32062 COMPUTER AIDED DESIGN AND MANUFACTURING

1. Computer Aided Design
2. Computer Aided Manufacturing
3. CNC Programming and Rapid Prototyping
4. Computer Integrated Manufacturing, Flexible Manufacturing System (FMS). Automated Guided Vehicle (AGV). Robot
5. Concurrent Engineering, Quality Function Development Cycle, Augmented Reality

Basic definition about CAD and CAM

- CAD

Computer Aided Design may be defined as the use of computer system to help in the creation, modification, analysis and of a design.

- CAM

Computer Aided Manufacturing may be defined as the effective use of computer technology in manufacturing, planning and control.

UNIT 1 – COMPUTER AIDED DESIGN

- TOPICS
  1. Shigley's process
  2. CAD activities
  3. Transformations
     i) Translation
     ii) Rotation
     iii) Scaling
  4. Geometric modelling
     i) Wireframe modelling
     ii) Surface modelling
     iii) Solid modelling
        a) CSG
        b) B-rep
  5. Finite Element Analysis

1. Shigley’s design process

- Recognition of need
- Definition of problem
- Synthesis
- Analysis and optimization
- Evaluation
- Presentation

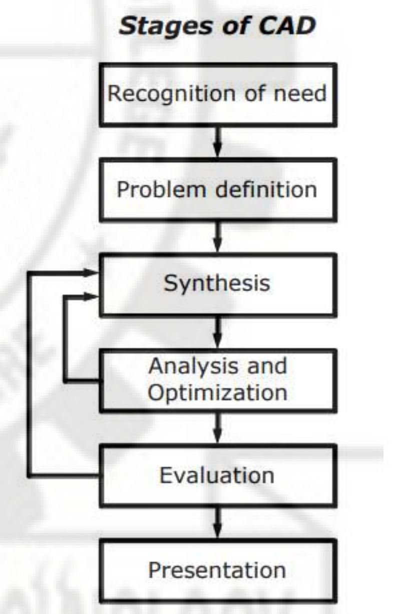


Fig.1.1 Shigley’s design process

- Recognition of need
  - ❖It is the process of identifying the same defect in the design, which may need correction for better performance or identifying the new product which may satisfy the customer needs.

- Definition of problem
  - ❖It involves complete specifications of the product be designed. This specification includes.

    Physical characteristics

    size, shape, appearance, weight etc…

    Functional characteristics

    operating performance, cost, quality etc…

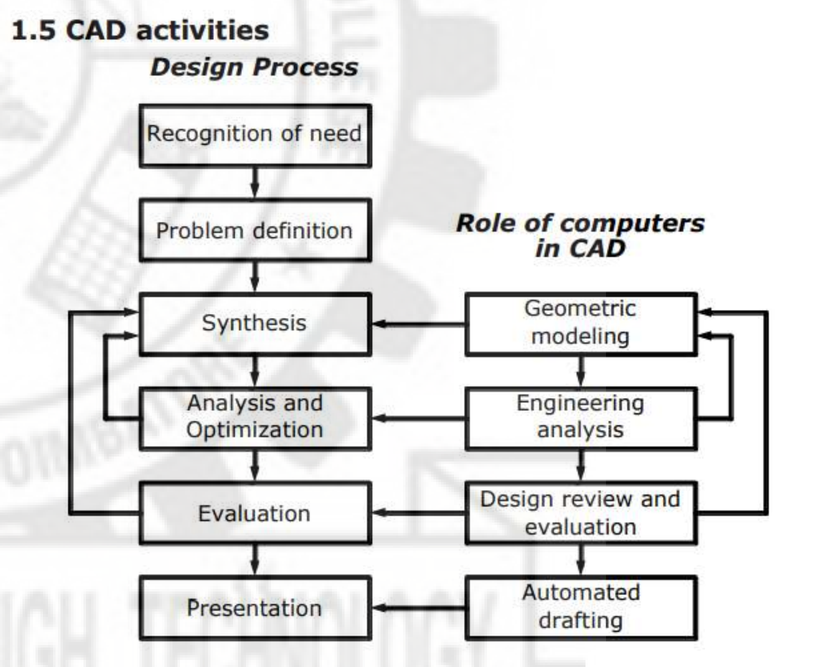
- Synthesis
  - ❖It is the process of developing new concepts about the shape, form and technology used in product by the creativity of the designer or by the research of similar products or design in use.

- Analysis and optimization
  - ❖The developed conceptual design is analysed to check the suitability for the intended purpose. If the developed design is not satisfied, then it is modified, redesigned and analysed till we get the optimized design.

- Evaluation
  - ❖It is the process of measuring the design against the specification established in problem definition phase. This evaluation often requires the fabrication and testing of a prototype model to assess operating performance, quality, reliability and other criteria.
- Presentation
  - ❖Documentation of design by means of drawings.
  - ❖Material specifications.
  - ❖Sectional views.
  - ❖Assembly list.
  - ❖Bill of materials etc…..

2. CAD Activities

- Geometric modelling
- Engineering analysis
- Design review and evaluation
- Automated drafting



- Geometric modelling
  - ❖ Computer compatible mathematical description of the geometry of an object is called geometric modelling.

    The geometric models may be the any one of the following types.

    1. Wire frame modelling
    2. Surface modelling
    3. Solid modelling

    Example: Auto CAD, Pro-E etc…..

- Engineering analysis
  - ❖ The created models can be analysed to check the suitability of the models for intended purpose.

    1. Stress-strain analysis
    2. Heat transfer analysis
    3. Fluid flow analysis
    4. Kinematic analysis
    5. Dynamic analysis
    6. FEA analysis etc…..

    Example: ANSYS, ANSYS CFX etx…

- Design review and evaluation

Checking the accuracy of design.

- ❖Dimensioning and tolerancing
- ❖Layering
- ❖Interference checking in assemblies.
- ❖Animation of designed mechanism by means of kinematics.
- ❖Evaluation of areas and volumes.
- ❖Evaluation of mass and inertia properties.

- Automated drafting

It involves the creation of hard copies of design directly from the CAD database.

- ❖Preparation of detailed drawings.
- ❖Preparation of sectional views.
- ❖Preparation of assembly drawings.
- ❖Preparation of material specification.
- ❖Preparation of bill of materials etc….

Benefits of CAD and CAM

- Benefits of CAD in designing of engineering components :

✓Productivity improvement in design.

✓Shorter lead time.

✓More flexibility in design.

✓Fever design errors.

✓Improved design analysis.

✓Standardization of design, drafting and documentation.

✓Easier creation and modification of design.

✓Easier visualization of drawings

✓Preparation of near and more understandable working drawings.

✓Creation of realistic image of component before actually making it.

- Benefits of CAD in manufacturing :

✓Tool and fixture design.

✓Computer Aided Process Planning (CAPP).

✓Production Planning and Control (PPC).

✓Preparation of assembly lists and bill of materials.

✓Coding and classification of components.

✓Computer aided inspection.

✓Preparation of NC part programs.

✓Assembly sequence planning

3. Transformations

- The capability of any graphic software are mainly depends on the ability to change the orientation, size and shape of created model.

  2D Transformation

  3D Transformation

- The basic geometric transformations are

  1. Translation
  2. Rotation
  3. Scaling

Translation

It involves moving the geometric elements from one location to another location.

- 2D Translation

It moves the object on X and Y plane along straight line by adding increments in X-axis and Y-axis.

The, Homogeneous representation of above matrix is,

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

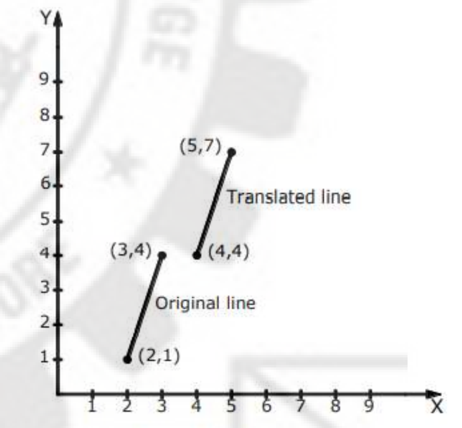


Fig.1.4 Translation

- 3D Translation

It move the object on xyz coordinates along straight line adding increments in x-axis, y-axis and z-axis.

