

KNOWLEDGE INSTITUTE OF TECHNOLOGY,SALEM.
Department of Mechanical Engineering

**ME6703 - Computer Integrated Manufacturing
Systems
Presented by
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UNIT I

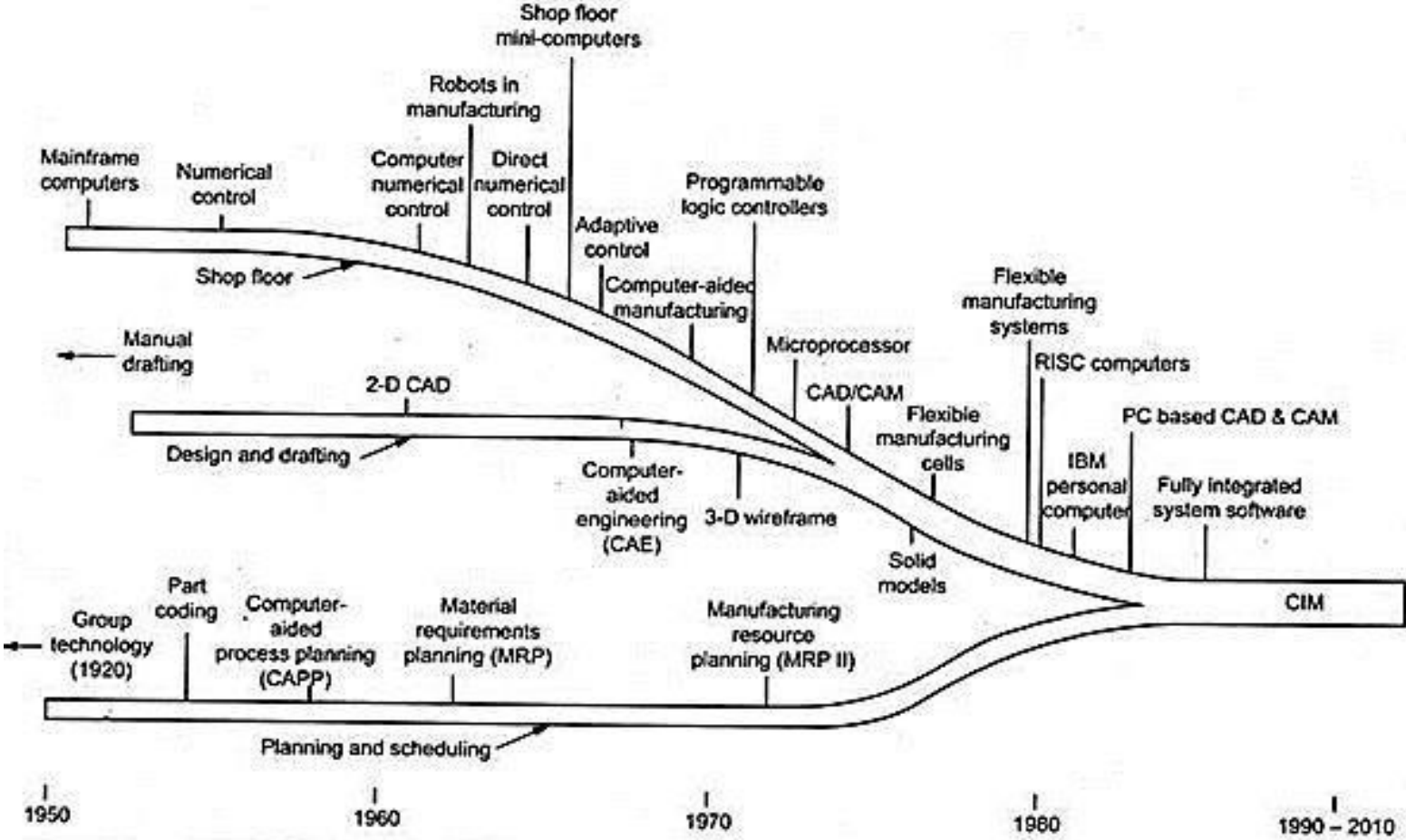
INTRODUCTION

Importance of CIM

Following factors have led to the development of the CIM concept and associated technologies:

1. Development of NC, CNC and DNC.
2. The advent and cost-effectiveness of computers.
3. Manufacturing challenges, such as
 - Global competition
 - High labour cost
 - Demand For quality products
 - Flexibility To meet the orders
 - Lower product cost
4. The capability-to-cost attractiveness of microcomputers.

Timeline of CIM



Activities of CIM

1. Evaluating and developing different product strategies.
2. Analysing markets and generating forecasts.
3. Analysing product/market characteristics and generating concepts of possible manufacturing system (i.e. FMS cells and FMS systems).
4. Designing and analysing components for machining, inspection, assembly and
all other processes relating to the nature of the component and/or product.

Activities of CIM

5 . Evaluating and/or determining batch sizes, manufacturing capacity,

scheduling and control strategies relating to the design and fabrication

processes involved in the particular product.

6. Analysis and feedback of certain selected parameters relating to the

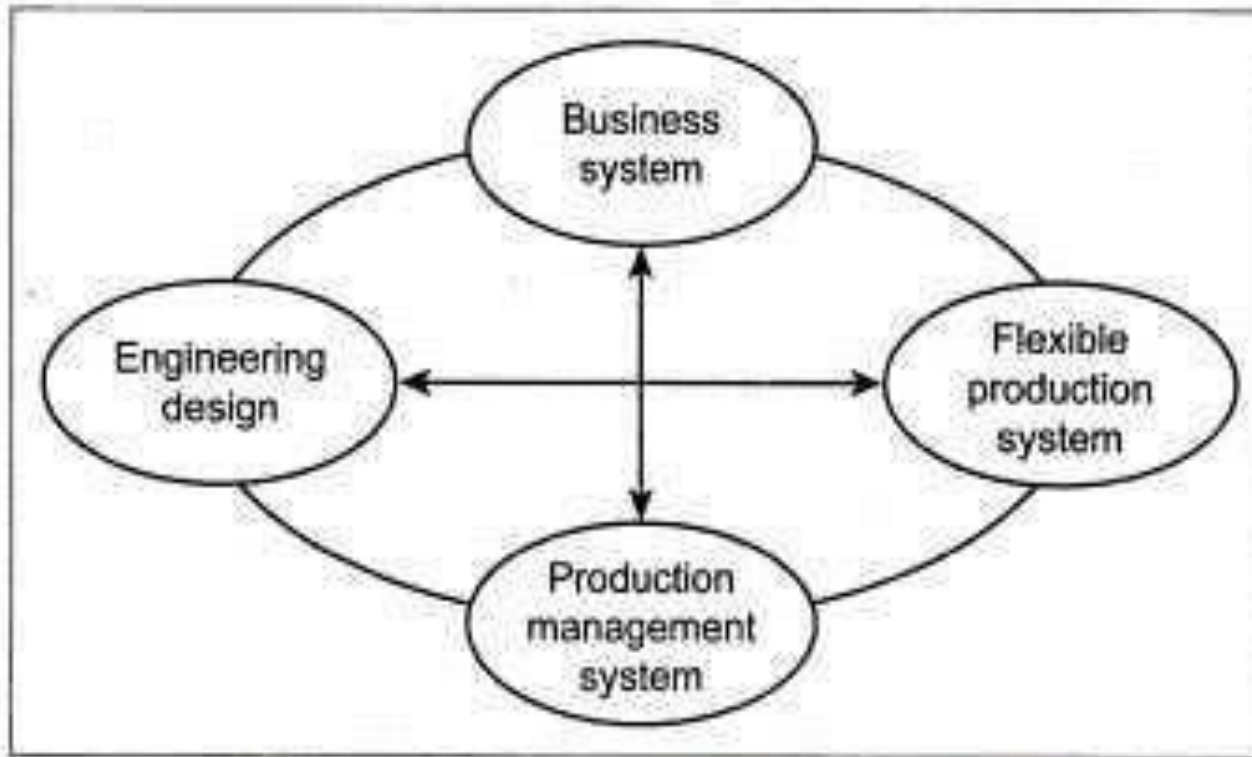
manufacturing processes, evaluation of status reports from the DNC system.

7. Analysing system disturbances and economic factors of the total system.

Elements of CIM System (Various Activities of CIM)

- ▶ CIM is a methodology and a goal rather than an assemblage of component and computers.
- ▶ The ideal CIM system operational functions manufacturing from order production to product delivery applies computer technology to all of the information processing through design and functions in

Elements of CIM System (Various Activities of CIM)



Elements of CIM System (Various Activities of CIM)

- ▶ At the broader level, CIM can be viewed as an integration of
 - Product and process design.
 - Production planning and control.
 - Production process.

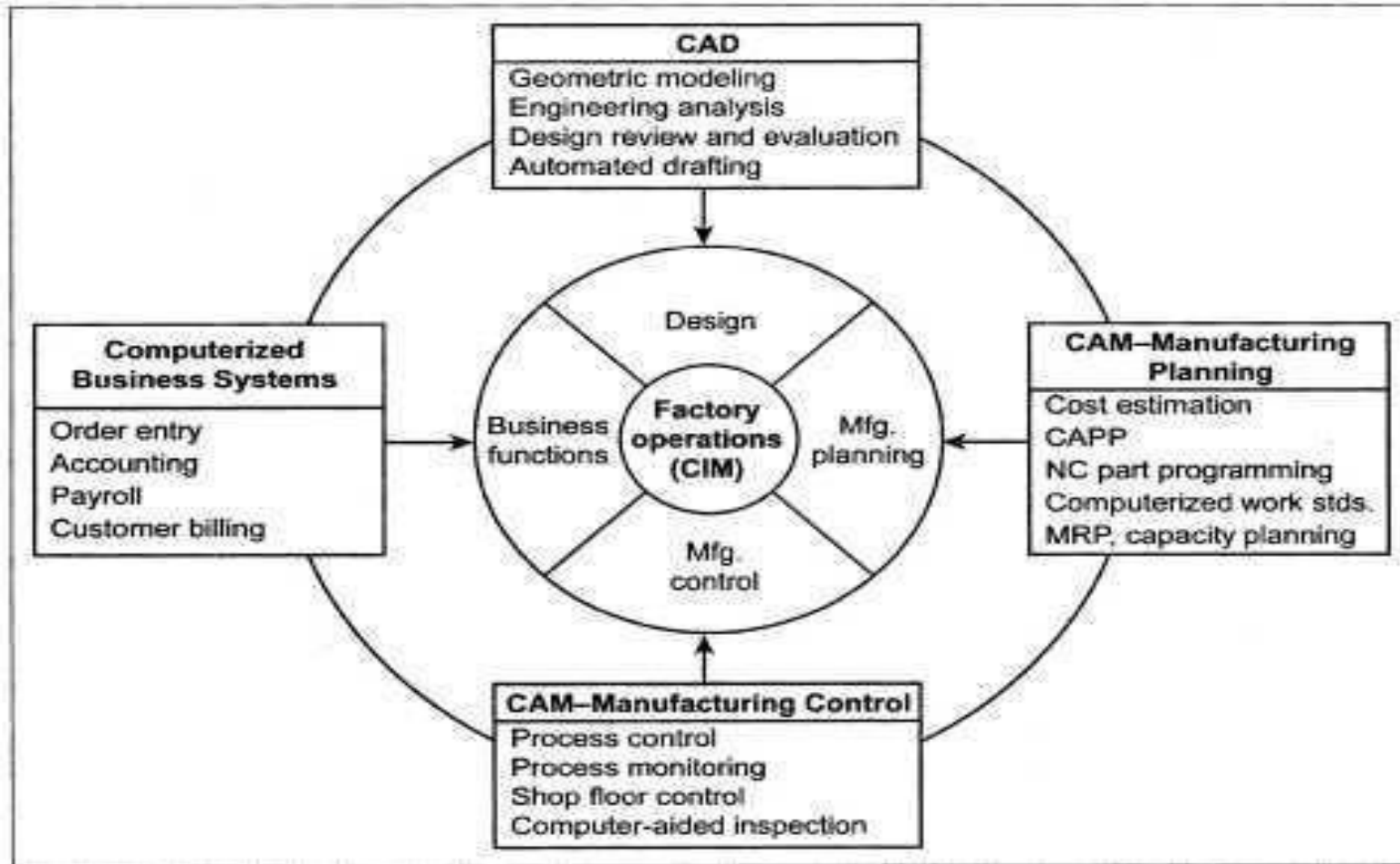
Elements of CIM System (Various Activities of CIM)

- ▶ Computer integrated manufacturing is the automated version of the manufacturing process .
- ▶ Three major manufacturing functions are product and process design, production planning and control and production process— are replaced by the automated technologies CAD/CAM, CAPP and automated material handling systems , Automated guided vehicles (AGVs) and computerised business systems like order entry, payroll and billing.

Elements of CIM System (Various Activities of CIM)

- ▶ CIM is also referred as completely automated factory with no human interference and factory of the future.
- ▶ CIM calls for the coordinated participation in all phases of manufacturing enterprises for the purpose of integration and supervision.
- ▶ Thus CIM includes:
 - ▶ Design of parts and components
 - ▶ Computer controlled flow of materials

Computerized elements of a CIM system



Subsystems of CIM

- ▶ CIM consists of subsystems that are integrated into a whole.
- ▶ These subsystems/elements consist of the following:
 - (i) Product design
 - (ii) Manufacturing planning
 - (iii) Manufacturing control
 - (iv) Business planning and support

Subsystems of CIM

- ▶ Subsystems are designed, developed and applied in such a manner that the output of one subsystem serves as the input of another system.
- ▶ These subsystems are usually divided into two functions as below:
 - ▶ Business planning functions
 - ▶ Business execution function

Subsystems of CIM

- ▶ 1. Business planning functions:

It Includes activities such as forecasting, scheduling, material-requirements planning, invoicing and accounting.

- ▶ 2. Business execution function:

It Includes production and process control, material handling, testing and inspection.

- ▶ Effectiveness of CIM depends greatly on the presence of a large-scale, integrated communications system involving computers, machines and their controls.

Islands of Automation

- ▶ The term 'islands of automation' represents the various technologies that facilitate manufacturing automation in isolation without having integrated with other manufacturing technologies.
- ▶ CIM represents the logical revolution of the islands of automation concept.
- ▶ As the 'islands' are not capable by themselves to bring out a 'big picture' of the entire manufacturing activities the evolution of CIM has become a natural evolution by the integration of these 'islands of automation'.

Types of Production

- ▶ Production activity is classified according to the quantity of product made.
- ▶ In this classification there are three types of production:
 - Job shop production.
 - Batch production.
 - Mass production.

