM HARDWARE AND CIM SOFTWARE

CIM Hardware comprises the following:

i. Manufacturing equipment such as CNC machines or computerized work centers, robotic work cells, DNC/FMS systems, work handling and tool handling devices, storage devices, sensors, shop floor data collection devices, inspection machines etc.

ii. Computers, controllers, CAD/CAM systems, workstations / terminals, data entry terminals, bar code readers, RFID tags, printers, plotters and other peripheral devices, modems, cables, connectors etc.,

CIM software comprises computer programs to carry out the following functions:

- Management Information System
- Sales
- Marketing
- Finance
- Database Management
- Modeling and Design
- Analysis
- Simulation
- Communications
- Monitoring
- Production Control
- Manufacturing Area Control
- Job Tracking
- Inventory Control
- Shop Floor Data Collection
- Order Entry
- Materials Handling
- Device Drivers
- Process Planning
- Manufacturing Facilities Planning
- Work Flow Automation
- Business Process Engineering
- Network Management
- Quality Management

NATURE AND ROLE OF THE ELEMENTS OF CIM SYSTEM

Nine major elements of a CIM system are in Figure 1.5 they are,

- Marketing
- Product Design
- Planning
- Purchase
- Manufacturing Engineering
- Factory Automation Hardware
- Warehousing- Logistics and Supply Chain Management
- Finance
- Information Management

Figure 1.5. Major elements of CIM systems

i. Marketing: The need for a product is identified by the marketing division. The specifications of the product, the projection of manufacturing quantities and the strategy for marketing the product are also decided by the marketing department. Marketing also works out the manufacturing costs to assess the economic viability of the product.

ii. *Product Design:* The design department of the company establishes the initial database for production of a proposed product. In a CIM system this is accomplished through activities such as geometric modeling and computer aided design while considering the product requirements and concepts generated by the creativity of the design engineer. Configuration management is an important activity in many designs.

Complex designs are usually carried out by several teams working simultaneously, located often in different parts of the world. The design process is constrained by the costs that will be incurred in actual production and by the capabilities of the available production equipment and processes. The design process creates the database required to manufacture the part.

iii. *Planning:* The planning department takes the database established by the design department and enriches it with production data and information to produce a plan for the production of the product. Planning involves several subsystems dealing with materials, facility, process, tools, manpower, capacity, scheduling, outsourcing, assembly, inspection, logistics etc. In a CIM system, this planning process should be constrained by the production costs and by the production equipment and process capability, in order to generate an optimized plan.

iv. *Purchase:* The purchase departments is responsible for placing the purchase orders and follow up, ensure quality in the production process of the vendor, receive the items, arrange for inspection and supply the items to the stores or arrange timely delivery depending on the production schedule for eventual supply to manufacture and assembly.

v. *Manufacturing Engineering:* Manufacturing Engineering is the activity of carrying out the production of the product, involving further enrichment of the database with performance data and information about the production equipment and processes. In CIM, this requires activities like CNC programming, simulation and computer aided scheduling of the production activity. This should include online dynamic scheduling and control based on the real time performance of the equipment and processes to assure continuous production activity. Often, the need to meet fluctuating market demand requires the manufacturing system flexible and agile.

vi. *Factory Automation Hardware:* Factory automation equipment further enriches the database with equipment and process data, resident either in the operator or the equipment to carry out the production process. In CIM system this consists of computer controlled process machinery such as CNC machine tools, flexible manufacturing systems (FMS), Computer controlled robots, material handling systems, computer controlled assembly systems, flexibly automated inspection systems and so on.

vii. *Warehousing:* Warehousing is the function involving storage and retrieval of raw materials, components, finished goods as well as shipment of items. In today's complex outsourcing scenario and the need for just-in-time supply of components and subsystems, logistics and supply chain management assume great importance.

viii. *Finance:* Finance deals with the resources pertaining to money. Planning of investment, working capital, and cash flow control, realization of receipts, accounting and allocation of funds are the major tasks of the finance departments.

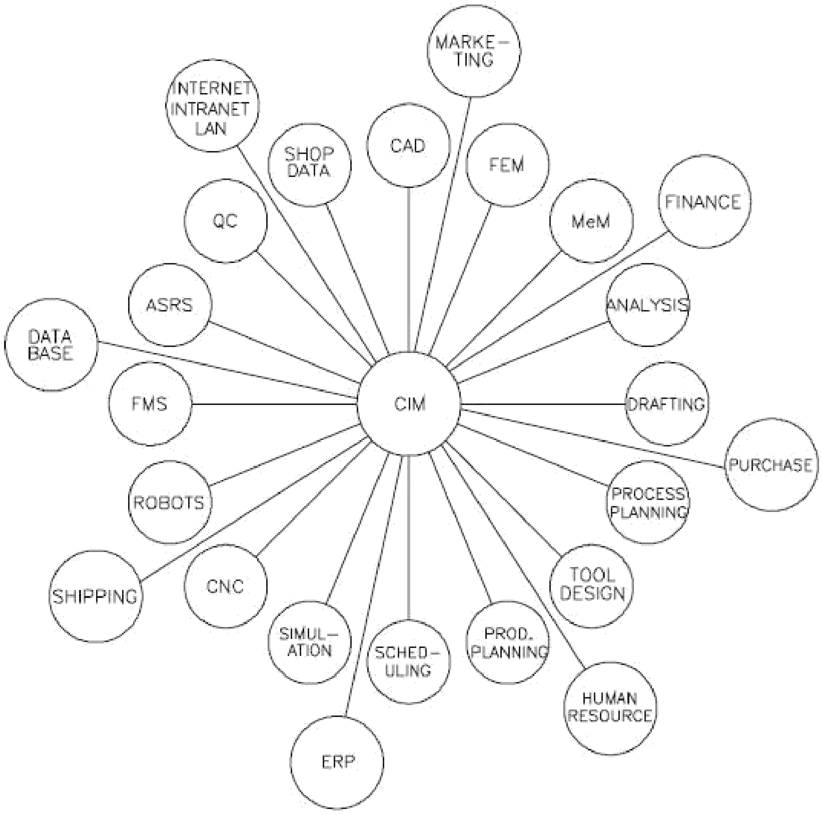


Figure 1.6. Various Activities in CIM

FEM - Finite Element Modeling MeM - Mechanism Modeling ERP – Enterprise Resource Planning

ix. Information Management: Information Management is perhaps one of the crucial tasks in CIM. This involves master production scheduling, database management, communication, manufacturing systems integration and management information systems.

It can be seen from Figure above that CIM technology ties together all the manufacturing and related functions in a company. Implementation of CIM technology thus involves basically integration of all the activities of the enterprise.

WORKSTATIONS

Engineering workstations are computer systems with adequate computing power, based on 32 or 64 bit microprocessors. Workstations are typically divided into two broad categories: Low-end and high-end. Low-end work stations generally consist of personal computers. Appropriate software and special hardware like graphics accelerator cards are added to these for boosting the performance. Personal computers have the additional advantage of being able to run a substantial amount of software such as programs for analysis, database management, etc. The processing capability of personal computers is generally enhanced by the addition of a co-processor in the microprocessor circuit which increases the processing speed by two or three times. Special custom-built graphics boards increase resolution and decrease drawing times. High resolution color monitors and multifunction cards improve the versatility of personal computers. High-end workstations are designed around one or more powerful RISC processors. Examples of such processors are PA-RISC, MIPS, and SPARC etc. Hardware in these systems generally consists of high resolution graphics display of 1024 X 1024 pixels, or more, a processor capable of 2 to 4 MIPS or more and 512 MB to 8GB core memory and mass storage in the range of 36-146 GB (Giga Byte), with optional magnetic tape backup. These will also have the ability to operate in a computer network with other workstations or to work as host computers, to PC nodes which may be intelligent or dumb.

Computers used for high end workstations are optimized for engineering analysis and graphics work. Many of them use custom-built processors often incorporating hardware features to boost the speed of processing. However the systems using standard processors have the advantage of several software packages with practically little customization.

Workstations consist of three basic components:

A primary processor

Associated memory

Graphics display system and software

Figure 1.7. Shows a system level block diagram of a typical high end CAD workstation

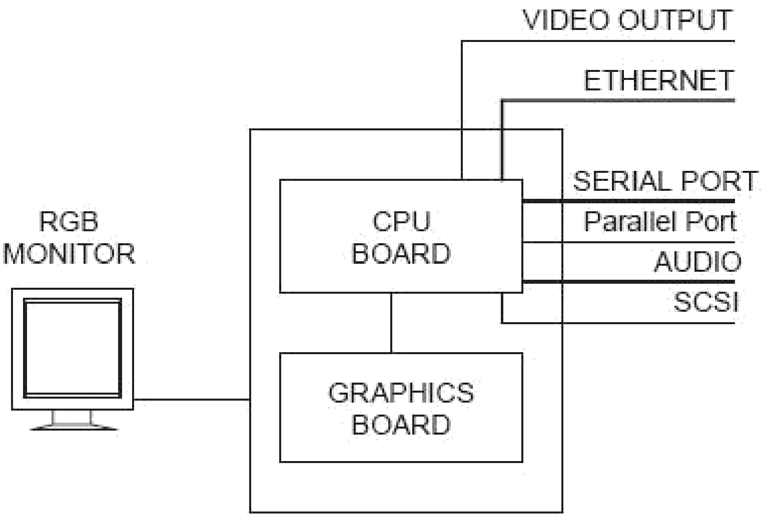


Figure 1.7. Block diagram of a CAD Workstation

<u>FUNDAMENTALS OF COMMUNICATION</u>

Computers need to communicate with printers, terminals and other computers. This kind of input/output is typically called data communications, since streams of data are transferred between sources and destinations. This flow must be synchronized. This is typically done under the control of "handshaking" conventions that use either dedicated hardware lines or special character sequences. A simple example of handshaking involves a printer capable of printing only 120 characters per second, but receiving data at 10 times that rate. When the printer's input buffer is full, it sends a busy signal to the data source (by pulling high a line connecting the two), indicating that it cannot accept any more data for a while. Later it can accept more data. The "busy" signal here is what is meant by a handshake signal.

Some popular devices for transferring digital data are considered below:

i. Parallel interface
ii. Serial RS 232 data link
iii. IEEE 488 interface bus (also called General Purpose Interface Bus - GPIB)
iv. USB port
v. Modems
vi. Computer to computer communications.

MODES OF DATA TRANSMISSION

There are two modes of data transmission they are:

1.Parallel Transmission

2.Serial Transmission

PARALLEL TRANSMISSION

A parallel transmission is one that moves information 8 bits or more at a time. Centronics printer interface is a standard parallel interface. This interface allows data to be transferred to a printer, 8 bits at a time. Fig. 1.8 shows the timing diagram of a parallel interface.

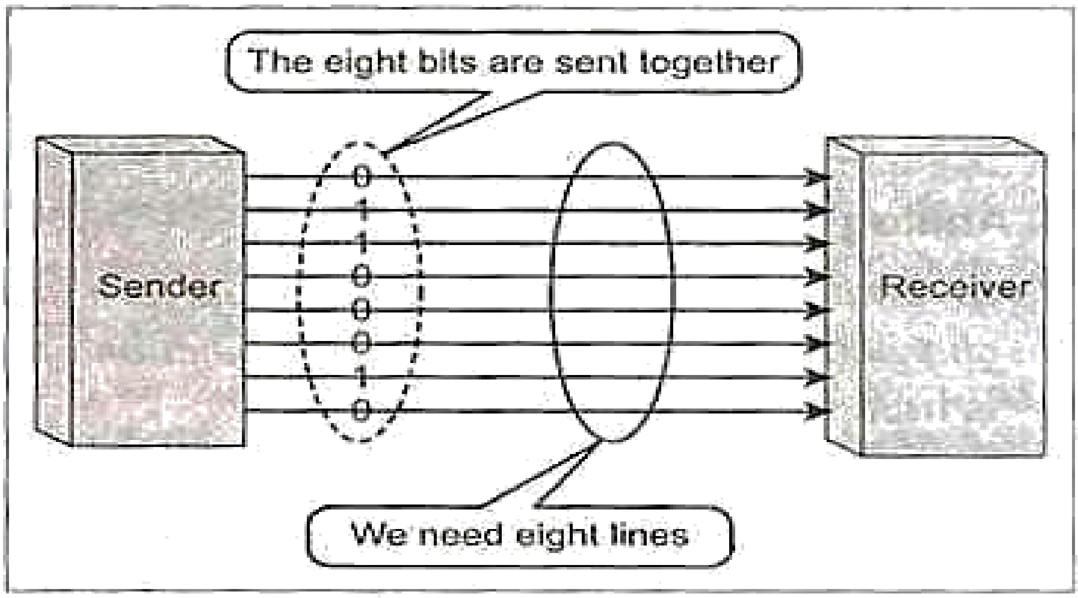


Fig. 1.8 Parallel Transmission

SERIAL TRANSMISSION

A serial transmission is one that moves information one bit at a time. This interface allows data to be transferred to a receiver, 1 bit at a time. Fig. 1.9 shows the timing diagram of a serial interface.

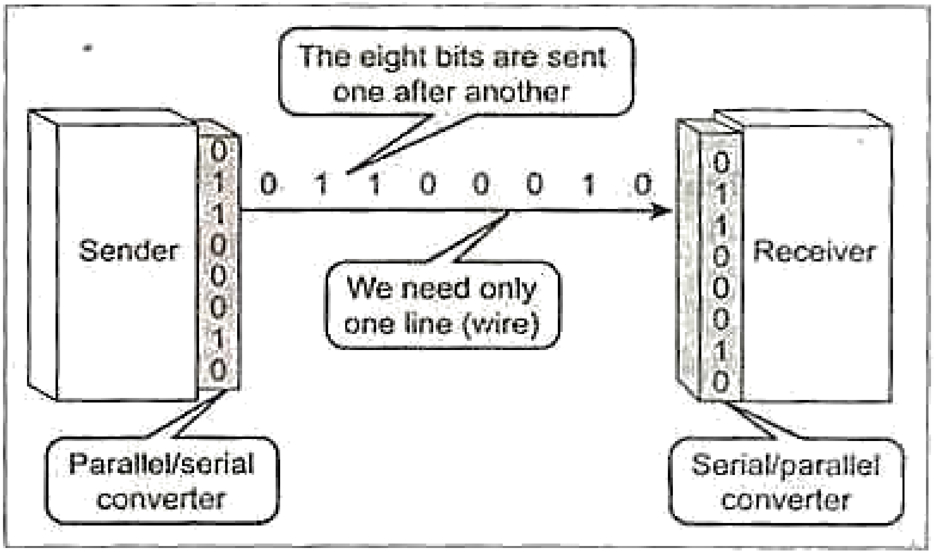


Fig. 1.9 Serial Transmission

TRANSMISSION MEDIA

The transmission of an electrical signal between two pieces of equipment requires the use of a transmission medium, which takes the form of a transmission line. The major types of transmission media are:

a) Two-wire open lines
b) Twisted pair lines
c) Co-axial cable
d) Optical fibre
e) Microwaves

TYPES OF COMMUNICATION LINES AND HARDWARE:

Power line communication or power line carrier (PLC), also known as power line digital subscriber line (PDSL), mains communication, power line telecom (PLT), power line networking (PLN), or broadband over power lines (BPL) are systems for carrying data on a conductor also used for electric power transmission. A wide range of power line communication technologies are needed for different applications, ranging from home automation to Internet access. Electrical power is transmitted over long distances using high voltage transmission lines, distributed over medium voltages, and used inside buildings at lower voltages. Most PLC technologies limit themselves to one set of wires (such as premises wiring within a single building), but some can cross between two levels (for example, both the distribution network and premises wiring). Typically transformers prevent propagating the signal, which requires multiple technologies to form very large networks. Various data rates and frequencies are used in different situations.

A number of difficult technical problems are common between wireless and power line communication, notably those of spread spectrum radio signals operating in a crowded environment. Potential interference, for example, has been a long concern of amateur radio groups.

NETWORK ARCHITECTURES

THE SEVEN LAYERS – OSI MODEL

The International Standardization Organization (ISO) developed a model for data communications. This is known as ISO-Open System interconnection (OSI) model. This model is shown in Fig. 1.10. This standard defines a series of seven layers in which communication processing takes place.

These protocol layers are:

i. Physical layer
ii. Data link layer
iii. Network layer
iv. Transport layer
v. Session layer
vi. Presentation layer
vii. Application layer

Each layer contains a specific set of functions. It is organized such that any given layer may be implemented in a number of ways and remains compatible with layers above and below it. There have been also standard protocols and techniques established for implementing individual layers.

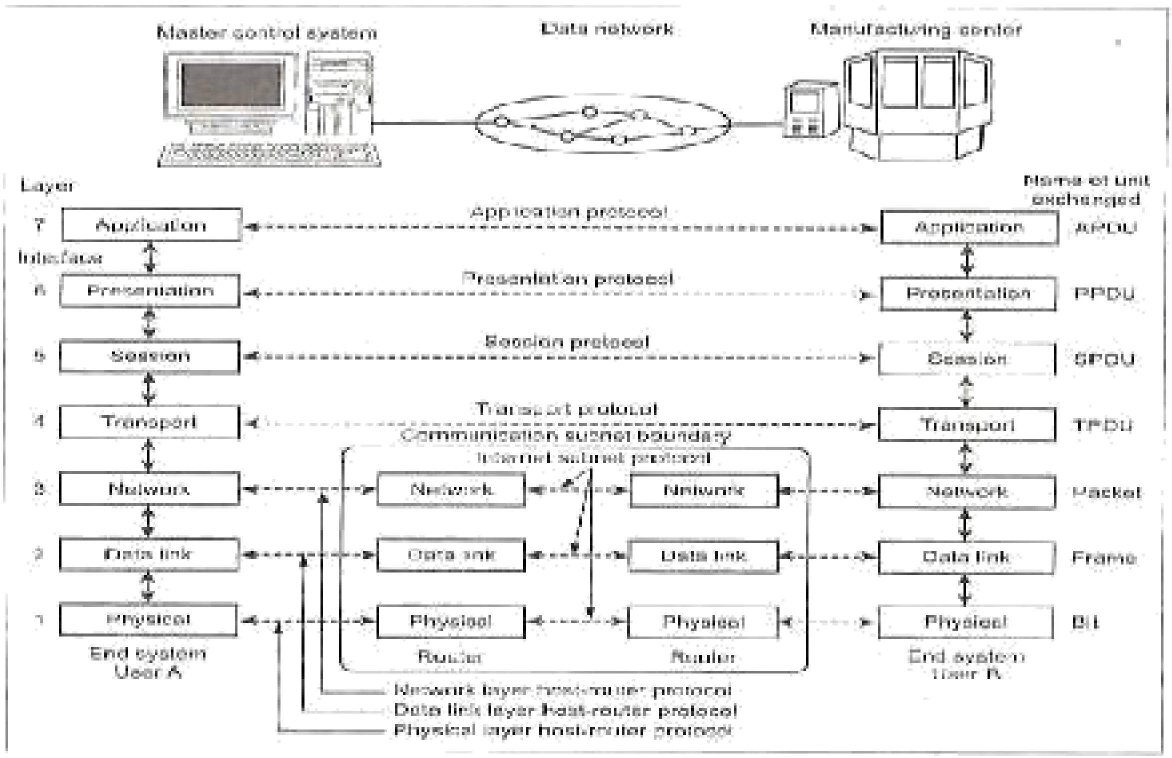


Fig1.10. The seven layers – OSI

Model The specific description for each layer is as follows:

Layer 1: Physical Layer

It defines the physical connection between the computer and the network communication system. This connection includes cables, connectors, and modulation equipment and specifies the frequencies and voltages of connectors. The bandwidth of the cable transmission and the physical layout (topology) are defined in this layer.

Traffic control is necessary within any given channel, and various techniques exist for handling this control. NETWORK TRAFFIC CONTROL: It is necessary to regulate the transmission of information in a network. A frequently used technique for controlling traffic on a network is CSMA/CD (Carrier Sense Multiple Access/Collision Detect). When a node has message to send, it listens on the line to see if any other message is in the process of being sent. If not, it broadcasts its message on the line. The receiving node acknowledges it.

There is a chance that two nodes will begin transmitting at the same time. The collision detect action determines when this happens by measuring a higher energy level in the line. Both nodes involved in the collision wait for a random period of time (each different) and try again.

Another popular network control method is called token passing. Here, the right to transmit data is called a token, and this token is passed from one node to another node in an organized fashion. Whichever node has the token has right to transmit data for a preset maximum amount of time. It must then next pass the token to the next node in sequence. If a node is sending and maximum time passes before all data is sent, that node must be stop sending and pass the token. It may resume when it gets the token back again. An advantage of this method is that one can compute the maximum amount of time any given node will have to wait before receiving the token and being able to send messages.

Two major token-passing schemes are token ring and token bus. Token ring uses nodes connected in a ring structure whereas token bus utilizes a bus network.

Layer 2: Data Link Layer

Defines how the data is to be packaged when it is sent between physical connections. This layer defines the network access control mechanisms. The formats used in network message units are also defined here. LANs do not send messages as a continuous stream. Instead, messages are broken up into message units called packets. Each packet carries the addresses of its source and destination along with suitable error detection mechanisms. An established protocol is higher level Data Line Control (HDLC). Another is Bisynchronous Communication (BSC). These are two standardized ways of transmitting data.

Layer 3: Network Layer

This layer defines switching and routing information between networks and how packets of data are exchanged between different LANs. An example is the X.25 standard, which defines standards for packet switching networks.

Layer 4: Transport Layer

The transport layer defines network addressing and the way in which connections between networks can be linked or unlinked. The transport layer guarantees the message delivery with no omissions or duplications.

Layer 5: Session Layer

The primary function of this layer is to define an application interface to the transport layer. This layer maps names to network addresses so that applications can use names to communicate with devices. Layers 3, 4 and 5 combine to form a sub-net level containing the software, which controls the network hardware. Though cables are attached to every device in a network, actual communication involves only two devices—the sender and the receiver. The subnet level establishes and manages a temporary link called virtual connection between the sender and the receiver.

Layer 6: Presentation Layer

This layer defines the translation formats and syntax from an application to the network and the manner in which software applications enter the network.

Layer 7: Application Layer

This layer contains several programs that define the network applications that support file serving. The developments in computer communication during the last two years have significantly simplified the communication protocols.

There are other network architecture models, such as IBM SNA (Systems Network Architecture) model.

NETWORK TYPES

Common examples of area network types are:

LAN - Local Area Network

WLAN - Wireless Local Area Network

WAN - Wide Area Network

MAN - Metropolitan Area Network.

LOCAL AREA NETWORK (LAN)

A network is a linking of a group of computers to communicate with each other and share software and hardware resources via the cables and interfaces that connect the computers and peripherals. Application softwares used in a network allow several users access the same program and data at the same time. As the name implies, a Local Area Network or LAN is a system that covers short distances. Usually LAN is limited to a single department or a single building or a single campus. Typical data transmission speeds are one to 100 megabits per second.

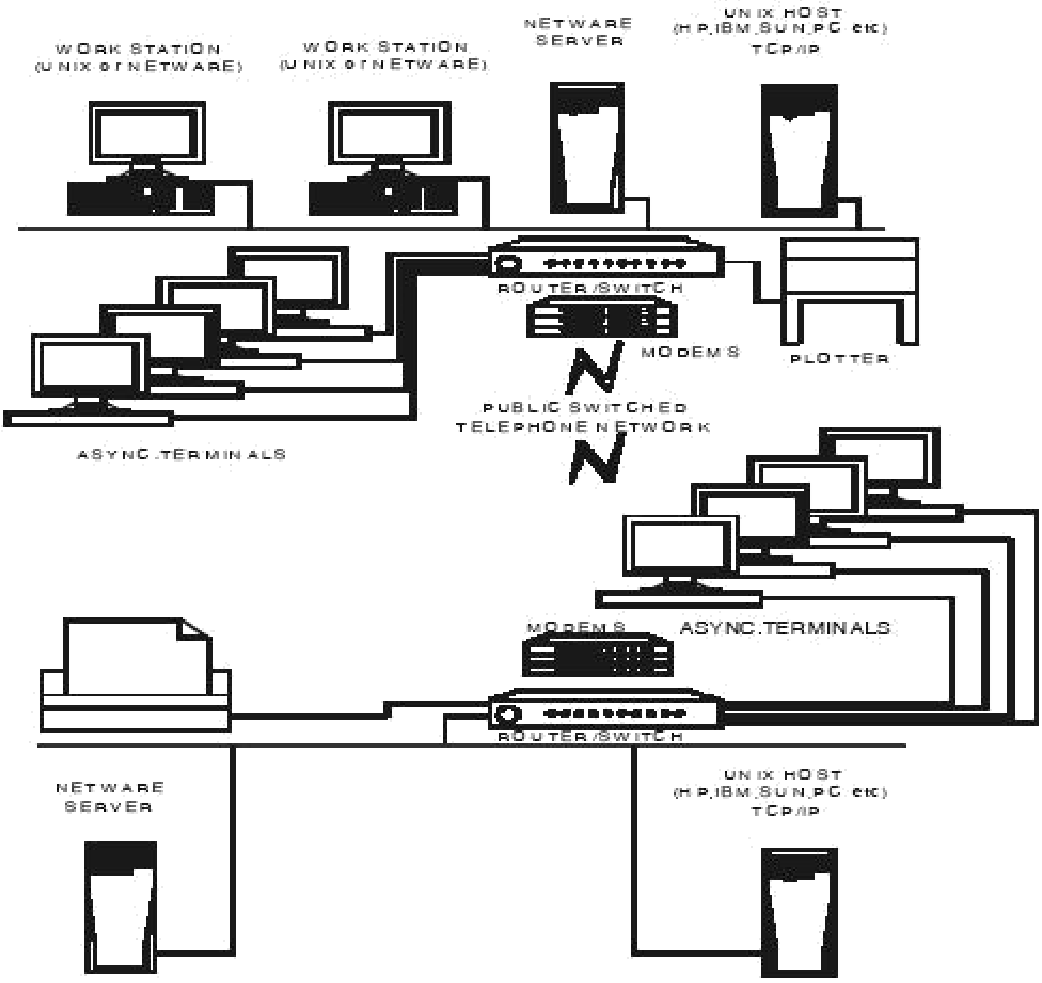


Figure 1.11. A Typical Local Area Network

Fig 1.11. Shows a typical network, in which two LAN's are shown, each networking a number of computers connected to its file server. A network connects together a number of workstations, as shown in the figure. Another way of interconnection is through a router to which a number of asynchronous terminals are connected. Remote access to another LAN can be affected through a Router-Modem-Public Switched Telephone Network- Modem-Router scheme. A router is intermediate equipment, which transfers data between two networks that use the same protocols.

Modem is an equipment that connects a computer to a telephone line (usually voice grade). Modems also connect a large local network to a network provider over a leased line which is a dedicated communication line leased from the Department of Telecommunications (DOT) by one or more user organizations. Leased lines provide faster communication capability than dial-up lines. Common resources of the network include a bank of printers and plotters and facilities for disc mirroring and disc duplexing.

Local area networks (LANs) fall into different sizes. Their topology, access method, medium, and market are different throughout. It is a private data communications system covering a limited geographical area, which is typically about a kilometre long. A LAN lets a factory network communicate with computers vertically and horizontally. It allows sharing of input and output devices and databases. The LAN allows access to remote mainframes. Many LAN topologies are available today.

A LAN is capable of data transfer rates of 1-10 Mbits/sec in computer-to-computer communications. It also handles requirements of dissimilar devices found in various applications, involving human, machines, and databases. A LAN can integrate the hardware and data on shop floor. An advantage of a LAN is that it allows electronic communications to maintain, optimize, and use external database resources and process controls with less than 10 seconds response. It does appropriate filtering of messages so that bad messages ^ cannot get through, and it allows downloading of program and data into production equipment like programmable controllers, numerical controllers, and microprocessors to facilitate flexible manufacturing. LANs allow machines and managers and supervisors to monitor the entire process by "zooming" onto any particular segment in as great detail as -C necessary. The LAN can monitor quality and make corrections, or, stop process to allow humans to make corrections, before the quality or yield of system goes down below acceptable levels.