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

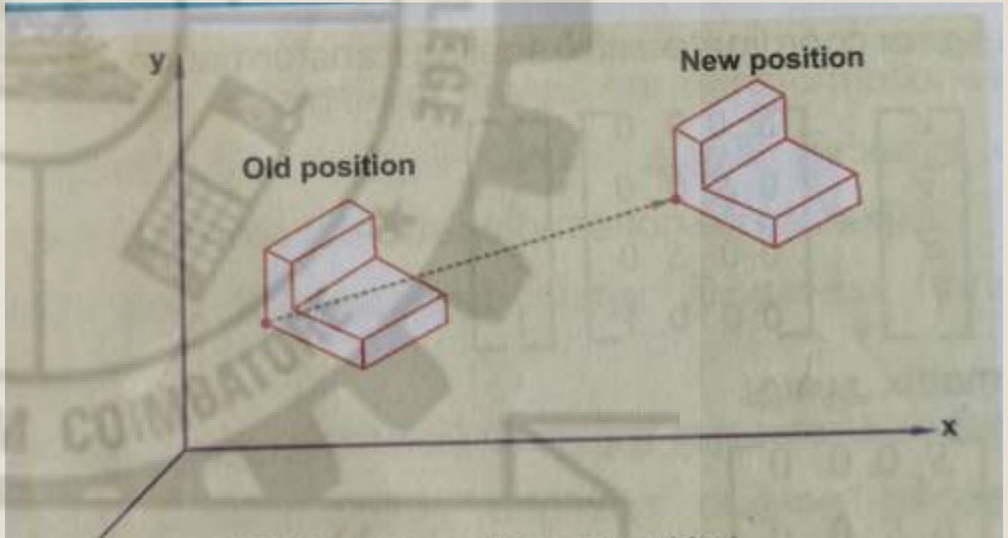


FIG 1.7 3D translation of an object

Rotation

It is the rigid body transformation that moves the object along the circular path in xy plane or in xyz coordinates without any deformation.

- 2D Rotation

It involves the rotation of an object about its origin by an angle θ. For a positive angle, this rotation is in the counter–clockwise direction. The object is moved while rotating.

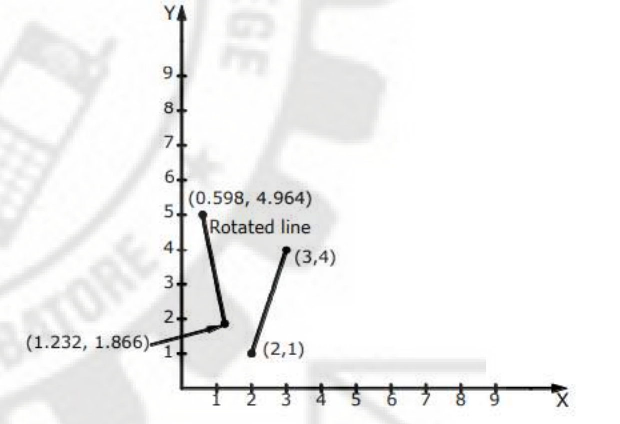


Fig.1.6 Rotation

The, Homogeneous representation of above matrix is,

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} cos\theta & 0 & 0 \\ 0 & sin\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

- 3D Rotation

The, Homogeneous representation of above matrix is,

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

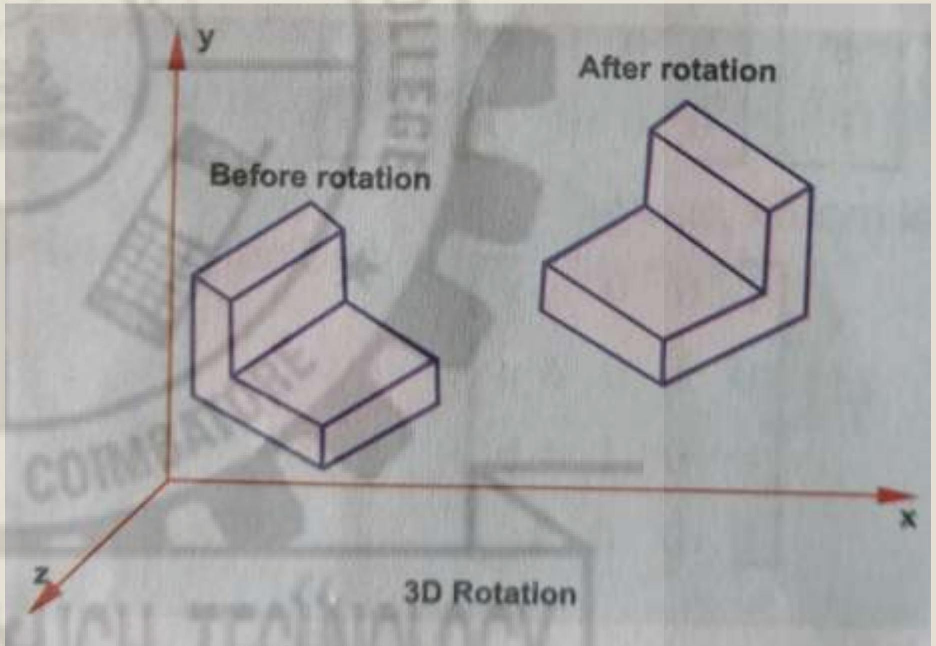


FIG 1.9

Scaling

It is used to enlarge or reduce the size of the object

- 2D Scaling

The, Homogeneous representation of above matrix is,

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} s_x & 0 & 0 \\ 0 & s_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

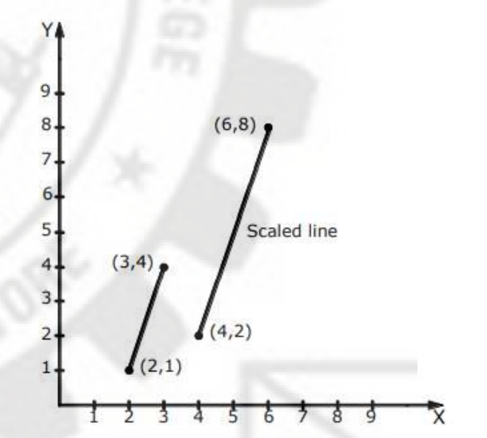


Fig.1.5 Scaling

- 3D Scaling

The, Homogeneous representation of above matrix is,

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & s_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

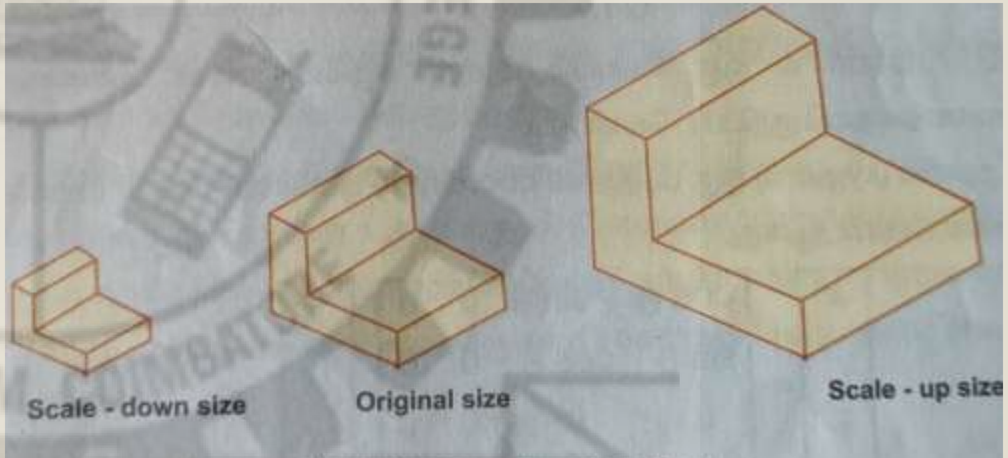


FIG 1.8 3D scaling of an object

Geometric Modelling

- In CAD, geometric modeling is concerned with the computer compatible mathematical description of the geometry of an object.

There are several methods of Geometric modeling

1. Wire frame modeling
2. Surface modeling
3. Solid modeling

WIREFRAME MODELING

- In this modelling the object is displayed by interconnecting lines.

2D model – Represent a flat object.

$2^1/_2$ D model – 3D object to be represented as long as it has no side-wall details.

3D model – Represented 3D object with more complex geometry.

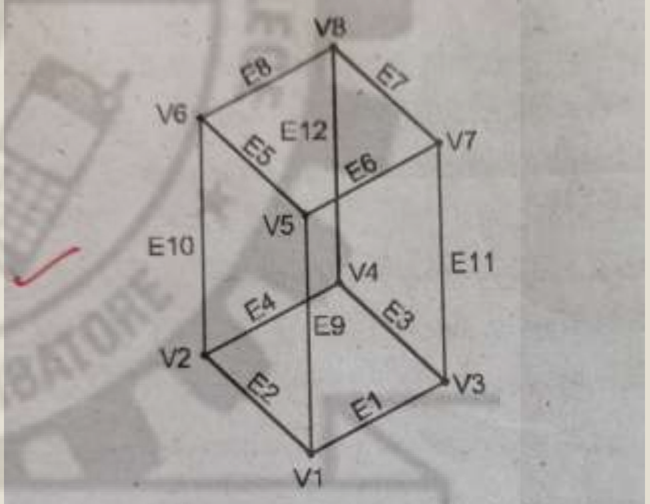


Fig.1.3.1 Wire frame model with straight edges

SURFACE MODELING

- A surface model of an object is more complete and less confusing representation than its wireframe model.
- A surface model can be built by defining the surface on the wireframe model.
- The boundary of an object may consist of surface, which are bounded by straight lines and curves either single or in combination.