Job Shop Production

- ▶ Job shop production is commonly used to meet specific customer orders and there is a great variety in the type of work the plant must do.
- ▶ Production equipment must be flexible and general purpose to allow for this variety of work.
- ▶ Skill level of job shop workers must be relatively high so that they can perform a range of different work assignments.
- ▶ Examples of products manufactured in a job shop include space vehicles, aircraft, machine tools, special tools and equipment and prototypes of future products.
- ▶ Construction work and shipbuilding are not normally identified with the job shop category.
- ▶ Though these two activities involve the transformation of raw

Batch Production

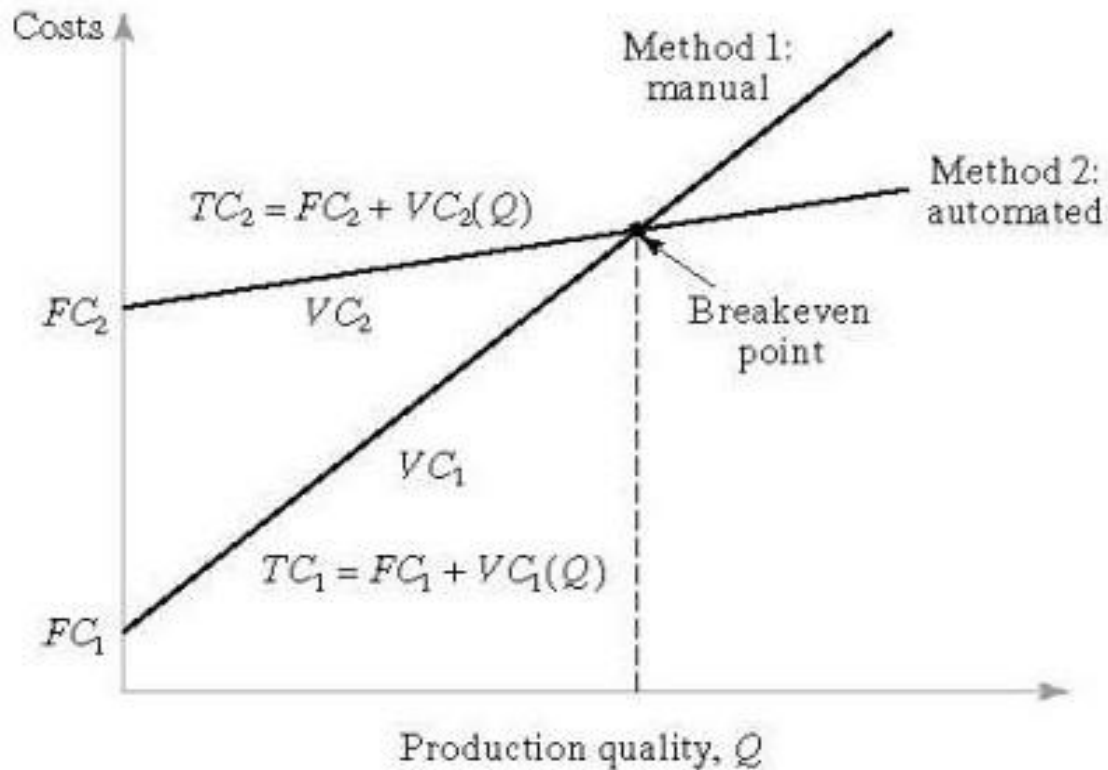
- ▶ It involves the manufacture of medium-sized lots of the same item or product.
- ▶ Lots may be produced only once, or they may be produced at regular intervals.
- ▶ Purpose of batch production is often to satisfy continuous customer demand for an item.
- ▶ Examples of items made in batch-type shops include industrial equipment, furniture, textbooks and component parts for many assembled consumer products (household appliances, lawn mowers, etc.).
- ▶ Batch production plants include machine shops, casting foundries, plastic moulding factories and press working shops.

Mass Production

- ▶ It involves continuous specialized manufacture of identical products.
- ▶ Characterized by very high production rates, equipment that is completely dedicated to the manufacture of a particular product and very high demand rates for the product.
- ▶ Equipment is not only dedicated to one product, but the entire plant is often designed for the exclusive purpose of producing the particular product.
- ▶ Equipment is special purpose rather than general-purpose.
- ▶ Investment in machines and specialized tooling is high.
- ▶ Production skill has been transferred from the operator to the machine.
- ▶ The skill level of labour in a mass production plant tends to be lower than in a batch plant or job shop.

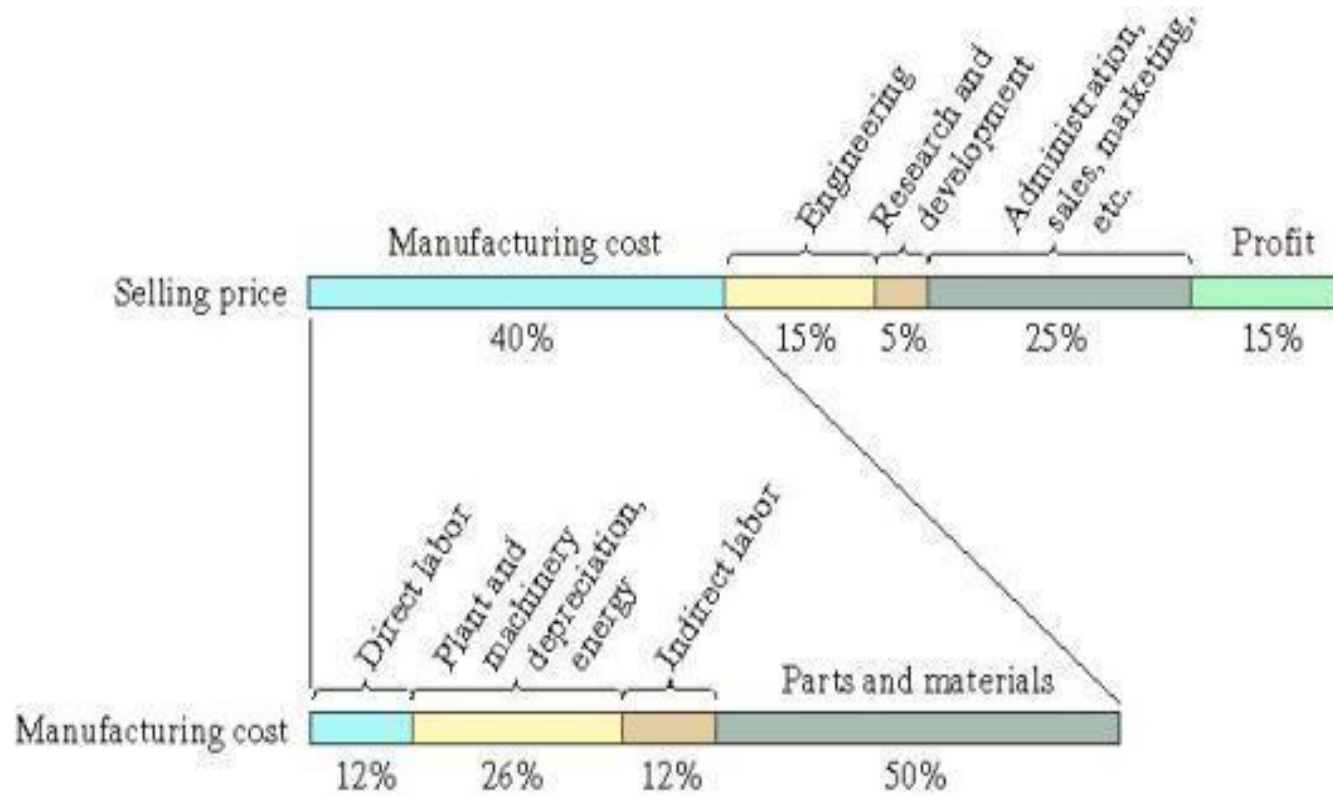
Manufacturing Models and Metrics

- Fixed and Variable Costs



Manufacturing Models and Metrics

- ▶ Typical Manufacturing Costs



Manufacturing Models and Metrics

- ▶ Overhead Rates

- ▶ Factory overhead rate:

$$FOHR = \frac{FOHC}{DLC}$$

- ▶ Corporate overhead rate:

$$COHR = \frac{COHC}{DLC}$$

Where, DLC = Direct labour costs

Manufacturing Planning & Control System

It includes the following functionalities:

- ▶ Restate business objectives in operations management terms.
- ▶ Ensure feasibility of plans.
- ▶ Identify gaps in current resources.
- ▶ Help formulate connective action-Suppliers.
- ▶ Prioritize activities - scheduling ,Facilitate feedback.

Master Production Schedule

▶ A detailed aggregation of production plan tends to be:

- Short time horizon
- More detailed product information
- More concern over capacity
- Corporate plan
- Quasi-contract
- Updated regularly

Material Requirements Planning

▶ MRP Elements:

- Gross Requirements
- On-Hand Inventory
- Allocations
- Scheduled Receipts
- Net Requirements
- Planned and Order Releases
- Time-phasing
- Parent/Component

Material Requirements Planning

▶ Advantages of MRP

- Forward looking when planning (visibility). Useful simulator.
- Provides valid, credible priorities.
- Priorities reflect actual needs, not implied needs.
- Provides managers with control over the execution system.

Material Requirements Planning

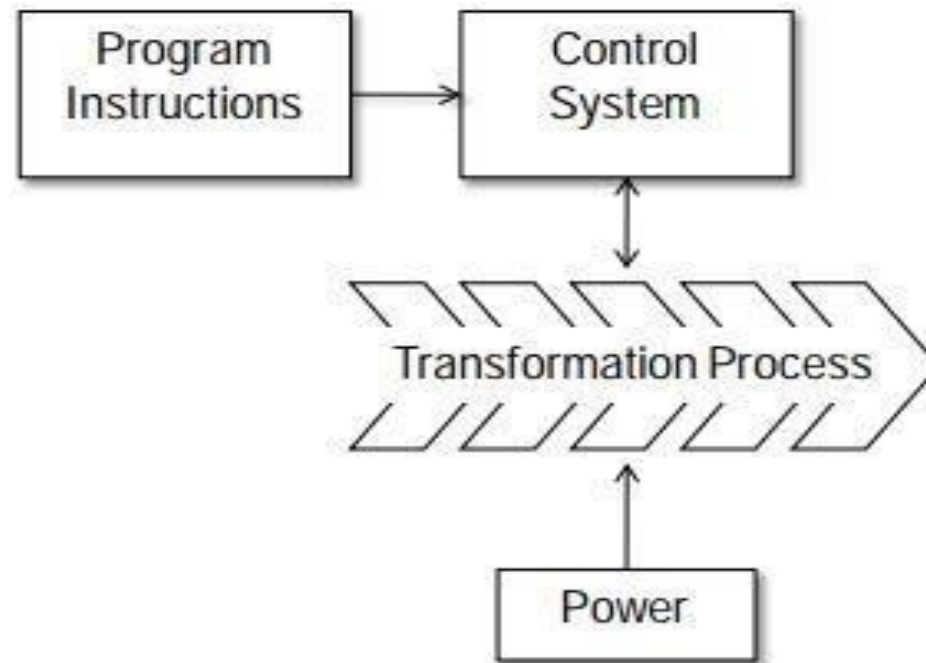
▶ Limitations of MRP

- Looks at materials, ignores capacity, shop floor conditions.
- Requires user discipline.
- Requires accurate information/data.
- Requires valid MPS.
- High volume production.

Basic Elements of an Automated System

- ▶ Automation consists of three basic elements when applied to a particular transformation process:
 - ▶ Power to achieve the process and operate the system.
 - ▶ Programme of instructions to direct the process.
 - ▶ Control system to actuate the instructions.

Basic Elements of an Automated System



Basic Elements of an Automated System

- ▶ The programme of instructions used by the automated system is the series of controlled actions that are carried-out in the manufacturing or assembly process.
- ▶ Parts or products are usually processed as part of a work cycle and it is within this work cycle structure that programme steps may be defined, hence the term work cycle programmes.
- ▶ In numerical control work cycle programmes are called part programmes. The program of instructions can also be called software program.
- ▶ In complicated systems the work cycle consists of a number of work steps that are repeated with no deviation from one cycle to the next.

Basic Elements of an Automated System

- ▶ An example of this work cycle can be drawn from discrete-part manufacturing operation systems and consists of the following steps:

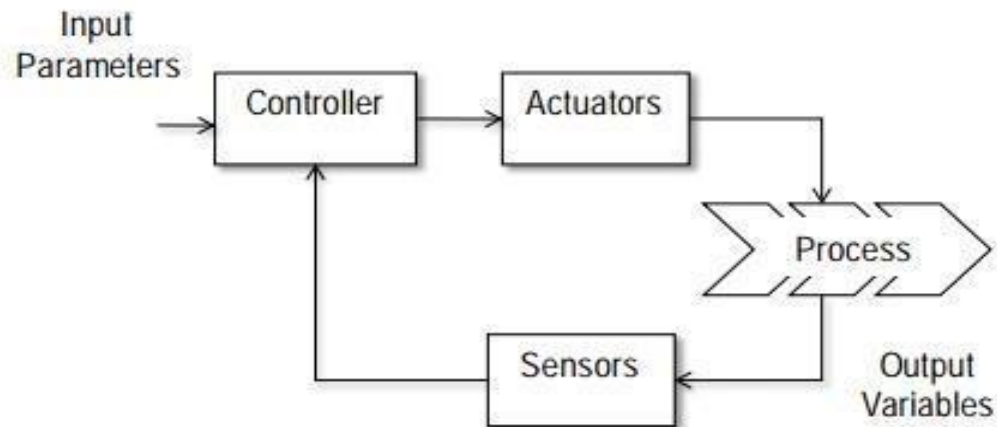
NUMLIST

- ▶ Load part into production machine.
- ▶ Perform process.
- ▶ Unload part from production machine.

Basic Elements of an Automated System

ENDLIST

- ▶ At each & every step, process parameters are being changed. A process parameters are inputs to the process, such as the initial process settings.
- ▶ Process parameters can be distinguished from process variables which are outputs from the process—these include actual process settings as the process is being performed.
- ▶ Different process parameters may be changed in each step.



Levels of Automation

- ▶ There are various levels at which automation can be applied in the context of the enterprise.
- ▶ A temperature sensor that feedback information to a regular in a shower is a reasonably low level of automation.
- ▶ On the other hand a high level automation system is required to run a train system in a city.

Levels of Automation

Five Level and Description:

▶ Device level:

The lowest level, it includes hardware components that comprise the machine level, such as actuators and sensors. Control loop devices are predominant here.

▶ Machine level :

Hardware at the device level is assembled into individual machines.

Control functions at this level include performing the sequence of steps in the programme of instructions.

Lean Production

- ▶ It is also known as lean manufacturing. Also called as the Toyota Production System (TPS), as the concept was originated at Toyota motors.
- ▶ It is Defined as an adoption of mass production in which workers and work cells are made more flexible and efficient by adopting methods that reduce waste in all forms.

Objectives of Lean Production

- ▶ The main benefits of lean production are lower production costs, increased output and shorter production lead times.

Some of the objectives of lean production are as follows.

- ▶ To reduce defects and unnecessary physical wastage, including excess use of raw material inputs, preventable defects, costs associated with reprocessing defective items.
- ▶ To reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages.

Objectives of Lean Production

- ▶ To minimize inventory levels at all stages of production, particularly works-in-progress between production stages.
- ▶ To improve labour productivity both by reducing the idle time of workers and ensuring that when workers are working they are using their effort as productively as possible.
- ▶ To use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production through existing equipment, while minimizing machine downtime.

Lean Manufacturing

Key principles behind lean manufacturing can be summarized as

▶ Recognition of waste: follows:

The first step is to recognize what does not create value from the customer's perspective. Any material process or feature which is not required for creating value from the customer's perspective is waste and should be eliminated.