A basic requirement of a LAN is that it must have a flexible architecture to permit PC's and other computers located where they are needed. It must also be possible to remove a computer without causing disruption. Reliability is another important aspect. Since the manufacturing activities depend upon the working of LAN, the LAN system must be highly reliable. The most widely used LAN system is Ethernet.

PC's attached to a LAN can use the processing capabilities of other intelligent devices in the network as in a host-to-terminal network.

MANUFACTURING AUTOMATION PROTOCOL (MAP)

MAP is a hardware/software protocol developed jointly by a group of industries and vendors of computers and PLCs. It follows the ISO OSI model. MAP was developed as a result of the plans of General Motors to automate its factories.

MAP uses a broad band LAN, with a token ring protocol for traffic control. Since it is broadband, all devices in the LAN like computers, CNC machines, robots, and PLC's etc. share the same cable, but different groups of devices can be placed on separate "channels" on the line. Additionally, closed circuit TV (video) channel can also be accommodated on same cable. MAP physical level is based on the IEEE 802.4 token-bus standard. At the data link level, it uses the IEEE 802.2 logical control standard. MAP also uses 8473 network layer protocol for connectionless-mode network service.

NETWORK TOPOLOGIES

The study of network topology recognizes five topologies:

- Bus topology
- Star topology
- Ring topology
- Tree topology
- Mesh topology

Bus network topology

o In local area networks where bus topology is used, each machine is connected to a single cable. Each computer or server is connected to the single bus cable through some kind of connector.

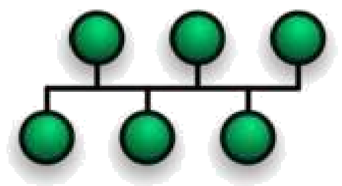
o A terminator is required at each end of the bus cable to prevent the signal from bouncing back and forth on the bus cable.

o A signal from the source travels in both directions to all machines connected on the bus cable until it finds the MAC address or IP address on the network that is the intended recipient.

o If the machine address does not match the intended address for the data, the machine ignores the data.

o Alternatively, if the data does match the machine address, the data is accepted. Since the bus topology consists of only one wire, it is rather inexpensive to implement when compared to other topologies.

o However, the low cost of implementing the technology is offset by the high cost of managing the network. Additionally, since only one cable is utilized, it can be the single point of failure. If the network cable breaks, the entire network will be down.



Notes:

1.) All of the endpoints of the common transmission medium are normally terminated with a device called a 'terminator' .

2.) The physical linear bus topology is sometimes considered to be a special case of the physical distributed bus topology – i.e., a distributed bus with no branching segments.

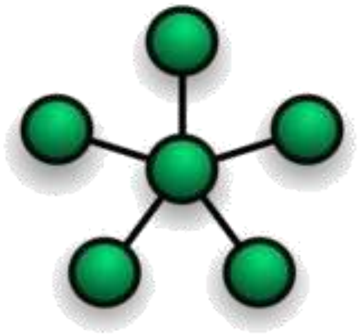
Star network topology

o In local area networks where the star topology is used, each machine is connected to a central hub.

o In contrast to the bus topology, the star topology allows each machine on the network to have a point to point connection to the central hub.

o All of the traffic which transverses the network passes through the central hub. The hub acts as a signal booster or repeater which in turn allows the signal to travel greater distances.

o As a result of each machine connecting directly to the hub, the star topology is considered the easiest topology to design and implement.



o An advantage of the star topology is the simplicity of adding other machines. The primary disadvantage of the star topology is the hub is a single point of failure.

o If the hub were to fail the entire network would fail as a result of the hub being connected to every machine on the network.

Notes:

1.) A point-to-point link (described above) is sometimes categorized as a special instance of the physical star topology – therefore, the simplest type of network that is based upon the physical star topology would consist of one node with a single point-to-point link to a second node, the choice of which node is the 'hub' and which node is the 'spoke' being arbitrary.

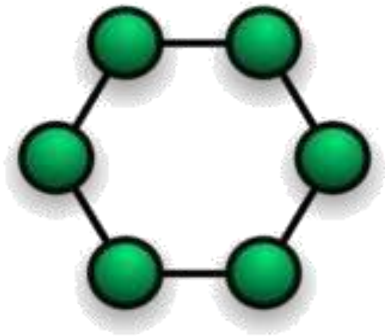
2.) After the special case of the point-to-point link, as in note 1 above, the next simplest type of network that is based upon the physical star topology would consist of one central node – the 'hub' – with two separate point-to-point links to two peripheral nodes – the 'spokes'.

Ring network topology

o In local area networks where the ring topology is used, each computer is connected to the network in a closed loop or ring. Each machine or computer has a unique address that is used for identification purposes.

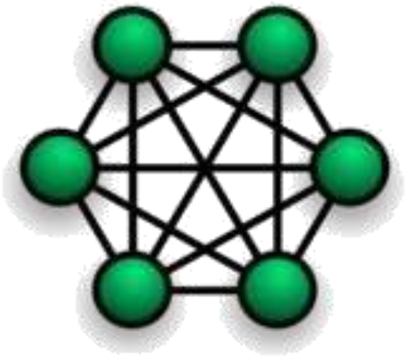
o The signal passes through each machine or computer connected to the ring in one direction. Ring topologies typically utilize a token passing scheme, used to control access to the network. By utilizing this scheme, only one machine can transmit on the network at a time.

o The machines or computers connected to the ring act as signal boosters or repeaters which strengthen the signals that transverse the network. The primary disadvantage of ring topology is the failure of one machine will cause the entire network to fail.



Fully connected mesh topology

The value of fully meshed networks is proportional to the exponent of the number of subscribers, assuming that communicating groups of any two endpoints, up to and including all the endpoints, is approximated by Reed's Law.



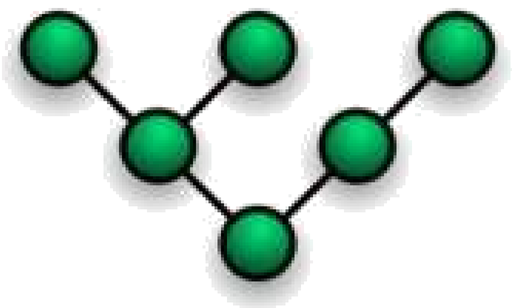
Note:

The physical fully connected mesh topology is generally too costly and complex for practical networks, although the topology is used when there are only a small number of nodes to be interconnected.

In most practical networks that are based upon the physical partially connected mesh topology, all of the data that is transmitted between nodes in the network takes the shortest path (or an approximation of the shortest path) between nodes, except in the case of a failure or break in one of the links, in which case the data takes an alternative path to the destination. This requires that the nodes of the network possess some type of logical 'routing' algorithm to determine the correct path to use at any particular time.

Tree network topology.

The type of network topology in which a central 'root' node (the top level of the hierarchy) is connected to one or more other nodes that are one level lower in the hierarchy (i.e., the second level) with a point-to-point link between each of the second level nodes and the top level central 'root' node, while each of the second level nodes that are connected to the top level central 'root' node will also have one or more other nodes that are one level lower in the hierarchy (i.e., the third level) connected to it, also with a point-to-point link, the top level central 'root' node being the only node that has no other node above it in the hierarchy (The hierarchy of the tree is symmetrical.) Each node in the network having a specific fixed number, of nodes connected to it at the next lower level in the hierarchy, the number, being referred to as the 'branching factor' of the hierarchical tree. Also known as a **hierarchical network**



NOTE

1.) A network that is based upon the physical hierarchical topology must have at least three levels in the hierarchy of the tree, since a network with a central 'root' node and only one hierarchical level below it would exhibit the physical topology of a star.

2.) A network that is based upon the physical hierarchical topology and with a branching factor of 1 would be classified as a physical linear topology.

3.) The total number of point-to-point links in a network that is based upon the physical hierarchical topology will be one less than the total number of nodes in the network.

UNIT II

Data base: Introduction – Manufacturing data- Data base models, Data base Management – Data base required for a shop floor control (Fundamentals only)

Product Design: Design Process, Design for Manufacturability, CAD – areas of Application, Benefits, CAD to CAM, CAE (Fundamentals only) (09 hours)

DATA BASE

A data base can be defined as a collection of data in a single location designed to be used by different programmers for a variety of applications. The term database denotes a common base of data collection designed to be used by different programmers. More specifically it is a collection of logically related data stored together in a set of files intended to serve one or more applications in an optimal fashion. Data are stored such that they are independent of the data. A database must also have a predetermined structure and organization suitable for access, interpretation, or processing either manually or automatically. A database not only stores the data but also provides several ways to view the data depending upon the needs of the user. There are several classifications of data.

I. **Physical data:** These are data stored in the computer's storage device. The volume of data required by a manufacturing company is so large that secondary storage devices such as hard discs, tapes, CD-ROMs, and other digital storage devices of several gigabyte capacities will be used.

II. **Logical data:** This indicates how a user views the physical data. The distinction between the physical data and the corresponding logical view is that the user conceptualizes certain meaningful relationships among the physical data elements. For example, we may have a set of items and quantities recorded in files. The logical view or interpretation of these sets of data can be that the items represent components available in stores and that the quantities recorded correspond to their inventory.

III. **Data independence:** Database management systems (DBMS) are used by the users to manage the physical data. DBMS makes a distinction between the two namely, the user and the physical data. Changes in the organization of physical data and or in the storage device parameters are absorbed by DBMS and therefore do not affect the user or more accurately, the application program. This flexibility is absent in the traditional file systems.

OBJECTIVES OF DATABASE

A database serves the following objectives:

- Reduce or eliminate redundant data
- Integrate existing data
- Provide security
- Share data among users
- Incorporate changes quickly and effectively
- Exercise effective control over data
- Simplify the method of using data
- Reduce the cost of storage and retrieval of data
- Improve accuracy and integrity of data

ISSUES OF CONCERN IN DATABASE

There are, of course, some issues to be considered while implementing a database. These include:

- High investment in hardware and software
- Need to use larger and faster hardware
- Necessity to have highly trained manpower
- Redundancy to take care of eventualities like crash of the database server.
- Need to ensure integrity and reliability of data

MANUFACTURING DATA

The information required for manufacturing is complex covering a wide range of disciplines and serving a multitude of inter-related yet vastly differing needs. The CIM database comprises basically four classes of data:

i. Product Data: Data about parts to be manufactured. It includes text and geometry data.

ii. Manufacturing Data: The information as to how the parts are to be manufactured is available in production data.

iii. Operational Data: Closely related to manufacturing data but describes the things specific to production, such as lot size, schedule, assembly sequence, qualification scheme etc.

iv. Resource Data: This is closely related to operational data but describes the resources involved in operations, such as materials, machines, human resources and money.

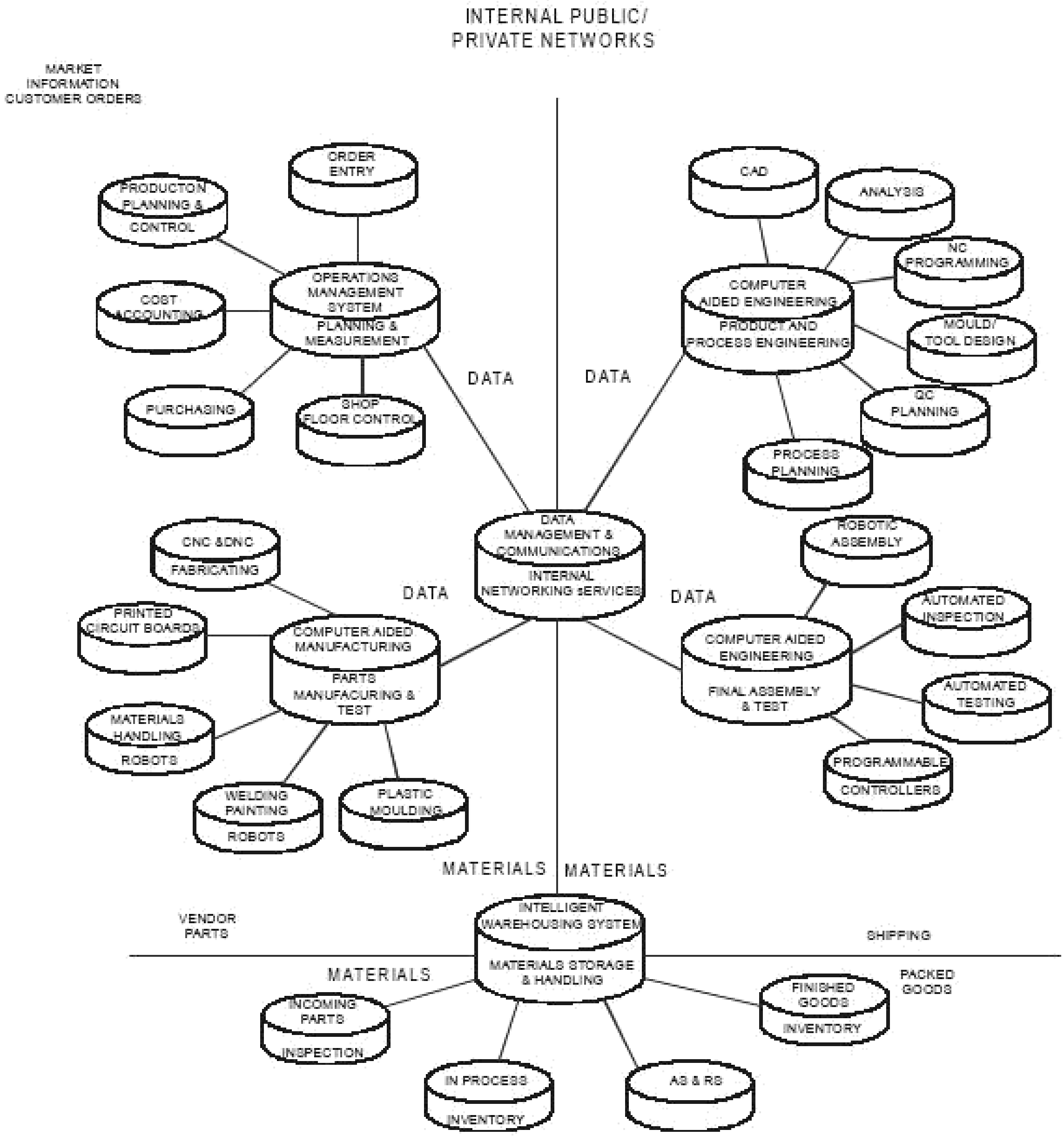


Fig.2.1 CIM Database

Product Design and Manufacturing process increasingly requires access to substantial technical information in various stages like design, analysis and manufacturing as well as smooth co-ordination among the many functions constituting an enterprise. Manufacturing organizations may waste a considerable portion of their resources due to delayed or error prone communication from one segment to another. It would therefore be desirable to have one single central database that would contain all information.

DATABASE REQUIREMENTS OF CIM:

A major challenge facing the implementation of CIM is to establish the type of data needed to bridge the mechanical design and manufacturing functions. Following is the list of varied tasks one might expect to accomplish in a CIM environment.

i. Designing assemblies and performing tolerance analysis on those assemblies.

ii. Preparing production drawings of assemblies, individual parts, tooling, fixtures and other manufacturing facilities.

iii. Creating analytical models of parts for structural, kinematical and thermal analysis (FEM, MeM etc).

iv. Calculating weights, volumes, centres of gravity and other mass properties and costs of manufacturing (cost estimation).

v. Classifying existing parts according to shape, function, and the process by which they are manufactured and retrieving these parts from the parts library on demand (Group technology and coding).

vi. Preparing part lists and bill of materials (BOM).

vii. Preparing process plans for individual part manufacture and assembly (Variant or Generative).

viii. Programming CNC machines for processing complete parts (CAM).

ix. Designing work cells and programming the movement of components in those cells using work handling devices like robots, conveyors, AGV's/ RGV's, etc. (Cellular manufacture).

x. Controlling engineering changes and maintaining associativity between design and manufacturing (PDM, VPDM, concurrent associativity etc).

xi. Preparing programs to handle components or manipulate production equipment (like welding torches or robots).

xii. Preparing inspection programs including programs for CNC co-ordinate measuring machines [CNC CMM's].

The exchange of graphic information has been advanced with increasing acceptance of Initial Graphics Exchange Specification (IGES) and STEP.

DATABASE MANAGEMENT

The manufacturing database and its management are major issues in CIM. The issues are complex but they are beginning to be addressed in a number of ways, including schemes for organizing data, standards for product data exchange and standards for communication protocols.

A major problem to be solved to implement CIM has always been that of distributing information among different computer based systems. As indicated in earlier chapters CIM is typically integration of islands of computer aided functions running on different computers using different databases. Joining those islands into an effective CIM enterprise requires proper methods of processing information. Information, if it is to be useful, must be appropriate, machine-interpretable, and available when and where it is needed.

DATABASE MANAGEMENT SYSTEM

A database management system consists of a collection of interrelated data and a set of programs to access that data. Database management involves:

- Organize a database.
- Add new data to the database.
- Sort the data in some meaningful order.
- Search the database for types of information.
- Print the data into formatted reports.
- Edit the data.
- Delete the data.

DBMS ARCHITECTURE

Fig.2.2 below shows a typical RDBMS architecture. In this architecture, multiple models are derived from a single conceptual data model. It has more abstraction capability. This is also referred to as the syntactic or operational data model meaning that it is more syntactically driven and is a vehicle of user's manipulations.

There are several levels of abstraction in data modeling. These influence the RDBMS architecture. The architecture of Fig. 8.4 has multiple levels, which is a price to be paid for flexibility.

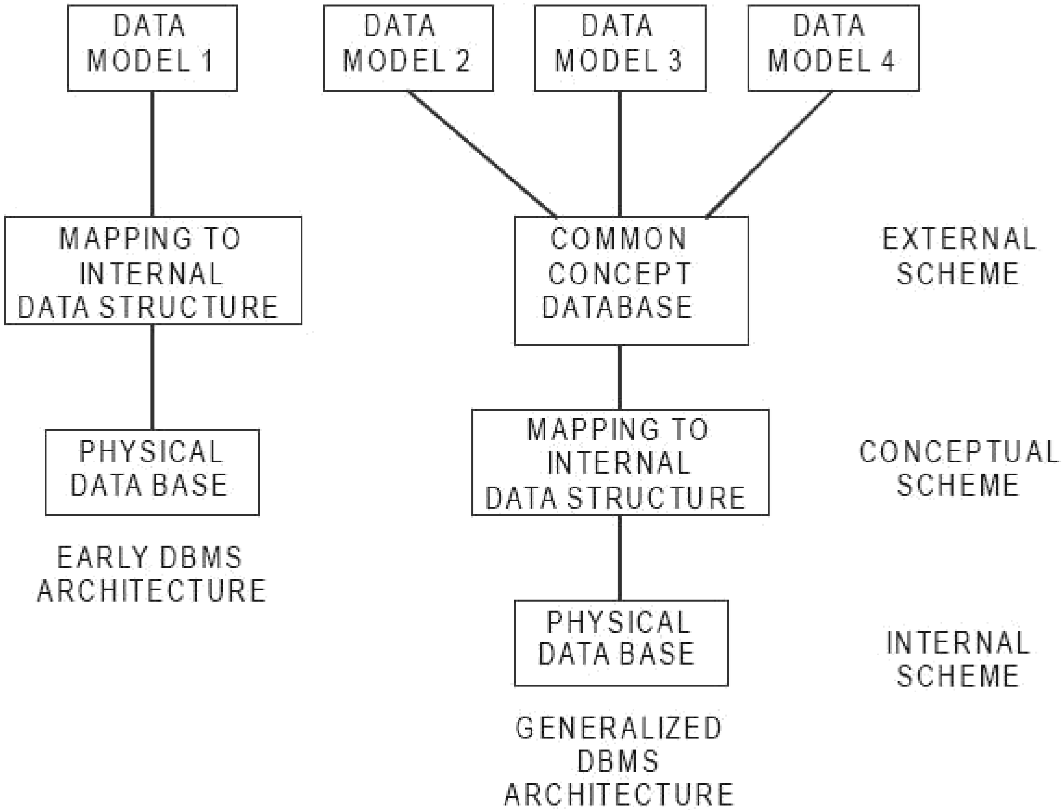


Fig.2.2 RDBMS Architecture

DATABASE ADMINISTRATOR

The person responsible for managing the database is often referred to as database administrator. His functions include:

- Creating the primary database structure
- Backing up and restoring data in case of crash
- Modifying the structure
- Transfer data to external files
- Allocate and control user access rights
- Monitoring performance

COMPARISON OF DATABASE AND TRADITIONAL FILE SYSTEMS

File system represents a tight coupling between physical data and user’s program. They lack almost all the flexibilities offered by DBMS. Most of the indispensable facilities of DBMS of are, therefore forced to be absorbed by user’s program. In other words besides the logic of the application the user has to provide logic for constructing the logical view of data, has to interpret the operations on the logical view and translate them in to the primitive file operations, and has to be responsible for maintaining the files that store the physical data. The tight coupling and interdependence of between a user's application and the physical data would not allow sharing of the same data by other applications that may need to view and manipulate them differently. This then forces the data to be duplicated among various applications. File systems lack dynamism in the sense that the application programs are designed, coded, debugged, and catalogued ahead of time for the preconceived requests and applications. The following list summarizes the problems of file systems that can be overcome by DBMS.

i. Data dependence
ii. Rigidity
iii. Static nature
iv. Lack of integration
v. Data duplication
vi. Inconsistency
vii. Difficulty in sharing information
viii. Inefficiency
ix. Inability to handle adhoc requests.

DATABASE MODELS

There are three ways in which data can be organized: hierarchical, network or relational.

HIERARCHICAL DATABASE

Fig.2.3 below shows a typical hierarchical file structure. The nodes in level 2 are the children of node at level1. The nodes at level 2 in turn become parents of nodes in level 3 and so on.

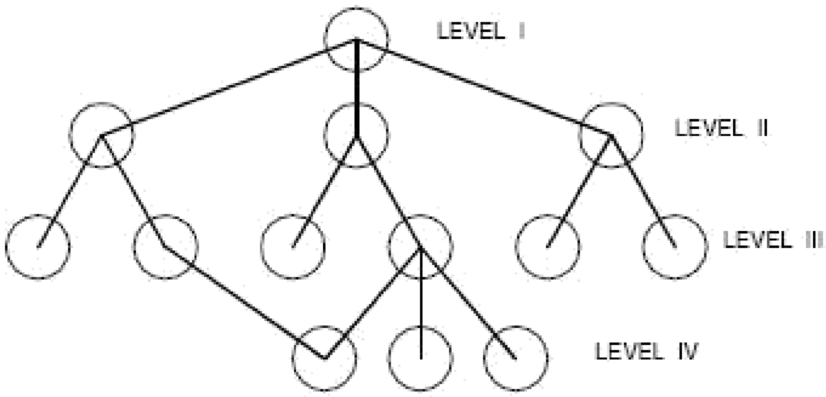


Fig.2.3 A typical Hierarchical File Structure

In a hierarchical model, data files are arranged in a tree like structure which facilitates searches along branch lines; records are subordinated to other records at a higher level. Starting at the root of the tree, each file has a one-to-many relationship to its branches. A parent file can have several children. A good example of such an organization might be a parts list, in which each product is composed of assemblies which are in turn composed of sub-assemblies and/or component parts. As an example of hierarchical database structure, the parts list of lathe assembly is shown in Fig.2.4 below. Examples of hierarchical database management systems are IMS and SYSTEM 2000.

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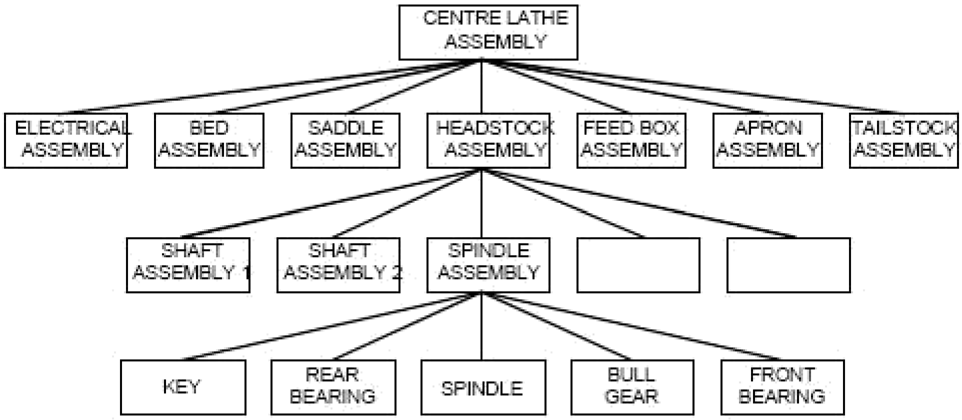


Fig.2.4 Parts of a Lathe Assembly

NETWORK DATABASE

The network database is a combination of several hierarchies in which child files can have more than one parent file, thereby establishing a many-to- many relationship among data. A hierarchical model is actually a subset of a network model. Examples of network database languages are TOTAL and IDMS.

In both hierarchical and network databases data relationships are predefined and embedded in the structure of the database. Access to data is processed by associated application programs. A limitation of both hierarchical and network systems is the restriction they place on data access. They both require that the rules of data access be defined when the data structure is defined. The access rules are difficult to modify after the database has been implemented. They are suited for batch operations that are highly structured and repetitive involving high transaction rates.

RELATIONAL DATABASE MANAGEMENT SYSTEMS (RDBMS)

Data is organized in the form of a table for a large variety of manufacturing applications. An example of such a set of data is given in Table 2.1 below

Table 2.1 Dimensions for Deep Groove Ball Bearings

No.	D	D1	D	D2	B	r	r1
6403	17	26	62	53	17	2	1
6404	20	20	72	63	19	2	1
6405	25	36	0.00	69	21	2	1
6403	17	26	62	53	17	2	1

SHOP FLOOR CONTROL

Shop floor control deals with managing the work-in-process. This consists of the release of production orders to the factory, controlling the progress of the orders through the various work stations, and getting the current information of the status of the orders.

This can be shown in the form of a factory information system. (Fig.2.5). the input to the shop floor control system is the collection of production plans. These can be in the form of master schedule, manufacturing capacity planning and ERP data. The factory production operations are the processes to be controlled.

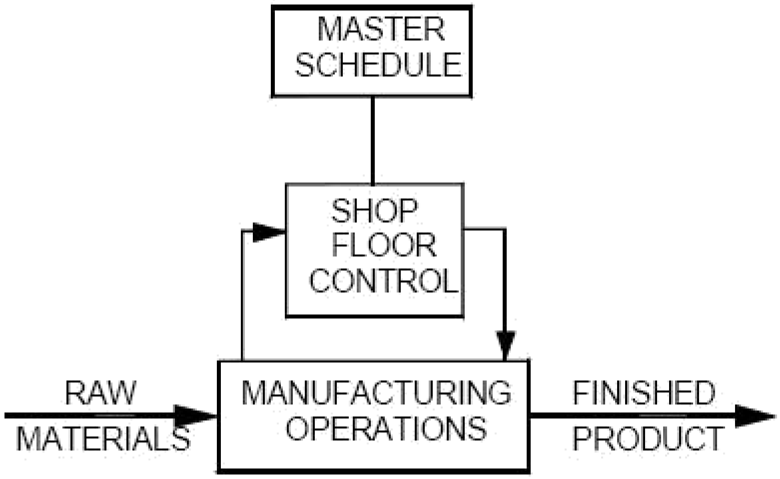


Fig.2.5 Factory Information System

A typical shop floor control system consists of three phases. In a computer integrated manufacturing system these phases are managed by computer software. These three phases connected with the production management is shown in Fig.2.6. In today's implementation of shop floor control, these are executed by a combination of computers and human resources. The following sections describe the important activities connected with this task.