Fig.1.9 Representation of surface modelling

SOLID MODELING

- The best method for the 3D model construction is the solid modeling technique. It provides the user with complete information about the model.

1. Creating
2. Modifying
3. Inspecting
4. Dimensions

Representation schemes are available for creating solid models

1. Constructive Solid Geometry (CSG)
2. Boundary representation
3. Pure Primitive instancing
4. Generalized sweep
5. Cellular decomposition
6. Hybrid scheme

- Constructive Solid Geometry (CSG)

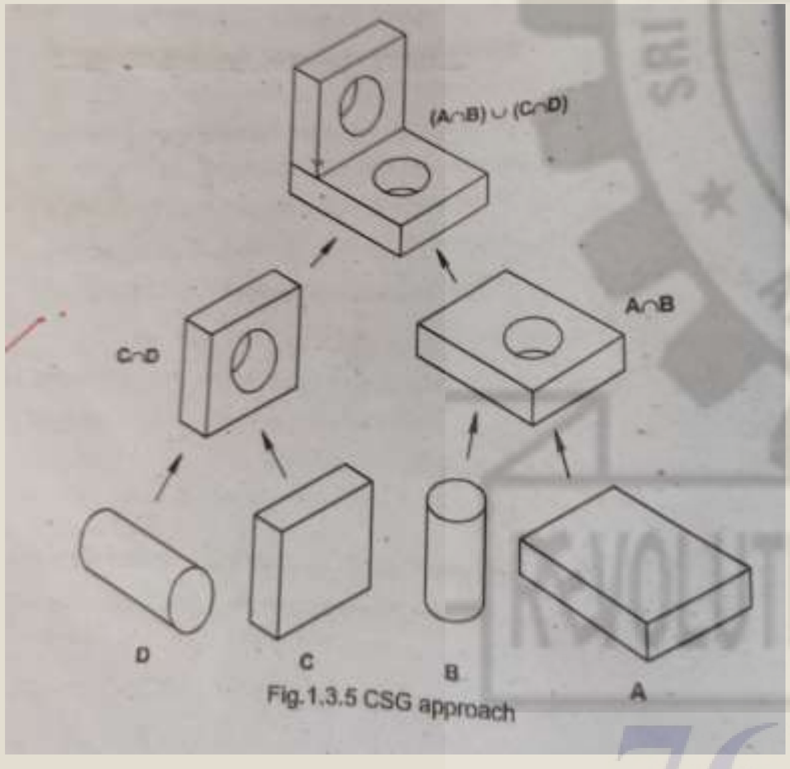
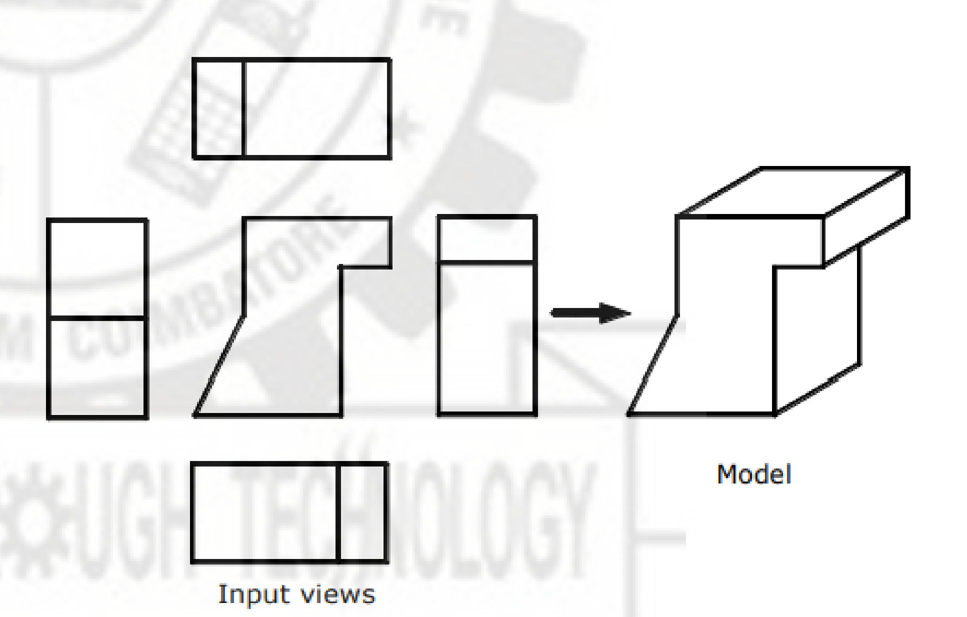


Fig.1.3.5 CSG approach

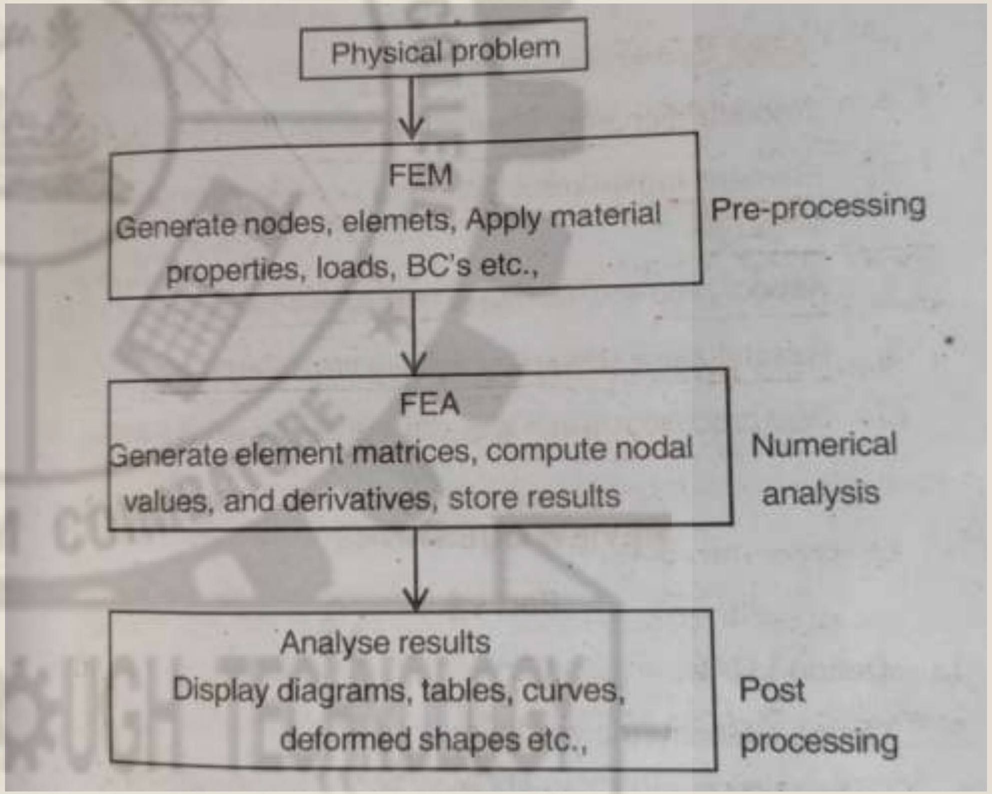
- Boundary Representation (B-rep)



Finite Element Analysis

- Finite Element Analysis is a computer simulation technique used in engineering analysis to determine the behavior of structures and components under a variety of conditions.

    1. Pre-Processing
    2. Numerical analysis
    3. Post-Processing

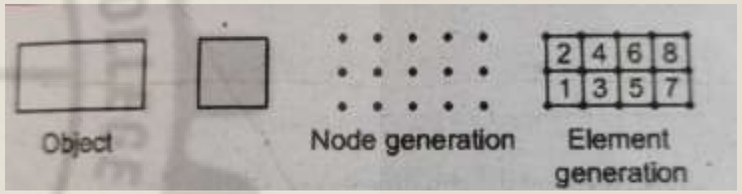


Basic steps involved in FEA

- Discretization of domain
- Approximate the solution within an element
- Develop element matrices and equation

1. Direct method
2. Variation method
3. Weighted residual method
4. Energy method

- Assemble element matrices into global system matrix and equations
- Solve the system of equation to find unknown values
- Interpret the results



UNIT 2

COMPUTER AIDED MANUFACTURING

2.1.1. CAM definition

- ✓ CAM is the term that means Computer Aided Manufacturing. It can be defined as the use of computer system to plan, manage and control the operations of a shop floor. In other words, the use of computer system in manufacturing process is called CAM.

2.2.1. Group Technology (GT)

Group Technology (GT) is a manufacturing philosophy in which similar parts are identified and grouped together. The similarities in design and production are taken the advantage for manufacturing. Similar parts are arranged into part families. Each family possesses similar design and manufacturing characteristics.