▶ Standard processes:

Lean requires the implementation of very detailed production guidelines called standard work, which clearly state the content, sequence, timing and outcome of all actions by workers. This eliminates variation in the way that workers perform their tasks.

Key Principles of Lean Manufacturing

▶ Continuous flow:

Lean usually aims for the implementation of a continuous production flow free of bottlenecks, interruption, detours, back flows or waiting.

▶ Pull-production:

Also called Just-In-Time (JIT), pull-production aims to produce only what is needed, when it is needed. Production is pulled by the downstream workstation so that each workstation should only produce what is requested by the next workstation.

Key Principles of Lean Manufacturing

- ▶ **Quality at the source:**

Lean aims for defects to be eliminated at the source and for quality inspection to be done by the workers as part of the in-line production process.

- ▶ **Continuous improvement:**

Lean requires striving for perfection by continually removing layers of waste as they are uncovered. This in turn requires a high level of worker involvement in the continuous improvement process.

Just-In-Time Production Systems

- ▶ It is a management philosophy that strives to eliminate sources of manufacturing waste by producing the right part in the right place at the right time.
- ▶ It is also known as stockless production. Improves profits and return on investment by:
 - ▶ Reducing inventory levels.
 - ▶ Reducing variability.
 - ▶ Improving product quality.
 - ▶ Reducing production and delivery lead times.
 - ▶ Reducing others costs such as machine setup cost and equipment breakdown cost.

Objectives of JIT

▶ The JIT is applied to achieve the following goals:

- 1) Zero defects
- 2) Zero setup time
- 3) Zero inventories
- 4) Zero handling
- 5) Zero breakdowns
- 6) Zero lead time
- 7) Lot size of one.

Elements of JIT

Some of the key elements of the JIT philosophy are:

- ▶ The Reduce or eliminate Setup times
- ▶ The Reduce manufacturing and purchasing lot sizes
- ▶ The Reduce production and delivery lead times
- ▶ The Preventive maintenance
- ▶ The Stabilize and level the production schedule with uniform plant loading
- ▶ The Flexible workforce
- ▶ The Require supplier quality assurance and implement a zero defects quality program
- ▶ The Small unit (single unit) conveyance

Kanban Production Control System

- ▶ Kanban means 'sign' or 'instruction card' in Japanese.
- ▶ Kanban is a card that is attached to a storage and transport container.
- ▶ Identifies the part number and container capacity, along with other information.

Kanban Production Control System

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Two Main Types of Kanban

- ▶ 1. Production Kanban (P-Kanban): Signals the need to produce more parts.
- ▶ 2. Transport or Conveyance Kanban (T-Kanban): Signals the need to deliver more parts to the next work centre. T-Kanban is also called as 'more Kanban' or 'withdrawal Kanban'.

Pull Vs Push Systems

- ▶ A Kanban system is a pull system, in which the Kanban is used to pull parts to the next production stage when they are needed. Here product is made-to-order.
- ▶ A MRP system (or any schedule based system) is a push system in which a detailed production schedule for each part is used to push parts to the next production stage when scheduled. In a push system the product is made-to-stock.
- ▶ A weakness of a push system over a pull system is excess inventory, longer lead time and more room for error.

Benefits of JIT

▶ JIT implementation leads to the following benefits:

- Lower inventory cost.
- Lower scrap and waste costs.
- Improved quality and zero defect products.
- Improved worker involvement.
- Higher motivation and morale.
- Increased productivity.
- Reduced manufacturing lead time.
- Improved product design and increased product flexibility.
- Adherence to delivery time.

UNIT II

Process Planning

- Product design for each product has been developed in the design department.
- To convert the product design into a product, a manufacturing plan is required. Activity of developing such a plan is called process planning.
- Process planning consists of preparing sets of instructions that describe how to manufacture the product and its parts.

Process Planning

- The task of process planning consists of determining the manufacturing operations required to transform a part from a rough (raw material) to the finished state specified on the engineering drawing.
- Also known as operations planning.
- It is the systematic determination of the engineering processes and systems to manufacture a product competitively and economically.
- It is a detailed specification which lists the operations, tools and facilities.
- It is usually accomplished in manufacturing department.

Process Planning Definition

- It Can be defined as “an act of preparing a detailed processing documentation for the manufacture of a piece part or assembly.” According to the American Society of Tool and Manufacturing Engineers.
- Process planning is the systematic determination of the methods by which a product is to be manufactured economically and competitively.
- It Consists of devising, selecting and specifying processes, machine tools and other equipment, transform the raw material into finished product as per the specifications called for by the drawings.

Process Planning vs

Product Plannin

Process planning

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- It is Concerned with the engineering and technological issues of how to make the product and its parts.
- It specifies types of equipment and tooling required to fabricate the parts and assemble the product.

Production planning

- It is concerned with the logistics issues of making the product.
- It is concerned with ordering the materials and obtaining the resources required to make the product in sufficient quantities to satisfy demand for it.
- Production is done only after the process planning.

Importance of

Process Planning

- ▶ Process planning establishes the link between engineering design and shop floor manufacturing.
- ▶ It Determines how a part/product will be manufactured, the important determinant of production costs and profitability.
- ▶ Production process plans should be based on in-depth knowledge of process and equipment capabilities, tooling availability, material processing characteristics, related costs and shop practices.
- ▶ Economic future of the industry demands that process plans that are developed should be feasible low cost and consistent with plans for similar parts.
- ▶ Process planning facilitates the feedback from the shop floor to design engineering regarding the manufacturing ability of alternative.

Details of a Process Plan

- Detailed process plan usually contains the route, processes, process parameters and machine and tool selections.
- To prepare a process plan (also called as route. sheet), we require the following information:

1. Assembly and component drawings and bill of materials (part list):

- This detail give the information regarding the general description of part to be manufactured, raw material specification, dimensions and tolerances required, the surface finish and treatment required.

Details of a Process Plan

2. Machine and equipment details:

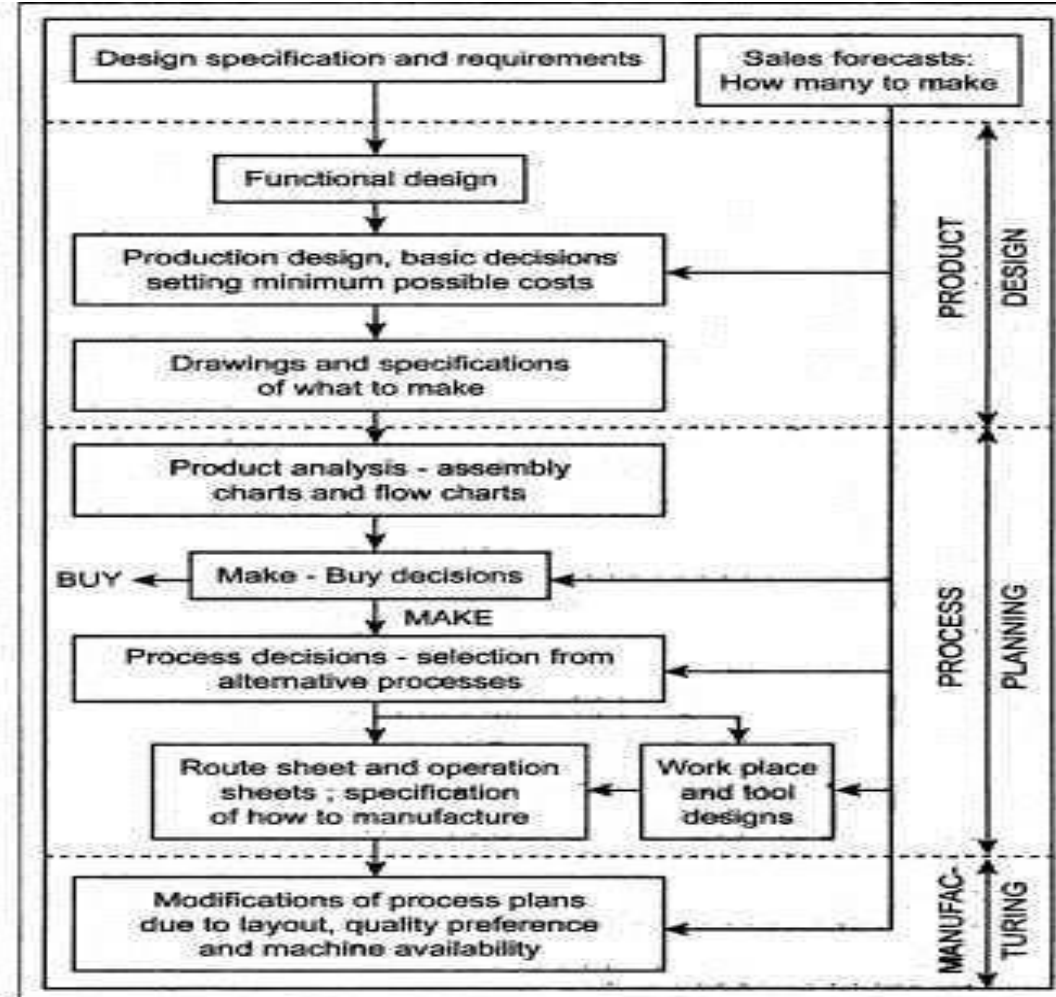
- (i) The various possible operations that can be performed.
- (ii) The maximum and minimum dimensions that can be machined on the machines.
- (iii) The accuracy of the dimensions that can be obtained.
- (iv) Available feeds and speeds on the machine.

3. Standard time for each operation and details of setup time for each job.

Details of a Process Plan

Plan

4. Availability of machines, equipment and tools.



Process Planning Activities

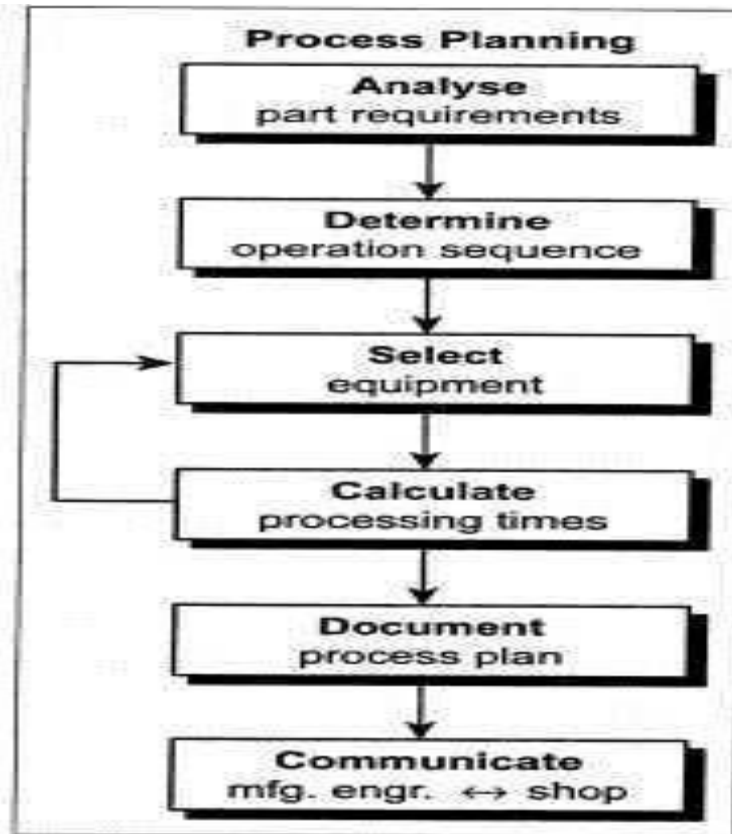
The different steps or specific activities involved in process planning are:

- Analysis of the finished part requirements as engineering specified in the design.
- Determining the sequence of operations required.
- Selecting the proper equipment to accomplish the required operations.
- Calculating the specific operation setup times and cycle times on each machine.
- Documenting the established process plans.
- Communicating the manufacturing knowledge to the shop floor.

Process Planning

Activities

The above process planning activities are diagrammatically presented in figure.



Manual Process Planning

- In traditional process planning systems the process plan is prepared manually.
- It involves examining and interpreting engineering drawings, making decisions on machining processes selection, equipment selection, operations sequence and shop practices.
- The manual process plan is very much dependent on the skill, judgement and experience of the process planner.
- If different planners were asked to develop a process plan for the same part, they would probably come up with different plans.

Advantages of Manual Process Planning

- Manual process planning is very much suitable for small scale companies with few process plans to generate.
- Highly flexible.
- Requires low investment costs.

Computer Aided Process Planning (CAPP)

- To overcome the drawbacks of manual process planning, the computer- aided process planning (CAPP) is used. With the use of computers in the process planning, one can reduce the routine clerical work of manufacturing engineers.
- It provides the opportunity to generate, rational consistent and optimal plans. In addition CAPP provides the interface between CAD and CAM.

Benefits of CAPP

The benefits of implementing CAPP include the following:

- **Process rationalization and standardization:** CAPP leads to more logical and consistent process plans than manual process planning.
- **Productivity improvement:** As a result of standard process plan, the productivity is improved.
- **Product cost reduction:** Standard plans tend to result in lower manufacturing costs and higher product quality.
- Elimination of human error.
- **Reduction in time:** As a result of computerised work, a job that used to take several days is now done in a few minutes.