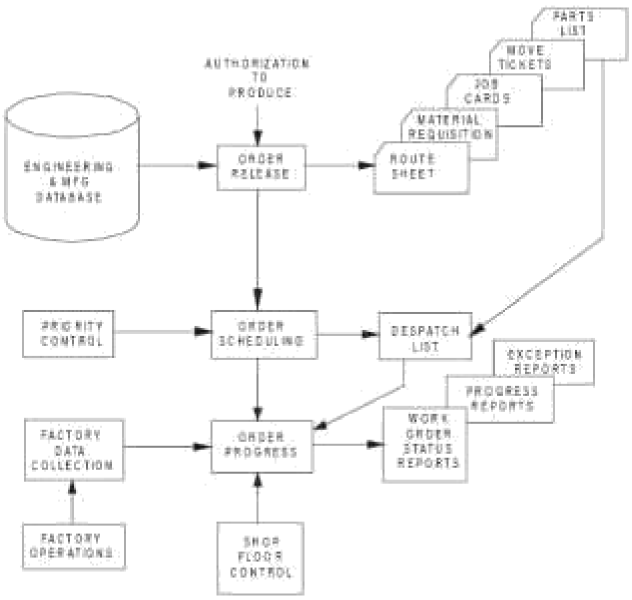


Fig.2.6 Three Phases of SFC

ORDER RELEASE

The order release in shop floor control provides the documentation needed to process a production order. The documents in the shop floor order may consists of the following documents

i. Route Sheet
ii. Material requisition to draw necessary materials from the stores
iii. Job cards or other means to report direct labour time given to the order.
iv. Instructions to material handling personnel to transport parts between the work centres in the factory
v. Parts list for assembly, in the case of assembly operations.

In a typical factory which works on manual processing of data these documents move with the production order and are used to track the progress through the shop. In a CIM factory, more automated methods are used to track the progress of the production orders.

The order release is connected with two inputs. Authorization proceeds through the various planning functions (MRP, capacity planning). These provide timing and scheduling information. The engineering and manufacturing database provides the product structure and process planning information needed to prepare the various documents that accompany the order through the shop.

ORDER SCHEDULING

This module assigns the production orders to various work centres, machine tools, welding stations, moulding machines etc., in the plant. It follows directly from the order release module. Order scheduling executes the dispatch function in production planning and control. The order scheduling module prepares a dispatch list that indicates which production order should be accomplished at the various work centres. It provides the information on the relative priorities of the various jobs by showing the due dates for each job. By following the dispatch list in making work assignments and allocating resources to different jobs the master schedule can be best achieved.

The order schedule module addresses to two important activities in shop floor production control.

i. Machine loading
ii. Job sequencing.

Allocating the orders to the work centres is termed as machine loading or shop loading, which refers to the loading of all machines in the plant. In most cases each work centre will have a queue of orders waiting to be processed. This queue problem can be solved by job sequencing. This involves determining the order in which the jobs will be processed through a given work centre. To determine this sequence, priorities are given to jobs in the queue and the jobs are processed according to the priorities. Several queuing models are available in operations management to solve this problem.

This control of priorities is an important input to the order scheduling module. Rules to establish the priorities are:

i. Earliest due date: These are given high priority
ii. Shortest processing time: Shorter processing time orders are given high priority.
iii. Least slack time: Orders with least slack time are given high priority.

Fluctuations in market demand, equipment breakdown, cancellation of the order by customer and defective raw material or delay in the receipt of materials affect the priority. The priority control plan reviews the relative priorities of the orders and adjusts the dispatch list accordingly.

Order Progress

The order progress module in the shop floor control system monitors the status of the various orders in the plant work-in-process and other characteristics that indicate the progress and performance of production. The function of the order progress module is to provide the information that is useful in managing the factory based on the data collected from the factory. The order progress report includes:

i. *Work order status reports:* These reports indicate the status of the production orders. Typical information in the report includes the current work centre where each order is located, processing hours remaining before completion of each order, whether the job is on-time or behind schedule, and priority level.

ii. *Progress report:* A progress report records the performance of the shop during the period of master schedule and reports the number of operations completed and not completed during the time period.

iii. *Exception reports:* These reports bring out the deviations from the production schedule (ex. overdue jobs).

The above reports are useful to production management in making the decisions about allocation of resources, authorization of the overtime hours, and other capacity issues, and in identifying areas of problems in the plant that adversely affect the implementation of the master production schedule.

SHOP FLOOR DATA COLLECTION

There are several of data collection techniques to gather data from the shop floor. Some of the data are keyed by the employees and the rest are recorded automatically. Later the data is compiled on a fully automated system that requires no human intervention. These methods are collectively called as shop floor data collection systems.

These data collection systems consist of various paper documents, terminals and automated devices located through the plant in a plant. The shop floor data collection system serves as an input to the order progress module in shop floor (Fig.20.4).

Examples of the data collection in shop floor are:

i. To supply data to the order progress module in the shop floor control system.

ii. To provide up to date information to the production supervisors and production control personnel.

iii. To enable the management to monitor implementation of master schedule.

To carry out this, the factory data collection system inputs the data to the computer system in the plant.

TYPES OF DATA COLLECTION SYSTEMS

The shop floor data collection systems can be classified into two groups.

i. On-line data collection systems

ii. Off-line data collection systems

ON-LINE DATA COLLECTION SYSTEMS

In an on-line system, the data are directly entered to the computer and are available to the order progress module. The advantage lies in the fact that the data file representing the status of the shop is always at the current state. As and when the changes in the order progress module are reported they can be fed to computer and in turn to the status file. In this way the production personnel are provided with most up-to-data information.

OFF-LINE (BATCH) DATA COLLECTION SYSTEMS

In this the data are collected temporarily in a storage device or a standalone computer system to be entered and processed by plant computer in a batch mode. In this mode there is delay in the entry and processing of the data. The delay may vary depending upon the situation. So this system cannot provide real time information of shop floor status. The advantage of this system is that it is easier to install and implement.

PRODUCT DESIGN

Product design is a critical function in the production system. The quality of the product design (i.e. how well the design department does its job) is probably the single most important factor in determining the commercial success and societal value of a product. If the product design is poor, no matter how well it is manufactured, the product is very likely doomed to contribute little to the wealth and well-being of the firm that produced it. If the product design is good, there is still the question of whether the product can be produced at sufficiently low cost to contribute to the company's profits and success. One of the facts of life about product design is that a very significant portion of the cost of the product is determined by its design. Design and manufacturing cannot he separated in the production system. They are bound together functionally, technologically, and economically.

THE DESIGN PROCESS

The general process of design is characterized by Shigley as an iterative process consisting of six phases:

1) Recognition of Need,
2) Problem Definition,
3) Synthesis,
4) Analysis and Optimization,
5) Evaluation,and
6) Presentation.

These six steps, and the iterative nature of the sequence in which they are performed, are depicted in Fig.2.7.

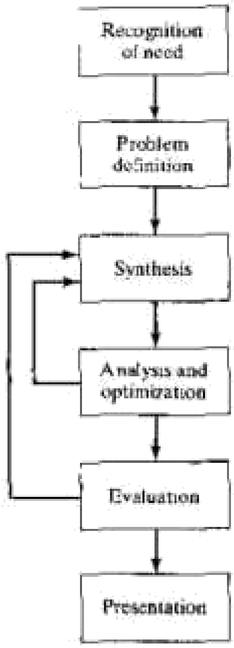


Fig.2.7 Design Process

Recognition of need (1) involves the realization by someone that a problem exists for which some corrective action can be taken in the form of a design solution. This recognition might mean identifying some deficiency in a current machine design by an engineer or perceiving of some new product opportunity by a salesperson. Problem definition (2) involves a thorough specification of the item to be designed. This specification includes the physical characteristics, function, cost, quality, and operating performance.

Synthesis (3) and analysis (4) are closely related and highly interactive in the design process. Consider the development of a certain product design: Each of the subsystems of the product must be conceptualized by the designer, analyzed, improved through this analysis procedure, redesigned, analyzed again, and so on. The process is repeated until the design has been optimized within the constraints imposed on the designer. The individual components are then synthesized and analyzed into the final product in a similar manner.

Evaluation (5) is concerned with measuring the design against the specifications established in the problem definition phase. This evaluation often requires the fabrication and testing of a prototype model to assess operating performance, quality, reliability, and other criteria. The final phase in the design procedure is the presentation of the design. Presentation (6) is concerned with documenting the design by means of drawings, material specifications, assembly lists, and so on. In essence, documentation means that the design data base is created.

Application of Computers in Design

Computer-aided design (CAD) is defined as any design activity that involves the effective use of the computer to create, modify, analyze, or document an engineering design. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system. The term CAD/CAM system is also used if it supports manufacturing as well as design applications. There are several good reasons for using a CAD system to support the engineering design function.

- To increase the productivity of the designer this is accomplished by helping the designer to conceptualize the product and its components. In tum, this helps reduce the time required by the designer to synthesize, analyze, and document the design.
- To improve the quality of the design, the use of a CAD system with appropriate hardware and software capabilities permits the designer to do a more complete engineering analysis and to consider a larger number and variety of design alternatives. The quality of the resulting design is thereby improved.
- To improve design documentation. The graphical output of a CAD system results in better documentation of the design than what is practical with manual drafting. The engineering drawings are superior, and there is more standardization among the drawings, fewer drafting errors, and greater legibility.
- To create a manufacturing data base. In the process of creating the documentation for the product design (geometric specification of the product, dimensions of the components, materials specifications, bill of materials, etc.), much of the required data base to manufacture the product is also created.

DFM, DFA & DFMA

Design for manufacturing (DFM) is the practice of designing products with manufacturing in mind. It simultaneously considers all of the design goals and constraints for product that will be manufactured. The ultimate is that product can:

- Be designed in the least time with the least development cost.
- Make the quickest and smoothest transition into production.
- Be assembled and tested with minimum cost in the minimum amount of time.

- Have the desired levels of quality and reliability.
- Satisfy customers' needs and compete well in the marketplace.

Design for Assembly (DFA) is a structured methodology for analyzing product concepts or existing products for simplification of the design and its assembly process, reduction in parts and assembly operations, and individual part geometry changes to ease assembly.

Design for manufacture and assembly (DFMA) is the process by which designs and assembly sequences and procedures are altered to increase the ease and effectiveness of assembly. DFMA is a combination of DFA (Design for Assembly) and DFM (Design for Manufacturing).

DESIGN FOR MANUFACTURABILITY (DFM)

Design for manufacturability (also sometimes known as design for manufacturing) (DFM) is the general engineering art of designing products in such a way that they are easy to manufacture. The basic idea exists in almost all engineering disciplines, but of course the details differ widely depending on the manufacturing technology. This design practice not only focuses on the design aspect of a part but also on the producibility. In simple language it means relative ease to manufacture a product, part or assembly.

The design stage is very important in product design. Most of the product lifecycle costs are committed at design stage. The product design is not just based on good design but it should be possible to produce by manufacturing as well. Often an otherwise good design is difficult or impossible to produce. Typically a design engineer will create a model or design and send it to manufacturing for review and invite feedback. This process is called as design review. If this process is not followed diligently, the product may fail at manufacturing stage.

If these DFM guidelines are not followed, it will result in iterative design, loss of manufacturing time and overall resulting in longer time to market. Hence many organizations have adopted concept of Design for Manufacturing.

Depending on various types of manufacturing processes there are set guidelines for DFM practices. These DFM guidelines help to precisely define various tolerances, rules and common manufacturing checks related to DFM.

While DFM is applicable to day to day design process, a similar concept called DFSS (Design for Six Sigma) is also practiced in many organizations.

COMPUTER-AIDED DESIGN (CAD)

It is the use of computer systems to assist 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.

Computer-aided design is used in many fields. Its use in designing electronic systems is known as Electronic Design Automation, or 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.[3]

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.[5]

The design of geometric models for object shapes, in particular, is occasionally called *computer-aided geometric design* (*CAGD*).

CAD & CAE

Computer-aided engineering (CAE) 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. CAE areas covered include:

(1)Stress analysis on components and assemblies using FEA (Finite Element Analysis);

(2)Thermal and fluid flow analysis Computational fluid dynamics (CFD);

(3)Multi body dynamics (MBD) & Kinematics;

(4) Analysis tools for process simulation for operations such as casting, molding, and die press forming.

(5)Optimization of the product or process.

(6) Safety analysis of postulate loss-of-coolant accident in nuclear reactor using realistic thermal-hydraulics code.

In general, there are three phases in any computer-aided engineering task:

- Pre-processing – defining the model and environmental factors to be applied to it. (typically a finite element model, but facet, voxel and thin sheet methods are also used)
- Analysis solver (usually performed on high powered computers)
- Post-processing of results (using visualization tools)

This cycle is iterated, often many times, either manually or with the use of commercial optimization software.

Unit – III

Concurrent / Simultaneous engineering: Introduction, Design for manufacturing and assembly, and other product design objectives. Advanced Manufacturing Planning.
Introduction to Reverse Engineering.
Process Planning: CAPP – Retrieval and Generative Model. (09 hours)

CONCURRENT / SIMULTANEOUS ENGINEERING

Concurrent engineering refers to an approach used in product development in which the functions of design engineering, manufacturing engineering, and other functions are integrated to reduce the elapsed time required to bring a new product to market. It is also called as Simultaneous engineering.

Concurrent engineering or Simultaneous Engineering is a methodology of restructuring the product development activity in a manufacturing organization using a cross functional team approach and is a technique adopted to improve the efficiency of product design and reduce the product development cycle time. This is also sometimes referred to as Parallel Engineering. Concurrent Engineering brings together a wide spectrum of people from several functional areas in the design and manufacture of a product. Representatives from R & D, engineering, manufacturing, materials management, quality assurance, marketing etc. develop the product as a team. Everyone interacts with each other from the start, and they perform their tasks in parallel. The team reviews the design from the point of view of marketing, process, tool design and procurement, operation, facility and capacity planning, design for manufacturability, assembly, testing and maintenance, standardization, procurement of components and sub-assemblies, quality assurance etc. as the design is evolved. Even the vendor development department is associated with the prototype development. Any possible bottleneck in the development process is thoroughly studied and rectified. All the departments get a chance to review the design and identify delays and difficulties. The departments can start their own processes simultaneously. For example, the tool design, procurement of material and machinery and recruitment and training of manpower which contributes to considerable delay can be taken up simultaneously as the design development is in progress. Issues are debated thoroughly and conflicts are resolved amicably.

Concurrent Engineering (CE) gives marketing and other groups the opportunity to review the design during the modeling, prototyping and soft tooling phases of development. CAD systems especially 3D modelers can play an important role in early product development phases. In fact, they can become the core of the CE. They offer a visual check when design changes cost the least.

Intensive teamwork between product development, production planning and manufacturing is essential for satisfactory implementation of concurrent engineering. The teamwork also brings additional advantages ; the co-operation between various specialists and systematic application of special methods such as QFD (Quality Function Deployment), DFMA (Design for Manufacture and Assembly) and FMEA (Failure Mode and Effect Analysis) ensures quick optimization of design and early detection of possible faults in product and production planning. This additionally leads to reduction in lead time which reduces cost of production and guarantees better quality.

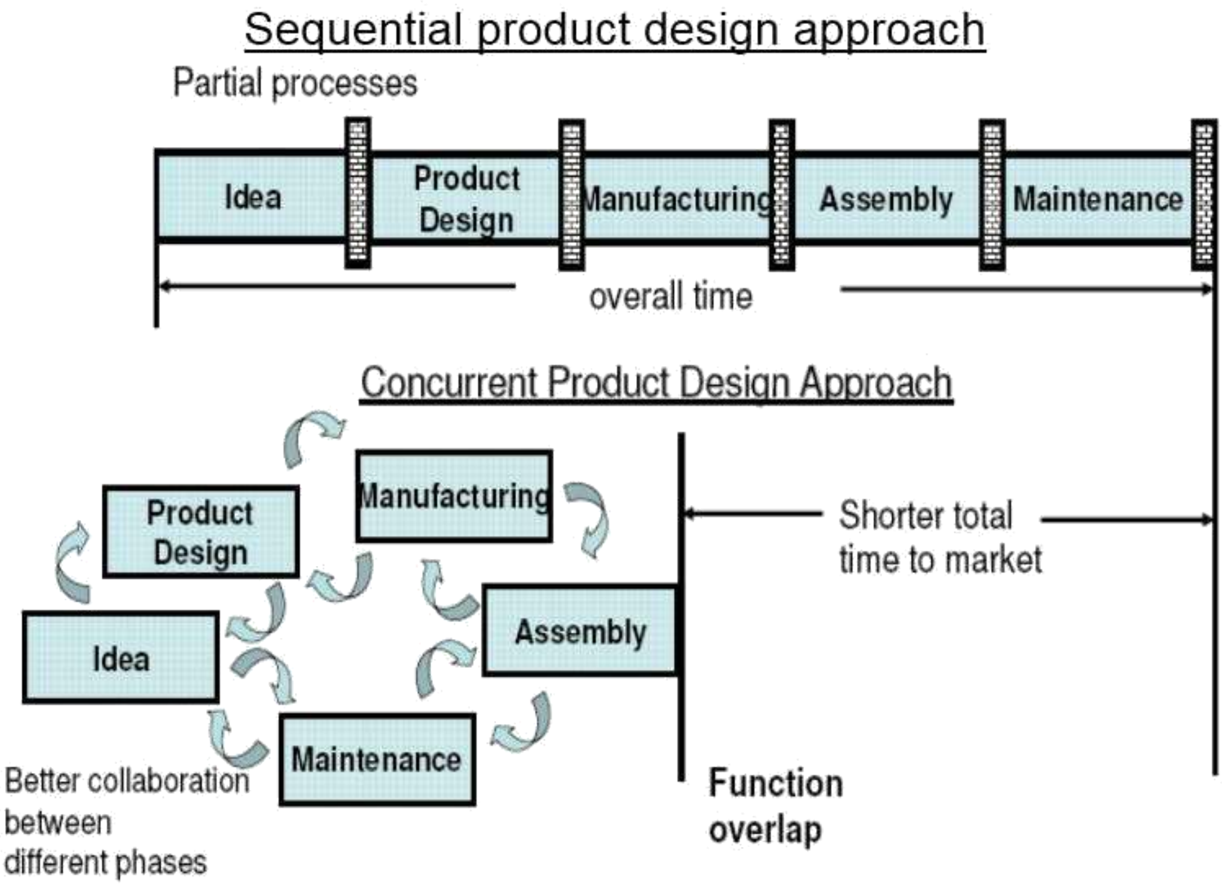


Fig3.1 Concurrent Engineering and Sequential Engineering

COMPARISON OF CONCURRENT ENGINEERING AND SEQUENTIAL ENGINEERING

A comparison of concurrent and sequential engineering based on cost is attempted in this section. The distribution of the product development cost during the product development cycle is shown in Fig 3.2. This figure shows that though only about 15% of the budget is spent at the time of design completion, whereas the remaining 85% is already committed. The decisions taken during the design stage have an important bearing on the cost of the development of the product. Therefore the development cost and product cost can be reduced by proper and careful design. CE facilitates this. The significantly large number of nonconformities detected in the later stages of product development cycle in sequential engineering results in large time and cost overrun.

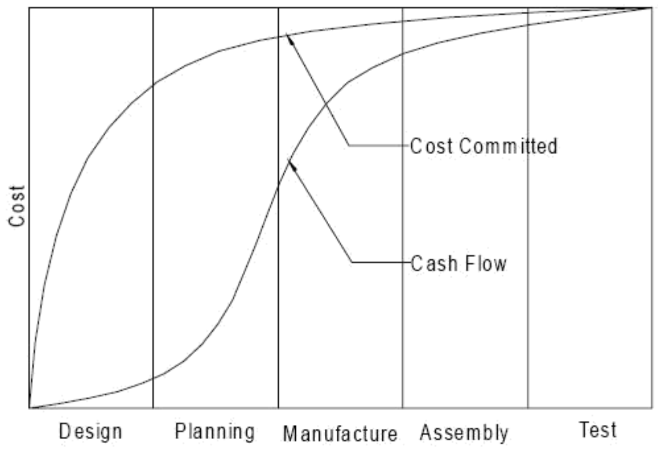


Fig 3.2 Distribution of Product Development Cost

REDUCTION IN THE NUMBER OF DESIGN CHANGES

The advantage of concurrent engineering over the traditional sequential (SE) and concurrent engineering (CE) is that a large number of design changes are identified and implemented at the beginning or in the early phase of product development cycle. In the case of CE this number goes on decreasing for the remaining period, whereas many changes are now and then incorporated at every stage of development in the case of traditional sequential approach. This is due to the fact that most of the design changes needed are detected early in design. The reduction in design change requests with CE is substantially less at the later stages of the product development process. Compared to this, defects are detected often during the sequential engineering process. This is shown graphically in Fig. 3.3.

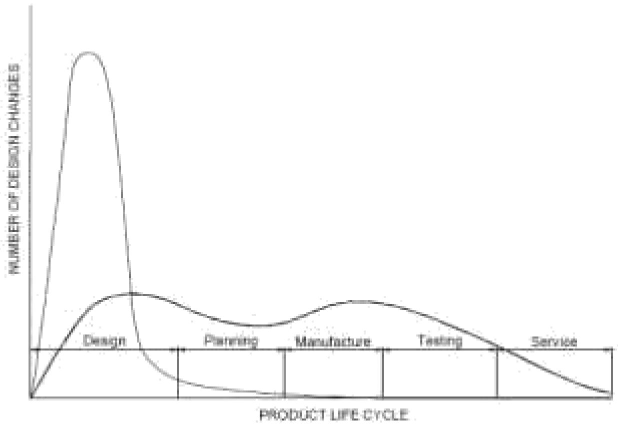


Fig 3.3 Distribution of Design Changes Across the Life Cycle of a Product

COST OF CHANGES IN DESIGN

The cost of introducing a design change in a product progressively increases as the development proceeds through design and manufacturing. This can be elaborated with a simple example. If a change in the conceptual 3D CAD model costs Rs.50, 000. The same change during the planning stage would cost Rs.1, 50,000. By the time the product moves to prototyping and testing, the change may cost Rs.2, 50,000. The cost goes up to Rs.25,00,000 if the product is in the manufacturing stage and Rs.50,00,000 or more after the company releases the product to sales and marketing. Fig 3.4 illustrates this. While these numbers differ greatly from company to company and from product to product, they give a feel of the importance of feedback early in the design cycle.

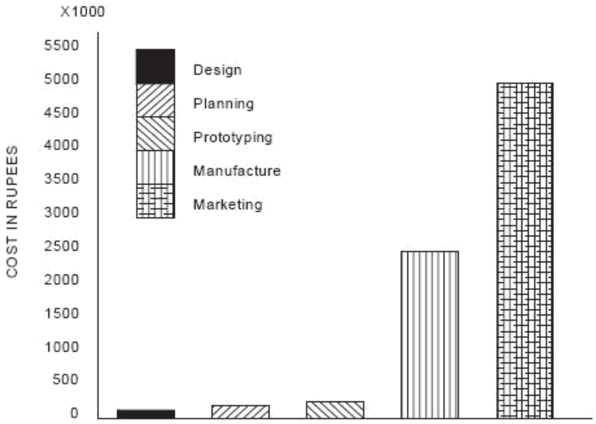


Fig 3.4 Cost of Design Change

HOLISTIC APPROACH TO PRODUCT DEVELOPMENT

Concurrent engineering approach introduces a new philosophy in product development. No longer is product development considered the exclusive activity of the design department. Participation of planning, manufacturing, quality, service, vendor development and marketing personnel in the development process enables the cross functional team to view the development as a total responsibility and this results in better communication among the various departments.

ROBUST PRODUCTS

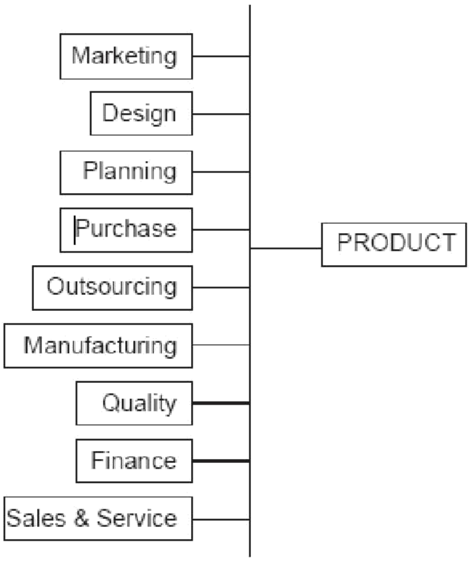
Concurrent approach to product design results in products with fewer errors and therefore avoids the loss of goodwill of the customers due to poorly engineered products. The entire product development team looks at each and every aspect of products - cost, specifications, aesthetics, ergonomics, performance and maintainability. The resulting product will naturally satisfy the customer.

REDUCTION IN LEAD TIME FOR PRODUCT DEVELOPMENT

Time compression in product development is an important issue today. Concurrent engineering reduces the product development time significantly as the preparatory work in all downstream functions can take place concurrently with design. Elimination of the errors in design appreciably reduces the possibility of time overrun, enabling the development schedule to be maintained.

IMPLEMENTATION OF CONCURRENT ENGINEERING

The cycle of engineering design and manufacturing planning involves interrelated activities in different engineering disciplines simultaneously, than sequentially as shown in Fig. 3.5 (A). In addition, the activities necessary to complete a particular task within a specific engineering discipline have to emerge wherever possible from their sequential flow into a concurrent workflow with a high degree of parallelism as illustrated in Fig. 3.5 (B). Concurrency implies that members of the multidisciplinary project team work in parallel. This also means that there is no strict demarcation of jobs among various departments. The multi-disciplinary approach has the advantage of several inputs which can be focused effectively early in the design process. Presently engineering departments are practicing this approach but still with a high degree of manual involvement and redundancy. Planning scenarios experience a similar approach. One of the most critical links in the entire product life cycle, i.e. the close interaction between design and manufacturing has been made possible in concurrent engineering. Thus the product development process has been freed from the large number of constraints arising from the limitations of the sequential engineering. This has changed the way manufacturers bring the products to market. For example, many manufacturers no longer view product development as a relay race in which marketing passes the baton to R &D, which in turn passes it to manufacturing. Representatives drawn from marketing, planning, design, purchase, vendors, manufacturing, quality control and other department participate in product development right from the beginning. Concurrent engineering is thus a cross- functional approach to product design. Total quality management which is being practiced by many companies is closely related to concurrent engineering.



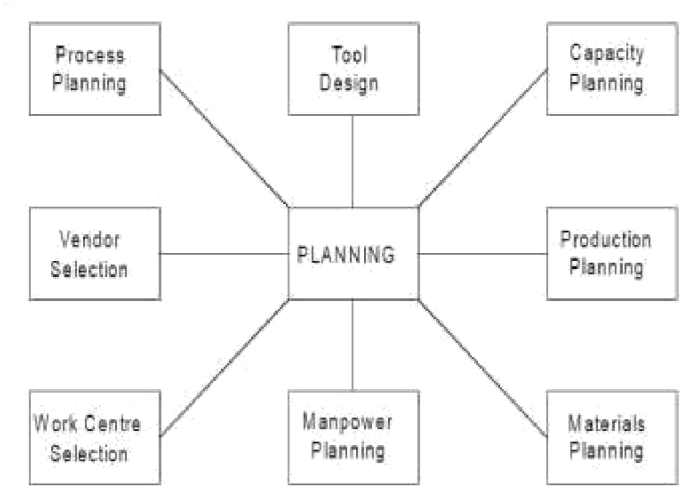


Fig 3. 5 (A) Concurrent Engineering Fig 3.5 (B) Concurrent Workflow

DESIGN FOR MANUFACTURING AND ASSEMBLY

Design for manufacture and assembly (DFMA) is the process by which designs and assembly sequences and procedures are altered to increase the ease and effectiveness of assembly. DFMA is a combination of DFA (Design for Assembly) and DFM (Design for Manufacturing).

It has been estimated that about 70% of the life cycle cost of a product is determined by basic decisions made during product design. These design decisions include the material for each part, part geometry, tolerances, surface finish, how parts arc organized into subassemblies and the assembly method, to be used. Once these decisions are made, the ability to reduce the manufacturing cost of the product is limited. For example. if the product designer decides that a part is to be made of an aluminum sand casting but which possesses features that can he achieved only by machining (such as threaded holes and close tolerances), the manufacturing engineer has no alternative except to plan a process sequence that starts with sand casting followed by the sequence of machining operations needed to achieve the specified features. In this example, a better decision might be to use a plastic molded part that can be made in a single step. It is important for the manufacturing engineer to be given the opportunity to advise the design engineer as the product design is evolving, to favorably influence the manufacturability of the product.