For example, a plant producing a greater number of parts may be able to group into small number of part families. Since each part family have almost similar processing activities of design and manufacturing.

The grouping of machines required for the processing of a part family leads to best and economical method of manufacturing is known as cellular manufacturing.

2.1.2. Functions of CAM

The functions of the CAM can be divided into two main categories.

1. Planning the manufacturing activities.

2. Controlling the manufacturing activities.

Planning the manufacturing activities:

The computer can be used to provide information for the effective planning and management of manufacturing activities. The manufacturing planning includes the following activities.

Controlling the manufacturing activities:

It is concerned with the use of computer systems for managing and controlling the physical operations in the industry. The manufacturing control includes the following activities.

2.2.2. Part Families

A part family is nothing but the collection of parts which are similar in geometric shape and size or similar steps of manufacturing process are required in the production.

The parts may be grouped in group technology by the following

1. Design attributes.

2. Manufacturing attributes.

- ✓ Design attributes in design attributes the parts are grouped in a family with similar design characteristic and features. The basic idea of design engineers will be of function and performance and the design should be creative. Mostly in manufacturing industries a considerable number of similarities available in the part manufacturing. Creating new parts and introducing new parts are expensive. Therefore, the design of the parts should be modified to a common structure that will reduce the cost considerably.

- ✓ The figure 2.1 (a) and (b) illustrates examples of two parts from the same family. These parts are placed in same family due to its similarity in size and other design features. They have exactly same shape and size but the production method different. Even though these parts are grouped with respect to size and shape based on the design attributes.

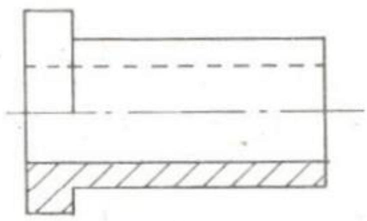


Figure 2.1 a

50,000 components / Year

Tolerance ± 0.01 mm

Material: M.S

Machine used: CNC Lathe

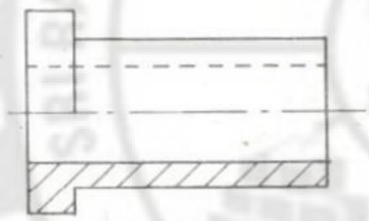


Figure 2.1 b

500 components / Year

Tolerance ± 0.001 mm

Material: Stainless steel

Machine used: Automatic Lathe

2.2.4. Coding structure

Coding structure is defined as a sequence of symbols that identifies the part design and manufacturing attributes. The symbols in the code can be numerical and alphabetic or combination of the both. The type of coding system structures are

1. Hierarchical structure
2. Chain type structure
3. Hybrid structure

1. Hierarchical structure

In this structure the interpretation of each succeeding symbol depends on the value of the proceeding symbols. In this system there will be a relation between the consecutive numbers. It is also called as monocode. This system has a short code contains large amount of information.

2. Chain type structure

In this type the interpretation of each symbol in the sequence is fixed. It depends on the value of proceeding digits. This is also called as polycode.

3. Hybrid structure

It is the combination of both hierarchical and chain type structure. This method is widely used in industries.

2.2.4. Coding structure

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3. Hybrid structure: It is the combination of both hierarchical and chain type structure. This method is widely used in industries.

2.2.5. THE OPTIZ SYSTEM

This system uses a hybrid code structure. It has a form code and a supplementary code.

The first five digits are form code represents the design attributes.

The next four digits are supplementary code represents the manufacturing attributes.

It is extendable further by 4 more digits are secondary code.

1 2 3 4	**5 6 7 8 9**	**A B C D**
Form code	**Supplementary code**	**Secondary code**

The form code uses a 5 digit representing (i) Component class, (ii) basic shape, (iii) rotational surface machining, (iv) plane surface machining, (v) Auxiliary holes, gear teeth and forming.

A supplementary code has 4 digits in which the 1st digit denotes the major dimension. The 2nd, 3rd and 4th digits denote material, raw material shape and accuracy respectively. The figure 2.5 shows the basic structure of the OPTIZ system.

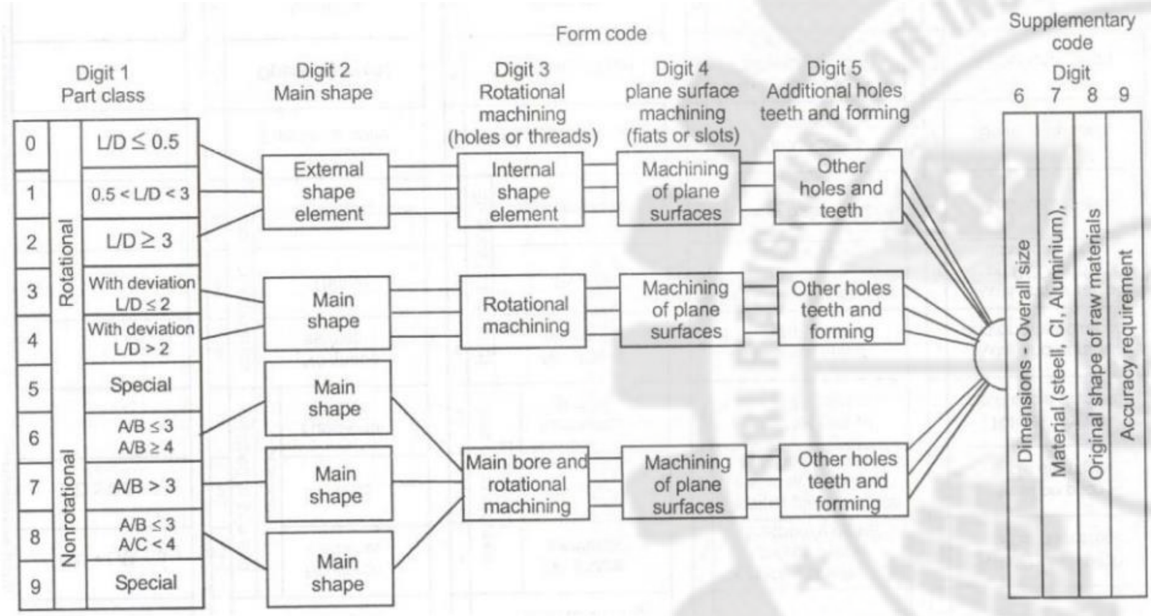


Figure 2.5 Structure of the OPTIZ system

2.2.6. MICLASS SYSTEM (Metal Institute Classification System)

It is a chain structure code of 12 digits and is designed to be universal. It includes both design and manufacturing information. An additional 18 digits of code is also available for user specified information. The supplementary digits provide flexibility for system expansion. Universal Code Position

1st digit - Main shape

2nd & 3rd digit - Shape elements

4th digit - Position of shape elements

5th & 6th digit - Main dimensions

7th digit - Dimension ratio

8th digit - Auxiliary dimension

9th & 10th digit - Tolerance codes

11th & 12th digit - Material codes

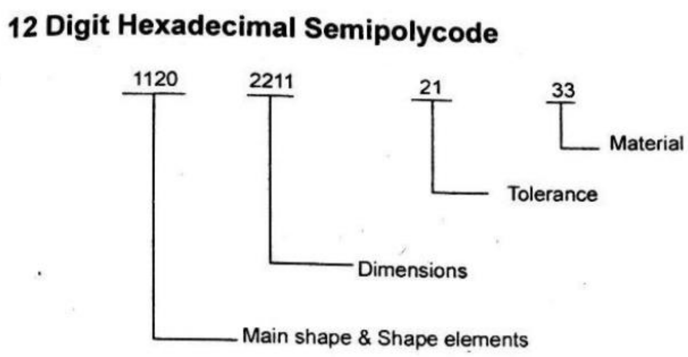


Figure 2.6

2.3.2. Computer Aided Process Planning (CAPP)

CAPP is an automatic process planning functions by means of computers. CAPP accomplishes the complex task of production planning, so that the individual operations and steps involved in production are co-ordinated perfectly with other system and are performed efficiently with the help of computers. CAPP requires extensive software and co-ordinates with CAD/CAM. It is a powerful tool for efficient planning and scheduling the manufacturing operations.

2.3.3. Types of Process Planning

There are four basic important approaches to perform the task of process planning.

They are

♣Manual approach

♣Variant approach

♣Generative approach

♣Hybrid approach

2.3.4. Variant (or) Retrieval Process Planning

Variant process planning uses of existing process plans, and then allow the user to edit the plan for their new parts. The variant CAPP systems are based on GT and parts classification and coding. In this system, a standard process is stored in computer files for each part code number, and the process plan for new part is created by identifying and retrieving an existing plan for similar part and the plan is edited for modification.

The standard plans may be based on current routings or ideal plan is prepared for each family. The basic variant approach to process planning with group technology (GT) is,

♣Go through normal group technology setup procedures.