Approaches of CAPP

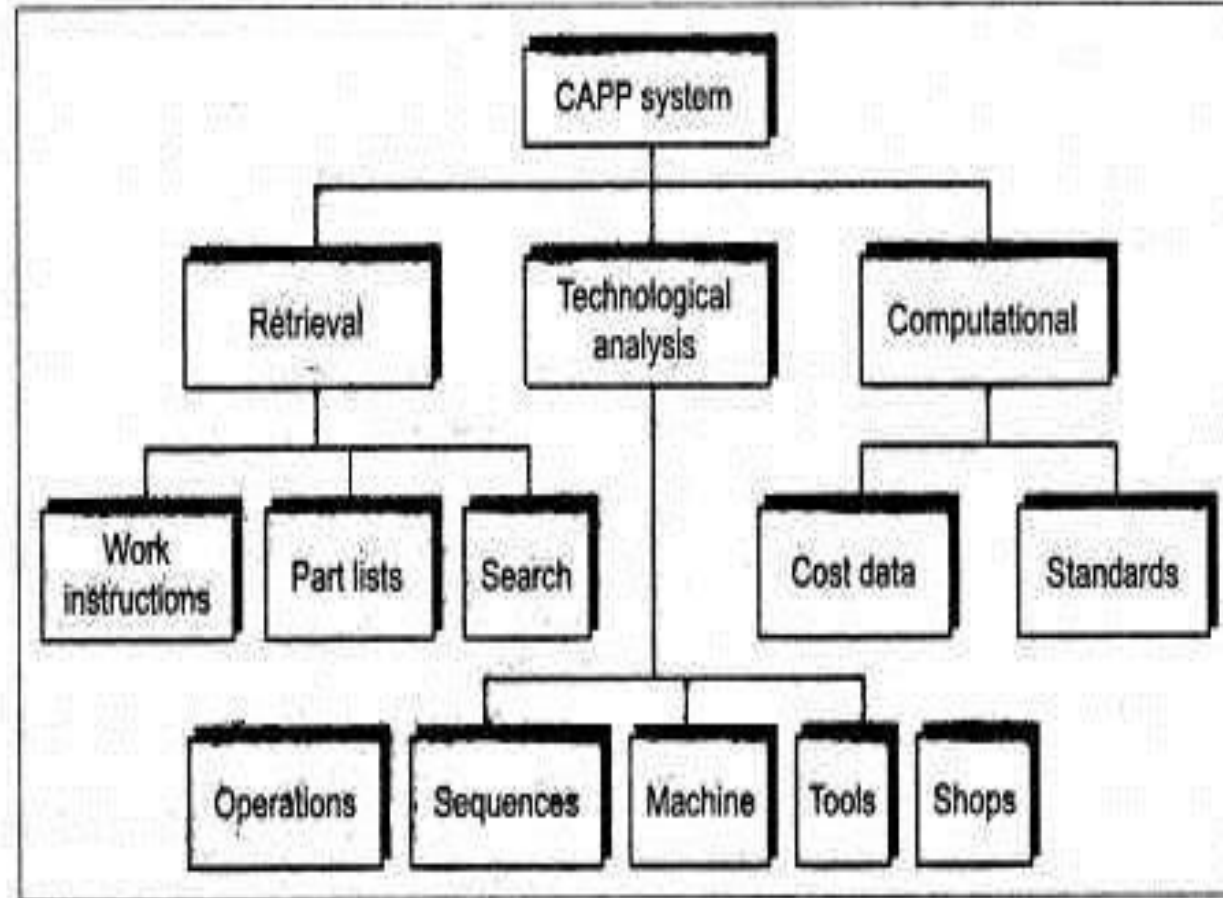
The two basic approaches or types of CAPP system are:

1. Retrieval (or variant) CAPP system.
2. Generative CAPP system.

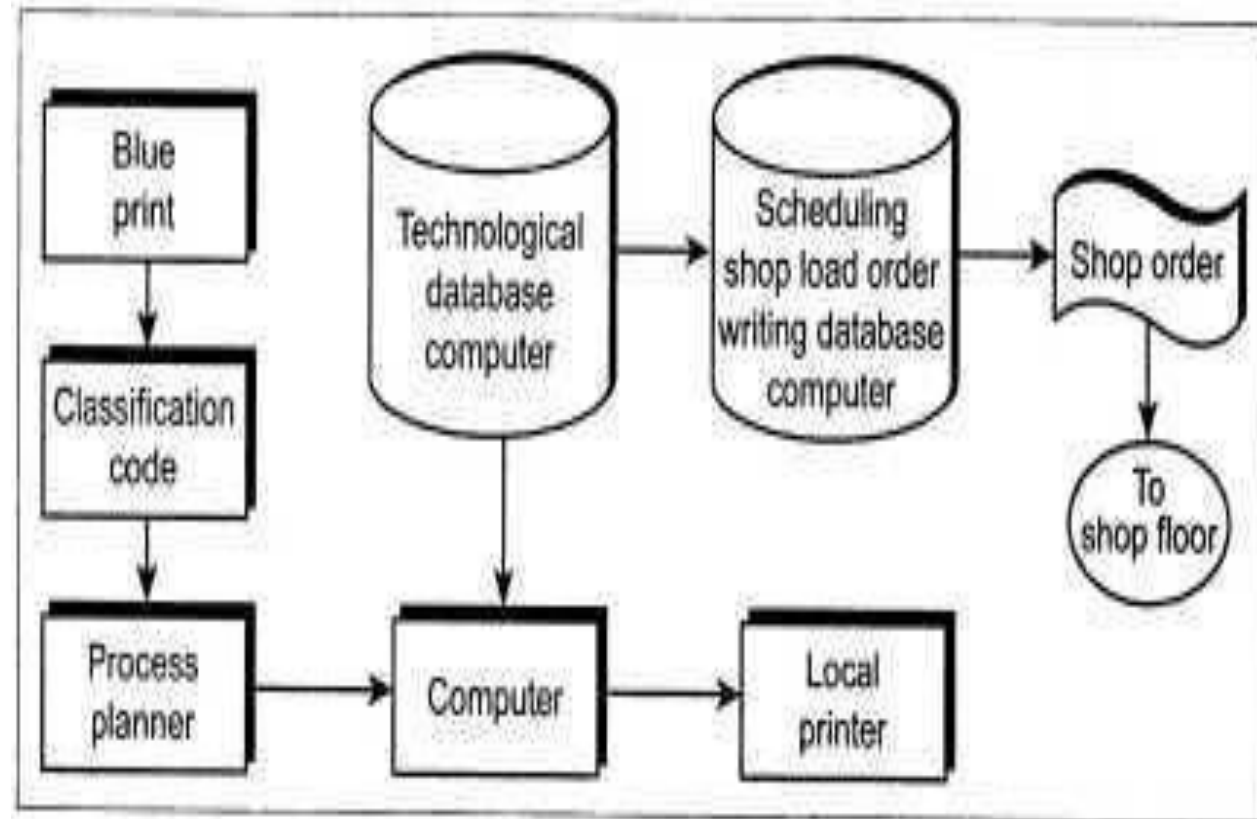
➤ A CAPP tool can be represented as having three separate functions:

- (i) Retrieval
- (ii) Technological analysis
- (iii) Computational

Approaches of CAPP



CAPP System for Engineering Data



Retrieval (or Variant) CAPP System

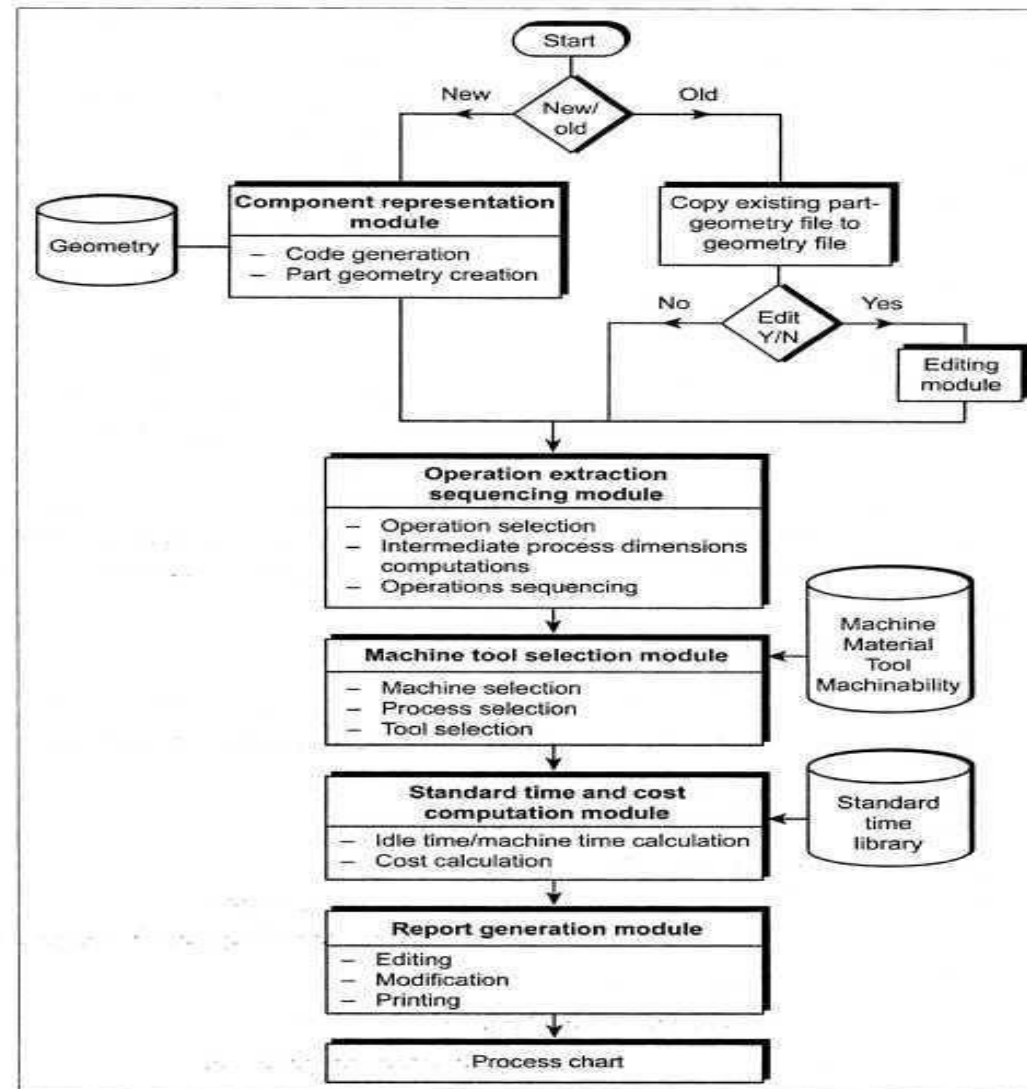
- It is also called a variant CAPP system and has been widely used in machining applications.
- Basic idea behind the retrieval CAPP is that similar parts will have similar process plans.
- A process plan for a new part is created by recalling, identifying and retrieving an existing plan for a similar part and making the necessary modifications for the new part.
- Variant CAPP is a computer-assisted extension of the manual approach.

Components of a Generative CAPP System

The various components of a generative system are:

- A part description, which identifies a series of component characteristics, including geometric features, dimensions, tolerances and surface condition.
- A subsystem to define the machining parameters, for example using look-up tables and analytical results for cutting parameters.
- A database of available machines and tooling.
- A report generator which prepares the process plan report.

Structure of a Generative CAPP System



Advantages of Generative CAPP System

The generative CAPP has the following advantages:

- It can generate consistent process plans rapidly.
- New components can be planned as easily as existing components.
- It has potential for integrating with an automated manufacturing facility to provide detailed control information.

Aggregate Production Planning and the Master Production Schedule

Aggregate Production Planning

- Aggregate planning is concerned with determining the quantity and timing of production for the intermediate future (often 3 to 8 months) ahead, setting employment, inventory and subcontracting.
- Aggregate plans should be coordinated among various functions in the firm, including product design, production, marketing and sales.

Aggregate Production Planning and the Master Production Schedule

Aggregate Production Planning

- The aggregate production planning strategy provides the data to plan the variable resources, which include full and temporary employment levels, total labour hours per period and number of subcontractors.
- In addition, the aggregate production plan, along with forecasted customer demand, provides the aggregate information from which the disaggregate master production schedule (MPS) is produced.

Aggregate Production Planning

| | Month | | | | |
|--|-------|------|------|------|------|
| | Jan. | Feb. | Mar. | Apr. | May |
| Planned output (Number of units of product) | 1400 | 1750 | 1700 | 2250 | 2750 |
| Product line models | Month | | | | |
| | Jan. | Feb. | Mar. | Apr. | May |
| Model M1 | 475 | 500 | 500 | 600 | 625 |
| Model M2 | 150 | 400 | 425 | 450 | 650 |
| Model M3 | 450 | 500 | 475 | 600 | 675 |
| Model M4 | 175 | 150 | 125 | 275 | 425 |
| Model M5 | 150 | 200 | 175 | 250 | 300 |

Aggregate Production Planning and the Master Production Schedule

Master Production Schedule

- The aggregate production plan must be converted into master production schedule (MPS).
- Master production schedule is a listing of the products to be manufactured, when they are to be delivered and in what quantities.
- Aggregate plan lists the production quantities of the major product lines, whereas MPS provides a very specific schedule of individual products.

- Usually, MPS is developed from customer orders and forecasts

Basic Characteristics of MRP

➤ Two basic characteristics of MRP are:

1. Drives demand for components, sub assemblies, materials, etc. from demand for and production schedules of parent items.
2. Offsets replenishment orders (purchase orders or production schedules) relative to the date when replenishment is needed.

Information Needed for MRP

The following information are needed for MRP:

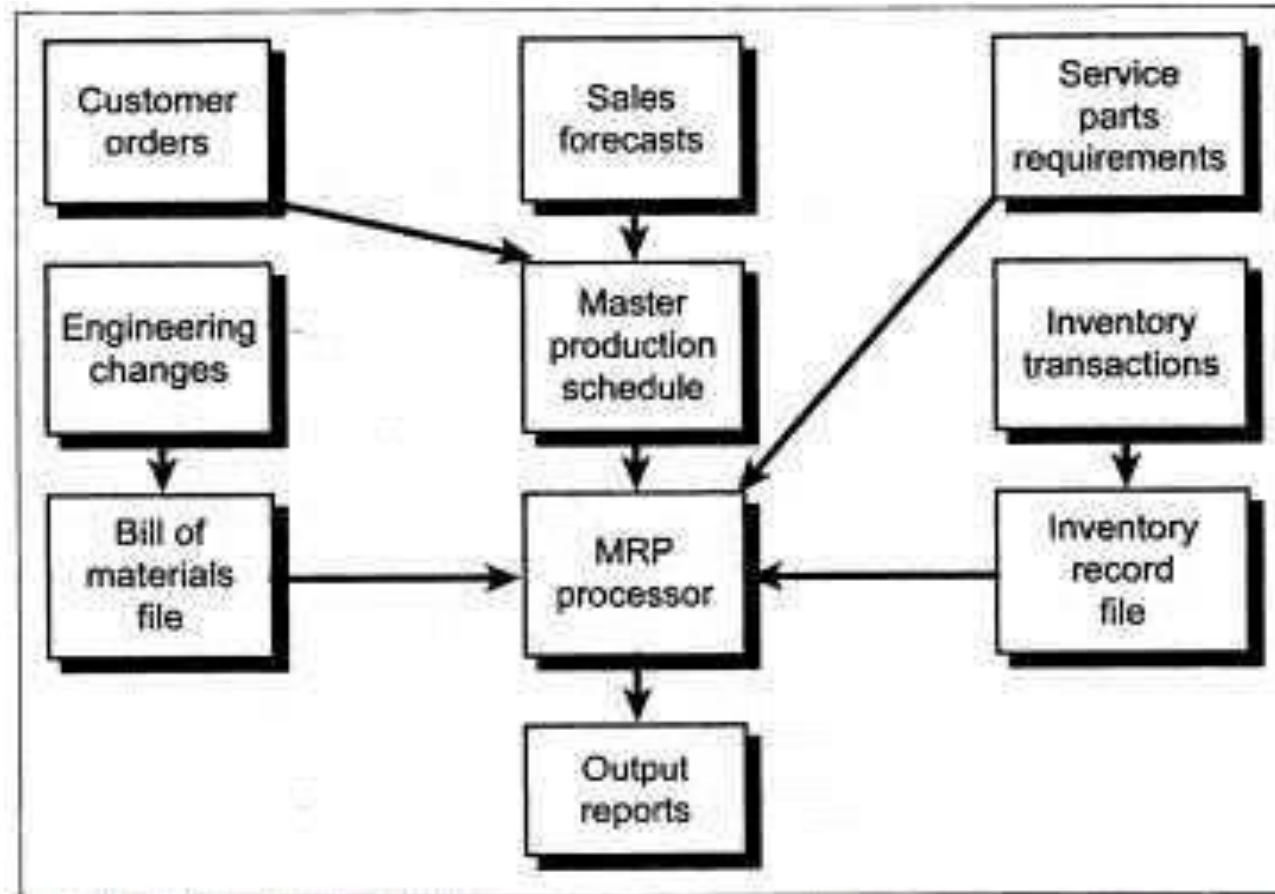
- Demand for all products.
- Lead times for all finished goods, components, parts and raw materials.
- Lot sizing policies for all parts.
- Opening inventory levels.
- Safety stock requirements.
- Any orders previously placed but which haven't arrived yet.