Terms used to describe such attempts to favorably influence the manufacturability of a new product are design for manufacturing (DFM) and design for assembly (DFA). Of course, DFM and DFA are inextricably linked, so let use the term design for manufacturing and assembly (DFMA). Design for manufacturing and assembly involves the systematic consideration of manufacturability and assemble-ability in the development of a new product design. This includes: (l) organizational changes and (2) design principles and guideline.

Organizational Changes in DFMA. Effective implementation of DFMA, involves making changes in a company's organizational structure either formally or informally, so that closer interaction and better communication occurs between design and manufacturing personnel. This can be accomplished in several ways: (1) by creating project teams consisting of product designers, manufacturing engineers, and other specialties (e.g., quality engineers, material scientists) to develop the new product design; (2) by requiring design engineers to spend some career time in manufacturing to witness first-hand how manufacturability and assemble-ability are impacted by a product's design; and (3) by assigning manufacturing engineers to the product design department on either a temporary or fulltime basis to serve as produce-ability consultants.

Design Principles and Guidelines. DFMA also relies on the use of design principles and guidelines for how to design a given product to maximize manufacturability and assemble-ability.

NEED FOR DFMA:

- In the earlier industrial practices, design and manufacture tasks have been performed independently.
- In this scenario, the designer designs a product and the design is sent to the manufacturer for production operation.
- There is no interaction between the designer and manufacturer and often what results is a design that is difficult to manufacture.
- What is required is a co-ordination between all aspects of the engineering staff, beginning with product conception followed by production all the way through Inspection and Delivery.
- By tapping into the expertise of all engineering areas (design, automation, manufacturing), an equally functional and high quality design will result, but it will be much easier to reliably manufacture in a production system.

GENERAL GUIDELINES OF DFMA:

1.Simplify the design and reduce the number of parts
2.Standardize and use common parts and material
3.Design for ease of fabrication.
4.Design within process capabilities and avoid unneeded surface finish requirements.
5.Mistake-proof product design and assembly
6.Design for parts orientation and handling
7.Minimize flexible parts and interconnections
8.Design for ease of assembly
9.Design for efficient joining and fastening.
10. Design modular products
11. Design for automated production.

ADVANCED MANUFACTURING PLANNING

Advanced manufacturing planning emphasizes planning for the future. It is a corporate level activity that is distinct from process planning because it is concerned with products being contemplated in the company's long-tern- plans (2-10-year future), rather than products currently being designed and released. Advanced manufacturing planning involves working with sales, marketing, and design engineering to forecast the new products that will be introduced and to determine what production resources will be needed to make those future products. Future products may require manufacturing technologies and facilities not currently available within the firm. In advanced manufacturing planning, the current equipment and facilities are compared with the processing needs created by future planned products to determine what new facilities should be installed. The general planning cycle is portrayed in Fig 3.6.

Activities in advanced manufacturing planning include: (1) new technology evaluation, (2) investment project management, (3) facilities planning. And (4) manufacturing research

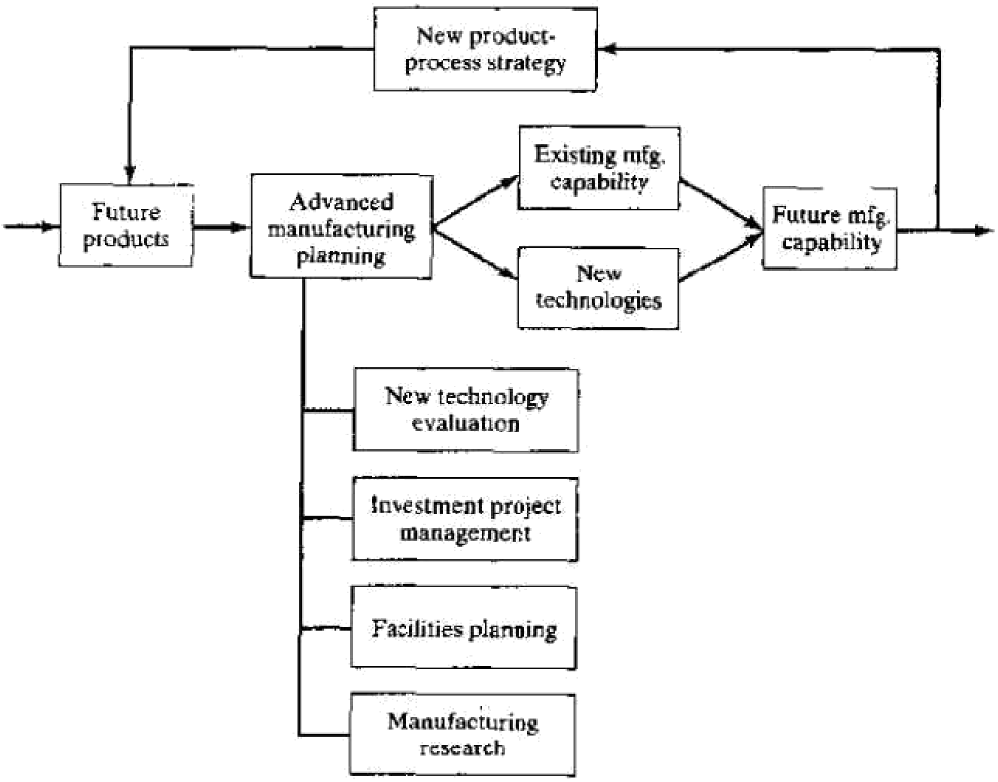


Fig 3.6 Advanced manufacturing planning cycle

(1) New Technology Evaluation. Certainly one of the reasons why a company may consider installing new technologies is because future product lines require processing methods not currently used by the company. To introduce the new products, the company must either implement new processing technologies in-house or purchase the components made by the new technologies from vendors. For strategic reasons, it may be in the company's interest to install a new technology internally and develop staff expertise in that technology as a distinctive competitive advantage for the company. These issues must be analyzed, and the processing technology itself must be evaluated to assess its merits and demerits.

A good example of the need for technology evaluation has occurred in the microelectronics industry, whose history spans only the past several decades. The technology of microelectronics has progressed very rapidly, driven by the need to include ever-greater numbers of devices into smaller and smaller packages. As each new generation has evolved, alternative technologies have been developed both in the products themselves and the required processes to fabricate them. It has been necessary for the companies in this industry as well as companies that use their products, to evaluate the alternative technologies and decide which should be adopted.

There are other reasons why a company may need to introduce new technologies:

(1) Quality improvement. (2) Productivity improvement, (3) cost reduction, (4) lead time reduction, and (5) modernization and replacement of worn-out facilities with new equipment. A good example of the introduction of a new technology is the CAD/CAM systems that were installed by many companies during the 1980s. Initially, CAD/CAM was introduced to modernize and increase productivity in the drafting function in product design.

As CAD/CAM technology itself evolved and its capabilities expanded to include three-dimensional geometric modeling, design engineers began developing their product designs on these more powerful systems. Engineering analysis programs were written to perform finite-element calculations for complex heat transfer and stress problems. The use of CAD had the effect of increasing design productivity, improving the quality of the design, improving communications, and creating a data base for manufacturing. In addition, CAM software was introduced to implement process planning functions such as numerical control part programming and CAPP, thus reducing transition time from design to production.

Investment Project Management. Investments in new technologies or new equipment are generally made one project at a time. The duration of each project may be several months to several years. The management of the project requires a collaboration between the finance department that oversees the disbursements, manufacturing engineering that provides technical expertise in the production technology, and other functional areas that may be related to the project. For each project, the following sequence of steps must usually be accomplished: (1) Proposal to justify the investment is prepared. (2) Management approvals are granted for the investment. (3) Vendor quotations are solicited. (4) Order is placed to the winning vendor. (5) Vendor progress in building the equipment is monitored. (6) Any special tooling and supplies are ordered. (7) The equipment is installed and debugged. (8) Training of operators. (9) Responsibility for running the equipment is turned over to the operating department.

Facilities Planning. When new equipment is installed in an existing plant, an alteration of the facility is required. Floor space must be allocated to the equipment, other equipment may need to be relocated or removed, utilities (power, heat, light, air, etc.) must be connected, safety systems must be installed if needed, and various other activities must be accomplished to complete the installation. In extreme cases, an entire new plant may need to be designed to produce a new product line or expand production of an existing line. The planning work required to renovate an existing facility or design a new one is carried out by the plant engineering department (or similar title) and is called facilities planning. In the design or redesign of a production facility, manufacturing engineering and plant engineering must work closely to achieve a successful installation.

Manufacturing Research and Development. To develop the required manufacturing technologies, the company may find it necessary to undertake a program of manufacturing research and development (R&D). Some of this research is done internally, whereas in other cases projects are contracted to university and commercial research laboratories specializing in the associated technologies.

REVERSE ENGINEERING

Classification of Engineering Processes

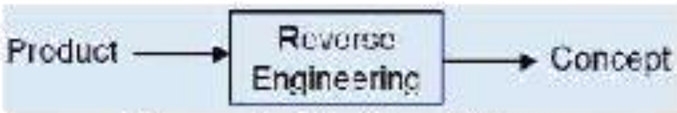
Forward engineering

It is the traditional process of moving from high-level abstractions and logical designs to the physical implementation of a system.

Forward Engineering

Reverse Engineering

It is the process of duplicating an existing component, subassembly, or product, without the aid of drawings, documentation, or computer.



Reverse Engineering

Why Reverse Engineering?

Some of the important reasons for the for reverse engineering of a product or part are:

▪The original manufacturer of a product no longer produces a product;

▪There is inadequate documentation of the original design;

▪The original manufacturer no longer exists, but a customer needs the product;

The original design documentation has been lost or never existed;

▪Some bad features of a product need to be designed out. For example, excessive wear might indicate where a product should be improved;

▪To strengthen the good features of a product based on long-term usage of the product;

▪To analyze the good and bad features of competitors' product;

To explore new avenues to improve product performance and features ;

▪To gain competitive benchmarking methods to understand competitor's products and develop better products;

▪The original CAD model is not sufficient to support modifications or current manufacturing methods;

▪To update obsolete materials or antiquated manufacturing processes with more current, less-expensive technologies;

Reverse Engineering Methodology

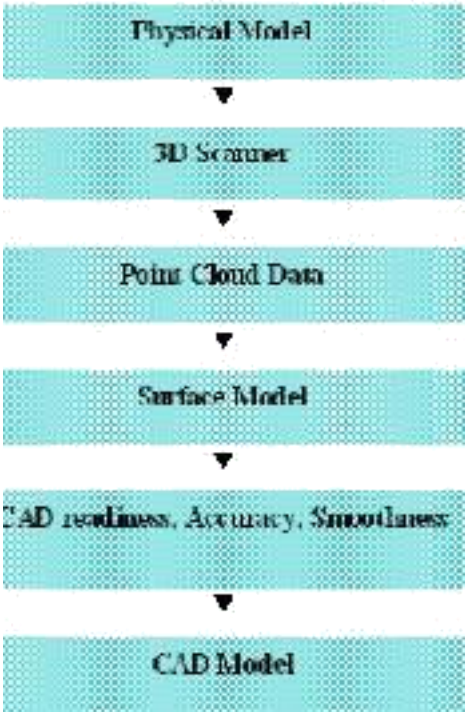


Fig 3.7 RE Methodology

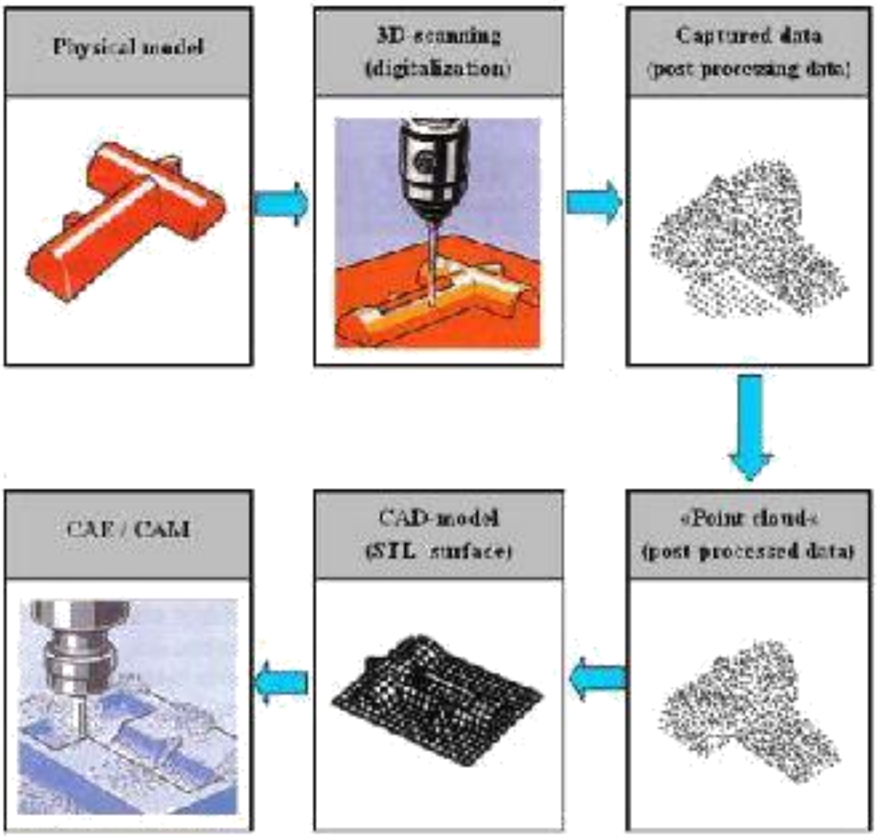


Fig 3.8 Diagrammatic Representation of RE

Digitizing or Collecting Data from Physical Part

One of the reverse engineering methods is construction of a CAD model of the physical parts whose drawing is not available.

This is done by digitizing an existing prototype which is mainly creating a computer model and then using it to manufacture the component.
The objective of this method is to generate a 3D mapping of the product in form of a CAD file.

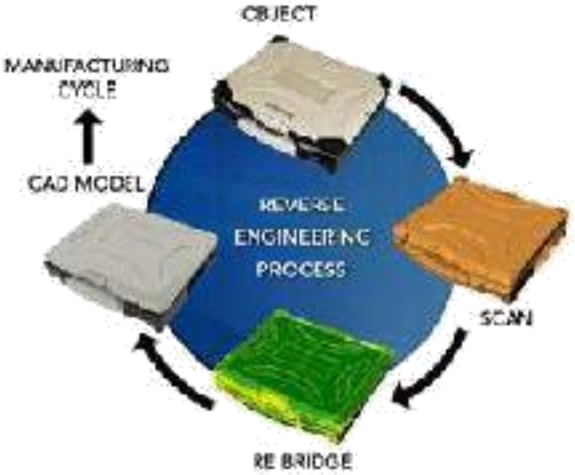


Fig 3.9 RE Process

Digitizing or Collecting Data from Physical Part

This involves the acquisition of the product surface data by either contact or non-contact methods in form of X, Y and Z coordinates of large number of points on the product surface.

Fig 3.10 Coordinate Measuring Machine (CMM)

Digitizing or Collecting Data from Physical Part

The methods of obtaining the product surface data can be divided into two broad categories; 1.Contact method and
2.Non-contact method.

The contact method requires contact between the component surface and a measuring tool that is usually a probe or a stylus.

The non-contact method uses laser or light as the main tool in extracting the required information.

Coordinates Measuring Machine (CMM)

A CMM is a 3-dimensional measuring device that uses a contact probe to detect the surface of the object.

The linear distances moved along the 3 axes are recorded, thus providing the X, Y and Z co-ordinates of the point.

The part to be discretized is placed on the measuring table, and the co-ordinates of a number of points on the surface of the object are then read.

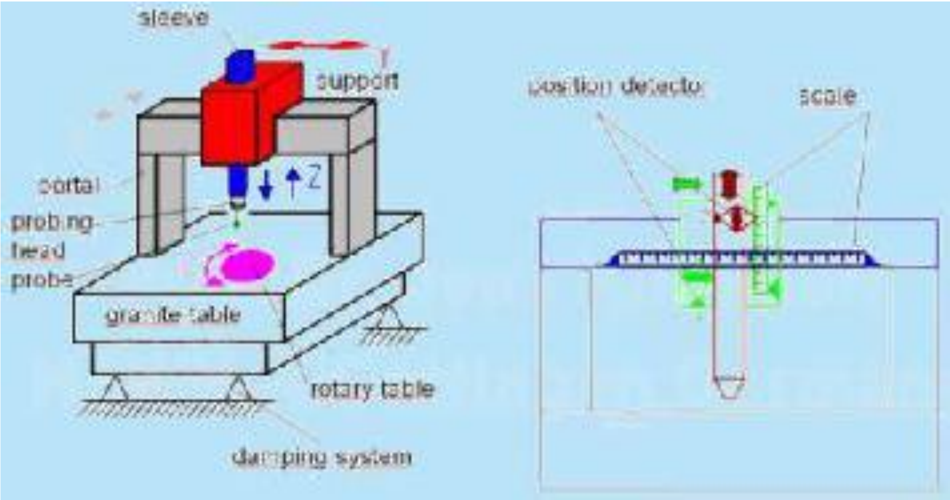


Fig 3.11 CMM Machine

Electromagnetic Digitizers

In electromagnetic digitizers, the product to be digitized is placed on a table which encloses electronic equipment and a magnetic field source.

It creates a magnetic field in the volume of space above table.

A hand held stylus is used to trace the surface of the part.

This stylus houses a magnetic field sensor that, in conjunction with the electronic unit, detects the position and orientation of the stylus.

The data can be transferred to a computer through a serial port.

Sonic Digitizers

In sonic digitizers, sound waves are used to calculate the position of a point relative to a reference point.

In this technique, the object is placed in front of a vertical rectangular board on the corners of which are mounted four microphone sensors.

A free hand held stylus is used to trace the contours of the object. When a foot or a hand switch is pressed, the stylus emits an ultrasonic impulse, and, simultaneously four clocks are activated. When the impulse is detected by a microphone, the corresponding clock is stopped and the times taken to reach each of the microphones recorded.

These time recordings, called slant ranges, are processed by a computer to calculate the x, y and z coordinates of the point.

Manipulation of the collected data to obtain a CAD model

After obtaining the product surface data as a sea of points in space, the next important step is the fitting of geometry to this point data.

Various methods were developed for the fitting of surfaces to the point data.
The surface can be mathematically described as either algebraicor parametric surfaces.
Parametric surfaces on the other hand, are finite surfaces defined by certain basis functions and control points e.g. Beizersurfaces, NURBS surfaces.

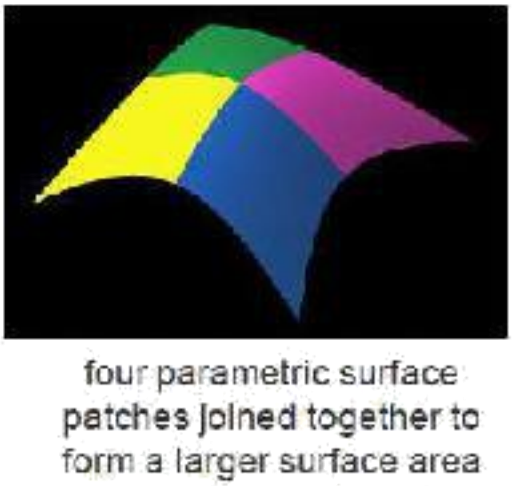


Fig 3.12 Curve generation

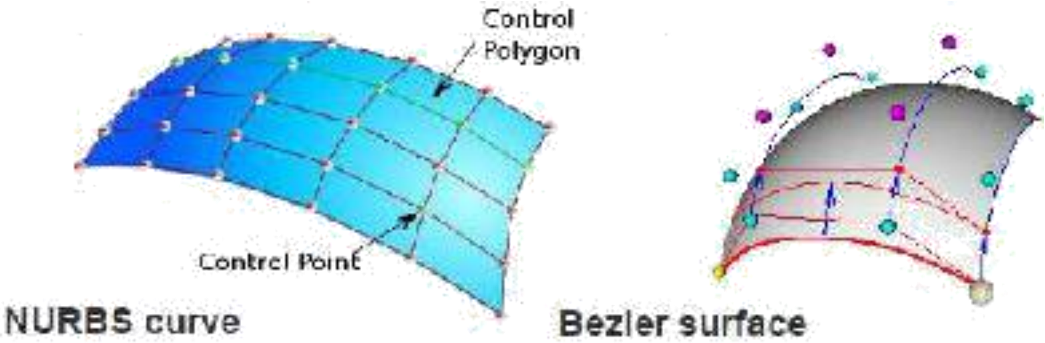


Fig 3.13 Curve surface Generation

▪Surface fitting techniques can be broadly classified in to two categories; interpolation techniques and approximation techniques.

▪In interpolation technique, the surface to be fitted passes through all the data points and is normally used when the data points are accurately measured without any errors.

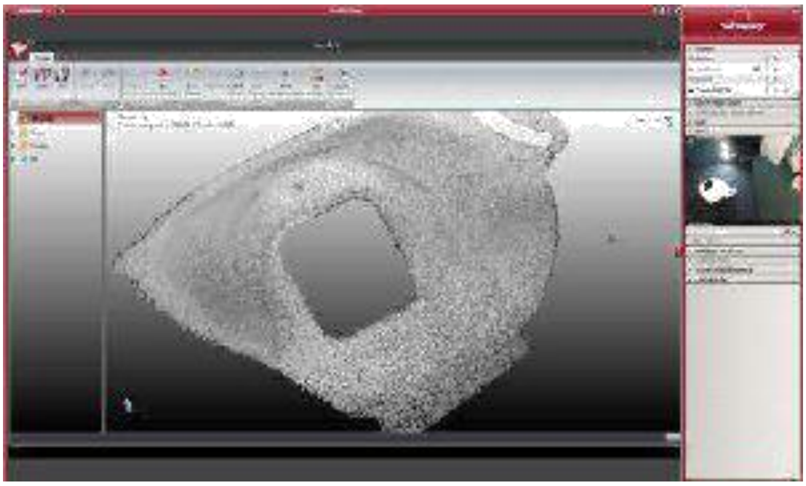


Fig 3.14 CAD Model Generation

▪In approximation technique, the surface need not to pass through any of the data points, but represents a generalized average or a best fit to the data points.

▪This is usually used when there are a large number of data points through which the surface has to be fitted, or when there errors in the measurement are to be averaged out. Generation of functional parts from CAD model

▪Once the geometric model is obtained, it can be used as the basis for a variety of operations such as automated process planning, automated manufacturing, automated dimensional inspection and automated tolerance analysis.

▪In automated manufacturing, these geometric models can be used to generate the tool motion commands which can be made execute on any of the standard CNC machines or input CAD model for rapid prototyping processes

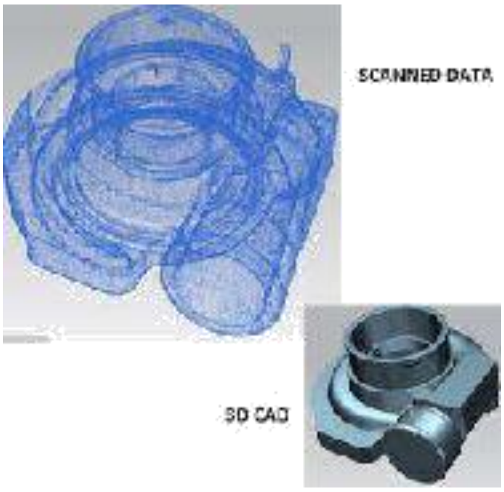


Fig 3.15 Generated CAD Model

▪These applications require feature extraction from the geometric model, followed by a process plan for the object, which involves definition of various manufacturing sequences required to manufacture the object

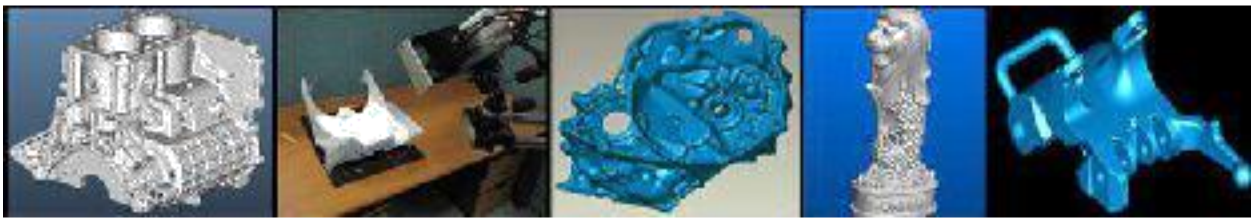


Fig 3.16 CAD Models by RE Process

Reverse engineering is a methodology for constructing CAD models of physical parts whose drawings are not available by digitizing an existing prototype, creating a computer model and then using it to manufacture the component. The techniques available for reverse engineering, with particular emphasis on the three-dimensional model generation.

The different steps involved in the process are described, and then a number of techniques available for the model generation from the point data are illustrated. These are then compared with regards to speed, accuracy and domain of problems solved. Thus, this paper brings together the literature on the subject in a unified way.

Creation of new products from existing solutions (product re-design) shortens new product introduction phases and reduces costs. The product re-engineering process is a new approach to the realization of substitute components without the benefit of original design process documentation or any other documentation relating to the component.

Re-engineering comprises stages which are potentially applicable to many industries. This research applies an enterprise modeling architecture to modeling the re-engineering process, producing descriptions of the process from several different descriptive views, namely function, information, resource and organization.

This results in a more complete description of the process, in which the model itself may be used as a reference for the implementation of a re-design process in a particular company. This research also shows how the information modelling constructs of CIMOSA can be used to meet the particular unique requirements of the process of re-design.

PROCESS PLANNING

Process planning encompasses the activities and functions to prepare a detailed set of plans and instructions to produce a part. The planning begins with engineering drawings, specifications, parts or material lists and a forecast of demand. The results of the planning are:

- Routings which specify operations, operation sequences, work centers, standards, tooling and fixtures. This routing becomes a major input to the manufacturing resource planning system to define operations for production activity control purposes and define required resources for capacity requirements planning purposes.
- Process plans which typically provide more detailed, step-by-step work instructions including dimensions related to individual operations, machining parameters, set-up instructions, and quality assurance checkpoints.
- Fabrication and assembly drawings to support manufacture (as opposed to engineering drawings to define the part).

Manual process planning is based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes, and tooling. Process planning is very time-consuming and the results vary based on the person doing the planning

INTRODUCTION TO CAPP

Process planning translates design information into the process steps and instructions to efficiently and effectively manufacture products. As the design process is supported by many computer-aided tools, computer-aided process planning (CAPP) has evolved to simplify and improve process planning and achieve more effective use of manufacturing resources.

Computer-aided process planning (CAPP)

Computer-aided process planning (CAPP) is the use of computer technology to aid in the process planning of a part or product, in manufacturing. CAPP is the link between CAD and CAM in that it provides for the planning of the process to be used in producing a designed part. Process planning is concerned with determining the sequence of individual manufacturing operations needed to produce a given part or product. The resulting operation sequence is documented on a form typically referred to as a route sheet containing a listing of the production operations and associated machine tools for a workpart or assembly. Process planning in manufacturing also refers to the planning of use of blanks, spare parts, packaging material, user instructions (manuals) etc.

The term "Computer-Aided Production Planning" is used in different context on different parts of the production process; to some extent CAPP overlaps with the term "PIC" (Production and Inventory Control).

Process planning translates design information into the process steps and instructions to efficiently and effectively manufacture products. As the design process is supported by many computer-aided tools, computer-aided process planning (CAPP) has evolved to simplify and improve process planning and achieve more effective use of manufacturing resources.

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- Fabrication and assembly drawings to support manufacture (as opposed to engineering drawings to define the part).

Keneth Crow stated that "Manual process planning is based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes, and tooling. Process planning is very time-consuming and the results vary based on the person doing the planning".

According to Engelke, the need for CAPP is greater with an increased number of different types of parts being manufactured, and with a more complex manufacturing process.

Computer-aided process planning initially evolved as a means to electronically store a process plan once it was created, retrieve it, modify it for a new part and print the plan. Other capabilities were table-driven cost and standard estimating systems, for sales representatives to create customer quotations and estimate delivery time.