♣After part families identified, develop standard process plan for each.

♣When a new plan has been designed, prepare a GT-code for each part.

♣Use the GT system to lookup which part family is the closest match, and retrieve the standard plan for that part family.

♣Edit standard plan so that values now match the new design parameters, and add or delete steps are required.

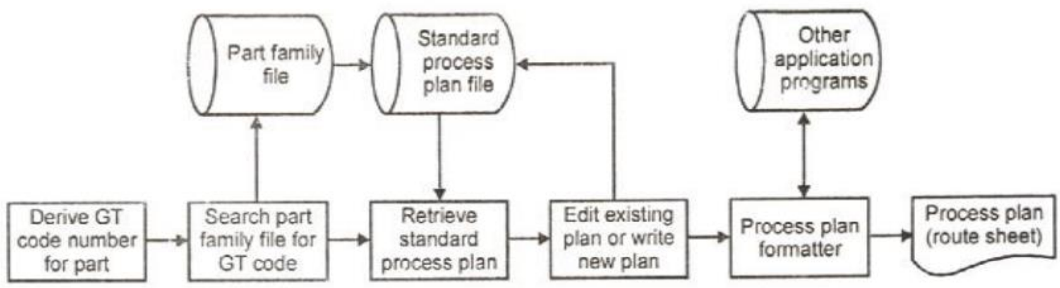


Figure 2.8 Variant (or) Retrieval Process Planning

2.3.5. Generative CAPP

Generative process planners should create a new process plan. This does not imply that the process planner is automatic. It is an alternative system to variant CAPP. A generative CAPP creates the process plan using systematic procedure rather than retrieving and editing the existing plans form a database. Generative plans are generated by means of decision logics, formula technology algorithms and geometric based data used for converting a part from the raw material to finished state. The rules of manufacturing and equipment capabilities are stored in a computer system.

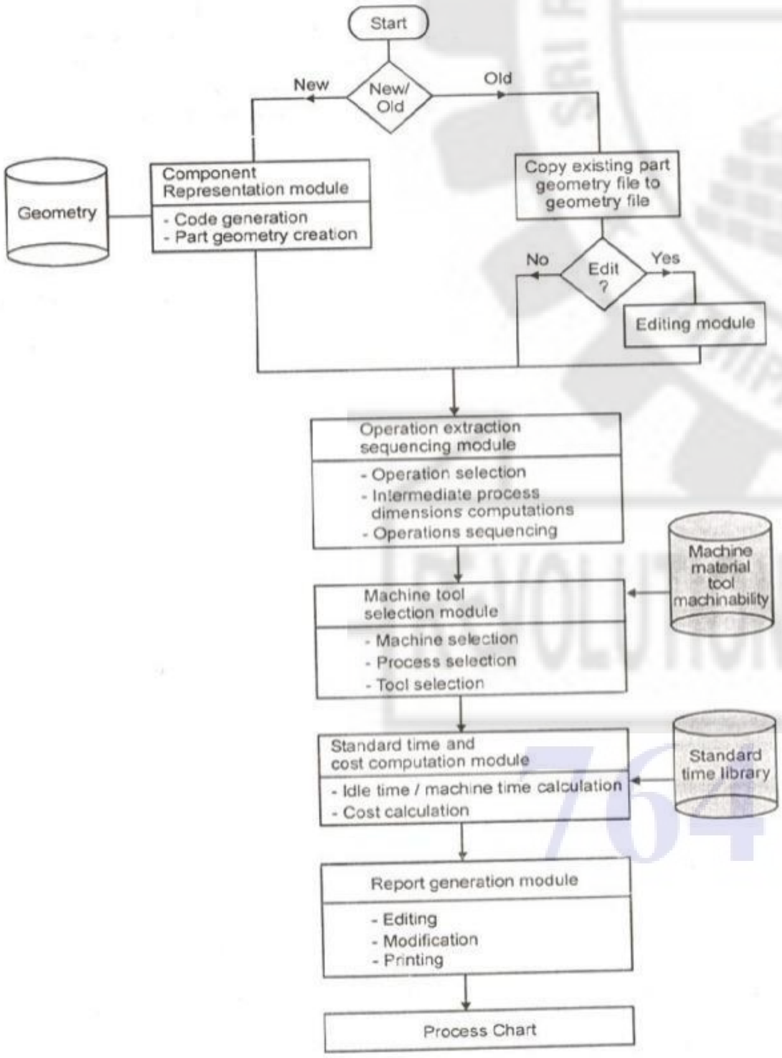


Figure 2.9 Generative Process Planning

2.4.4. Master Production Schedule (MPS)

A MPS is generally defined as an anticipated build schedule for manufacturing of product. It is a key decision-making activity. The demands coming from business planning are translated at the MPS level into demands on the manufacturing system.

The MPS is driven by a combination of actual customer orders and forecasts of likely orders. The interaction of the various components of information with the MPS is shown in figure 2.11.

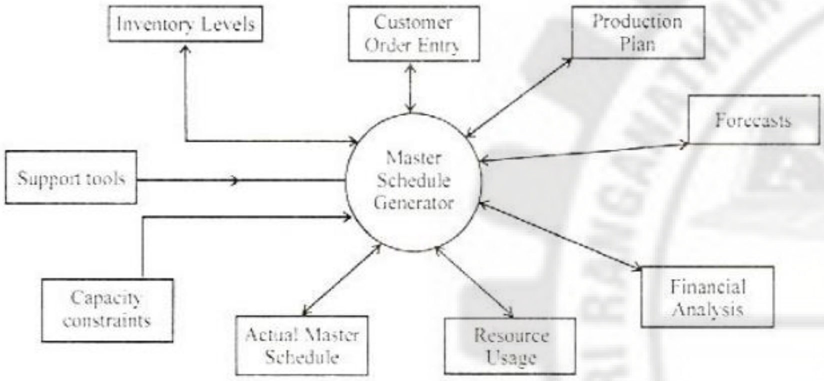


Figure 2.11 MPS

2.4.5. Capacity Planning

For short-term adjustments, decisions on the following factors are needed:

· Employment level

· Number of work shifts.

· Labour overtime hours or reduced workweek.

· Inventory stockpiling

· Order backlogs.

· Subcontracting

Long-term capacity requirements would include the following types of decisions:

· New more productive modern machines.

· New plant construction.

· Purchase of existing plants from other companies.

· Closing down or selling off existing facilities which will not be needed in the future.

2.4.6. MATERIAL REQUIREMENTS PLANNING (MRP)

MRP systems have been installed almost universally in manufacturing industries, even those considered small. The reason is that MRP is a logical, easily understandable approach to the problem of determining the number of parts, components, and materials needed to produce each end item. MRP also provides the time schedule specifying when each of these materials, parts, and components should be ordered or produced.

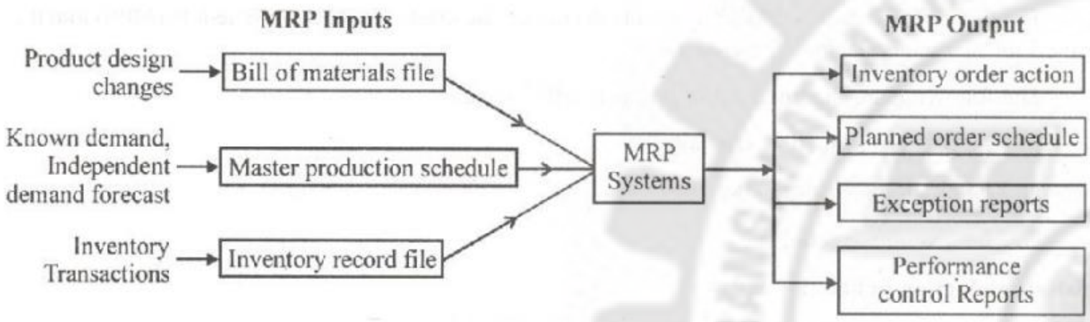
Purpose of MRP

The important purpose of a MRP system is

· Control the inventory levels.

· Assign priorities of operation.

· Plan the capacity to load the production system.



2.12.MRP System

2.4.7. MANUFACTURING RESOURCE PLANNING (MRP- II)

MRP - II is a company operating system which is used to connect the material requirement planning the financial systems. This is the one of the effective planning tool of a company. It is concerned with all activities of the business, including sales, production, engineering, inventories, and cash flows. In all cases the operations of the individual departments are reduced to the same common denominator, financial data. This common base provides the company management with the information needed to manage it successfully, in essence, MRP - II is quite similar to CIM (Computer Integrated Manufacturing Systems).