Inputs to MRP

The three important inputs to MRP are:

1. Master production schedule,
2. Bill of materials file and
3. Inventory record file.

Inputs to MRP



Master Production Schedule

- It is a detailed plan that states how many end items (i.e. the final product to be sold to the customer) will be available for sale or distribution during specific periods.

Purpose of the master production schedule:

- (i) To set due dates for the availability of end items.
- (ii) To provide information regarding resources and materials required to support the aggregate plan.
- (iii) Input to MRP will set specific production schedules for parts and components used in end items.

Bill of Materials File

- Designates what items and how many of each are used to make up a specified final product.
- Used to compute the raw material and component requirements for end products listed in the master schedule.
- It Provides information on the product structure by listing the component parts and subassemblies that make up each product.

Working of MRP

- MPS provides a period-by-period list of final products required.
- BOM defines what materials and components are needed for each product.
- Inventory record file contains information on the current and future inventory status of each component. using these three inputs, the MRP processor computes the number of each component and raw material required for the given final product.

MRP Output Reports

| Types of reports | Purpose |
|---|---|
| II. Secondary Output Reports | |
| 1. Performance reports of various types | To indicate costs, item usage, etc |
| 2. Exception reports | To show deviations from schedule, orders that are overdue, scrap and so on |
| 3. Inventory forecasts | To indicate the projected level in future periods |
| 4. Cancellation notices | To indicate the cancellation of open orders because of changes in the master schedule |
| 5. Reports on inventory status | To indicate the current status of the inventory |

Capacity Planning

- It is a major business problem Dependent on the type of company and the state of business;
- Much easier if the work load is declining.
- Simplified if the factory has been laid out, after careful simulation, for a planned production level.
- It takes place in three phases, which need to be reviewed within CIM systems.
- Finite capacity calculations are often optimistic, because they do not show the effect of future work, i.e. work not yet released to the factory.

Logic Required In Capacity Planning Under CIM

- The logic for detailed finite capacity planning (i.e. calculations based on actual capacity) must include the ability to summarize the various priority factors such as lateness on due date, important customer, accumulated cost, into a single numeric value so that queues can be sequenced.

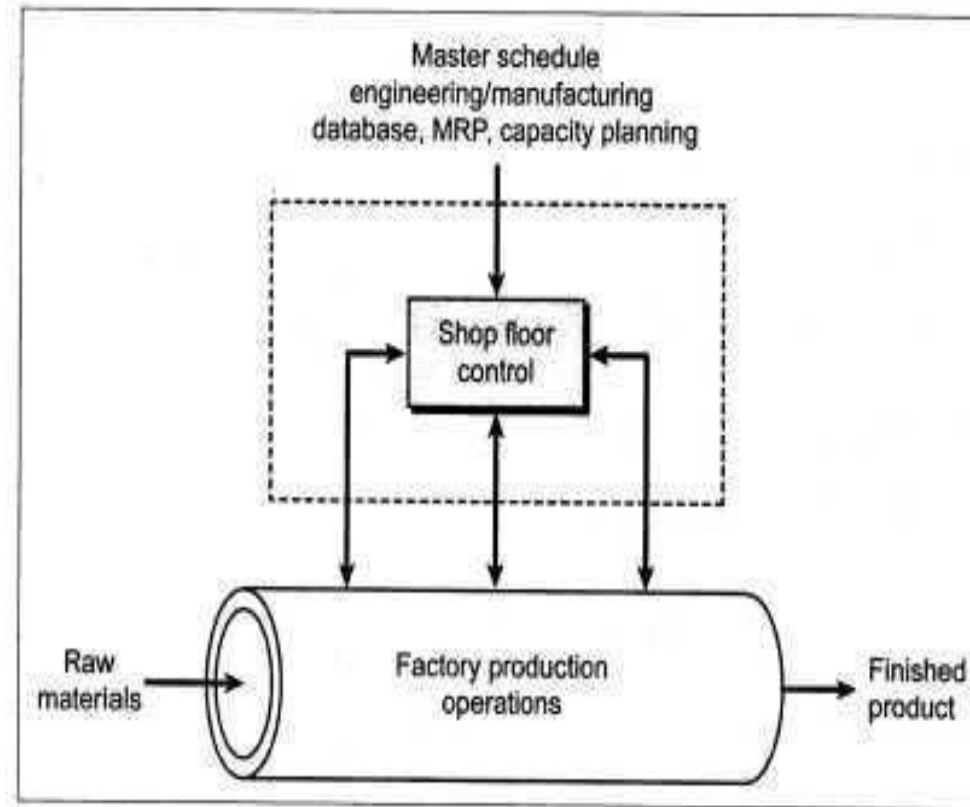
Logic Required In Capacity Planning Under CIM

In addition, a number of other process routines that are as follows:

- Reduction of standard inter-operation (or move) time for urgent jobs.
- Overlapping of jobs across different work centres, e.g. the first items in a batch being heat treated while the last items are still being machined.
- Splitting of batches across identical machines,
- Use of alternative routing data, i.e. there may be different ways of making a product that could be chosen, depending on the load at the time on different work centres.

Shop Floor Control

Shop Floor Control



Manufacturing Resource Planning (MRP- II)

- It Represents the natural evolution of closed-loop MRP (materials requirements planning).
- It is an integrated information system that synchronize all aspects of the business.
- It is Coordinates sales, purchasing, manufacturing, finance and engineering by adopting a focal production plan and by using one unified database to plan and update the activities in all the systems.
- MRP II consists of virtually all the functions in the PPC system (presented in Figure) plus additional business functions that are related to production.

Manufacturing Resource Planning (MRP- II)

➤ Important MRP II system functions include:

1. Management planning — business strategy, aggregate production planning, master production scheduling, rough-cut capacity planning and budget planning.

2. Customer services — sales forecasting, order entry, sales analysis and finished goods inventory.

3. Operations planning — purchase order and work order release.

4. Operations execution — purchasing, product scheduling and control, work-in
- process inventory control, shop floor control and labour hour tracking.

5. Financial functions — cost accounting, accounts receivable,
accounts payable, general ledger and payroll

Manufacturing Resource Planning (MRP- II)

Now-a-days many commercial software are available incorporating MRP II functions with more features.

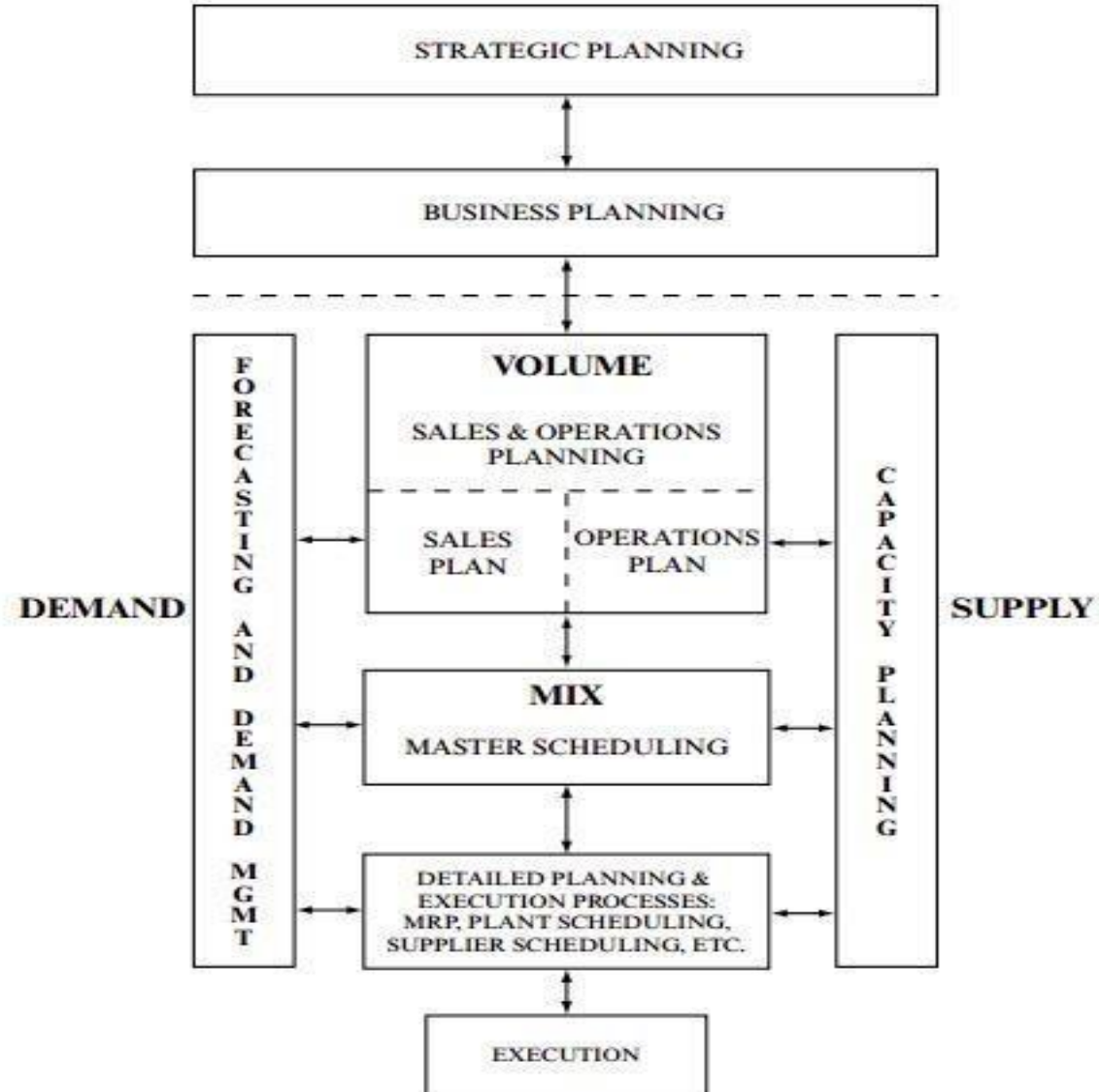
Some of them include:

- Enterprise Resource Planning (ERP)
- Customer-Oriented Manufacturing Management Systems (COMMS)
- Manufacturing Execution Systems (MES)
- Customer-Oriented Management Systems (COMS).

Enterprise Resource Planning (ERP)

- It latest step in this evolution is Enterprise Resource Planning (ERP).
- Fundamentals of ERP are the same as with MRP II.
- Predicts and balances demand and supply.
- It is an enterprise-wide set of forecasting, planning and scheduling tools.
- Links customers and suppliers into a complete supply chain, Employs proven processes for decision-making and Coordinates sales, marketing, operations, logistics, purchasing, finance, product development and human resources.
- Goals include high levels of customer service, productivity, cost reduction and inventory turnover and it provides the foundation for effective supply chain management and e-commerce.

Enterprise Resource Planning (ERP)



Enterprise Resource Planning (ERP)

► The Applicability of ERP

ERP and its predecessor, MRP II, have been successfully implemented in companies with the following characteristics:

- Make-to-stock
- Design-to-order
- Simple product
- Single plant
- Manufacturers with distribution networks
- Make-to-order
- Complex product
- Multiple plants
- Contract manufacturers
- Sell direct to end users

UNIT III

Group Technology (GT)

- Group technology (GT) is a manufacturing philosophy to increase production efficiency by grouping a variety of parts having similarities of shape, dimension and/or process route.
- GT may be defined as a manufacturing philosophy that justifies batch production by capitalizing on design and/or manufacturing similarities among component parts. In batch production, the products are made in small batches and in large variety.
- Every batch contains identical items but every batch is different from the others.
- For example, a plant producing many parts (say 5000 different parts) may be grouped into several distinct families (say 20 to 25 part families). Each family possesses similar design and manufacturing characteristics.
- This grouping philosophy results in increased manufacturing efficiencies.

Group Technology (GT)

BENEFITS OF GT

- Group technology, when successfully implemented, offers many benefits to industries.
- GT benefits can be realised in a manufacturing organisation in the following areas;
 1. Product design
 2. Tooling and setups
 3. Materials handling
 4. Production and inventory control
 5. Process planning
 6. Management and employees.

Group Technology (GT)

1. Product design

- Importance of GT for product design come in cost and time savings.
- Design engineers can quickly and easily search the database for parts that either presently exist or can be used with slight modifications, rather than issuing new part numbers.
- Similar cost savings can be realised in the elimination of two or more identical parts with different part numbers.
- Advantage is the standardisation of designs.
- Design features such as corner radii, tolerances, counter bores, and surface finishes can be standardized with GT.

Group Technology (GT)

2) Tooling and Setups

- In the area of tooling, group jigs and fixtures are designed to accommodate every member of a part family.
- Also work holding devices are designed to use special adapters in such a way that this general fixture can accept each part family member.
- Since setup times are very short between different parts in a family, a group layout can also result in dramatic reductions in setup times.

3) Materials Handling

- GT facilitates a group layout of the shop.
- Since machines are arranged as cells, in a group layout, the materials handling cost can be reduced by reducing travel and facilitating increased automation.

Group Technology (GT)

- 4) Production and Inventory Control
- GT simplifies production and planning control.
- In addition, reduced setup times and effective handling result in shorter manufacturing lead times

Group Technology (GT)

5) Process Planning

- Concept of group technology parts, classification and coding lead to an automated process planning system.
- Grouping parts allows an examination of the various planning/route sheets for all members of a particular family.
- Once this has been accomplished, the same basic plans can be applied to other members, thereby optimizing the shop flow for the group.

Advantages of Group Technology (GT)

- GT facilitates (a) efficient retrieval of similar parts, (b) development of a database containing effective product design data and (c) avoidance of design duplication.
- GT encourages standardization of designs, tooling, fixing and setups.
- GT facilitates (a) development of a computer-aided process planning (CAPP) system, (b) retrieval of process plans for part families and (c) development of standard routings for part families.
- Times and costs for material handling and waiting between stages are reduced.
- Production planning and control is simplified.
- Setup time and setup cost for each job are reduced, because several jobs are grouped and processed in sequence.
- Machining cells can reduce work-in-process inventory, resulting in shorter queues and shorter manufacturing throughput times.
- Part and product quality are improved.
- GT facilitates better employee involvement and increases workers satisfaction.