Variant (Retrieval) CAPP Methodology

Variant process planning approach is sometimes referred as a data retrieval method. In this approach, process plan for a new part is generated by recalling, identifying and retrieving an existing plan for a similar part and making necessary modifications for new part. As name suggests a set of standard plans is established and maintained for each part family in a preparatory stage. Such parts are called master part. The similarity in design attributes and manufacturing methods are exploited for the purpose of formation of part families. Using coding and classification schemes of group technology (GT), a number of methods such as coefficient based algorithm and mathematical programming models have been developed for part family formation and plan retrieval. After identifying a new part with a family, the task of developing process plan is simple. It involves retrieving and modifying the process plan of master part of the family.

The general steps for data retrieval modification are as follows :

Establishing the Coding Scheme

A variant system usually begins with building a classification and coding scheme. Because, classification and coding provide a relatively easy way to identify similarity among existing and new parts. Today, several classification and coding systems are commercially available. In some extreme cases, a new coding scheme may be developed. If variant CAPP is preferred than it is useful for a company to look into several commercially available coding and classification systems (e.g. DCLASS, JD-CAPP etc.). Now, it is compared with companies before developing their own coding and classification system. Because using an existing system can save tremendous development time and manpower.

(i) Form the Part Families by Grouping Parts

The whole idea of GT lies into group numerous parts into a manageable number of part families. One of the key issues in forming part families is that all parts in the same family should have common and easily identifiable machined features. As a standard process plan are attached with each part family, thereby reducing the total number of standard process plans.

(ii) Develop Standard Process Plans

After formation of part families, standard process plan is developed for each part families based on common part features. The standard plan should be as simple as possible but detailed enough to distinguish it from other.

(iii) Retrieve and Modify the Standard Plans for New Parts

Step1 to step 3 are often referred as preparatory work. Each time when a new part enters the systems, it is designed and coded based on its feature, using the coding and classification scheme, and than assigned to a part family. The part should be similar to its fellow parts in the same family.

Also, family's standard plan should represent the basic set of processes that the part has to go through. In order to generate detailed process routes and operation sheets to this part, the standard plan is retrieved from the data base and modified. Modification is done by human process planar. After this stage parts are ready for release to the shop.

The success of aforementioned process planning system is dependent on selection of coding scheme, the standard process plan and the modification process, because the system is generally application oriented. It may be possible that one coding scheme is preferable for one company and same is not for other company.

Due to use and advancement of computers, the information management capability of variant process planning is much superior. Otherwise it is quite similar to manual experience-based planning.

Advantages of Variant CAPP

Following advantages are associated with variant process planning approach:

(i) Processing and evaluation of complicated activities and managerial issues are done in an efficient manner. Hence lead to the reduction of time and labour requirement.

(ii) Structuring manufacturing knowledge of the process plans to company's needs through standardized procedures.

(iii) Reduced development and hardware cost and shorter development time. This is an essential issue for small and medium scale companies, where product variety is not so high and process planner are interested in establishing their own process planning research activities.

Disadvantages of Variant Process Planning Approach

Following disadvantages are associated with variant process planning approach

(i) It is difficult to maintain consistency during editing.

(ii) Proper accommodation of various combinations of attributes such as material, geometry, size, precision, quality, alternate processing sequence and machine loading among many other factors are difficult.

(iii) The quality of the final process plan largely depends on the knowledge and experience of process planner. The dependency on process planner is one of the major shortcomings of variant process planning.

Generative Process Planning, Advantages and Disadvantages

In generative process planning, process plans are generated by means of decision logic, formulas, technology algorithms, and geometry based data to perform uniquely processing decisions. Main aim is to convert a part form raw material to finished state.

Hence, generative process plan may be defined as a system that synthesizes process information in order to create a process plan for a new component automatically.

Generative process plan mainly consists of two major components :

(i) Geometry based coding scheme.

(ii) Proportional knowledge in the form of decision logic and data. Geometry-based Coding Scheme

All the geometric features for all process such as related surfaces, feature dimension, locations, on the features are defined by geometry based coding scheme. The level of detail is much greater in generative system than a variant system.

For example, various details such as rough and finished state of the part are provided to transform into desired state.

Proportional Knowledge in the Form of Decision Logic and Data

Process knowledge in the form of decision logic and data are used for matching of part geometry requirement with the manufacturing capabilities. All the methods mentioned above is performed automatically.

Operation instruction sets are automatically generated to help the operators to run the machines in case of manual operation. NC codes are automatically generated, when numerically controlled machines are used.

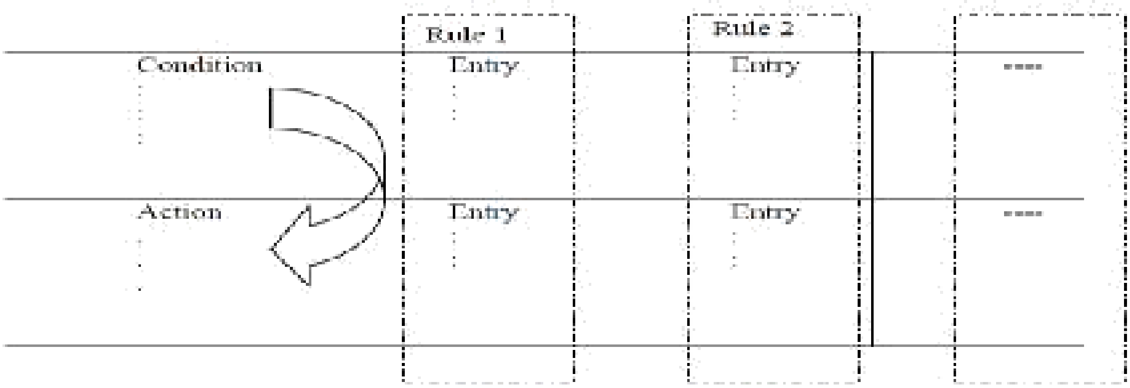


Figure 9.5 : Framework of a Decision Table

Manufacturing knowledge plays a vital role in process planning. The process of acquisition and documentation of manufacturing knowledge is a recurring dynamic phenomenon. In addition, there are various sources of manufacturing knowledge such experience of manufacturing personnel, handbooks, supplier of machine tools, tools, jigs and fixtures materials, inspection equipment and customers etc. Hence, in order to understand manufacturing information, ensuring its clarity and providing a framework for future modification, it is not only necessary but also inevitable to develop a good knowledge structure from wide spectrum of knowledge. Flowchart, decision trees, decision tables, algorithms, concepts of unit machined surfaces, pattern recognition techniques, and artificial intelligent based tools are used to serve the purpose. A brief discussion on decision table is given below. The basic elements of decision tables are condition, action and rules. They are represented in the form of allocation matrix. Figure 9.4 is one such representation where condition states the goal that we want to achieve and action states the operation that we have to perform. On the basis of experience the expert rules are formed by entry values to establish the relationship between condition and action. Table 9.1 is one such representation where entry are of Boolean-types (true, false, don't care). Similarly, in Table 9.2, continuous value type entries are shown.

Table 9.1 : Boolean Value-Type Entries

Length of bar ≥ 8 in.	T*	F	
Diameter of bar ≤ 1 in.			
Diameter of bar ≥ 1 in.	T		T
-	-	-	-
Extra Support	T		

* T : *True;* F : *False;* blank : *don't care.*

Table 9.2 : Continuous Value-type Entries

Length of bar (in)	≤ 4		≥ 4	≤ 16	≥ 16
Diameter of bar (in)	≤ 0.2	> 0.2	1>diameter>0.2	≥ 1	
Extra support	T		T		T

* T : *true;* blank : *do not care*

The decision making process works as follow.

For a particular set of condition entries, look for its corresponding rule from that rule determine the action.

Description of various generative and variant and generative CAPP systems is mentioned Table 9.3.

Table 9.3 : Some of the Variant and Generative CAPP Systems

CAPP System	Part Shapes	Process Planning Approaches	Characteristics and Commercial Situation	Programming Languages Used	Developers
CMPP	Rotational	Generative	Uses English like language(COPPL)	FORTRAN 77	UTRC (USA)
GENPLAN	All	Variant and Generative	Interfaced with CAD/CAM		Lockheed-Georgia(USA)
GT-CAPP	All	Generative	Part family code used		Rockwell Inc (USA)
KAPTS	Rotational and Prismatic	Generative	Part family numbers used	LISP	Kobe Univ. (JAPAN)
MIPLAN	Rotational and Prismatic	Variant	Expert system based on MICLASS		OIR and GE Co.(USA)
RTCAPP	Prismatic	Generative	Generic shell		USC (USA)
TURBO-CAPP	Rotational	Generative	Knowledge based interfaced with CAD	PROLOG	Penn. State Univ (USA)
XPLAN	All	Generative	Expert system based on DCLASS	FORTRAN 77	Tech. Univ. of DK (Denmark)
XPLAN-R	Rotational	Generative	Expert system based on DCLASS	FORTRAN 77	Tech. Univ. of DK (Denmark)
XPLANE	Rotational	Generative	Knowledge based	FORTRAN	Twente Univ. Tech. (Netherland)
XPS-1	All	Variant and Generative	COPPL used	FORTRAN	UTRC and CAM-I (USA)

CAPP benefits

Significant benefits can result from the implementation of CAPP. In a detailed survey of twenty-two large and small companies using generative-type CAPP systems, the following estimated cost savings were achieved:

- 58% reduction in process planning effort
- 10% saving in direct labor
- 4% saving in material
- 10% saving in scrap
- 12% saving in tooling
- 6% reduction in work-in-process

In addition, there are intangible benefits as follows:

- Reduced process planning and production leadtime; faster response to engineering changes
- Greater process plan consistency; access to up-to-date information in a central database
- Improved cost estimating procedures and fewer calculation errors
- More complete and detailed process plans

- Improved production scheduling and capacity utilization
- Improved ability to introduce new manufacturing technology and rapidly update process plans to utilize the improved technology.

Unit – IV

Production Planning and Control: Computerized PPL, Aggregate Production Planning, MPS, MRP, MRP II, ERP and JIT. Automated Data Collection – Bar Codes, OCR, Image Processing, RF Identification, Magnetic Identification, Voice Technology, Comparison, Control Types-PLC. (09 hours)

PRODUCTION PLANNING AND CONTROL (PPC)

Production planning and control (PPC) is concerned with the logistics problems that are encountered in manufacturing, that is, managing the details of what and how many products to produce and when, and obtaining the raw materials, parts, and resources to produce those products. PPC solves these logistics problems by managing information. The computer is essential for processing the tremendous amounts of data involved to define the products and the manufacturing resources to produce them and to reconcile these technical details with the desired production schedule. In a very real sense. PPC is the integrator in computer integrated manufacturing.

Planning and control in PPC must themselves be integrated functions. It is insufficient to plan production if there is no control of the factory resources to achieve the plan, And it is ineffective to control production if there is no plan against which to compare factory progress. Both planning and control must be accomplished and they must be coordinated with each other and with other functions in the manufacturing firm, such as process planning, concurrent engineering and advanced manufacturing planning. Now, having emphasized the integrated nature of PPC, let us nevertheless try to explain what is involved in each of the two functions production planning and production control.

Production planning is concerned with: (1) deciding which products to make, how many of each, and when they should he completed: (2) scheduling the delivery and/or production of the pans and products: and (3) planning the manpower and equipment resources needed to accomplish the production plan. Activities within the scope of production planning include:

• Aggregate production planning: This involves planning the production output levels for major product lines produced by the firm. These plans must be coordinated among various functions in the firm, including product design, production, marketing and sales.

• Master production planning. The aggregate production plan must be converted into a master production schedule (MPS) which is a specific plan of the quantities to be produced of individual models within each product line.

• Material requirements planning (MRP) is a planning technique, usually implemented by computer- that translates the MPS of end products into a detailed schedule for the raw materials and parts used in those end products.

• Capacity planning is concerned with determining the labor and equipment resources needed to achieve the master schedule.

Production planning activities divide into two stages: (1) aggregate planning which results in the MPS, and (2) detailed planning, which includes MRP and capacity planning. Aggregate planning involves planning 6 months or more into the future, whereas detailed planning is concerned with the shorter term (weeks to months)

Production control is concerned with determining whether the necessary resources to implement the production plan have been provided, and if not, it attempts to take corrective action to address the deficiencies. As its name suggests, production control includes various systems and techniques for controlling production and inventory in the factory. The major topic, that are involved in a PPC are:

• Shop floor control. Shop floor control systems compare the progress and status of production orders in the factory to the production plans (MPS and parts explosion accomplished by MRP) •Inventory control. Inventory control includes a variety of techniques for managing the inventory of a firm. One of the important tools in inventory control is the economic order quantity formula.

• Manufacturing resource planning. Also known as MRP II, Manufacturing resource planning combines MRP and capacity planning as well as shop floor control and other functions related to PPC

•Just-in-time production systems. The term "just-in-time" refers to a scheduling discipline in which materials and parts are delivered to the next work cell or production line station just prior to their being used. This type of discipline tends to reduce inventory and other kinds of waste in manufacturing.

The activities in a modem pre system and their interrelationships are depicted in Figure 26.1. As the figure indicates, PPC ultimately extends to the company's supplier base and customer base. This expanded scope of PPC control is known as supply chain management.

AGGREGATE PRODUCTION PLANNING AND THE MASTER PRODUCTION SCHEDULE

Aggregate planning is an operational activity that does an aggregate plan for the production process, in advance of 2 to 18 months, to give an idea to management as to what quantity of materials and other resources are to be procured and when, so that the total cost of operations of the organization is kept to the minimum over that period.

The quantity of outsourcing, subcontracting of items, overtime of labour, numbers to be hired and fired in each period and the amount of inventory to be held in stock and to be backlogged for each period are decided. All of these activities are done within the framework of the company ethics, policies, and long term commitment to the society, community and the country of operation.

Aggregate planning has certain pre-required inputs which are inevitable. They include:

- Information about the resources and the facilities available.
- Demand forecast for the period for which the planning has to be done.
- Cost of various alternatives and resources. This includes cost of holding inventory, ordering cost, and cost of production through various production alternatives like subcontracting, backordering and overtime.
- Organizational policies regarding the usage of above alternatives.

Concept of Aggregate production planning

It refers to the process of deciding the overall quantities of products to be manufactured or produced in a plant or other manufacturing facility during a medium term planning period such as a month, or a quarter. The aggregate plan output consist of the total quantities of each product or a group of product to be manufactured in the plan period of going into details of scheduling of different manufacturing activities required to achieve the planned production levels. The aggregate production will also not specify details such as the dates when material ordered against individual customer order will be ready for delivery.

	Week									
Product line	1	2	3	4	5	6	7	8	9	10
M model line	200	200	200	150	150	120	120	100	100	100
N model line	80	60	50	40	30	20	10			
P model line							70	130	25	100

(a) Aggregate production plan

	Week									
Product line models	1	2	3	4	5	6	7	8	9	10
Model M3	120	120	120	100	100	80	80	70	70	70
Model M4	80	80	80	50	50	40	40	30	30	30
Model N8	80	60	50	40	30	20	10			
Model P1								50		100
Model P2							70	80	25	

(b) Master production schedule

Table 4.1 Aggregate production planning & Master Production Schedule

The aggregate production plan is prepared as a means of setting overall production targets and as input for planning availability of other inputs and supporting activities to meet the production targets. The aggregate plans then form the basis of more detailed production, including such as daily and weekly production schedules and customer delivery schedules. Such production plan are further detailed out as machine loading schedules.

MASTER PRODUCTION SCHEDULE

The production quantities of the major product lines listed in the aggregate plan must be converted into a very specific schedule of individual products, known as the Master Production Schedule (MPS). It is a list or the products to be manufactured, when they should be completed and delivered, and in what quantities.

The production plan is in turn translated into the master production schedule (MPS). The master schedule is a macro level document which sets top-level priorities for what will be manufactured and when, looking at the material that will be required over the production cycle.

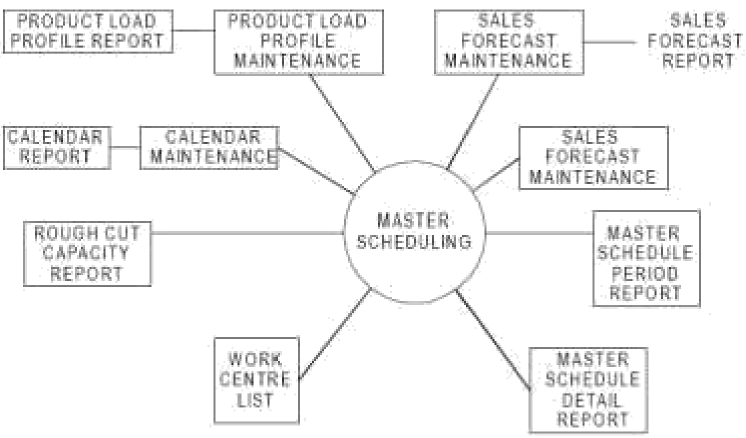


Fig 4.1 Modules of Master Scheduling

The MPS planning period, or horizon, can be of any length, but should be at least as long as a company's longest cumulative lead time (the time it takes to complete a product from raw material to finished goods. Many systems include a rough cut capacity planning (RCCP) capability, which compares certain MPS items of the master schedule to specified key resources of the plant (or multiple plants) to determine if the master schedule is workable, given current the plant capacity. If the master schedule is not achievable, the system modifies the MPS or the production plan (For example, reduce the amount of products to be produced or commit to increasing the capacity of the plant) until the master schedule is achievable.

MATERIALS REQUIREMENTS PLANNING (MRP)

The master production schedule becomes a direct input to the material requirements planning (MRP) function, which determines the material needed at each work centre location in order to meet the master production schedule. MRP is the heart of any manufacturing control system. It uses information from the bills of material, inventory, shop and purchase orders, and the master schedule to draw a detailed material requirements plan. MRP accesses the data from the master production to determine what products will be built during the planning period.

Bills of material and routings define the raw materials required to produce the product, the instructions and routing(s) through the shop the shop floor for producing the product. MRP determines the total gross requirements and compares against current inventory and scheduled receipts (any replenishment orders due).

If MRP determines that material will not be available when it is required, it can regenerate planned orders for that material. Figure illustrates the important sub- modules of MRP.

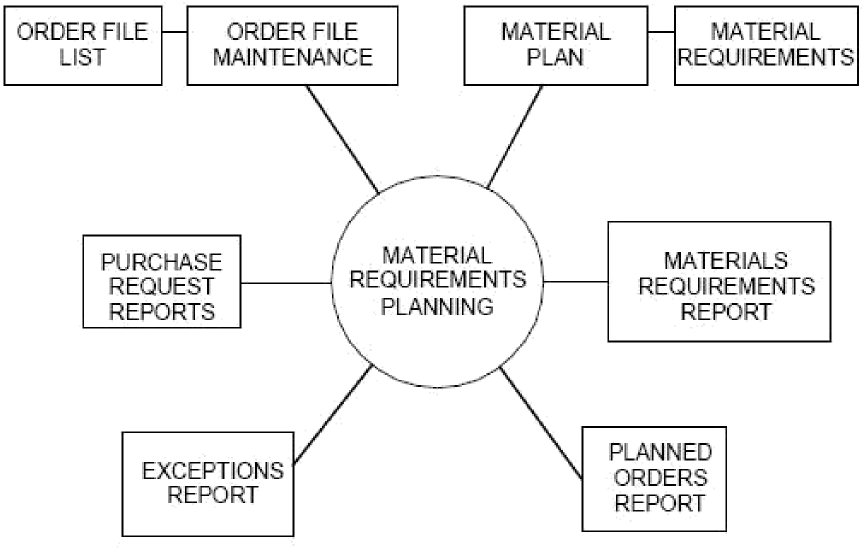


Fig 4.2 Sub-modules of Material Requirements Planning

The MRP modules carry out the following:

- Computes when and in what quantities component parts and raw materials are required.
- Supports minimum, maximum, and multiple order quantity modifications.
- Allows creation and modification of a shop calendar and a variety of reporting calendars.
- Reports exceptions and recommends changes to order quantities and dates.
- Supports changes in product structures.
- Uses actual components planned for shop orders as a firm planned bill of material to accurately reflect true material needs.

Manufacturing Resource Planning - MRP II

Manufacturing resource planning can be defined as a computer-based system for planning, scheduling, and controlling the materials, resources, and supporting activities needed to meet the MPS. MRP II is a closed-loop system that integrates and coordinates all of the major functions of the business to produce the right products at the right times, The term "closed-loop system" means that MRP II incorporates feedback of data on various aspects of operating performance so that corrective action can be taken in a timely manner; that is, MRP II includes a shop floor control system.

Application modules typically provided in a high-end MRP II system include the following:

- Management planning. Functions included in this module are business strategy, aggregate production planning, master production scheduling, rough-cut capacity planning and budget planning.
- Customer service. Typical components in this module are sales forecasting, order entry, sales analysis, and finished goods inventory.
- Operations planning. This is the MRP module enhanced with capacity requirements planning. The output consists of purchase order and work order releases.
- Operations execution. This includes purchasing, production scheduling and control, WIP inventory control, shop floor control and labor hour tracking.
- Financial functions. These include cost accounting, accounts receivable, account, payable, general ledger and payroll.

ENTERPRISE RESOURCE PLANNING (ERP)

Enterprise resource planning (ERP) system is a business management system that comprises integrated sets of comprehensive software, which can be used, when successfully implemented, to manage and integrate all the business functions within an organization.

Enterprises to-day employ a mixture of several approaches to manufacturing. They include:

- Make to stock
- Design to order
- Make to order
- Assemble to order

It must be possible to operate the company in all these modes. The emerging trend of amalgamations, acquisitions and strategic alliances among competing corporations required more capable software to manage such multi-facility enterprises. Another challenging task is the co-ordination of manufacturing in facilities which are geographically dispersed. For example, a multinational company will have divisions and subsidiaries in U.S.A, Canada, UK, India, Germany, Korea and Japan. An Indian multinational company may have plants in Poland, Belgium and UK. Each country will have its own currency and tax laws. This requires multi-currency functionality for the planning software. The need for managing the entire enterprise within a more global, tightly integrated closed-loop solution has led to the evolution of ERP software.

The core activity in ERP is the creation of an integrated data model, covering employees, customers, suppliers etc. A distinguishing feature of the ERP software is that it incorporates best practices. This means that the manufacturing solution developed using ERP is an optimum one.

The implementation of an ERP system includes the following stages:

i. Definition of the scope of the project
ii. Identification of the objectives and deliverables
iii. Project organization
   - Identifying an executive responsible for successful implementation of ERP
   - Establish a senior management steering committee
   - Establish a project team
   - Define the role of consultants
iv. Work plan development
v. Assessment of the business of the company - where it is to day and where it should go
vi. Education of key managers
vii. Cost/benefit analysis

JUST-IN-TIME PRODUCTION SYSTEMS

The term "just-in-time" refers to a scheduling discipline in which materials and parts are delivered to the next work cell or production line station just prior to their being used. This type of discipline tends to reduce inventory and other kinds of waste in manufacturing.

Just-in-time (JIT) production systems were developed in Japan to minimize inventories, especially Work-In-Progress (WIP). WIP and other types of inventory are seen by the Japanese as waste that should be minimized or eliminated. The ideal just-in-time production system produces and delivers exactly the required number of each component to the downstream operation in the manufacturing sequence just at the time when that component is needed.

Each component is delivered "just in time" This delivery discipline minimizes WIP and manufacturing lead time as well as the space and money invested in WIP, The JIT discipline can be applied not only to production operations but to supplier delivery operations as well.

Whereas the development of JIT production systems is largely credited to the Japanese, the philosophy of JIT has been adopted by many U.S. manufacturing firms. Other terms have sometimes been applied to the American practice of JIT to suggest differences with the Japanese practice. For example, continuous flow manufacturing is a widely used term in the United States that denotes a JIT style of production operations. Prior to JIT, the traditional U.S. practice might be described as a “just-In-case” philosophy. That is, to hold large in-process inventories to cope with production problems such as late deliveries of components, machine breakdowns. defective components, and wildcat strikes, The JIT production discipline has shown itself to be very effective in high volume repetitive operations, such as those found in the automotive industry. The potential for WIP accumulation in this type of manufacturing is significant due to the large quantities of products made and the large numbers of components per product. The principal objective of JIT is to reduce inventories.

AUTOMATED DATA COLLECTION

Automatic Identification and Data Capture (AIDC) refers to the methods of automatically identifying objects, collecting data about them, and entering that data directly into computer systems (i.e. without human involvement). Technologies typically considered as part of AIDC include bar codes, Radio Frequency Identification (RFID), biometrics, magnetic stripes, Optical Character Recognition (OCR), smart cards, and voice recognition. AIDC is also commonly referred to as “Automatic Identification,” “Auto-ID,” and "Automatic Data Capture."

The advantages of the automatic data collection methods are:

i. The accuracy of data collected increases

ii. The time required by the workers to make the data entry can be reduced. The basic elements in data collection systems are:

iii. Machine readable media

iv. Terminal configuration

v. Software for data collection.

BAR CODE TECHNOLOGY

Bar code technology is primarily an automatic identification technique. The data is simply reduced to a printed form, which consists of a symbol made of successive line segments. A bar code reader is used to illuminate the bar code symbol and examine successive segments of the symbol. The detected area may be a highly reflected area (space) or a non-reflective (bar). As the reader moves over the bar code symbol, due to reflectivity and non- reflectivity, alternate transitions from light to dark and dark to light occur.

Fig 4.3 Example of a Bar Code

Optical character recognition (OCR):

Optical character recognition, usually abbreviated to OCR, is the mechanical or electronic translation of scanned images of handwritten, typewritten or printed text into machine-encoded text. It is widely used to convert books and documents into electronic files, to computerize a record-keeping system in an office, or to publish the text on a website. OCR makes it possible to edit the text, search for a word or phrase, store it more compactly, display or print a copy free of scanning artifacts, and apply techniques such as machine translation, text-to-speech and text mining to it. OCR is a field of research in pattern recognition, artificial intelligence and computer vision. OCR systems require calibration to read a specific font; early versions needed to be programmed with images of each character, and worked on one font at a time. "Intelligent" systems with a high degree of recognition accuracy for most fonts are now common. Some systems are capable of reproducing formatted output that closely approximates the original scanned page including images, columns and other non-textual components.

Image processing

In electrical engineering and computer science, image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or, a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

Image processing usually refers to digital image processing, but optical and analog image processing also are possible. This article is about general techniques that apply to all of them. The *acquisition* of images (producing the input image in the first place) is referred to as imaging.

Radio-frequency identification

Radio-frequency identification (RFID) is a technology that uses radio waves to transfer data from an electronic tag, called RFID tag or label, attached to an object, through a reader for the purpose of identifying and tracking the object. Some RFID tags can be read from several meters away and beyond the line of sight of the reader. The application of bulk reading enables an almost-parallel reading of tags.

The tag's information is stored electronically. The RFID tag includes a small RF transmitter and receiver. An RFID reader transmits an encoded radio signal to interrogate the tag. The tag receives the message and responds with its identification information. Many RFID tags do not use a battery. Instead, the tag uses the radio energy transmitted by the reader as its energy source. The RFID system design includes a method of discriminating several tags that might be within the range of the RFID reader.

A number of organizations have set standards for RFID, including the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), ASTM International, the DASH7 Alliance and EPCglobal. (Refer to Regulation and standardization below.) There are also several specific industries that have set guidelines. These industries include the Financial Services Technology Consortium (FSTC) which has set a standard for tracking IT Assets with RFID, the Computer Technology Industry Association CompTIA which has set a standard for certifying RFID engineers, and the International Airlines Transport Association IATA which has set tagging guidelines for luggage in airports. RFID can be used in many applications. A tag can be affixed to any object and used to track and manage inventory, assets, people, etc. For example, it can be affixed to cars, computer equipment, books, mobile phones, etc. The Healthcare industry has used RFID to reduce counting, looking for things and auditing items. Many financial institutions use RFID to track key assets and automate compliance. Also with recent advances in social media RFID is being used to tie the physical world with the virtual world.