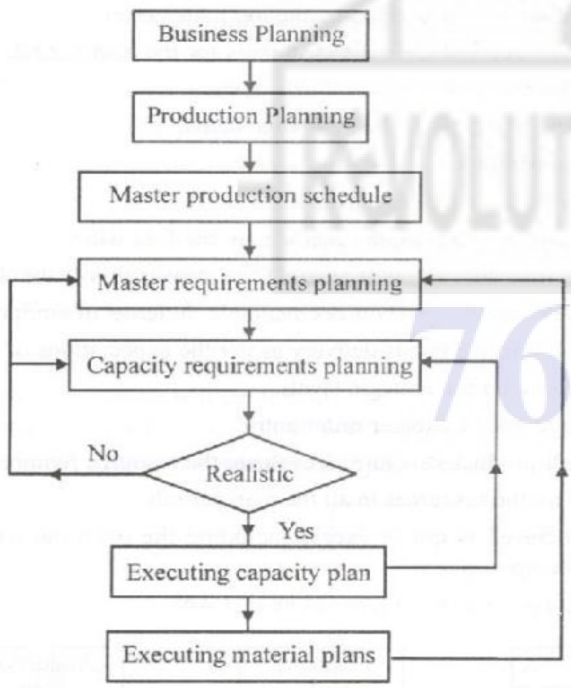


Figure 2.13 MRP II System

2.4.8. Shop floor control system

It is concerned with the release of production orders to the factory monitoring and controlling. It is progress of the orders through the various work centres and collecting information on the status of the orders. The organization of a computerized shop floor control system is shown in fig.2.14. The diagram differentiates those portions of SFC which are computer driven and those which require human participation. The computer generates various documents which are used by people to control production in the factory.

The shop floor control system contains three steps

- Order release
- Order scheduling
- Order progress

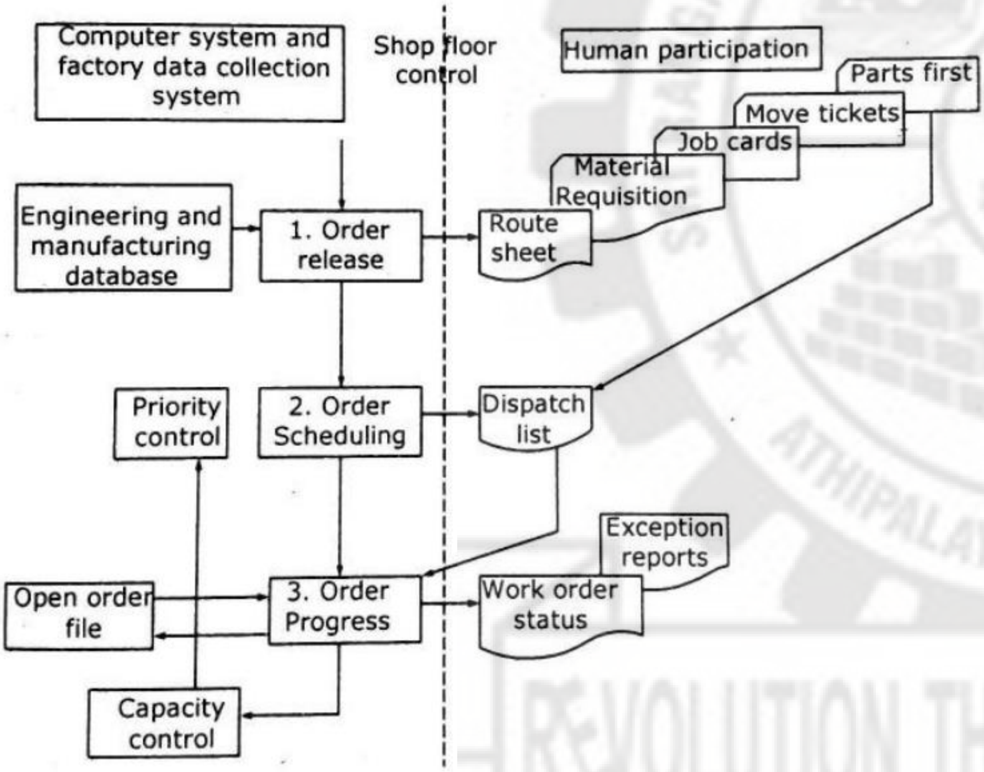


Figure 2.14 Shop floor control system

1.Order release They are the different orders necessary to complete the job. The different orders related to a particular job are kept collectively in a packet known as shop packet. This moves with the job through the sequence of processing or assembly operations. It consists of the following.

- Route sheet
- Material requisition
- Job cards
- Move ticket
- Part lists

2. Order scheduling Its purpose is to assign orders to the various machines of the shop as per priority. This order is also known as dispatch list. It reports the jobs that should be done at each machine and some detail about the routing of the part. This list is generated each day in the shop floor. The setbacks if any in the schedule will be adjusted in the next schedule through priority control.

3. Order progress It is concerned with the collection of data from the shop floor and to generate reports. This can be useful for production control. When the complete particular of the

process are specified in the route sheet from these data the following reports are generated to control the production.

Work order status report

Exception reports

2.4.9. JUST IN TIME APPROACH

Just In Time (JIT) is a management philosophy that to eliminate sources of manufacturing waste by producing the right part in the right place at the right time. Waste results from any activity adds cost without adding value, such as moving and storing. JIT should improve profits and return on investment by reducing inventory levels.

Objectives of the JIT

JIT seeks to meet the objectives by achieving the following goals

· Zero defects

· Zero set up time

· Zero inventory

· Zero handling

· Zero breakdowns

· Zero lead time

· Batch size of one

UNIT 3 – CNC PROGRAMMING AND RAPID PROTOTYPING

- Topics
  - ✓Stereolithography (SLA)
  - ✓Laser Sintering (LS) or Direct Metal Laser Sintering (DMLS) or Selective Laser Sintering (SLS)
  - ✓Fused Deposition Modelling (FDM)
  - ✓3D Printing

Rapid Prototyping

Rapid prototyping is the automatic construction of physical objects using subtractive or additive manufacturing technology.

- Subtractive Manufacturing
  - ❖It is a process by which 3D objects are constructed by successively cutting material away from a solid block of material. Subtractive prototypes are created using traditional manufacturing processes or CNC machining
- Additive Manufacturing
  - ❖It is a process by which 3D objects are constructed by successively adding layers of liquid, powder, or sheet material and joining them together to create the final shape.

Rapid Prototyping steps

- Rapid Prototyping

1. Creation of CAD model

❖ Select any one of modelling software packages.

❖ Example: Pro-E, CATIA, SOLID WORKS

2. Conversion of CAD model into STL format

❖ The standard file format used in RP process is the conversion of the CAD model in to STL format.

3. Slicing of model in STL format

❖ The pre-processing software slices the STL model into number of layers from 0.01mm to 0.7mm thick, depending on type of technique is going to be used to build the model.

4. Layer by layer construction of physical model

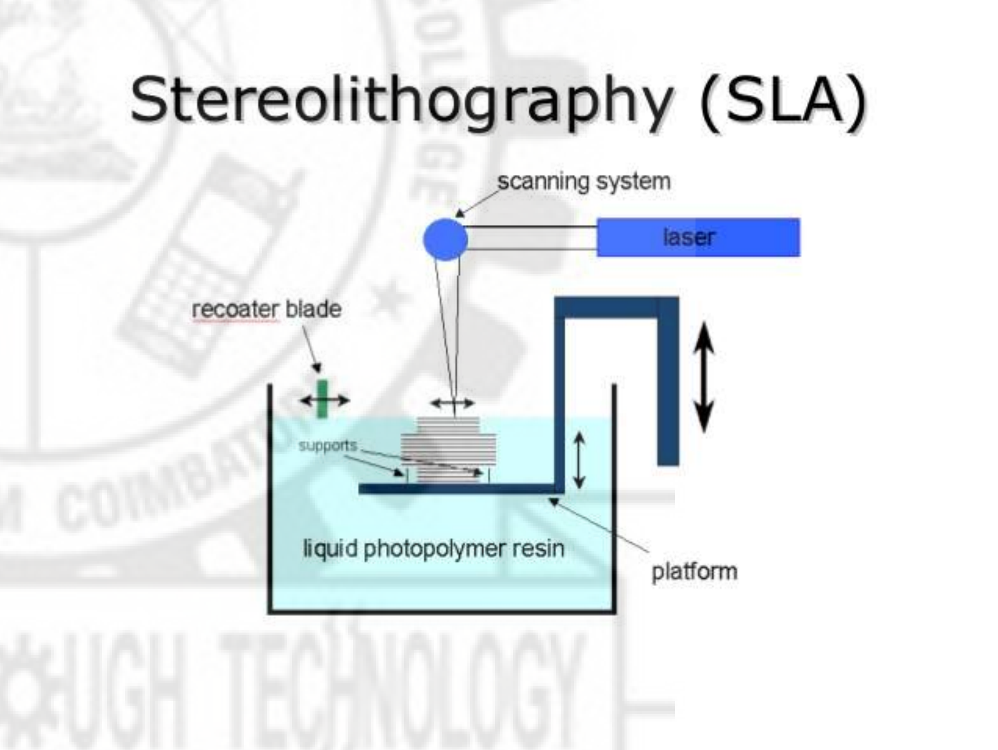
❖ It build the model by adding material layer by layer.