Limitations of Group Technology (GT)

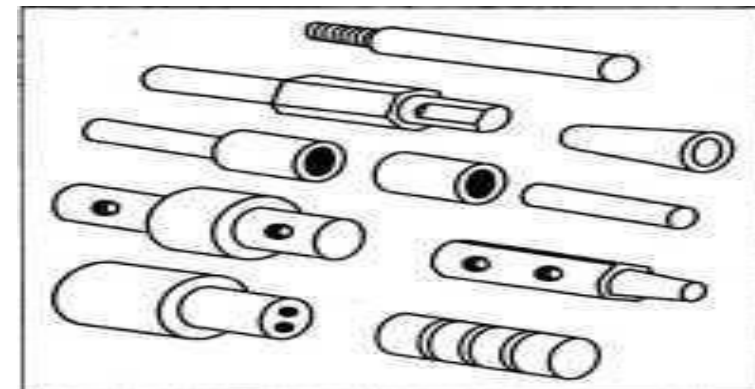
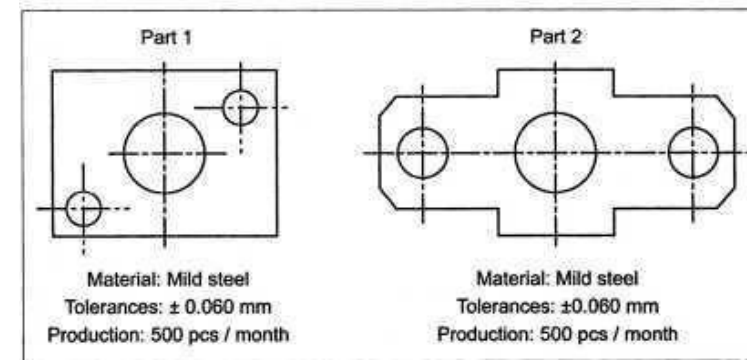
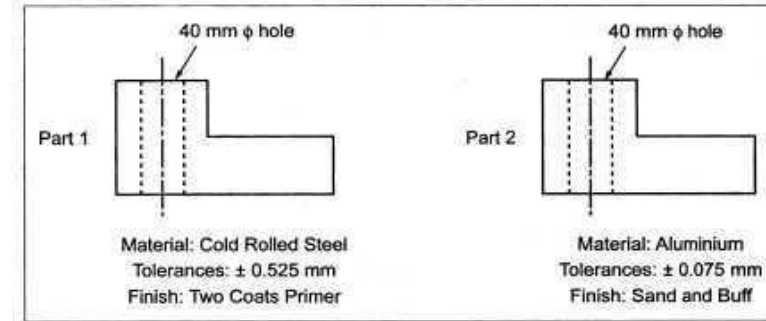
- Implementing GT is expensive.
- Large costs may be incurred in rearranging the plant into machine cells or groups.
- Installing a coding and classification system is very time-consuming.
- As there is no common implementation approach, the implementation of GT is often difficult.

Part Families

- Part family is a collection of parts which are similar either because of geometric shape and size or because similar processing steps are required in their manufacture.
- Parts which are similar in their design characteristics (i.e. shape and geometry) are grouped in a family referred to as a design part family.
- Parts which are similar in their manufacturing characteristics are grouped in a family referred to as a manufacturing part family.
- Characteristics used in classifying parts are referred to as “attributes”.

Part Families

- Design part family
- Manufacturing part family
- A family of parts with similar manufacturing process requirements but different design attributes.



Part Families

Methods for Part Family Formation

- The three general methods for grouping parts into families are:

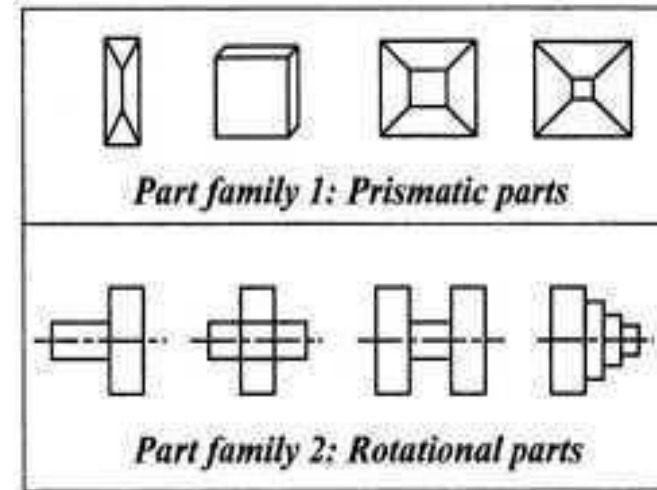
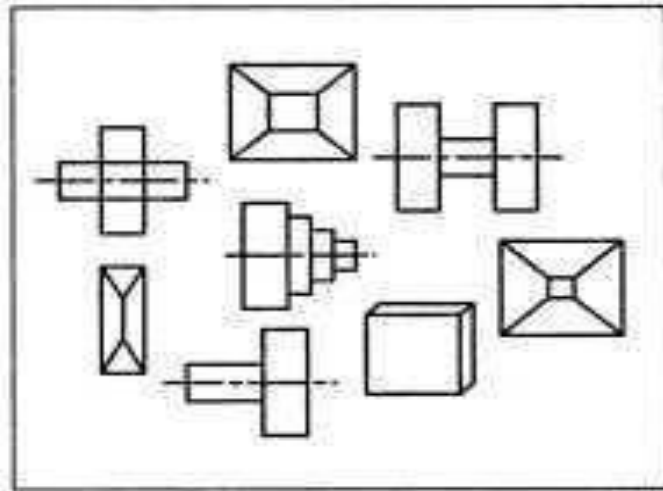
1. Visual inspection

2. Parts classification and coding system

3. Production flow analysis.

Visual Inspection Method

- Visual inspection method is the simplest and least expensive method.
- It involves looking at parts, photos of parts or drawings of parts and arranging them into similar groups.



Parts Classification and Coding

- Coding is a systematic process of establishing an alphanumeric value for parts based on selected part features. Classification is the grouping of parts based on code values.
- It is the most sophisticated, most difficult, most time-consuming and widely used of the three methods.
- Here the various design and/or manufacturing attributes of a part are identified, listed and assigned a code number.
- Though several classification and coding systems have been developed, no system has been universally adopted. one of the reasons for this is that the information that is to be represented in the classification and coding system will vary from one company to another company.

Parts Classification and Coding

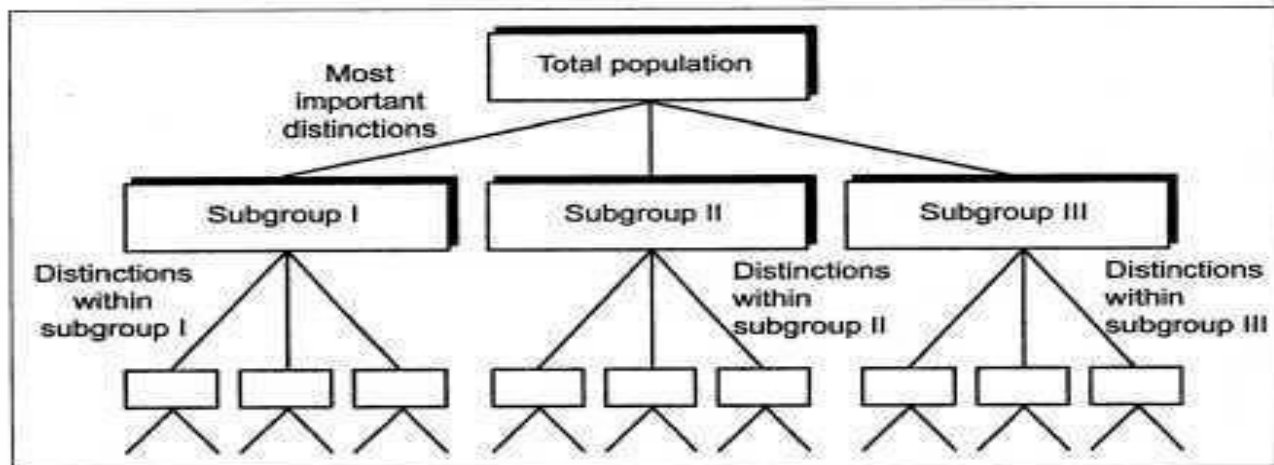
Design and Manufacturing Attributes

- Any parts classification systems fall into one of the following three categories:
 1. Systems based on part design attributes.
 2. Systems based on part manufacturing attributes.
 3. Systems based on both design and manufacturing attributes.

Parts Classification and Coding

1. Hierarchical Code (or Mono code)

- Interpretation of each successive symbol depends on the value of the preceding symbols.
- Each symbol amplifies the information contained in the preceding digit, so a digit in the code cannot be interpreted alone. Structure of these codes is like a tree in which each symbol amplifies the information provided in the previous digit.
- Hierarchical coding system can be depicted using a tree structure as shown in Figure.



Parts Classification and Coding

2) Attribute Code (or Poly code)

- In this structure, the interpretation of each symbol in the sequence does not depend on the value of preceding symbols.
- Each digit in this code represents information in its own right and does not directly qualify the information provided by the other digits.
- Attribute code is also known by other names „poly code“, „chain code“, „discrete code“ and „fixed-digit code“.

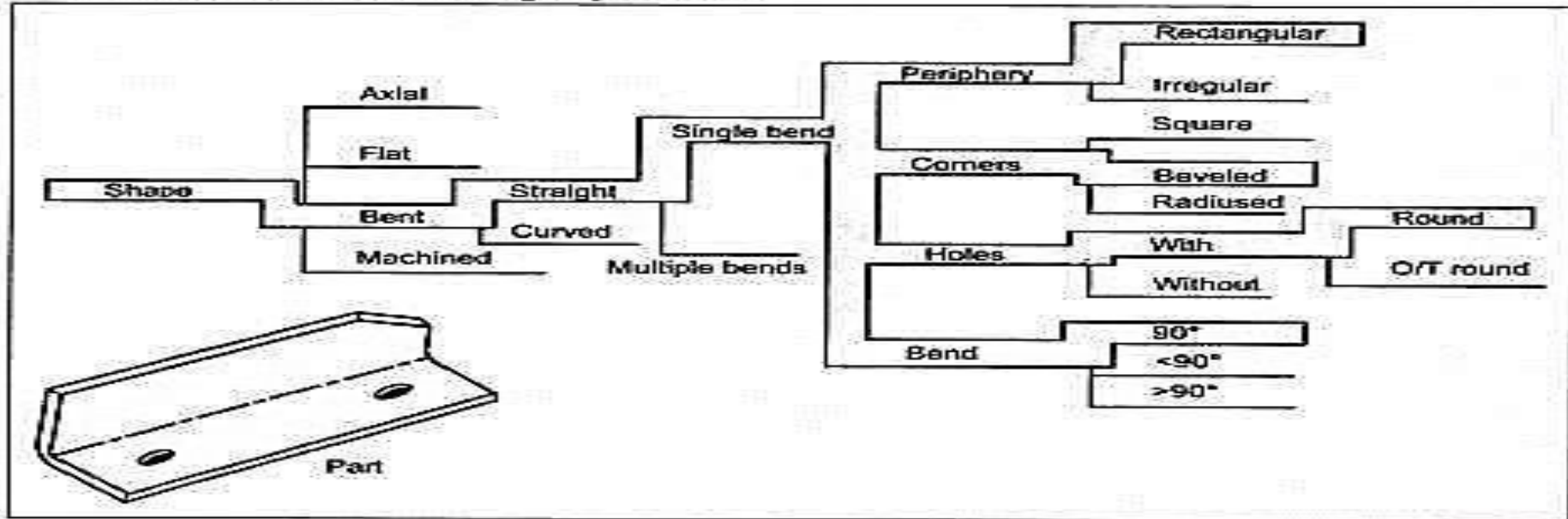
Parts Classification and Coding

3. Decision-Tree (or Hybrid) Code

- A hybrid code captures the best features of the hierarchical and poly code structures.
- This system is also known as decision-tree coding and it combines both design and manufacturing attributes.
- In practice, most coding systems use a hybrid construction to combine the best.
- To reduce the length of a strict poly code, the first digit of such a system may split the population into appropriate subgroups, as in a mono code structure. Then each subgroup can have its own poly code structure.
- For example, the first digit might be used to denote the type of part, such as gear.
- The next four positions might be reserved for a short attribute that would describe the attributes of the gear.

Parts Classification and Coding

features of monocodes and polycodes.



- The next digit position 6, might be used to designate another subgroup, such as material, followed by another attribute code that would describe the attributes. Thus, a hybrid code can be generated.
- Hybrid code is relatively more compact than a pure attribute code while retaining the ability to easily identify parts with specific characteristics.

Production Flow Analysis

Steps Involved in PFA

- The following four steps are followed to carryout PFA:

(i) Data collection

(ii) Sortation of process routings

(iii) Preparation of PFA chart

(iv) Cluster analysis

Production Flow Analysis

Step 1: Data collection

- The step in the PFA procedure is to collect the necessary data.
- Route sheets of all the components to be manufactured in the shop are prepared.
- Route sheet should contain the part number and operation sequence.
- Other data that can be collected/obtained from route sheet/operation sheet include lot size, time standards and annual demand.

Step 2: Sortation of process routes

- The second step in the PFA is to arrange the parts into groups according to the similarity of their process routings.
- A typical card format is required for organizing the data such as the part number, sequence of code and lot size. A sortation procedure is used to arrange the parts into „packs“.
- Pack is nothing but a group of parts with identical process routings. Some pack may even contain only one part number. A pack identification or letter is provided for each pack.

Production Flow Analysis

Step 3: PFA chart

- A PFA chart is a graphical representation of the process used for each pack.
- It is a tabulation of the process or machine code numbers for all of the part packs. Also known as „part-machine incidence matrix“ or „component-machine incidence matrix“.

- The table below shows the PFA chart for 7 machines (M1 to M7) and 9 parts.

| Machines | Parts | | | | | | | | |
|----------|-------|----|----|----|----|----|----|----|----|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 |
| M1 | 1 | 1 | | 1 | | | | 1 | |
| m2 | | | | | 1 | | | | 1 |
| m3 | | | 1 | | 1 | | | | 1 |
| m4 | | 1 | | 1 | | 1 | | | |
| M5 | 1 | | | | | | | 1 | |
| m6 | | | 1 | | | | | | 1 |
| m7 | | 1 | | | | 1 | 1 | | |

Production Flow Analysis

- In this matrix, the entries have a value $x_{ij} = 1$ or 0:
- A value of $x_{ij} = 1$ indicates that the corresponding part i requires processing on machine j
- $x_{ij} = 0$ indicates that no processing of component i is accomplished on machine j
- However, in Table , the 0s are indicated as blank (entry) entries for better clarity of the matrix

| Machines | Parts | | | | | | | | |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | P ₁ | P ₂ | P ₃ | P ₄ | P ₅ | P ₆ | P ₇ | P ₈ | P ₉ |
| M ₁ | 1 | 1 | | 1 | | | | 1 | |
| m ₂ | | | | | 1 | | | | 1 |
| m ₃ | | | 1 | | 1 | | | | 1 |
| m ₄ | | 1 | | 1 | | 1 | | | |
| M ₅ | 1 | | | | | | | 1 | |
| m ₆ | | | 1 | | | | | | 1 |
| m ₇ | | 1 | | | | 1 | 1 | | |

Production Flow Analysis

Step 4: Cluster analysis

- From the PFA chart, related grouping are identified and rearranged into a new pattern that brings together packs with similar machine sequences.
- Table shows one possible rearrangement of the original PFA chart.
- It is clear that for the PFA chart considered we have three part families and three machine cells, as shown below.

| Machines | Parts | | | | | | | | |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | P ₁ | P ₈ | P ₂ | P ₄ | P ₆ | P ₇ | P ₉ | P ₃ | P ₅ |
| M ₁ | 1 | 1 | 1 | 1 | | | | | |
| m ₅ | 1 | 1 | | | | | | | |
| m ₄ | | | 1 | 1 | 1 | | | | |
| m ₇ | | | 1 | | 1 | 1 | | | |
| m ₃ | | | | | | | 1 | 1 | 1 |
| m ₆ | | | | | | | 1 | 1 | |
| m ₂ | | | | | | | 1 | | 1 |

Production Flow Analysis

Table : Rearranged PFA chart, indicating possible machine grouping Part Families: Cell groups:

$$PF_1 = \{P_1, P_8\} C_1 = \{$$

$$M_1, M_5\} PF_2 = \{P_2,$$

$$P_4, P_6\} C_2 = \{M_4, M_7\}$$

$$PF_3 = \{P_3,$$

| Machines | Parts | | | | | | | | |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | P ₁ | P ₈ | P ₂ | P ₄ | P ₆ | P ₇ | P ₉ | P ₃ | P ₅ |
| M ₁ | 1 | 1 | 1 | 1 | | | | | |
| m ₅ | 1 | 1 | | | | | | | |
| m ₄ | | | 1 | 1 | 1 | | | | |
| m ₇ | | | 1 | | 1 | 1 | | | |
| m ₃ | | | | | | | 1 | 1 | 1 |
| m ₆ | | | | | | | 1 | 1 | |
| m ₂ | | | | | | | 1 | | 1 |

Production Flow Analysis

Advantages of PFA

- Parts classification and coding uses design data and the PFA uses manufacturing data (i.e., route sheet) to identify part families.
- Due to this fact, as pointed out by Groover, PFA can overcome two possible anomalies that can occur in parts classification and coding.
- First, parts whose basic geometries are quite different may nevertheless require similar or identical process routings.
- Second, parts whose geometries are similar may nevertheless require process routings that are quite different.
- Also PFA requires less time than a complete parts classification and coding procedure.