RFID is a superior and more efficient way of identifying objects than manual system or use of bar code systems that have been in use since the 1970s. Furthermore, passive RFID tags (those without a battery) can be read if passed within close enough proximity to an RFID reader. It is not necessary to "show" the tag to the reader device, as with a bar code. In other words it does not require line of sight to "see" an RFID tag, the tag can be read inside a case, carton, box or other container, and unlike barcodes RFID tags can be read hundreds at a time. Bar codes can only be read one at a time.

Magnetic identification

MID is an active identification technology device with the unique ability of being able to go through metal and liquids. It uses a very low frequency and can be used for very specific applications.

MIDs are currently being developed by RFIDEA; this is exclusive technology. **VOICE RECOGNITION**

Speech is the most natural way of communication. This eliminates the need of the user to understand a computer system. Voice technology is intelligently packaged and applied in several applications. Moreover the training can be minimized and the key board entry can be eliminated and hand and eye co-ordination is no longer needed. Voice recognition (VR) is of two types:

i. Speaker dependent
ii. Speaker independent

Most voice recognition systems are speaker independent systems. VR systems recognize the user's vocabulary and store a computer image of each utterance and compare later the input words to the computer stored words. If the input matches the stored pattern, recognition is achieved. This provides larger vocabulary and accurate recognition. Commercial VR systems are having around a few hundred words in active vocabulary and skilful programming can develop application dependent vocabularies.

Real application of VR systems rests on the fact that user need not be trained to use the system. Speaker independent system uses recognition template from memories of the previously recorded images. The templates represent speech patterns of both male and female speakers. These are now available with limited vocabularies.

PROGRAMMABLE LOGIC CONTROLLER (PLC)

Introduction

The National Electrical Manufacturers Association (NEMA) as defines a programmable logic controller: A digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control, through digital or analog input/output modules, various types of machines or processes.

In essence, the programmable logic controller consists of computer hardware, which is programmed to simulate the operation of the individual logic and sequence elements that might be contained in a bank of relays, timers, counters, and other hard-wired components.

We will adopt the initials PLC as an abbreviation for the programmable logic controller. PC Is widely used in industry for the programmable controller, but the increasingly popular personal computer is also abbreviated PC. To avoid confusion in our book, we will use PLC exclusively for the programmable controller and PC for the personal computer.

The PLC was introduced around 1969 largely as a result of specifications written by the General Motors Corporation. The automotive industry had traditionally been a large buyer and user of electromechanical relays to control transfer lines, mechanized production lines, and other automated systems. In an effort to reduce the cost of new relays purchased each year, GM prepared the specifications for a "programmable logic controller" in 1968. The requirements included:

• The device must be programmable and re-programmable.

• It must be designed to operate in an industrial environment.
• It must accept 120-V ac signals from standard pushbuttons and limit switches.
• Its outputs must be designed to switch and continuously operate loads such as motors and relays of 2-A rating.
• Its price and installation cost must be competitive with relay and solid —state logic devices then in use.

Several companies saw a commercial opportunity in the GM initiative and developed various versions of a special-purpose computer we now refer to as the PLC.

There are significant advantages in using a programmable logic controller rather than conventional relays, timers, counters, and other hardware elements. These advantages include:

• Programming the PLC is easier than wiring the relay control panel. We discuss PLC programming in one of the following subsections.
• The PLC can be reprogrammed. Conventional controls must be rewired and are often scrapped instead.
• PLCs take less floor space then relay control panels.
• Maintenance of the OPLC is easier, and reliability is greater.
• The PLC can be connected to the plant computer systems more easily than relays can.

The following subsections describe the components, programming, and operation of the PLC. We also survey some of its additional capabilities beyond logic control and sequencing.

Components of the PLC

A schematic diagram of a programmable logic controller is presented. The basic components of the OPLC are the following

• Input module
• Output module
• Processor
• Memory
• Power supply
• Programming device

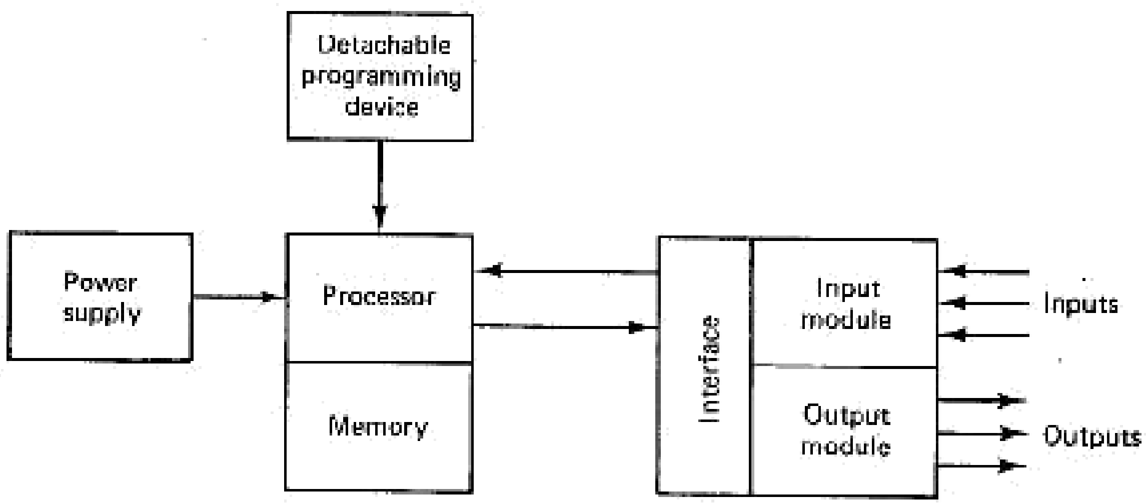


Diagram of the programmable logic controller

The components are housed in a suitable cabinet designed for the industrial environment. A commercially available PLC is shown in figure.

The input module and output module are the connections to the industrial process that in to be controlled. The inputs to the controller are signals from limit switches, pushbuttons, sensors, and other on/off devices. In addition, as we will describe later, larger PLCs are capable of accepting signals from analog devices of the type modeled. The outputs from the controller are on/off signals to operate motors, valves, and other devices required to actuate the process. The processor is the central processing unit (CPU) of the programmable controller. It executes the various logic and sequencing functions described in previous Sections by operating on the PLC INPUTS TO DETERMINE THE APPROPRIATE OUTPUT SIGNALS. The processor is microprocessor very similar in its construction to those used in personal computers and other data-processing equipment. Tied to the CPU is the PLC memory, which contains the program of logic, sequencing, and other input/output operations. The memory for a programmable logic controller is specified in the same way as for a computer, and may range from 1k to over 48 k of storage capacity. A power supply of 115 V ac is specially used to drive the PLC even though the components of the industrial process that are regulated may have a higher voltage and power rating than the controller itself.

The PLC is programmed by means of a programming device. The programming device (sometimes referred to as a programmer) is usually detachable from the PLC cabinet so that it can be shared between different controllers. Different PLC manufactures provide different devices, ranging from simple teach pendant-type devices, similar to those used in robotics, to special PLC programming keyboards and CRT displays.

Programming the PLC

Most of the programming methods in use today for PLCs are based on the ladder logic diagram. This diagram has been found to be very convenient for shop personnel who are familiar with circuit diagrams because it does not require them to learn an entirely new programming language. What is required is a means of inputting the program into the OPLC memory: There are various approaches for entering and interconnecting the individual logic elements.

These include:

1. Entry of the ladder logic diagram
2. Low-level computer-type languages
3. High-level computer-type languages
4. Functional blocks
5. Sequential function chart

The first method involves direct entry of the ladder logic diagram into the PLC memory. This method requires the use of a keyboard and CRT with limited graphics capability to display symbols representing the components and their interrelationships in the ladder logic diagram. The PLC keyboard device is often designed with keys for each of the individual symbols.

Programming is accomplished by inserting the appropriate components into the rungs if the ladder diagram. The components are of two basic types. Contacts and coils. Contacts are used to represent loads such as motors, Solenoids, relays, timers, counters, etc. in effect; the programmer inputs the ladder logic circuit diagram rung by rung into the PLC memory with the CRT displaying the results for verification. The second method makes use of a low-level computer-type language that parallels the ladder logic diagram. Using the language instructions, the programmer contracts the ladder diagram by specifying the various components and their relationships for each rung. Let us explain this approach by developing an elementary PLC instruction set. Our PLC “language” will be a composite of various manufacturers’ languages, containing perhaps fewer features than most commercially available PLCs. We will assume that the programming device consists of a suitable keyboard for entering the individual components on each rung of the ladder logic diagram. A CRT capable of displaying each ladder rung, and perhaps several rungs that precede it, is useful to verify the program. The low-level languages are generally limited to the types of logic and sequencing functions that can be defined in a ladder logic diagram. Although timers and counters have not been illustrated in the two preceding examples, some of the problems at the end of the chapter require the reader to make use of them. High-level computer-type languages are likely to become more common in the future to program the PLC. There are several of these languages that are beginning to be offered commercially, including [SYBIL (GTE Sylvania), MCL model APC-2 (Cincinnati Milacron), and Control Statements (Reliance Electric). Most of the available languages use an instruction set that is similar to the BASIC computer language for personal computers. There are additional statements available beyond the normal BASIC set to accomplish the control functions.

The principal advantage offered by the high-level languages for programming the PLC is their capability to perform data processing and calculations on values other than binary.. Ladder logic diagrams and low- level OPLC languages are usually quite limited in their ability to operate on signals that are other than ON/OFF types. The capability to perform data processing and computation permits the use of more complex control algorithms, communications with other computer-based systems display of data on a CRT console, and input of data by a human operator. Another advantage of the higher-level languages is the relative case with which a user can interpret a printout of a complicated control program. Explanatory comments can be inserted into the program to facilitate the interpretation.

Binary Control Logic

In some application of control systems, the variables are binary — they can be either of two possible values, 1 or 0. These values can be interpreted to mean ON or OFF, true of false, object present or not present, high voltage value or low voltage value, and so on. Followings are some binary input and output devices. Table I .1 Binary Input and Output devices

TABLE 1.1 Binary Input and Output Devices

Device	One/zero interpretation
Input	
Limit switch	Contact/no contact
Photodetector	Contact/no contact
Pushbutton switch	On/off
Timer	On/off
Control relay	Contact/no contact
Circuit breaker	Contact/no contact
Output	
Motor	On/off
Alarm buzzer	On/off
Control relay	Contact/no contact
Lights	On/off
Valves	Closed/open
Clutch	Engaged/not engaged
Solenoid	Energized/not energized

Logic Control And Sequencing

A logic control system is a switching system whose output at any moment is determined exclusively by the value of inputs.

A logic control system has no memory and does not consider any previous values of the input signals in determining the output signal. Neither does it have any operating characteristics that perform as a function of time.

An example from Robotics.

A sequencing system is one that uses internal timing devices to determine when to initiate changes in output variables.

Logic Control Elements

There are three basic elements of Logic Control, which are also called Logic Gates:

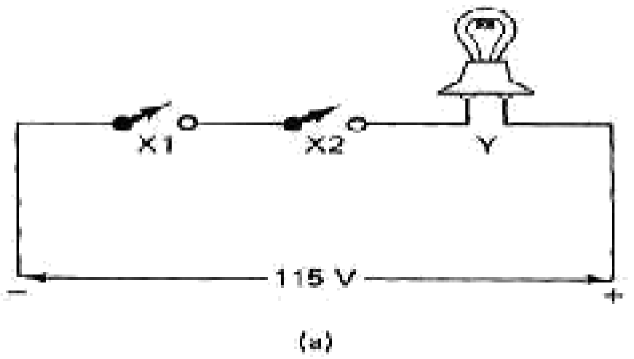
1. AND
2. OR
3. NOT

There are other elements which are derived from these three basic elements above like NOR, and NAND, etc.

In each case, the logic gate is designed to provide a specified output value based on the values of input(s). For both inputs and outputs, the values can be either of the two levels, the binary values 0 or 1. For purpose of industrial control, we will define 0 (zero) to mean OFF and 1 (one) to mean ON,

Logic Gate AND

The logic gate AND outputs a value of 1 if all of the inputs are 1, and 0 otherwise. Figure (a) illustrates the operation of a logical AND gate. If both of the switches, Xl and X2 (representing inputs), in the circuit are closed, the lamp Y (representing the output) is on. The truth table for the AND gate is shown in Figure (b).



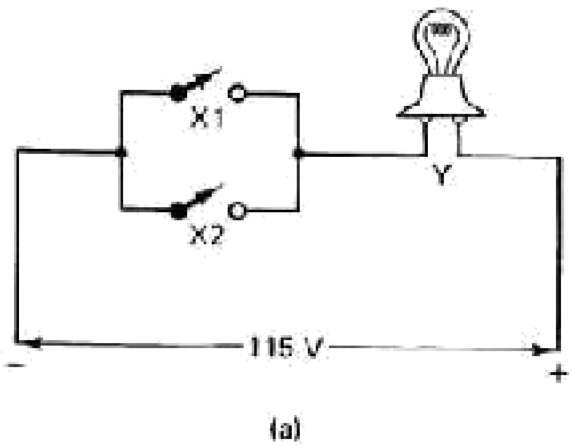
Inputs		Output
X1	X2	Y
0	0	0
0	1	0
1	0	0
1	1	1

(b)

Figure Logical AND gate: (a) Circuit illustrating the operation, (b) Its truth table

Logic Gate OR

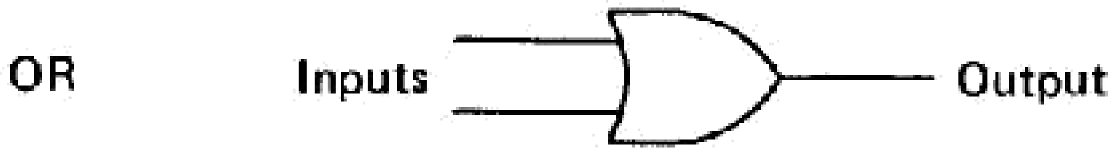
The logic gate OR outputs a value of 1 if either of the inputs have a value of 1, and 0 otherwise. Figure 10.3 (a) illustrates the operation of a logical OR gate. In this case, Xl and X2 (representing inputs) are arranged in a parallel circuit, so that if either of the switches is closed, the lamp Y (representing the output) will be on. The truth table for the OR gate is shown in Figure (b).



Inputs		Output
X1	X2	Y
0	0	0
0	1	1
1	0	1
1	1	1

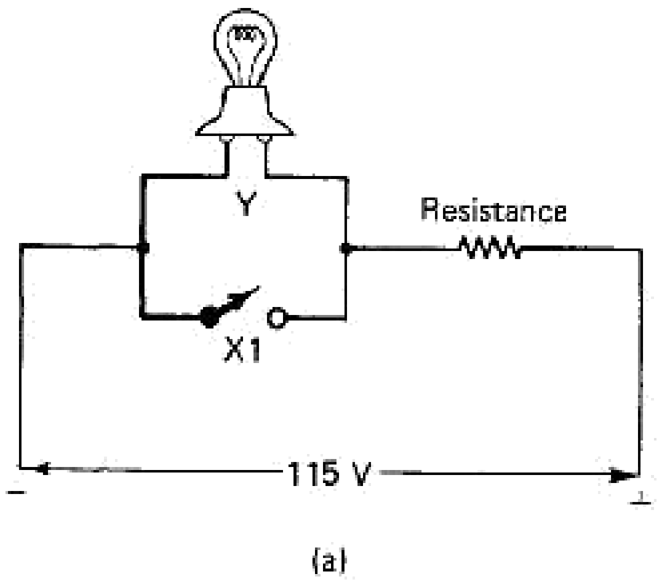
(b)

Figure Logical OR gate: (a) Circuit illustrating the operation, (b) Its truth table



Logic Gate NOT

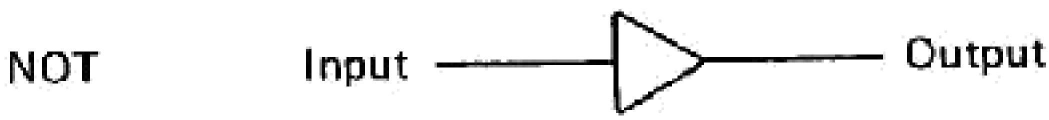
Unlike the AND and OR gate, logic gate NOT has a single input and a single output too. If the input is 1, the output is 0; if the input is 0, the output is 1. Figure 10.4 (a) shows a circuit in which the input switch Xl is arranged in parallel with the outputs so that the voltage flows through the lower path when the switched is closed (thus Y = 0), and the upper path when circuit is open (thus Y = 1), The truth table for the NOT gate is shown in Figure 10.4 (b).



Input	Output
X1	Y
0	1
1	0

(b)

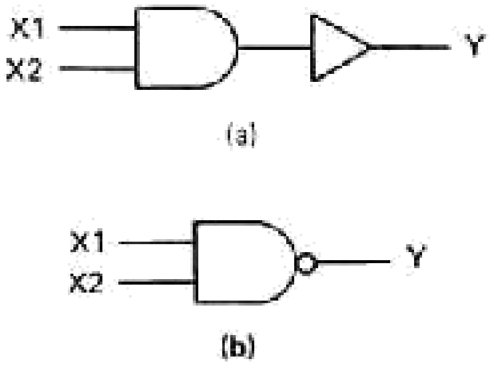
Figure 10.4: Logical NOT gate: (a) Circuit illustrating the operation, (b) Its truth table



In addition to the three basic elements, there are two more elements that can be identified for use in combinational switching circuits. These are the NAND and NOR gates.

Logic Gate NAND

Logic gate NAND is formed by combining and AND and a NOT gate in sequence, as shown in Figure 10.5(a). The logical network symbol for the NAND gate and its truth table are shown in Figure 10.5 (b) and Figure 10.5(c).



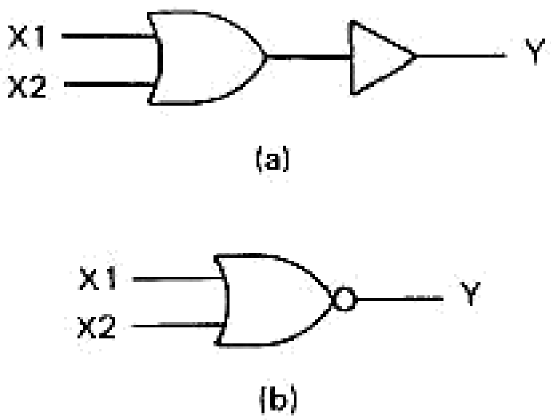
Inputs		Output
X1	X2	Y
0	0	1
0	1	1
1	0	1
1	1	0

(c)

Figure 10.5: NAND gate: (a) combining AND and NOT gates to form NAND; (b) logic network symbol for NAND; (c) truth table for NAND.

Logic Gate NOR

Logic gate NOR is formed by combining an OR gate followed by a NOT gate as illustrated in Figure 10.6 (a). The Logic Gate and truth table for the NOR gate are presented in Figure 10.6 (b) and Figure 10.6 (c).



Inputs		Output
X1	X2	Y
0	0	1
0	1	0
1	0	0
1	1	0

(c)

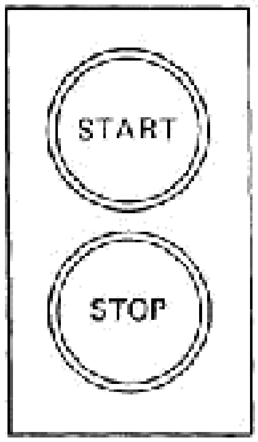
Figure 10.6: NOR gate: (a) combining OR and NOT gates to form NOR; (b) logic network symbol for NOR; (c) truth table for NOR.

Figure 10.5: NAND gate: (a) combining AND and NOT gates to form NAND; (b) logic network symbol for NAND; (c) truth table for NAND.

Figure 10.6: NOR gate: (a) combining OR and NOT gates to form NOR; (b) logic network symbol for NOR; (c) truth table for NOR.

Example

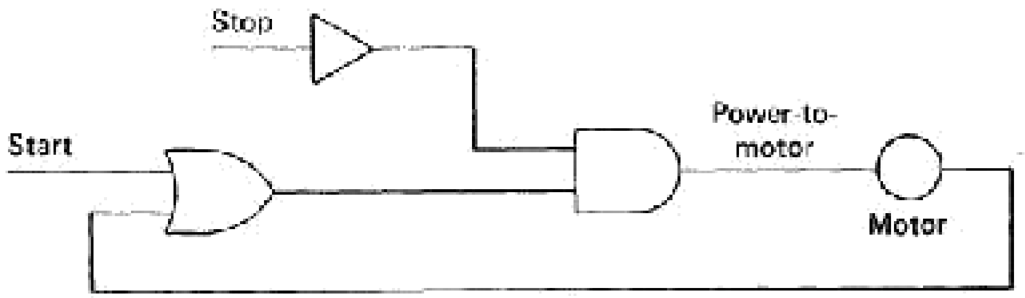
A motor has one start and one stop button. Being power to motor the output, construct the logic flow diagram and, the truth table.



(a)

Start	Stop	Motor	Power-to-motor
0	0	0	0
0	1	0	0
1	0	0	1
1	1	0	0
0	0	1	1
0	1	1	0
1	0	1	1
1	1	1	0

(b)



(c)

Figure 10.7: (a) Pushbutton switch; (b) its truth table; (c) its logic network diagram

Figure 10.7: (a) Pushbutton switch; (b) its truth table; (c) its logic network diagram

Logic Ladder Diagram

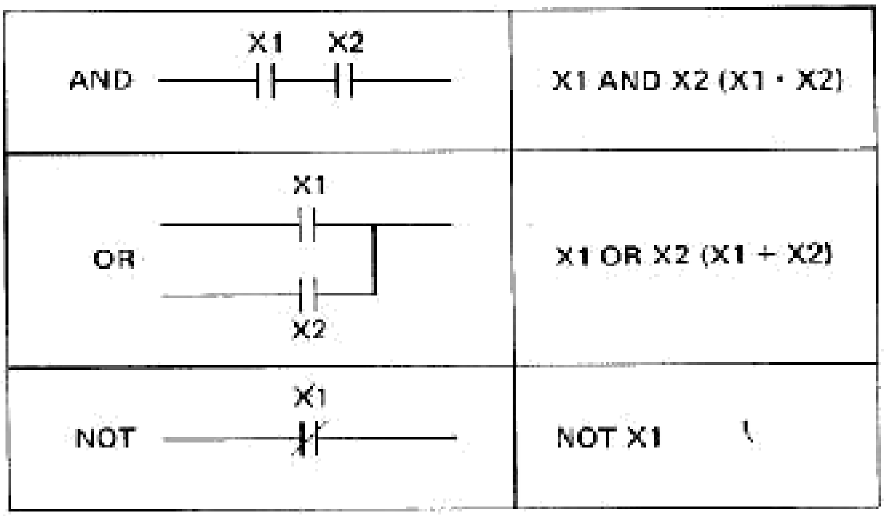


FIGURE Logic elements AND, OR, and NOT.

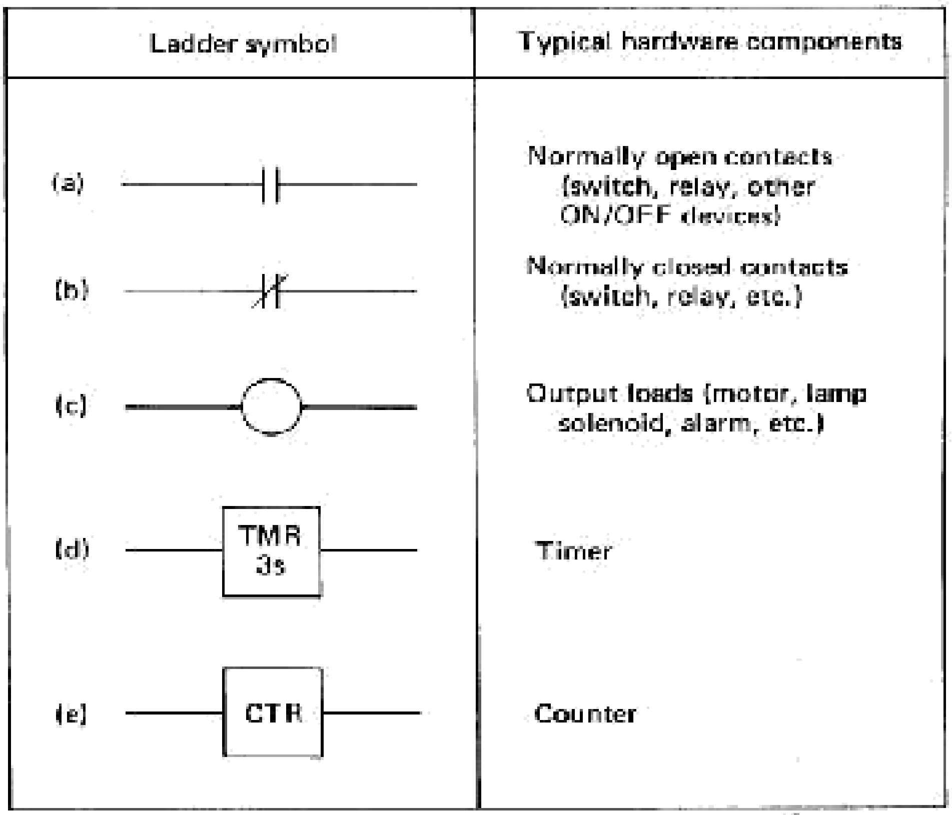


Figure 10.8: Symbols for common logic and sequence components in a ladder logic diagram

Figure 10.8: Symbols for common logic and sequence components in a ladder logic diagram
An example of Logic Ladder diagram

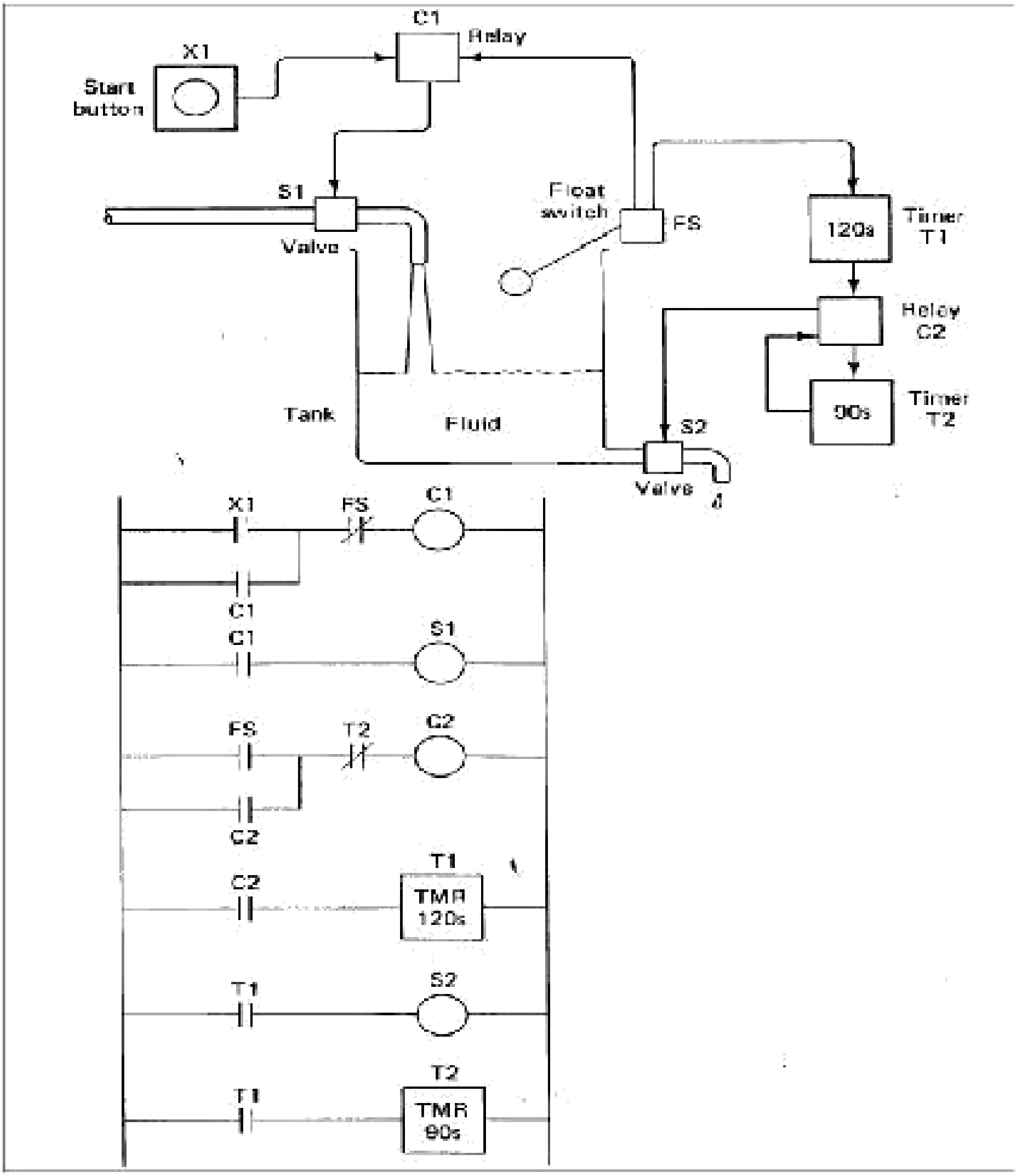


Figure 10.9: Logic ladder diagram

Unit – V

Quality: Modern Concepts, TQM, TPM – ISO Standards, CAQC – Contact & Non –Contact type, Introduction to CMM – Types

Inspection: Description, Working Principle and Application of Various Techniques and Equipments. Interfacing inspection with CAD/CAM. (09 hours) Quality Introduction

The dictionary defines quality as "the degree of excellence which a thing possesses" or "the feature, that make something what it is" its characteristic elements and attributes.