5. Cleaning and finishing the model

❖ Cleaning the finished of object produced

Stereolithography (SLA)

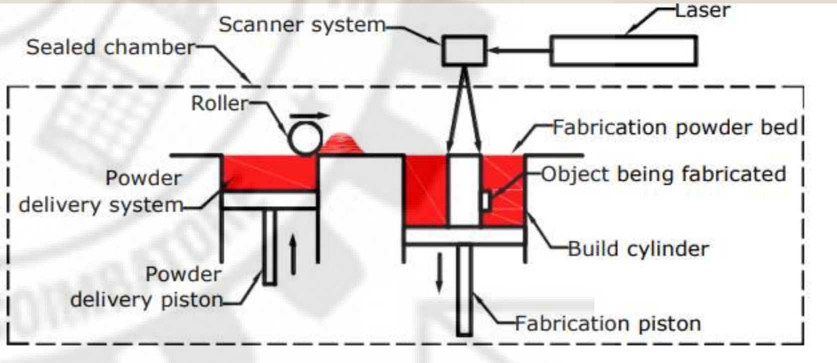
- Components of SLA
  - ❖Container
  - ❖Laser
  - ❖Movable scanner system
  - ❖Movable table
  - ❖Knife edge
  - ❖Sealed chamber



- Advantages
  - ❖Good surface finish.
  - ❖Good accuracy ± 100 µm.
  - ❖Un attended building process.
- Applications
  - ❖Skull model.
  - ❖Pattens for metal casting.
  - ❖Briefcase handle.
- Disadvantages
  - ❖High cost.
  - ❖Not suitable for thermal testing.
  - ❖High running cost.
  - ❖High maintenance cost.

Laser Sintering (LS) or Direct Metal Laser Sintering (DMLS) or Selective Laser Sintering (SLS)

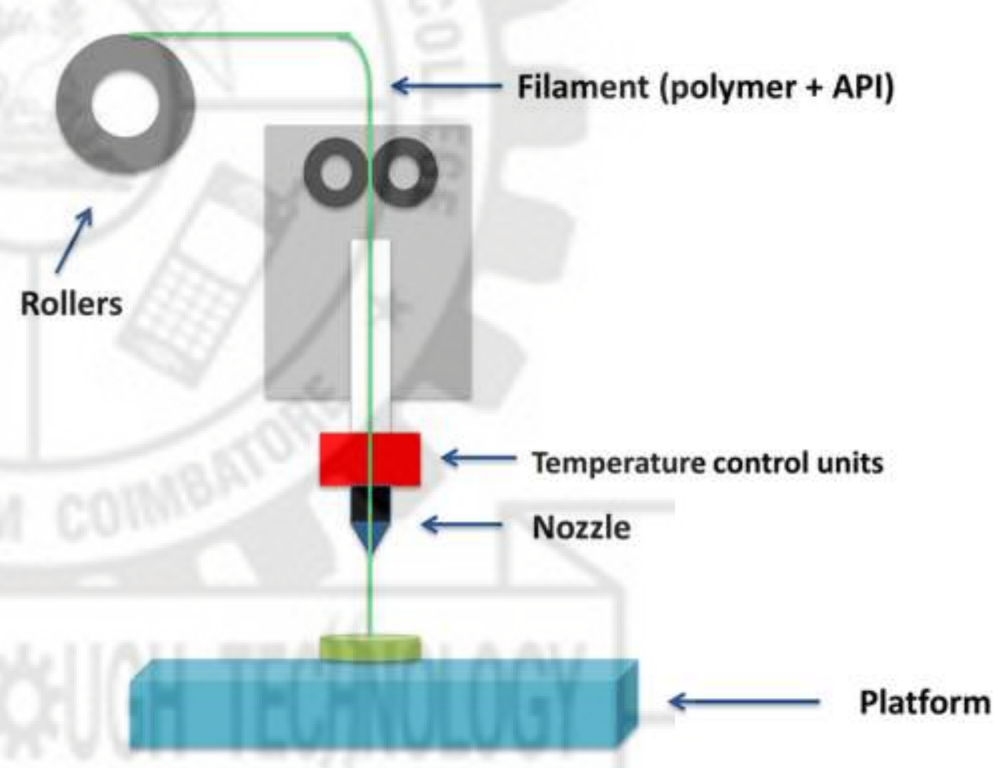
- Components of SLS
  - ❖Metal powder delivery system
  - ❖Recoating system (or) Roller
  - ❖Build chamber
  - ❖Laser system (200 to 250 watts)
  - ❖Scanner system
  - ❖Powder materials



- Advantages
  - ❖Un attended building process.
  - ❖Ability to create internal sharp corners.
  - ❖Ability to create complex geometry.
- Applications
  - ❖Making patterns for castings.
  - ❖Making functional prototypes.
  - ❖Making tooling inserts for injection moulds.
- Disadvantages
  - ❖Poor surface
  - ❖finish Product will be porous
  - ❖Strength of the product is low

Fused Deposition Modelling (FDM)

- Components of FDM
  - ❖Plastic filament supply coil
  - ❖Liquefier
  - ❖Feed rollers
  - ❖Deposition nozzle
  - ❖Molten filament



- Advantages
  - ❖Simple and quiet process.
  - ❖Fast process.
  - ❖The product has greater strength.
  - ❖Various types of materials can be used.
  - ❖The production cost is comparatively less.
- Disadvantages
  - ❖Slow for build heavy parts.
  - ❖Support structures are required.
  - ❖Poor strength in vertical direction.
- Applications
  - ❖Medical models.
  - ❖High strength prototypes.
  - ❖Functional prototypes.

3D Printing

- Components of 3D Printing
  - ❖Powder delivery system
  - ❖Roller
  - ❖Build cylinder
  - ❖Liquid supply
  - ❖Multi channel inkjet head
  - ❖Powdered material

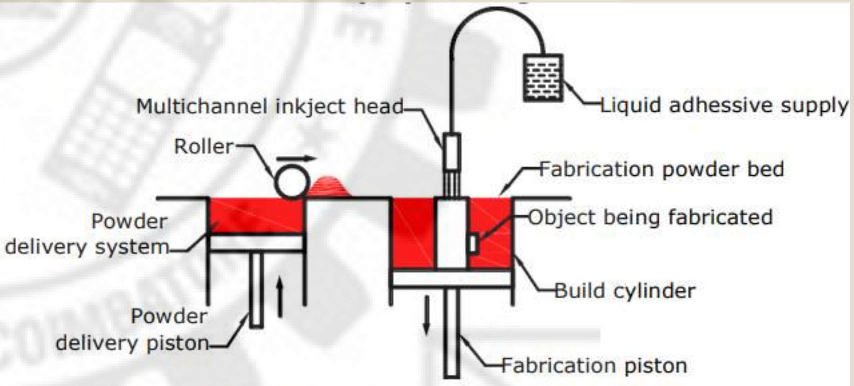


Fig.3.37 3D Printing

- Advantages
  - ❖Equipment cost is less.
  - ❖Easier to use.
  - ❖Printing of full colour prototypes.
  - ❖Fastest method.

- Disadvantages
  - ❖Final parts may be porous.
  - ❖Excess powder may be difficult to remove from any cavity.
- Applications
  - ❖Create coloured objects.
  - ❖Direct fabrication of metal, ceramic objects and tools.
  - ❖Tissue engineering application.