Production Flow Analysis

Disadvantages of PFA

- PFA does not provide any mechanism for rationalizing the manufacturing routings.
- No consideration being given to routing sheet whether the routings are optimal or consistent or logical.
- Process sequences from route sheets are prepared by different process planners, hence the routings may contain processing steps that are non- optimal, illogical and unnecessary.

Cellular Manufacturing

- It is an application of group technology in which dissimilar machines have been aggregated into cells, each of which is dedicated to the production of a part family.
- Primary advantage of CM implementation is that a large manufacturing system can be decomposed into smaller subsystems of machines called cells. Cells are dedicated to process part families based on similarities in manufacturing requirements. Parts having similar manufacturing requirements can be processed entirely in that cell.
- In addition, cells represent sociological units conducive to team work which lead to higher levels of motivation for process improvements.
- Benefits associated with the application of CM include improved market response, more reliable delivery promises, reduced tooling and fixtures and simplified scheduling.
- Literature surveys confirm substantial benefits from implementing cellular manufacturing in manufacturing industries.

Cellular Manufacturing

| Rank | Reasons for implementing manufacturing cells | Average improvement |
|------|--|---------------------|
| 1 | Reduce manufacturing lead time | 61 |
| 2 | Reduce work-in-process | 48 |
| 3 | Improve part and/or product quality | 28 |
| 4 | Reduce response time for customer orders | 50 |
| 5 | Reduce more distances/more times | 61 |
| 6 | Increase manufacturing flexibility | — |
| 7 | Reduce unit costs | 16 |
| 8 | Simplify production planning and control | — |
| 9 | Facilitate employee involvement | |
| 10 | Reduce set-up times | 44 |
| 11 | Reduce finished goods inventory | 39 |

Cellular Manufacturing

- Design Considerations Guiding the Cell Formation
- We know that cell formation is the early activity in the cell design process where part families and associated machine groups are identified. Cell formation is influenced by a variety of objectives and concerns.
- Lists the important design considerations that should be taken into account during cell formation.

| Rank | Design considerations |
|-------------|---|
| 1 | Parts/products to be fully completed in the cell |
| 2 | Higher operator utilization |
| 3 | Fewer operators than equipment |
| 4 | Balanced equipment utilization in the cell |
| 5 | The number of part/product assigned to the cell |
| 6 | Unidirectional (linear) material flows |
| 7 | The number of cell operators |
| 8 | High utilization on expensive equipment |
| 9 | The number of workstations/machines in the cell |
| 10 | High equipment flexibility to ease new product introduction over time |
| 11 | High flexibility in selecting alternative routes through the cell |

Composite Part Concept

- Mitrofanov (1959) and Edwards (1970) proposed composite part have approach to implement the concept of cellular manufacturing.
- A composite part is formed by merging the primitives of all the parts of a part family.
- Composite is a single hypothetical part that can be completely processed in a manufacturing cell/group.
- If a new part is loaded in a machine group, the degree of dissimilarity of the part of its related part family or the hypothetical composite should have minimum deviation and desired to be zero.
- The manufacturing facility could be planned on the basis of composite part to facilitate economical production.

Composite Part Concept

- The primitives of three parts shown are merged into composite part by incorporating all the primitives of the three parts.

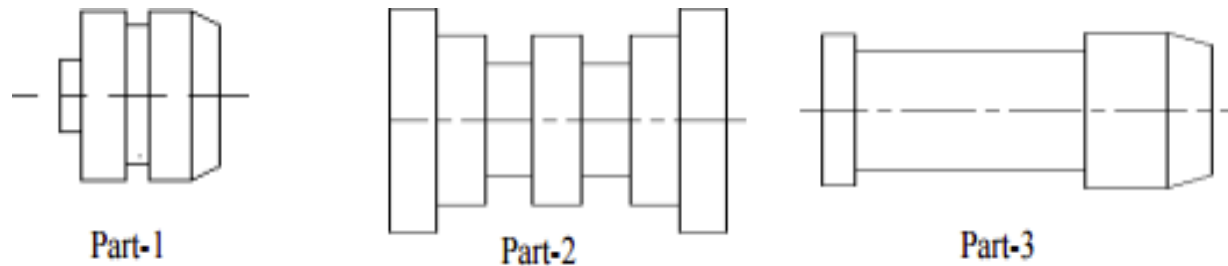
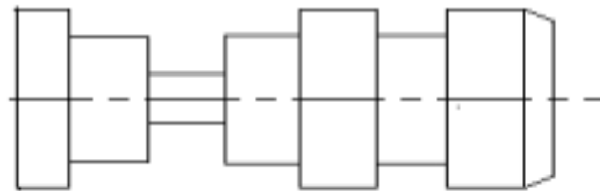


Figure 1: Individual parts



Composite Part Concept

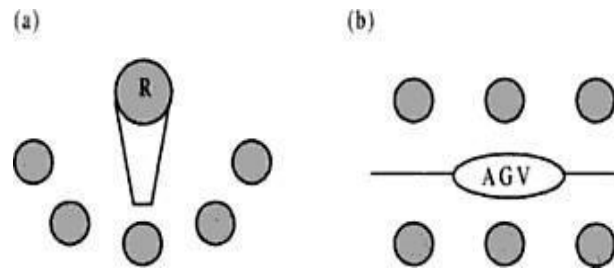
- It may not be judicious to merge all the primitives of parts due to various production considerations,
- In such situation the shop will converge back to a large job shop and all the benefits of CMS will be lost. Size of the manufacturing group depends on initial capital investment capacity, machines available and outsourcing facilities.
- Individual parts features (in terms of primitives) could be merged in the composite part based on their repetitions in the parts.
- Primitives having more repetitions will be more eligible candidates for merging in the composite part.
- Various techniques could be used for selection of optimum primitives for merging in composite parts.
- Genetic algorithm is proved to be one of the effective techniques.

Machine Cell Design and Layout

- Machine layout aims at determining the best arrangement of machines in each product cell.
- Minimization of material handling cost is an often used objective in determining the layout of machines in a cell.
- Constraints related to the availability of space, material handling system type and so on are considered.
- Type of operations and parts are not the only factors that impact the layout of machines.
- Type of material handling system to be used also needs to be considered;

Machine Cell Design and Layout

- Example, the articulated robot (R) in figure(a) implies a circular arrangement of machines.
- If an AGV had been selected to tend the same machines, it would have been necessary to use the layout in figure(b).



- Two step design of system



MECH-KIOT

Machine Cell Design and Layout

- Goal of machine cell layout is to arrange the product or functional cells formed on the factory floor.
- Determining the layout of machine cells involves locating the cells in order to minimize the total material handling cost subject to some constraints (e.g. shape of the facility).
- If all cells were square in shape and of the same size, then the cell layout could be modelled as the quadratic assignment problem (QAP).
- Cell layout problem can be viewed as a machine layout problem, where each machine represents a cell.
- Though cellular manufacturing offers numerous benefits, it is not always implemented due to the following:

1. Parts and machines may not form mutually exclusive clusters.

MECH-KIOT

2. The data required from the formation of cells might not be

Quantitative analysis in Cellular Manufacturing

Rank Order Clustering Method

- It also known as binary ordering algorithm (BOA), It is a simple algorithm used to form machine-part groups. it was Developed by J.R.King (1980).
- It considers two data:
 - Number of components and Component sequences. Based on the component sequences, a machine-part incidence matrix is developed.
 - Rows of the machine component incidence matrix represent the machines which are required to process the components. Columns of the matrix represent the component numbers.

Quantitative analysis in Cellular Manufacturing

| Advantages | Disadvantages |
|---|--|
| <p>Smooth and continuous work flow.</p> <p>Less space requirements for the same production volume.</p> <p>Automatic materials handling possible.</p> | <p>Lack of flexibility. That is product changes require major changes in layout.</p> <p>Large capital investment.</p> |
| <p>Lesser work-in-process inventory.</p> <p>Reduced product movement and processing time.</p> <p>Simple production planning and control, better co-ordination.</p> <p>Less skilled workers can serve the purpose.</p> | <p>Dedicated or special purpose machines.</p> <p>Dependence of the whole activity on each part. breakdown of any one machine in the sequence may result in stoppage of production.</p> |

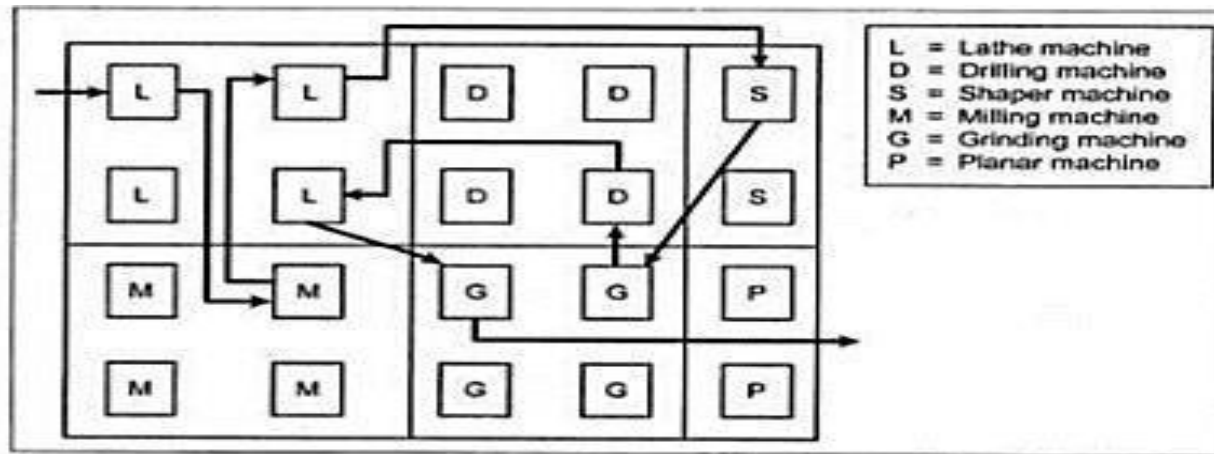
Table: Advantages and disadvantages of line layout

Quantitative analysis in Cellular Manufacturing

2) Functional (or Process) Layout

- Characterized by keeping similar machines, operations at one location, i.e. all lathes at one place, all milling machines at another place.
- In process layout, machines are arranged according to their functions.

Suitability: Suitable for job order/non-repetitive type production.



Quantitative analysis in Cellular Manufacturing

| Advantages | Disadvantages |
|---|---|
| Flexibility in assigning work to equipment and workers. | Automatic material handling is extremely difficult. |
| Better equipment utilisation. | Difficult production planning and control. |
| Comparatively less number of equipment needed. | More space is required. |
| Better product quality because of specialisation. | Large work-in-process inventory. |
| Variety of job makes the job challenging and interesting. | Higher grades of skill required. |
| | Lower productivity due to number of setups. |

Table: Advantages and disadvantages of process layout

Quantitative analysis in Cellular Manufacturing

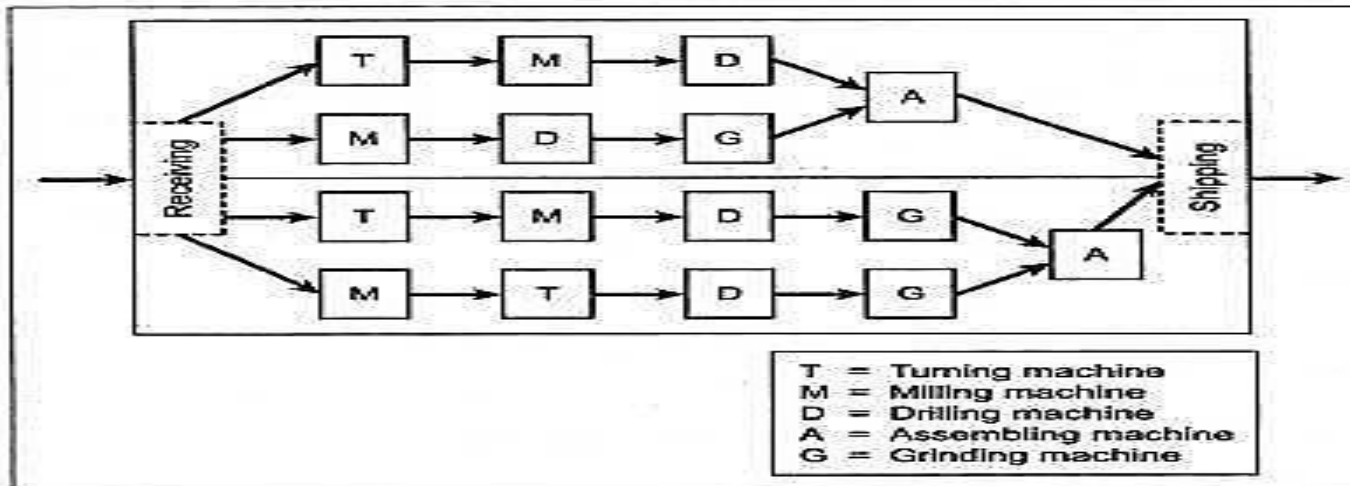
3) Group (or Combination) Layout

- It is a combination of the product layout and process layout.
- This layout Combines the advantages of both layout systems.
- Here machines are arranged into cells , each cell is capable of performing manufacturing operations on one or more families of part.
- If there are m machines and n components, in a group layout, the m -machines and n - components will be divided into distinct number of machines-component cells (groups) such that all the components assigned to a cell are almost processed within that cell itself.
- Objective is to minimize the inter-cell movements.

Suitability: Preferred for batch type production, where the products batches and in large variety.