QUALITY	
Traditional concept	**Modern concept**
Some minor defects and deviations are acceptable.	The goal is to have defects-free products and services.
Low quality is due to poor working people.	Automation is the key to higher quality.Low quality is due to poor labor management. Sincere evaluation and respect for people is the key to higher quality.
Higher quality means higher costs, reduced profits and makes productionharder.	Higher quality creates higher profits. It isthe major production target.
Control finished products quality and remove the low quality ones.	Improve the processes in advance to eliminate the reasons for the low quality.
The quality control department is a separate unit, checking the finished products.	Quality is everyone's business. Its total control includes all production phases.
Buy only from the cheapest suppliers. Compete suppliers to lower your overall costs.	Buy from quality and reliable suppliers.Even if you split your profit with such a supplier, you will win.
Quality depends only on production.	Quality depends on all phases of the production process - from the design till the delivery and after-sales service.
Business inventories are necessary to ensure a continuous process. Idle workers are direct net loss.	Maintaining surplus stocks sharply deteriorates economic performance. Idle workers are diverted to other useful activities.
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Quality depends only on production.	Quality depends on all phases of the production process - from the design till the delivery and after-sales service.
Business inventories are necessary to ensure a continuous process. Idle workers are direct net loss.	Maintaining surplus stocks sharply deteriorates economic performance. Idle workers are diverted to other useful activities.

TOTAL QUALITY MANAGEMENT (TQM)

Total quality management (TQM) denotes a management approach that pursues three main objectives: (1) achieving customer satisfaction, (2) continuous improvement, and (3) encouraging involvement of the entire work force.

TQM is based on the assumption that quality cannot be "inspected into" a product; it must be "built into" it. That means any amount of inspection after the products or the components are manufactured will not help to improve the quality. One must look at the process itself to avoid production of poor quality products. To ensure this, consideration of the following aspects is necessary.

i. ***Quality of design:*** Primary attribute of a good product is that the quality of its design must be superior. There are several factors, which influence the design quality.

These include:

- Choice of right materials
- Selection of appropriate raw material shapes
- Design involving minimum number of parts
- Use of standardization and variety reduction
- Reduction in the material removed during processing
- Economic use of materials
- Use of standard/bought out parts

A good product can be evolved if the design is analyzed using "Failure Modes, Effects and Criticality Analysis (FMECA)" as well as "Design for Manufacture and Assembly (DFMA)" techniques. Softwares are now available to carry out this task. The use of FMECA and DFMA techniques will ensure that all the weak aspects of design, which affect product quality and make manufacturing difficult, can be identified and rectified before the drawings are released for manufacture.

ii. ***Selection of appropriate process and equipment:*** Proper design of the manufacturing technique plays an important role in the quality of the product.

CIM lays great emphasis on manufacturing technology development for new product development, which often requires new manufacturing techniques or refinement of existing technique. However, choice of appropriate technique of manufacture is a key issue influencing the quality of the product.

iii. ***Choice of equipment:*** Choice of process equipment is another vital factor. The equipment must have the capability to produce parts of requisite quality without extra attention on the part of the operator. Since CIM uses equipment like computerized machines and handling equipment with integrated process monitoring and control, this aspect has been well taken care of.

iv. ***Training of personnel:*** One of the important aspects of quality production is that the personnel involved in the production must be properly and adequately trained to carry out their task. They ought to know how to produce the product, with the required quality. They should be well aware of the quality requirements. The axiom "doing it right, the first time, every time" is significant in this context.

Today, every manufacturer is keen to obtain ISO-9000 certification. Implementation of CIM automatically takes care of many documentation and communication requirements of ISO-9000, right from product design to testing and shipping, covering the entire gamut of manufacture.

TQM can be defined as the management of initiatives and procedures that are aimed at achieving the delivery of quality products and services. A number of key principles can be identified in defining TQM, including:

- Executive Management – Top management should act as the main driver for TQM and create an environment that ensures its success.
- Training – Employees should receive regular training on the methods and concepts of quality. • Customer Focus – Improvements in quality should improve customer satisfaction.
- Decision Making – Quality decisions should be made based on measurements.
- Methodology and Tools – Use of appropriate methodology and tools ensures that non-conformances are identified, measured and responded to consistently.
- Continuous Improvement – Companies should continuously work towards improving manufacturing and quality procedures.
- Company Culture – The culture of the company should aim at developing employees ability to work together to improve quality.

Employee Involvement – Employees should be encouraged to be pro-active in identifying and addressing quality related problems.

TOTAL PRODUCTIVE MAINTENANCE

Total productive maintenance (TPM) originated in Japan in 1971 as a method for improved machine availability through better utilization of maintenance and production resources. Whereas in most production settings the operator is not viewed as a member of the maintenance team, in TPM the machine operator is trained to perform many of the day-to-day tasks of simple maintenance and fault-finding. Teams are created that include a technical expert (often an engineer or maintenance technician) as well as operators. In this setting the operators are enabled to understand the machinery and identify potential problems, righting them before they can impact production and by so doing, decrease downtime and reduce costs of production. TPM is a critical adjunct to lean manufacturing. If machine uptime is not predictable and if process capability is not sustained, the process must keep extra stocks to buffer against this uncertainty and flow through the process will be interrupted. Unreliable uptime is caused by breakdowns or badly performed maintenance. Correct maintenance will allow uptime to improve and speed production through a given area allowing a machine to run at its designed capacity of production.

One way to think of TPM is "deterioration prevention": deterioration is what happens naturally to anything that is not "taken care of". For this reason many people[who?] refer to TPM as "total productive manufacturing" or "total process management". TPM is a proactive approach that essentially aims to identify issues as soon as possible and plan to prevent any issues before occurrence. One motto is "zero error, zero work-related accident, and zero loss".

Introduction

TPM is a maintenance process developed for improving productivity by making processes more reliable and less wasteful. TPM is an extension of TQM(Total Quality Management). The objective of TPM is to maintain the plant or equipment in good condition without interfering the daily process. To achieve this objective, preventive and predictive maintenance is required. By following the philosophy of TPM we can minimize the unexpected failure of the equipment. To implement TPM the production unit and maintenance unit should work jointly. Original goal of total productive management:

"*Continuously improve all operational conditions, within a production system;* by stimulating the daily awareness of all employees*" (by Seiichi Nakajima, Japan, JIPM)*

TPM focuses primarily on manufacturing (although its benefits are applicable to virtually any "process") and is the first methodology Toyota used to improve its global position (1950s). After TPM, the focus was stretched, and also suppliers and customers were involved (Supply Chain), this next methodology was called lean manufacturing. This sheet gives an overview of TPM in its original form.

An accurate and practical implementation of TPM, will increase productivity within the total organization, where:

(1) a clear business culture is designed to continuously improve the efficiency of the total production system

(2) a standardized and systematic approach is used, where all losses are prevented and/or known.

(3) all departments, influencing productivity, will be involved to move from a reactive- to a predictive mindset.

(4) a transparent multidisciplinary organization is reaching zero losses.

(5) steps are taken as a journey, not as a quick menu.

Finally TPM will provide practical and transparent ingredients to reach operational excellence Steps to start TPM are

- Management should learn the philosophy.
- Management must promote the philosophy.
- Training for all the employees.
- Identify the areas where improvement are needed.
- Make an implementation plan.
- Form an autonomous group.

COMPUTER AIDED QUALITY CONTROL

The use of computers for quality control of the product is called as the computer aided quality control or CAQC. Computer-aided inspection (CAI) and computer aided testing (CAT) are the two major segments of computer-aided quality control. Whereas these activities have been traditionally performed manually (with the help of gauges, measuring devices and testing apparatus), CAI and CAT are performed automatically using computer and sensor technology. Today, CAI and CAT can be well integrated into the overall CIM system.

The implications of the use of computer-aided quality control are important. The automated methods of CAQC will result in significant improvements in product quality. The following list summarizes the important benefits of CAQC.

i. With Computer aided inspection and computer aided testing inspection and testing will typically be done on a 100% basis rather by the sampling procedures normally used in traditional QC. This eliminates any problem in assembly later and therefore is important in CIM.

ii. Inspection is integrated into the manufacturing process. This will help to reduce the lead-time to complete the parts.

iii. The use of non-contact sensors is recommended for computer aided inspection and CIM. With contact inspection devices, the part must be stopped and often repositioned to allow the inspection device to be applied properly. These activities take time. With non-contact sensing devices the parts can be inspected while in operation. The inspection can thus be completed in a fraction of a second.

iv. The on-line non-contact sensors are useful as the feedback element of adaptive control systems. These systems will be capable of making adjustments to the process variables based on analysis of the data including trend analysis. An example of the application of trend analysis can be found in the compensation of gradual wear of cutting tool in a machining operation. This would not only help to identify out-of-tolerance conditions but also to take corrective action. By regulating the process in this manner, parts will be made much closer to the desired nominal dimension rather than merely within tolerance. This will help to reduce scrap losses and improve product quality.

v. Sensor technology will not be the only manifestation of automation in CAQC. Intelligent robots fitted with computer vision and other sensors, as an integral part of completely automated test cells is also a feature of CIM.

vi. An important feature of QC in a CIM environment is that the CAD/CAM database will be used to develop inspection plan.

As mentioned earlier inspection can be either contact or non-contact type. The contact method usually involves the use of coordinate measuring machines (CMM).

OBJECTIVES OF CAQC

The objectives of computer-aided quality control are to:

i. Improve product quality
ii. Increase productivity in the inspection process
iii. Increase productivity
iv. Reduce lead-time
v. Reduce wastage due to scrap/rework

The strategy for achieving these objectives is basically to automate the inspection process through the application of computers combined with sensor technology. Where technically possible and economically feasible, inspection should be done on a 100% basis rather sampling.

Inspection techniques

Inspection techniques can be divided into two broad categories:

1.Contact Inspection.

2.Non-contact Inspection

CONTACT INSPECTION TECHNIQUES

Contact inspection involves the use of a mechanical probe or other device that makes contact with the object being inspected. The purpose of the probe is to measure or gage the object in some way. By its nature, contact inspection is usually concerned with some physical dimension of the part. Accordingly, these techniques are widely used in the manufacturing industries in particular in the production of metal parts (machining, stamping and other metalworking processes). The principal contact inspection technologies are:

- Conventional measuring and gaging instruments, manual and automated
- Coordinate measuring machines (CMMs) and related techniques
- Stylus type surface texture measuring machines

Conventional measuring and gaging techniques and coordinate measuring machines measure dimensions and related specifications. Surface texture measuring machines measure surface characteristics such as roughness and waviness.

Reasons why these contact inspection methods are technologically and commercially important include the following:

- They are the most widely used inspection technologies today.
- They are accurate and reliable.
- In many cases, they represent the only methods available to accomplish the inspection. Noncontact Inspection Technologies

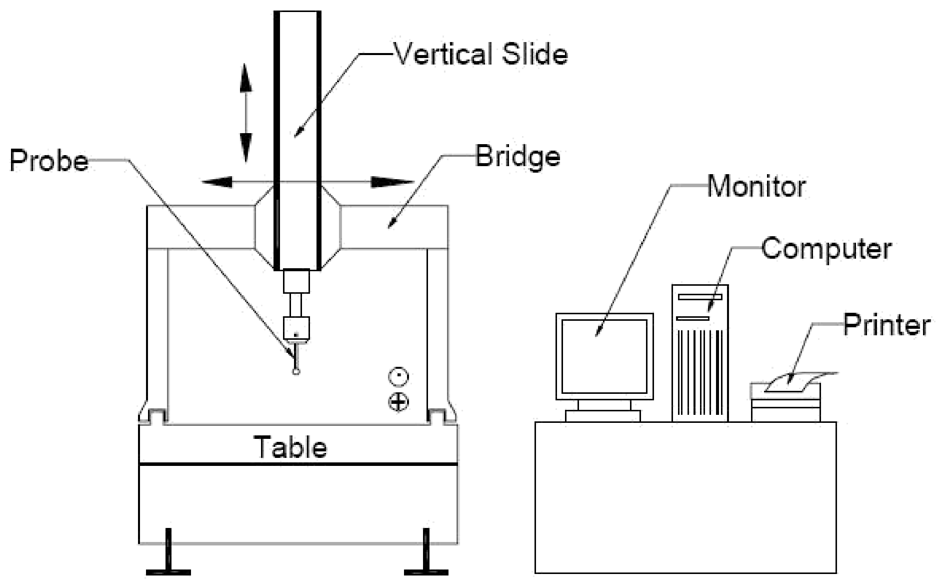
Noncontact inspection methods utilize a sensor located at a certain distance from the object to measure or gage the desired features. The noncontact inspection technologies can be classified into two categories: (1) optical and (2) non-optical. Optical inspection technologies make use of light to accomplish the measurement or gaging cycle. The most important optical technology is machine vision; however, other optical techniques are important in certain industries. Non-optical inspection technologies utilize energy forms other than light to perform the inspection; these other energies include various electrical fields, radiation (other than light), and ultrasonic. Noncontact inspection offers certain advantages over contact inspection techniques. The advantages include:

- Avoidance of damage to the surface that might result from contact inspection.
- Inherently faster inspection cycle times. The reason is that contact inspection procedures require the contacting probe to be positioned against the part, which takes time. Most of the noncontact methods use a stationary probe that does not need repositioning for each part.
- Noncontact methods can often be accomplished on the production line without the need for any additional handling of the parts, whereas special handling and positioning of the parts is usually required in contact inspection.

• Increased opportunity for 100% automated inspection. Faster inspection cycle times and reduced need for special handling means that 100% inspection is more feasible with noncontact methods.

COORDINATE MEASURING MACHINE

The coordinate measuring machine (CMM) is the most prominent example of the equipment used for contact inspection of parts. When used for CIM these machines are controlled by CNC. A typical three-dimensional measuring machine consists of a table, which holds the part in a fixed, position, and movable head, which holds a sensing, probe. The probe can be moved in three directions corresponding to the X, Y and Z Coordinates. For manual operation, the control unit is provided with joysticks, or other devices which drive X, Y and Z servo motors (AC/DC). During operation, the probe is brought into contact with the part surface to be measured and the three co-ordinate positions are indicated to a high level of accuracy. Typical accuracies of these machines are in the neighborhood of + 0.004 mm with a resolution of 0.001 mm. The measuring accuracy of a typical CMM is quoted 2.6 + L/300 micrometers, where L is the measured length in mm.



A typical CNC CMM

The major features of a CMM are:

(i) ***Stationary granite measuring table:*** Granite table provides a stable reference plane for locating parts to be measured. It is provided with a grid of threaded holes defining clamping locations and facilitating part mounting. As the table has a high load carrying capacity and is accessible from three sides, it can be easily integrated into the material flow system of CIM.

(ii) ***Length measuring system:*** A 3-axis CMM is provided with digital incremental length measuring system for each axis.

(iii) ***Air bearings:*** The Bridge, cross beam and spindle of the CMM are supported on air bearings with high rigidity. They are designed insensitive to vibrations.

(iv) ***Control unit:*** The control unit allows manual measurement and self-teach programming in addition to CNC operation. The control unit is microprocessor controlled. Usually a joystick is provided to activate the drive for manual measurement.

CNC Measuring Centres are provided with dynamic probe heads and a probe changing system, which can be operated manually or automatically.

(v) ***Software:*** The CMM, the computer and the software together represent one system whose efficiency and cost effectiveness depend to a large extent on the software.

The features of CMM software will include:

• Measurement of diameter, centre distances, lengths, geometrical and form errors in prismatic components etc.
• On-line statistics for statistical information in a batch.
• Parameter programming to minimize CNC programming time of similar parts.
• Measurement of plane and spatial curves.
• Data communications.
• Digital input and output commands for process integration.
• Programs for the measurement of spur, helical, bevel and hypoid gears.
• Interface to CAD software.

Typical software may also provide a generalized method for reverse engineering complex shaped objects. The component is digitized, taking a dense set of points, using a CNC CMM. The digitized data is then converted into a computer model, which describes the true surface of the component, with allowance for the digitizing probe diameter. The model may then be expanded, offset or mirrored to an allowance for the manufacturing process.

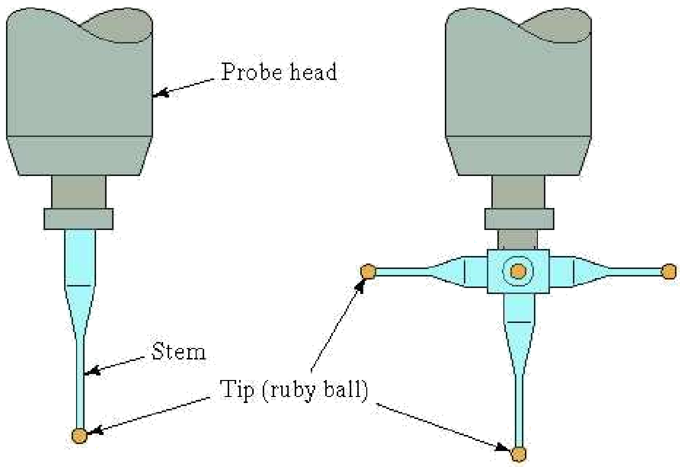
Recent advances in CMM technology are based largely on greater intelligence features provided by the computer software. These advances include the capability for automatic work part alignment on the table, interactive programming of the CMM for inspection personnel who are not experienced in the use of computers. Besides this, the software has the capability to orient the coordinate system as required (between polar and Cartesian coordinate systems). Similarly translation of origin can be effected as desired.

Savings in inspection time by using CMM are significant. Typically between 5 and 10% of the time is required on a CMM compared to traditional manual inspection methods. Other advantages include consistency in the inspection process from one part to the next, which cannot be matched by manual inspection, and reductions in production delays to get approval of the first workpiece in a batch.

Contact Probe Configurations

There are two types of probe configurations. They are:

(a) Single tip and (b) multiple tip probes



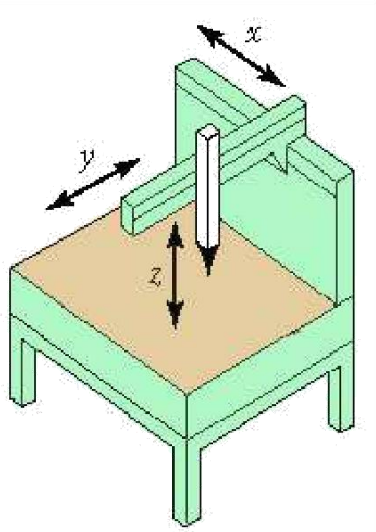
ADVANTAGES OF CNC OPERATION OF CMM

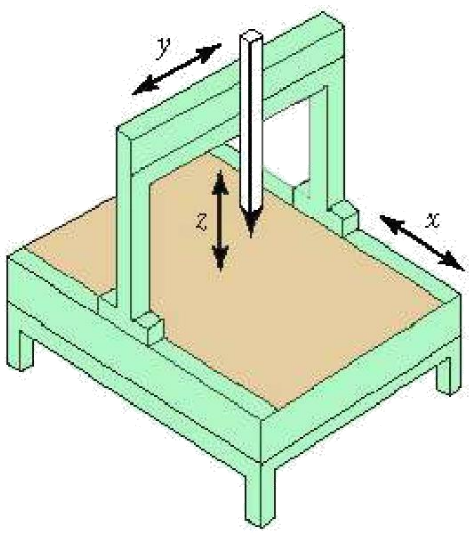
CNC operation increases cost effectiveness through the following advantages:

i. Shorter measuring times
ii. Higher throughput rates
iii. Better repeatability
iv. Economical even for small batches
v. Simple operation
vi. Unmanned second and third shift inspection of parts if parts are loaded automatically.

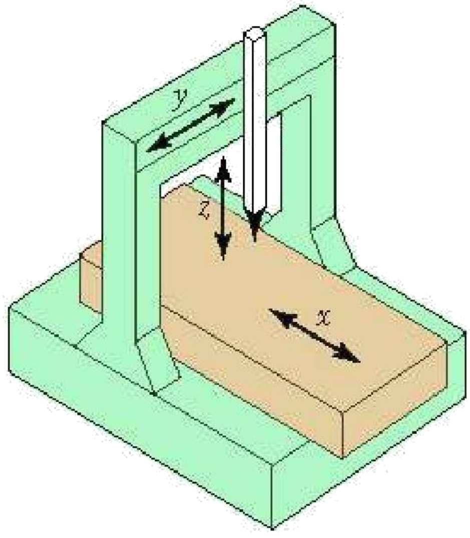
CMM Mechanical Structure Types

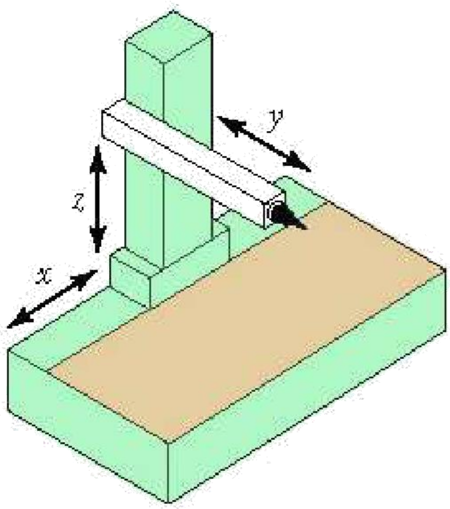
Six common types of CMM mechanical structures: 1.Cantilever
2.Moving bridge
3.Fixed bridge
4.Horizontal arm
5.Gantry
6.Column



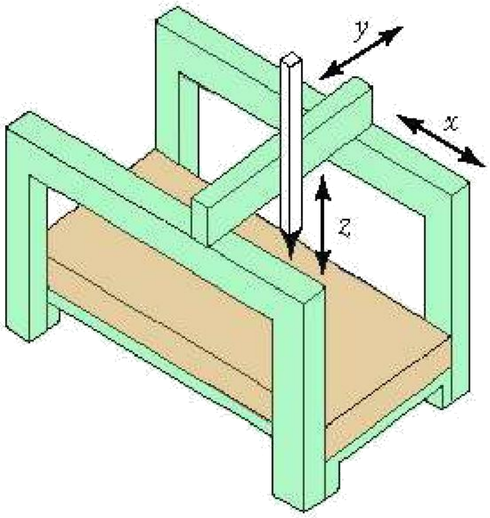


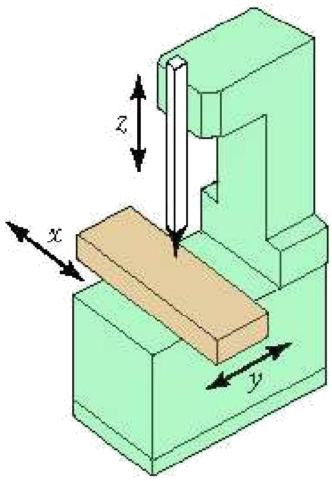
(a) Cantilever and (b) moving bridge structure





(c) Fixed bridge and (d) horizontal arm (moving ram type)





(e) Gantry and (f) column

NON-CONTACT INSPECTION METHODS

Non-contact inspection methods utilize a sensor located at a certain distance from the object to measure or gage the desired features.

The non-contact inspection technologies can be classified into two categories:

1. Optical inspection
2. Non-optical inspection

Optical inspection technologies make use of light to accomplish the measurement or gaging cycle. The most important optical technology is *machine vision*.

Non-optical inspection technologies utilize energy forms other than light to perform the inspection: these other energies include various electrical fields, radiation, and ultrasonics.

Optical inspection technologies

The field of non-contact inspection, in particular optical inspection is composed of the following basic areas:

i. Inspection of part dimensions.
ii. Inspection of surface defects.
iii. Inspection of completed or semi-completed parts.

The main advantages of non-contact inspection are:

i. It eliminates the need to reposition the workpiece.
ii. Non-contact inspection is faster than contact inspection.
iii. There is no mechanical wear encountered in the contact inspection probe.
iv. The possibility of damage to the surface of a part due to measuring pressure is eliminated. Some of the examples of non-contact inspection are laser interferometer measuring system, laser telemetric measuring system, machine vision system and optical gauging. These are discussed below.

MEASUREMENTS WITH LASERS

Laser stands for light amplification by stimulated emission of radiation. Lasers for measurement are low-power gas lasers that emit light in the visible range. Laser light beam is:

- Highly monochromatic - the light has a single wave length
- Highly collimated - the light rays are parallel

These properties have motivated many applications in measurement and inspection.

SCANNING LASER SYSTEMS

Laser beam deflected by a rotating mirror to sweeps a beam of light past an object. Photodetector on far side of the object senses the light beam during its sweep except for the short time while it is interrupted by the object. This time period can be measured quickly with great accuracy. A microprocessor system measures the time interruption related to the size of the object in the path of the laser, and converts it to a linear dimension.

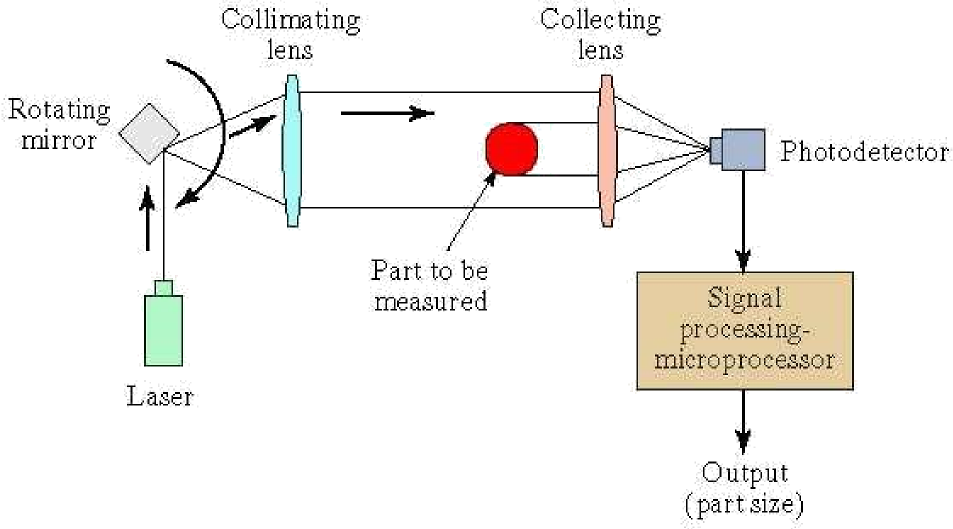
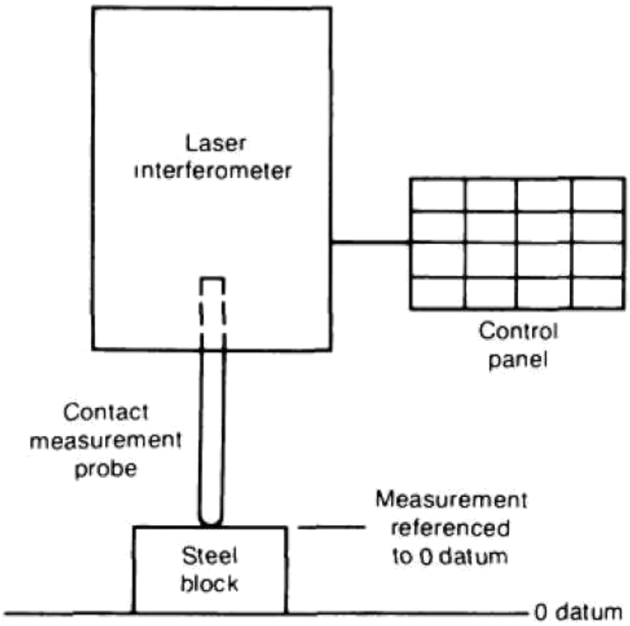


Figure Scanning laser system

LASER INTERFEROMETER MEASURING SYSTEM

Presently lasers are used as length measuring devices. They are commonly used for positional accuracy measurements. They are also used as length measuring machines of high accuracy (accuracy of the order of 0.01 micrometer). The feedback of this can be used for positioning of the machine and also for computation of measurements.