Quantitative analysis in Cellular Manufacturing

3) Group (or Combination) Layout



- If there are m machines and n components, in a group layout, the m -machines and n - components will be divided into distinct number of machines-component cells (groups) such that all the components assigned to a cell are almost processed within that cell itself.
- Objective is to minimize the inter-cell movements.

Suitability: Preferred for batch production, where the products are type batches and in large variety.

Quantitative analysis in Cellular Manufacturing

| Advantages | Disadvantages |
|---|--|
| Group technology layout can increase. | This type of layout may not be feasible for all situations. if the product mix is completely dissimilar, then we may not have meaningful cell formation. |
| Component standardization and rationalisation | |
| Reliability of estimates | Comparatively high investment in equipment is required. |
| Effective machine operation. | |
| Productivity | |
| Costing accuracy | Higher grades of skill are required. |
| Customer service | Groupings of machines may lead to poor utilization of some machines in the group. |

Unit IV

Types of Flexibility

- Many people are unaware of the fact that there are different types of flexibility. These different types of flexibility are grouped according to the various types of activities involved in athletic training.
- The ones which involve motion are called dynamic and the ones which do not are called static.
- The different types of flexibility are,
 1. Dynamic flexibility
 2. Static-active flexibility
 3. Static-passive flexibility

Types of Flexibility

1. Dynamic flexibility

- Dynamic flexibility (also called kinetic flexibility) is the ability to perform dynamic (or kinetic) movements of the muscles to bring a limb through its full range of motion in the joints.

2. Static-active flexibility

- Static-active flexibility (also called active flexibility) is the ability to assume and maintain extended positions using only the tension of the agonists and synergists while the antagonists are being stretched.
- For example, lifting the leg and keeping it high without any external support (other than from your own leg muscles).

Types of Flexibility

3. Static-passive flexibility

- Static-passive flexibility (also called passive flexibility) is the ability to assume extended positions and then maintain them using only our weight, the support of our limbs, or some other apparatus (such as a chair or barre).
- Note that the ability to maintain the position does not come solely from our muscles, as it does with static active flexibility.
- Being able to perform the splits is an example of static-passive flexibility.
- Research has shown that active flexibility is more closely related to the level of sports achievement than in passive flexibility.
- Active flexibility is harder to develop than passive flexibility (which is what most people think of as "flexibility"); not only does active flexibility require passive flexibility in order to assume an initial extended position, it also requires muscle strength to be able to hold and maintain.

FMS- Components

Components/Elements Of FMS:

- As pointed out in the definition a four basic components/elements of a FMS are:

(i) Workstations

(ii) Material handling and storage system

(iii) Computer

control system

(iv) Human

resources

FMS- Components

1) FMS Workstations

- The workstations/processing stations used in FMS depends upon the type of product manufactured by the system.
- In metal cutting/machining systems, the principle processing stations are usually CNC machine tools. In addition, a FMS requires other several machines for completing the manufacturing.
- The types of workstations that are usually found in a FMS are:
 - (i) Load/unload stations
 - (ii) Machining stations
 - (iii) Assembly workstations
 - (iv) Inspection stations
 - (v) Other

FMS- Components

2) Material Handling and Storage System:

- Material handling and storage system is the second main component of an FMS.
- Requirements set against the FMS material handling and storage system include part transportation, raw material and final product transportation and storage of work pieces, empty pallets, auxiliary materials, wastes, fixtures and tools.

FMS- Components

Functions of the material handling system

- **Convenient access for loading and unloading work parts.** The material handling system should provide a means to load and unload parts from the FMS. This can be achieved by locating one or more loading and/or unloading stations in the system.
- **Compatible with computer control.** Last but not the least, the material handling system should be capable of being controlled by the computer to direct it to the various workstations, load/unload stations and storage areas.

Types of Material Handling Equipment

The material handling function in a FMS is shared between two systems:

(i) Primary handling system

(ii) Secondary handling system.

Types of Material Handling Equipment

(i) Primary Handling System

- It establishes the basic layout of the FMS and is responsible for moving workparts between workstations in the system.
- Table given below summarizes the type of material handling equipment typically used as the primary handling system for the five FMS layouts.

FMS Layout

| SI.NO | Layout configuration | Typical material handling system |
|-------|-----------------------|--|
| 1. | In-line layout | Conveyor system Shuttle system Rail guided vehicle system |
| 2. | Loop layout | Conveyor system In-floor towline carts |
| 3. | Ladder layout | Conveyor system Rail guided vehicle system Automated guided vehicle system |
| 4. | Open-field layout | In-floor towline carts Automated guided vehicle system |
| 5. | Robot-centered layout | Industrial robot |

Types of Material Handling Equipment

(ii) Secondary Handling System

- It consists of transfer devices, automatic pallet changers, and similar mechanisms located at the workstations in the FMS.

The functions of the secondary handling systems are:

- (i) To transfer work parts from the primary system to the machine tool
- (ii) To position the work parts with sufficient accuracy and repeatability or other processing station.
- (iii) To provide buffer storage of work parts at each workstation, if required.
- (iv) To reorient the work parts, if necessary, to present the surface that is to be processed.

FMS Planning and Control

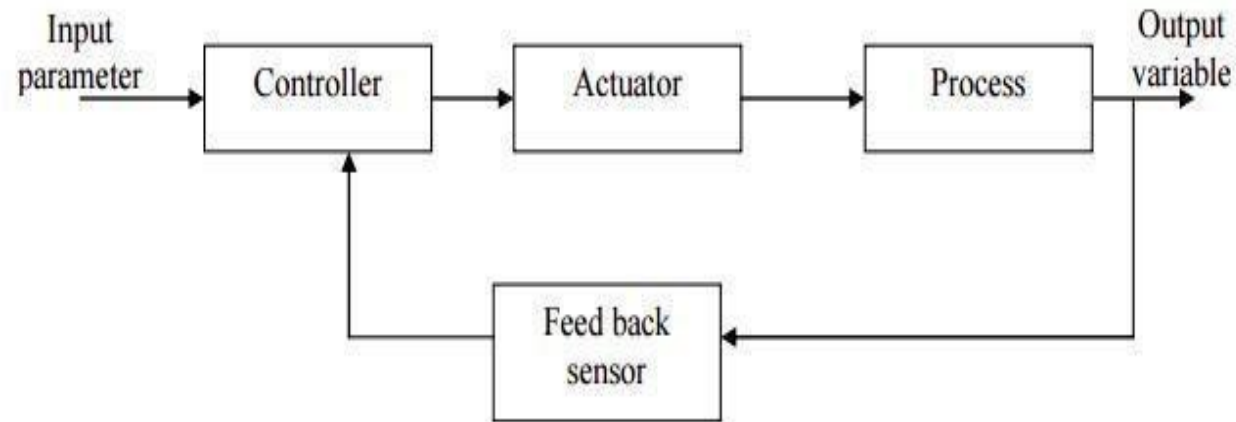
- FMS Planning and Control can be categorised as:
 - FMS Planning and Design issues
 - FMS Control issues

FMS Planning Issues

- The major issues of planning in the creation of FMS include:
 - Part family considerations
 - Processing requirements
 - Physical characteristics of the workparts
 - Production volume

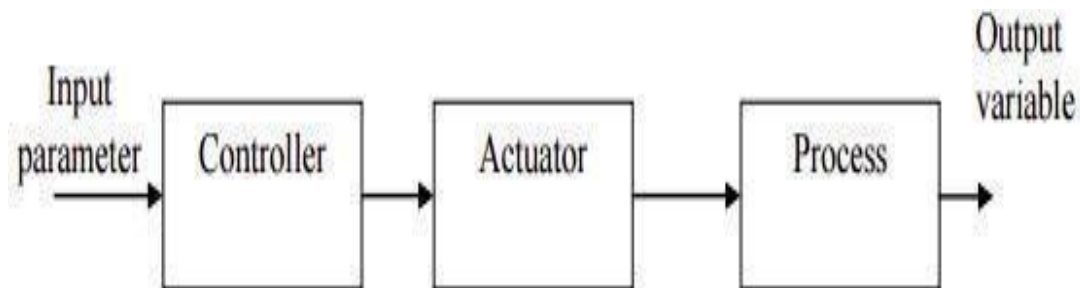
Control of FMS System – Closed Loop

- A closed loop control system is one in which the output variable is compared with an input parameter and any difference between the two is used to drive the output into agreement with the input.
- It is also known as feedback control system.
- A closed loop control system consists of six basic elements which is shown in figure below.



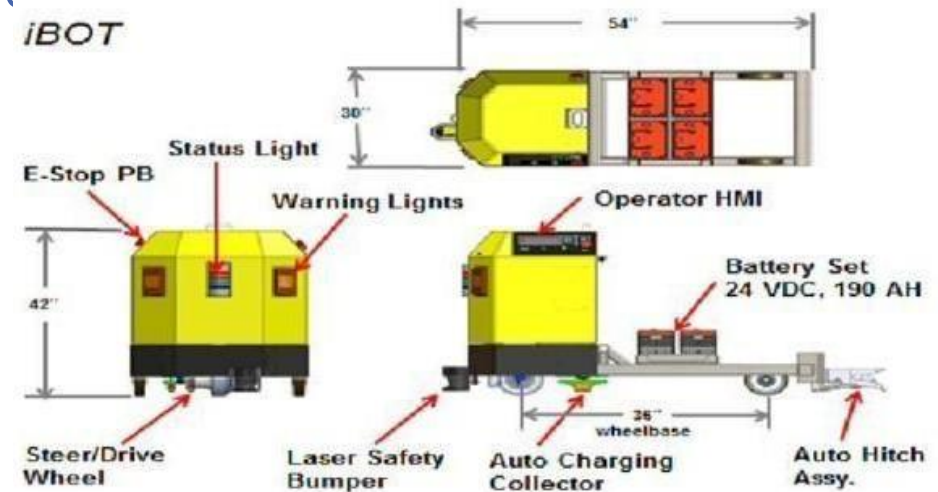
Control of FMS System – Open Loop

- Here, the controller compares the output value with the input and makes the required adjustment in the process to reduce the difference between them, which is accomplished by actuators.
- Actuators are the hardware devices that physically carry out the control actions such as an electric motor, electric fan.
- A sensor is used to measure the output variable and closed the loop between input and output. In contrast to the closed loop control system an open loop operates without the feedback loop as in figure below.



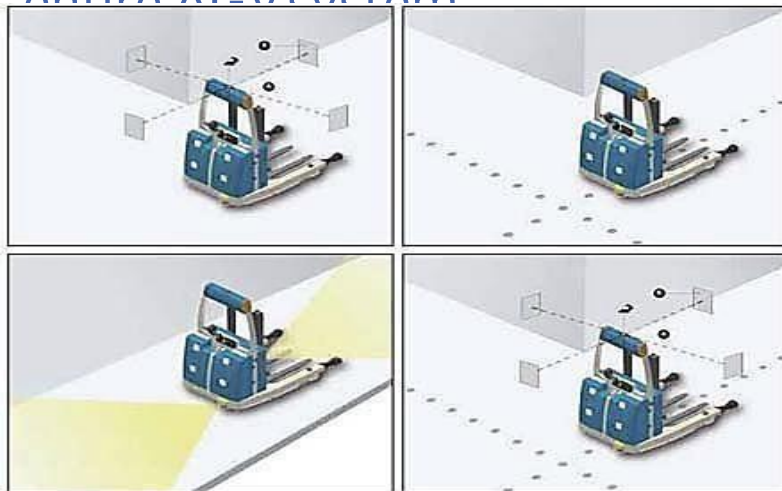
Automated Guided Vehicle System (AGVS)

- Automated guided vehicles (AGVs) are modern material-handling and conveying systems that are more appropriate for FMS applications and automation.
- An AGV is a computer controlled, driverless vehicle used for transporting materials from point-to-point in a manufacturing setting.
- AGVs are powered by means of on-board batteries that allow operation



Automated Guided Vehicle System (AGVS)

- A Painted, taped or chemical base paths have no distance limit.
- Route changes can be made easily without interrupting production.
- In FMS/CIM plant, AGVs are integrated with other plant equipment through their controllers and resources.
- The controller links the vehicle with the guide path and is thus the 'brain' of the entire AGV system.



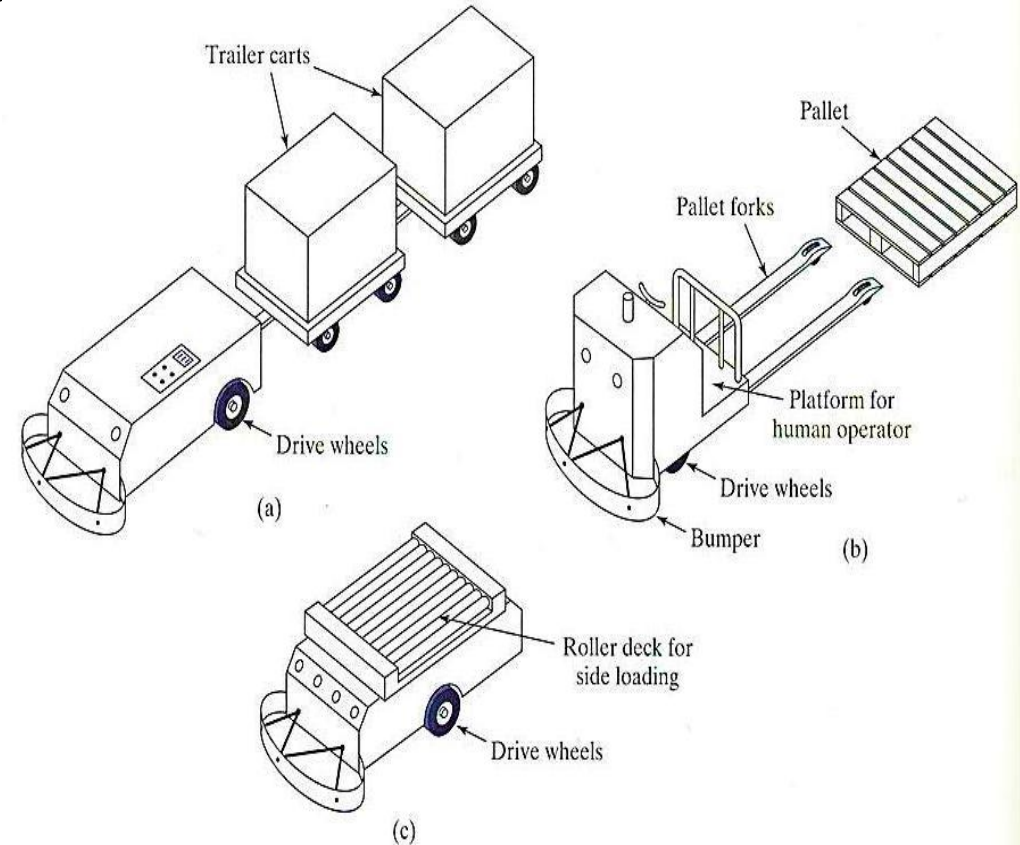
Automated Guided Vehicle System (AGVS)

The various typ

(a) Driverless trains

(b) AGVs pallet trucks

(c) AGVs unit load carriers



Automated Guided Vehicle System

(AGVS)

Applications AGVS

- Pharmaceutical
- Chemical
- Manufacturing
- Automotive
- Paper and print
- Food and beverage
- Hospital
- Warehousing
- Theme parks



Thank you