Nowadays it has become a common practice to use laser-measuring system for the calibration of CNC machines. Using laser-measuring system the measurements performed are reliable, accurate and faster compared to conventional methods. The laser interferometer can be directly interfaced with a computer. This makes it easy for the operator to evaluate the results as per the evaluation procedures mentioned in various standards like AMT, AFNOR, VDI, MTTA, and JIS etc. Using different attachments laser interferometer is also used for other measurements like straightness, flatness, squareness, velocity, pitch, yaw etc.



Laser interferometer measuring system

LASER TELEMETRIC MEASURING SYSTEMS

This is a high speed gauging system providing accuracy and repeatability of a contact type gauge with versatility of a non-contact type of gauge. The principle is explained below:

A thin band of laser beam projects from a transmitter to receiver. When an object is placed across the beam, the object casts a shadow. The signal from light entering the receiver is used by the microprocessor to detect the shadow and to calculate the dimension represented by the distance between the edges of the shadow.

The system consists of three modules:

i. Transmitter module

ii. Receiver module

iii. Processor electronics

The transmitter module contains a low power He-Ne gas laser and its power supply, a specially designed collimating lens, a synchronous motor, multi-faced reflector prism, a synchronous pulse detector and protective window. This produces a collimated parallel scanning laser beam moving at a high and constant speed. The scanning beam appears as a line of red light. The receiver module collects and photo electrically senses the laser light transmitted past the object being measured. The processor electronics takes the receiver signals and converts them to digital signal and displays the dimensions being gauged.

The information thus collected is processed not only to qualify or classify a part but also can be used to correct the manufacturing process that might have caused the undesirable deviation. This is done automatically without touching the part and without the need for human intervention. The microprocessor actuates precise computer control of continuously manufactured parts. The prompting formats guide the operator regarding the gauge setting. The operational procedures notify the operator in case any error occurs in the system by displaying error message on the CRT terminal. It also keeps the operator informed about the product in the production process, displays, prints out and records the complete measured and analyzed results.

Laser telemetric measuring systems give out a number of signal outputs and processing options to make the dimensional measurement more useful in production environment. Examples are listed below:

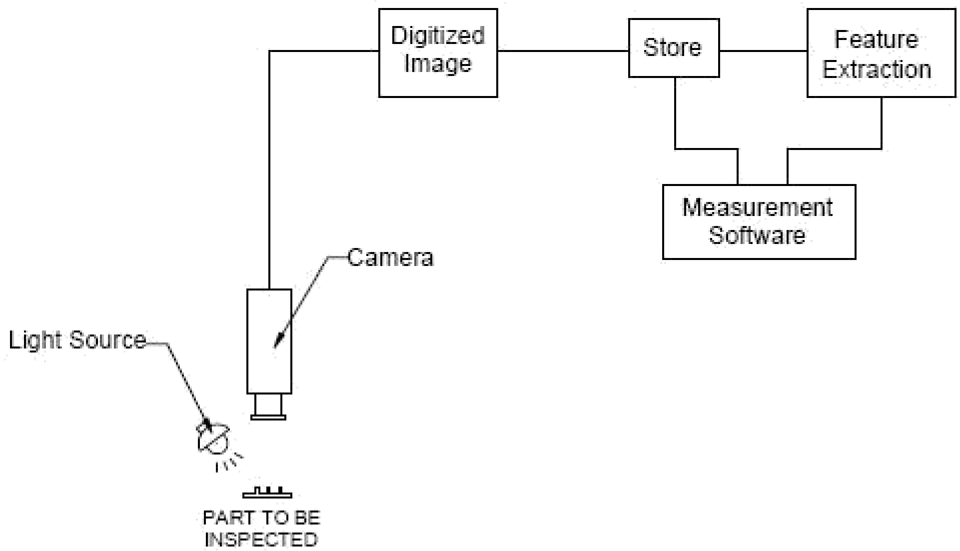
i. A high/low limit alarm option, which activates lights and connector panel, output when the tolerance limits are exceeded.

ii. A process control option, which makes it possible to provide a closed loop control of the diameter of a continuously processed product. The chart recorder and instrumentation interface provide both an analog output for plotting deviation and a RS-232C for digital transmission of other instruments and controls.

VISION SYSTEM

A vision system can be defined as a system for automatic acquisition and analysis of images to obtain desired data for interpreting or controlling an activity. In a broader sense, the term is applied to a wide range of non-contact electro-optical sensing techniques from simple triangulation and profiling to a 3D object recognition technique. These are based on sophisticated computerized image analysis routines. The applications range from relatively simple detection and measuring tasks to full-blown robot control, which include quality assurance, sorting, material handling and process control, robot guidance, calibration and testing, machine monitoring and safety.

The schematic diagram of a typical vision system is shown in Fig 14.2. This system involves image acquisition, image processing or image analysis and interpretation. Acquisition requires appropriate lighting, the use of electronic camera and means of storing a digital representation of the image. Processing involves manipulating the digital image to simplify and reduce number of data points that must be handled by subsequent analytical routines used to interpret the data. Computers with suitable softwares are used for this purpose.



Typical Vision System

By using the vision systems measurements can be carried out at any angle along all the three reference axes X, Y and Z without contacting the part. The measured values of the component parameters are then compared with the specified tolerances, which are stored in the memory of the computer.

The measured values, the specified values with the deviation and an indicating on whether the part is passed or not passed are displayed on the VDU. Using a sorting system it is also possible to sort the parts based on these results.

Computer vision systems offer several advantages like reduction of tooling and fixture costs, elimination of need for precise part location for handling by robots and integrated automation of dimensional verification and defect detection.

NON-OPTICAL INSPECTION TECHNIQUES

- Electrical field techniques
    - Reluctance, capacitance, inductance
- Radiation techniques
    - X-ray radiation
- Ultrasonic inspection methods
    - Reflected sound pattern from test part can be compared with standard
    - Parts must always be presented in the same position and orientation relative to the probe

ELECTRIC CURRENT PERTURBATION (ECP)

ELECTRIC CURRENT PERTURBATION (ECP) is an electromagnetic nondestructive evaluation method for detecting and characterizing defects in non-ferromagnetic material. Laboratory evaluations have shown that this method can detect very small surface and subsurface cracks in both low- and high-conductivity metals (for example, titanium and aluminum alloys).

The principle by which ECP detects flaws is illustrated in Fig. 1. An electric current density, j_0, is introduced into the region to be inspected, thus producing an associated magnetic-flux density, B_0 (Fig. 1a). A flaw perturbs the current flow, as shown in Fig. 1(b), and the flux density is changed by an amount ΔB. Flaw detection is accomplished by sensing this change in flux density, ΔB, with a magnetic-field sensing device (Fig. 2). The sensor coils are oriented to detect the x-axis component of the magnetic flux.

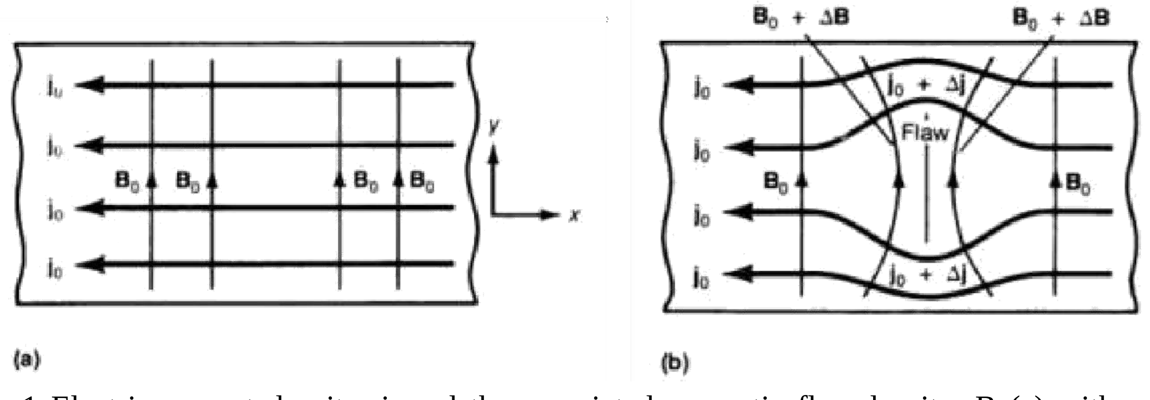


Fig. 1 Electric current density, j, and the associated magnetic flux density, B (a) with no surface flaw and (b) with a flaw (for example, a crack) perpendicular to the current flow

ULTRASONIC INSPECTION

ULTRASONIC INSPECTION is a nondestructive method in which beams of high-frequency sound waves are introduced into materials for the detection of surface and subsurface flaws in the material. The sound waves travel through the material with some attendant loss of energy (attenuation) and are reflected at interfaces. The reflected beam is displayed and then analyzed to define the presence and location of flaws or discontinuities.

Most ultrasonic inspection instruments detect flaws by monitoring one or more of the following:

- Reflection of sound from interfaces consisting of material boundaries or discontinuities within the metal itself
- Time of transit of a sound wave through the test-piece from the entrance point at the transducer to the exit point at the transducer
- Attenuation of sound waves by absorption and scattering within the test-piece
- Features in the spectral response for either a transmitted or a reflected signal

NON-CONTACT CNC CMM

The non-contact CNC CMM inspects a part by observing it with a video camera, analyzing the image and outputting the results. The construction of this CMM is similar to that of a conventional CMM. These are particularly useful to measure the following workpieces, which are difficult to measure with contact method:

- Printed circuit boards.
- Pins and connectors.
- Injection molded plastic items.
- Pressed parts.
- IC package.
- Ceramic parts.
- Photoelectric parts.
- Etched parts.

Some non-contact CMM's operate using laser digitization technique. These are particularly suitable for measurement of complex 3-D surfaces. This equipment makes product data generation for reverse engineering an easy task.

COMPUTER AIDED INSPECTION USING ROBOTS

Robots can be used to carry out inspection or testing operations for mechanical dimensions and other physical characteristics and product performance. Generally robot must work with other pieces of equipment in order to perform the operations. Examples include machine vision systems, robot manipulated inspection and/or testing equipment.

Checking robot, programmable robot, and co-ordinate robot are some of the titles given to multi-axis measuring machines aimed at high-speed measurement. These machines automatically perform all the basic routines of a CNC co-ordinate measuring machine but at a faster rate than that of a CMM. These machines are designed to be used in environments such as shop floor. They are not as accurate as precision CMM's but they can check up to accuracies of 5 micrometres which is often sufficient for many applications. However, quality levels can be improved by increasing the number of inspections. By using robots the dimensional drifts can be accurately and quickly detected and the appropriate process action can be taken. One example is, segregating the components according to the tolerance specifications.

Using the modern touch trigger probe, a co-ordinate robot or a pair of robots can take successive readings at high speed and evaluate the results using a computer graphics based real time statistical analysis system. This gives high-speed data processing of measured information and can provide early warning of rejection. The computer also monitors the geometry and wear of the tools, which produce the component. After the measurement, if the component is not acceptable it is placed on a conveyor where it slides under gravity into REJECT bin.

INTEGRATED COMPUTER AIDED INSPECTION SYSTEMS

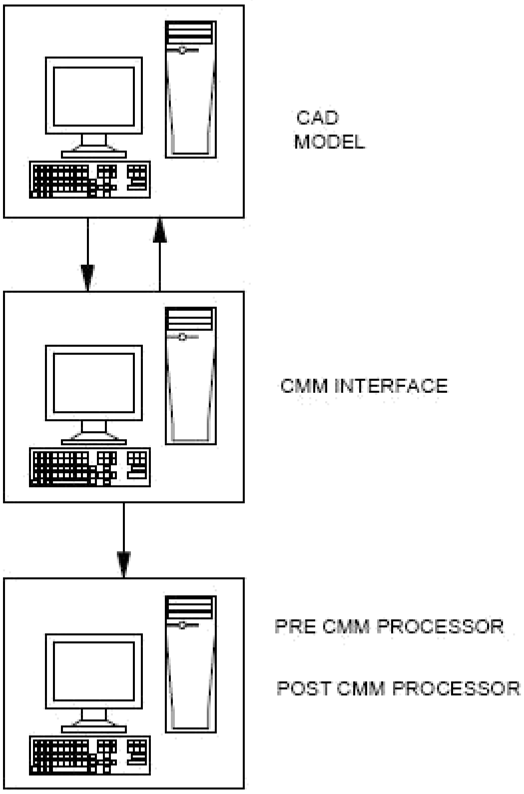
Automation in industries is intended to provide a batch oriented manufacturing. The integration of the activities starting from design to the part coming out of the factory leads to total automation. This closes the loop in a computer integrated manufacturing system. Some of the integrated systems are available in different configurations, examples being integrated CAD/CAM/CAI Systems with robots etc. Some of these are discussed in the following sections:

INTEGRATION OF CAD/CAM WITH INSPECTION SYSTEM

CAD/CAM systems are seen as a natural adjunct to automatic gauging wherein a product is designed, manufactured and inspected in one automatic process. There is a strong trend in the direction of a closed loop, fully adaptive manufacturing system.

One of the critical factors in manufacturing quality assurance is to ensure that every part coming off the production line is within design tolerance. The successful factory constantly monitors quality at each step of design and manufacturing process. In the shop, the coordinate measuring machine assists in this quality assurance function. The productivity of the coordinate measuring machine can be improved by interfacing with a CAD/CAM system. Interfacing with the CAD/CAM database, the operator can use the off-line programming capabilities of the CMM interface to process the input values for the part geometry being measured. This eliminates the laborious manual data entry techniques and reduces preparation time and increases availability of CMM for inspection.

The CAD/CAM-CMM interface helps the programming efforts in the quality assurance office where quick response to engineering changes can be made and current data to the CMM can be provided. Generally the CAD/CAM-CMM interface consists of a number of modules as shown in Fig.



CAD/CAM-CMM Interface

i. CMM-Interface: This interface allows interacting with the CAD/CAM database to generate a source file that can be converted to a CMM control data file. During source file creation, CMM probe path motions are simulated and displayed on the CAD/CAM workstation for visual verification.

   A set of CMM command statements allow the CMM Interface to take advantage of most of the CMM's functional capabilities. These command statements include setup, part datum control, feature construction, geometric relations, tolerancing, output control and feature measurements like measurements of lines, points, arcs/circles, splines, conics, planes, analytic surfaces, tabulated cylinders and sculptured surfaces.

ii. Pre-CMMprocessor: The pre-CMM processor converts the language source file generated by CMM Interface into the language of the specified Coordinate Measuring Machine. The output is a file stored in the CAD/CAM host operating system level. Whenever, a statement is encountered which is not supported by the selected CMM, the pre-CMM processor will display a warning message. This allows generation of multiple CMM control data files from one source file.

iii. Post-CMM processor: The post-CMM processor creates wire frame surface model from the CMM-ASCII output file. Comments are inserted into the ASCII-CMM output file to control the creation of the CAD/CAM entities, which include points, lines, arcs/circles, conics, splines and analytic surfaces.

PONDICHERRY UNIVERSITY
PREVIOUS YEAR QUESTIONS

Part-A ***Two Marks***

UNIT I

1. What are the types of network?
   Common examples of area network types are:
   - LAN - Local Area Network
   - WLAN - Wireless Local Area Network
   - WAN - Wide Area Network
   - MAN - Metropolitan Area Network
   - SAN - Storage Area Network, System Area Network, Server Area Network, or sometimes Small Area Network
   - CAN - Campus Area Network, Controller Area Network, or sometimes Cluster Area Network
   - PAN - Personal Area Network
   - DAN - Desk Area Network
2. Define CIM. / Define Computer Integrated Manufacturing.
   CIM is the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organizational and personnel efficiency.
3. List the various components of CIM.
   CAD, CAM, CAE, Network cables
4. List the types of network topologies.
   The study of network topology recognizes five topologies:
   - Bus topology
   - Star topology
   - Ring topology
   - Tree topology
   - Mesh topology
5. Define the term automation. / Define Automation.
   Automation is generally defined as the process of having machines follow a predetermined sequence of operations with little or no human labour, using specialized equipment and devices that performs and control manufacturing processes.
6. Write any two topologies used in local area networks.
   - Bus topology
   - Tree topology
7. What are the benefits of computer integrated manufacturing? / Write the benefits of CIM.
   - Improved customer service
   - Improved quality
   - Shorter time to market with new products
   - Shorter flow time
   - Shorter vendor lead time
   - Reduced inventory levels
   - Improved schedule performance
   - Greater flexibility and responsiveness

- Improved competitiveness
- Lower total cost
- Shorter customer lead time
- Increase in manufacturing productivity
- Decrease in work-in process inventory

8. Write the types of LAN networks.
   Local area networks are of two types:
   i. Client/server
   ii. Peer-to-Peer.
9. Write the implementation issues of CIM.
   - Implementation cost is high.
   - It is hard to distribute information among different computer based systems
10. What are the types of communication lines?
    Power line communication or power line carrier (PLC), power line digital subscriber line (PDSL), mains communication, power line telecom (PLT) & Broadband over power lines (BPL).

UNIT II

11. List down some of the drawing features in CAD packages.
    Line, Polyline, Circle, Rectangle, Polygon, etc.
12. Enumerate the typical applications of CAD/CAM.
    Geometry modeling of components, Mechanism analysis and Digital Manufacturing.
13. Define manufacturing database.
    Manufacturing Data is the information as to how the parts are to be manufactured is available in production data. The collection of this manufacturing data as a database is called as manufacturing database
14. Define Computer Aided Engineering.
    Computer-aided engineering (CAE) 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.
15. What is meant by DBMS?
    DBMS stands for Database management system. A program or collection of programs which lets you manage information in databases. The program we use to organize our data and the actual data structure we create with that program.
16. Write the application of CAD in industries.
    Geometry Modeling- 2D & 3D and Prototype Developing.
17. Define the term data and database management.
    Data is defined as a file or information about an entity that can be used to form a database.
    Database management involves:
    - Organize a database.
    - Add new data to the database.
    - Sort the data in some meaningful order.
    - Search the database for types of information.
    - Print the data into formatted reports.
    - Edit the data.
    - Delete the data.
18. What are the objectives of a database?
    A database serves the following objectives:

- Reduce or eliminate redundant data
- Integrate existing data
- Provide security
- Share data among users
- Incorporate changes quickly and effectively
- Exercise effective control over data
- Simplify the method of using data
- Reduce the cost of storage and retrieval of data
- Improve accuracy and integrity of data

19. List out the benefits of product design.

Increased productivity

Cost Reduction

Detailed Planning about the product

UNIT III

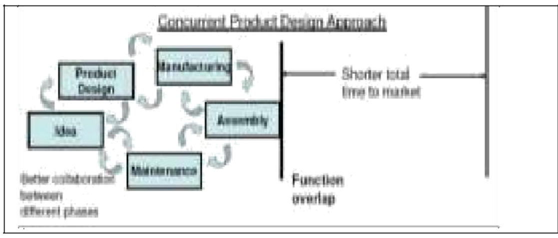
1. What is Process planning? / Define the term process planning.

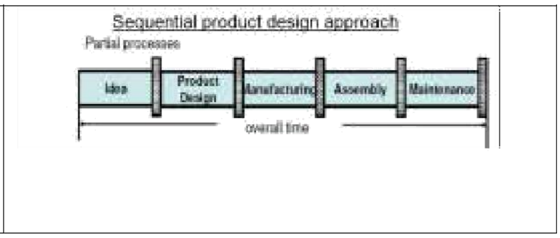
   Process planning consists of preparing a set of instructions that describe how to fabricate a part or build an assembly which will satisfy engineering design specifications. Process planning is the systematic determination of the methods by which product is to be manufactured, economically and competitively.
2. Define Reverse Engineering. / What is meant by reverse engineering concepts?

   It is the process of duplicating an existing component, subassembly, or product, without the aid of drawings, documentation, or computer. This process helps in generating documentation for the old products.
3. Define Computer Aided Process Planning.

   Computer-aided process planning (CAPP) is the use of computer technology to aid in the process planning of a part or product, in manufacturing.
4. Compare concurrent and sequential engineering.

Concurrent Engineering (CE)	**Sequential Engineering (SE)**
Concurrent engineering or Simultaneous Engineering is a methodology of restructuring the product development activity in a manufacturing organization using a cross functional team approach and is a technique adopted to improve the efficiency of product design and reduce the product development cycle time.	It is a sequential process of developing a product thus taking long time to complete the product.
Concurrency implies that members of the multidisciplinary project team work in parallel.	Multidisciplinary project teams works in a sequence such that some team awaits results from their previous team.





5. Write the benefits of CAPP.
   Cost savings were achieved.
   Reduced process planning and production lead-time
   Greater process plan consistency
   Fewer calculation errors
   Improved production scheduling & improved ability to introduce new manufacturing technology
6. What is meant by design for manufacturability?
   Design for manufacturability (DFM) is the practice of designing products with manufacturing in mind. It simultaneously considers all of the design goals and constraints for product that will be manufactured.
7. What is the need for computer aided process planning?
   Simplify and improve process planning and achieve more effective use of manufacturing resources

UNIT IV

8. What is MRP?
   Material requirements planning (MRP) is a planning technique, usually implemented by computer- that translates the Master Production Schedule of end products into a detailed schedule for the raw materials and parts used in those end products.
9. What is JIT? / What is meant by Just-in-Time Production system?
   Just-in-time production systems. The term "just-in-time" refers to a scheduling discipline in which materials and parts are delivered to the next work cell or production line station just prior to their being used. This type of discipline tends to reduce inventory and other kinds of waste in manufacturing.
10. Define MRP II.
    Manufacturing resource planning. Also known as MRP II, Manufacturing resource planning combines Material requirements planning (MRP) and capacity planning as well as shop floor control and other functions related to Production Planning Control.
11. List any two application examples of voice technology.
    - Google Search using voice command
    - Voice command enabled calling options
12. Write out the JIT improvement techniques?
    The term "just-in-time" refers to a scheduling discipline in which materials and parts are delivered to the next work cell or production line station just prior to their being used. This type of discipline tends to reduce inventory and other kinds of waste in manufacturing.
13. What is meant by PLC?
    Programmable Logic Controller (PLC) is a digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control, through digital or analog input/output modules, various types of machines or processes.
14. Mention the types of bar codes used for data capture systems.

Most commonly used bar codes are:

i. Universal Product Code (UPC)
ii. Interleaved 2 of 5 (ITF)
iii. Code 39

15. What are the goals of JIT?
    - To minimize inventories,
    - To reduce products that are Work In Progress (WIP)
16. What are the inputs and outputs of the MRP?
    Material requirements planning (MRP) uses information from the bills of material, inventory, shop and purchase orders, and the master schedule to draw a detailed material requirements plan.

UNIT V

17. What is Inventory Control?
    Inventory control includes a variety of techniques for managing the inventory of a firm. One of the important tools in inventory control is the economic order quantity formula.
18. What are the elements of TQM?
    To achieve TQM in an enterprise must concentrate on the following eight elements:
    Ethics, Integrity, Trust, Training, Teamwork, Leadership, Recognition & communication.
19. List any two major benefits of Computer Aided Quality Control.
    - Improve product quality
    - Increase productivity in the inspection process
    - Reduced lead-time to complete the parts
    - With non-contact sensing devices the parts can be inspected while in operation
20. Write a short notes on total productive maintenance. / What is meant by Total Productive Maintenance? / Define TPM.
    Total Productive Maintenance (TPM) is a maintenance process developed for improving productivity by making processes more reliable and less wasteful. TPM is an extension of TQM (Total Quality Management). The objective of TPM is to maintain the plant or equipment in good condition without interfering the daily process. To achieve this objective, preventive and predictive maintenance is required.
21. What are the advantages of non-contact inspection?
    Avoidance of damage to the surface, faster inspection cycle times & automated inspection
22. List out the objectives of computer aided quality control.
    To simplify and improve process planning and to achieve more effective use of manufacturing resources.

Part-B ***Eleven Marks***

UNIT I

1. Explain the components of a Local Area Network and Network topologies.
2. Explain the nature and role of the elements of CIM system.
3. Write a critical note on the hardware and software requirements of a typical CIM system. (6+5).
4. With a suitable illustration, describe the seven layers of networking. (11)
5. Explain the terms in CIM. (a) Hardware (b) Software (c) Workstation.
6. What is manufacturing automation protocol (MAP) explain it.
7. With a block diagram, explain the CIM wheel along with the features of CIM systems.
8. Explain in detail various networking methods with the necessary sketches.
9. (a) Define CIM. Explain the various elements of CIM system with a sketch. (b) Explain the benefits of CIM.
10. (a) Explain the open system interconnection architecture formulated by ISO. (b) What are the different Network Topologies available?

UNIT II

1. Explain the design process in CAD. / Explain the step-by-step procedure of product design.
2. Explain three phases of shop floor control.
3. (a) Write a note on database management. (6) (b) List any five major benefits of CAD.
4. Explain database models and data management techniques.
5. Explain the features of DBMS and database model.
6. Write short notes on (a) Design for manufacturing (b) CAE and CAM.
7. Write short note on: (a) RDBMS (b) Database requirements of CIM.
8. Write short notes on: (a) Stages in design process. (b) Benefits and applications of CAD.
9. Describe the architecture of a database management system.

UNIT III

1. Discuss the importance of process planning in product development.
2. Explain the retrieval and generative CAPP system.
3. (a).Write a note on generative CAPP. (b) Write a note on Concurrent Engineering
4. With suitable examples explain the concept of Design for manufacturability.
5. Discuss briefly the strategies for integrated product and process design objectives.
6. Explain a generative type computer aided process planning system with a neat sketch.
7. What is meant by Concurrent Engineering? Explain the steps in sequential engineering.
8. Explain the retrieval type of CAPP systems with a suitable sketch.
9. (a) Discuss the three database models.(7) (b) Explain the merits of relational database. (4)
10. Discuss the benefits of computer aided process planning (CAPP) and CAPP approaches in detail.

UNIT IV

1. Explain the structure and working of MRP system.
2. Discuss about the advantages and disadvantages of automatic data entry technologies.

3. (a) Write a note on Master Production Schedule. (b) Write a note on TQM.
4. With a suitable example, explain any two types of automated data collection system.
5. Discuss about the major steps involved in establishment process of JIT production system.
6. Explain the activities in a computer integrated production management systems.
7. Explain the role and structure of material resource planning with a block diagram.
8. Explain the RF identification and magnetic identification techniques used for automated data collection.
9. Explain briefly the despatching and Material Requirements Planning (MRP).
10. Explain the Manufacturing Resource Planning (MRP).

UNIT V

1. Discuss about contact and non-contact type inspection techniques.
2. Explain how to implement total productive maintenance (TPM).
3. (a).Write a note on the implementation issues of CIM. (b) Write a note on Just In Time
4. With a suitable example explain any two types of non-contact inspection methods.
5. With a neat sketch, explain the scanning laser beam devices for inspection work.
6. Explain the electrical field techniques applied to non-contact inspection techniques.
7. Discuss about any two concepts of TQM with suitable examples.
8. Discuss about the integration and implementation issues in CIM.
9. Define total quality management and explain its relevance to CIM.
10. Discuss major non-contact inspection methods.