UNIT 4 – COMPUTER INTEGRATED MANUFACTURING, FLEXIBLE MANUFACTURING SYSTEM, AUTOMATIC GUIDED VEHICLE, ROBOT

- Topics
  - ❖Introduction about CIM, FMS, AG and robot
  - ❖Concept of CIM
  - ❖FMS Components
  - ❖FMS Layouts
  - ❖Automated Guided Vehicle (AGV)
    - ❖Working of AGV
    - ❖Types of AGV

❖Robot
- ❖Robot configurations
- ❖End effectors
- ❖Industrial applications of robot
  - ❖Machine loading/unloading
  - ❖Robots in Arc welding
  - ❖Robots in Spray coating
  - ❖Robot is assembly and inspection

Basic Definitions

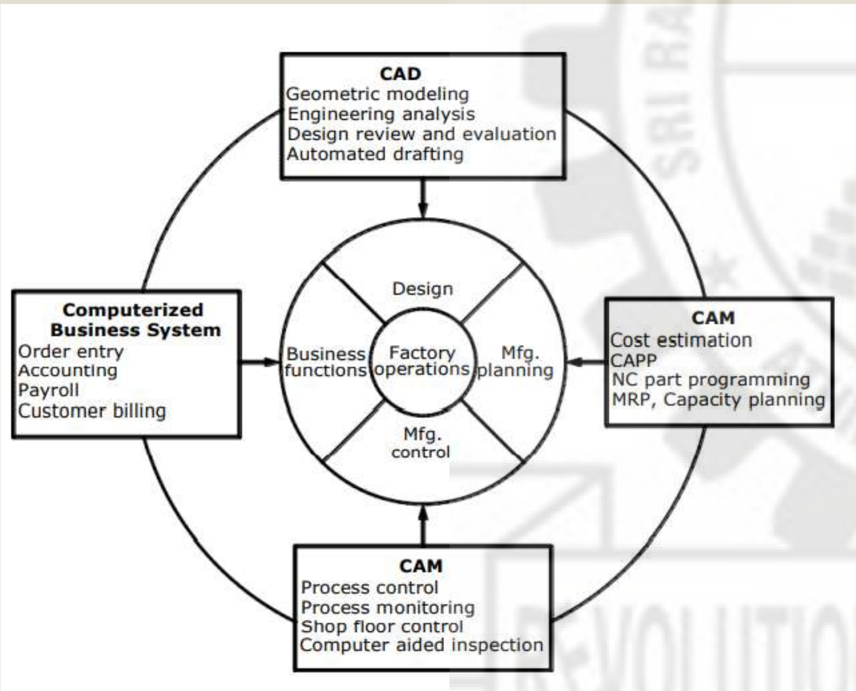
- CIM
  - ❖It is a term used to describe complete automation with all processes functioning under computer control. CIM uses the database and communication technologies to integrate the design, manufacturing and business functions.
- FMS
  - ❖Flexible Manufacturing System (FMS) is a highly automated GT machine cell. It consists of a group of machine tools interconnected by automated material handling and storage system, and controlled by a central computer.

Basic Definitions

- AG
  - ❖It is a computer controlled, self propelled and driverless vehicle meant for transporting raw materials, work-in-progress and finished products from one work station to another work station.

- ROBOT
  - ❖Robot is a programmed multi-function manipulator designed to move material, parts, tools or special devices for the performance of variety of tasks.

CONCEPT OF CIM

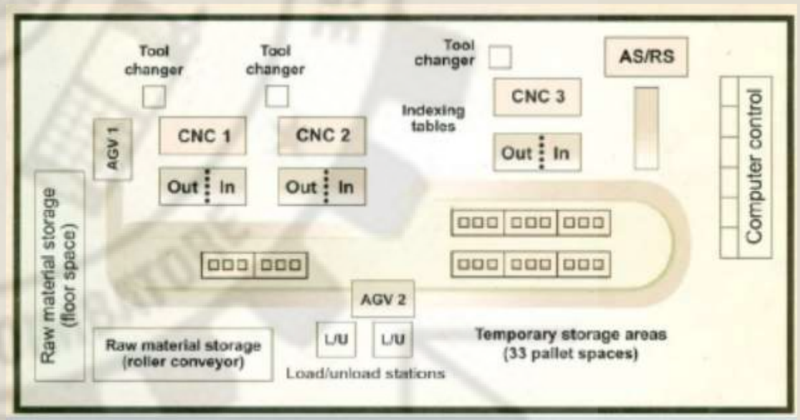


CONCEPT OF CIM

- CIM wheel shows the components of a CIM system. Customer orders are initially entered by the company's sales department. New products are designed on a CAD system. The bill of materials and assembly drawings are prepared by using CAD system.
- The output of the design department serves as the input to manufacturing engineering. Process planning, tool design and similar activities are accomplished to prepare for production.
- The output from the manufacturing engineering provides input to production planning and control department. MRP and scheduling are performed using the computer system. Thus all the activities from sales order to delivery of the product are performed using computers in CIM.

COMPONENTS OF FMS

- FMS consists of the following components.
  - ❖Work stations.
  - ❖Automated material handling and storage system.
  - ❖Computer control system.
  - ❖Human labour.



- Work stations
  - ❖The work station normally refers to a place or machine in which the production work or the processing work are carried out.
  - ❖The work stations convert the given raw material into a finished components.
    - ✓Assembly stations
    - ✓Inspection stations
    - ✓Painting stations
    - ✓Sheet metal stations

- Automated material handling and storage system
  - ❖A material handling system is one in which the raw materials, work-in-progress and finished products are transported from one work station to another work station.
  - ❖In between the work stations, the raw materials and work-in-progress are temporarily stored, when the machining operations are being carried out in the next stations.
    - ✓Automated Guided Vehicle (AGV)
    - ✓Robot etc…..

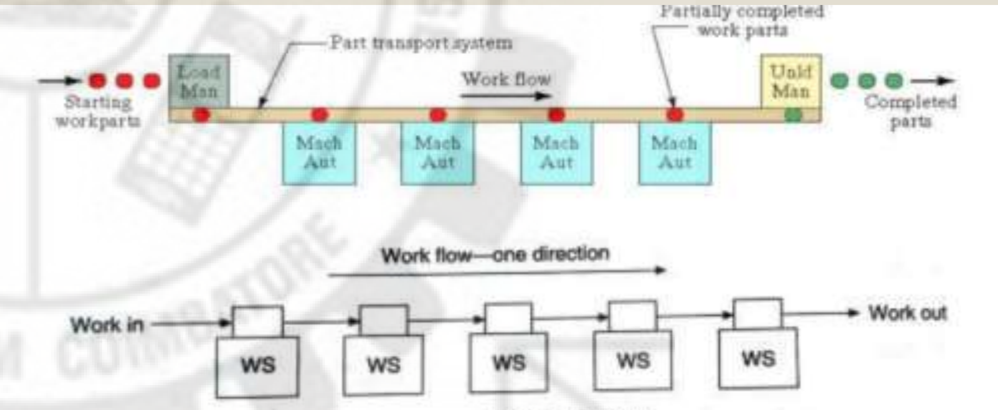
- Control system
  - ❖The function of control system is to co-ordinate and manage the activities of different components of FMS.
  - ❖The control system gives instruction to different work stations and the material handling systems to perform their respective functions.
  - ❖FMS employees computers to control the activities of the system as a whole.
- Human operator
  - ✓Loading and unloading of machines.
  - ✓Switch ON/OFF the machines.
  - ✓Tool settings.
  - ✓Preparing part programs for CNC machines.
  - ✓Repair and maintenance of machines and so on……….

FMS LAYOUT

- There are 5 types of FMS Layout
  - In-line layout
  - Loop layout
  - Ladder layout
  - Open field layout
  - Robot centered cell layout

IN-LINE LAYOUT

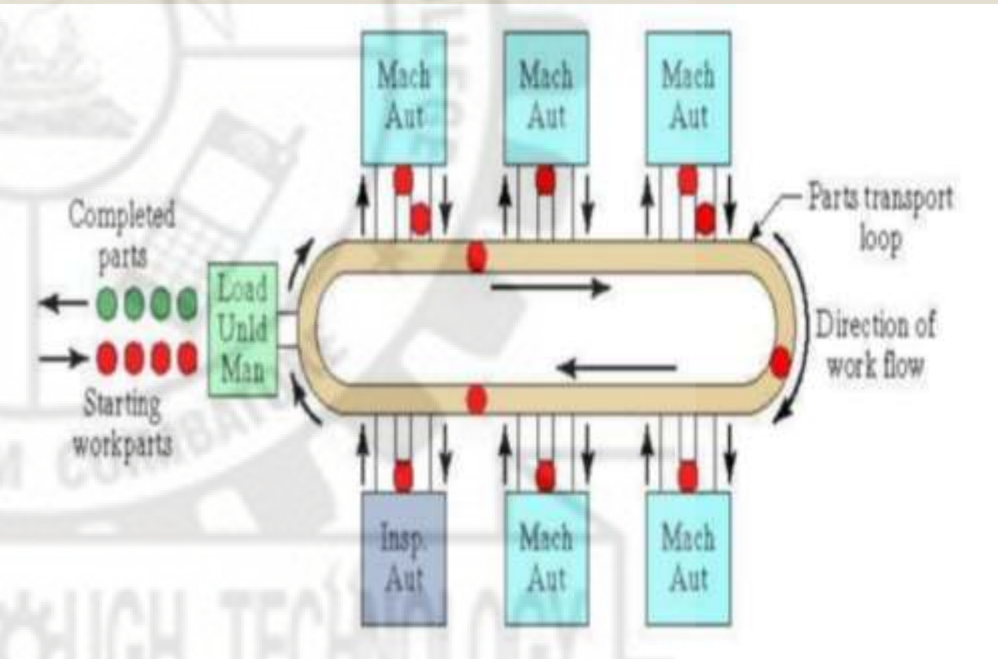
- In this layout, the machines and handling system are arranged in a straight line.
- The work part moves from one workstation to the next in a well– defined sequence.
- The work part always moves in one direction. No back flow is allowed.



In-line FMS layout.

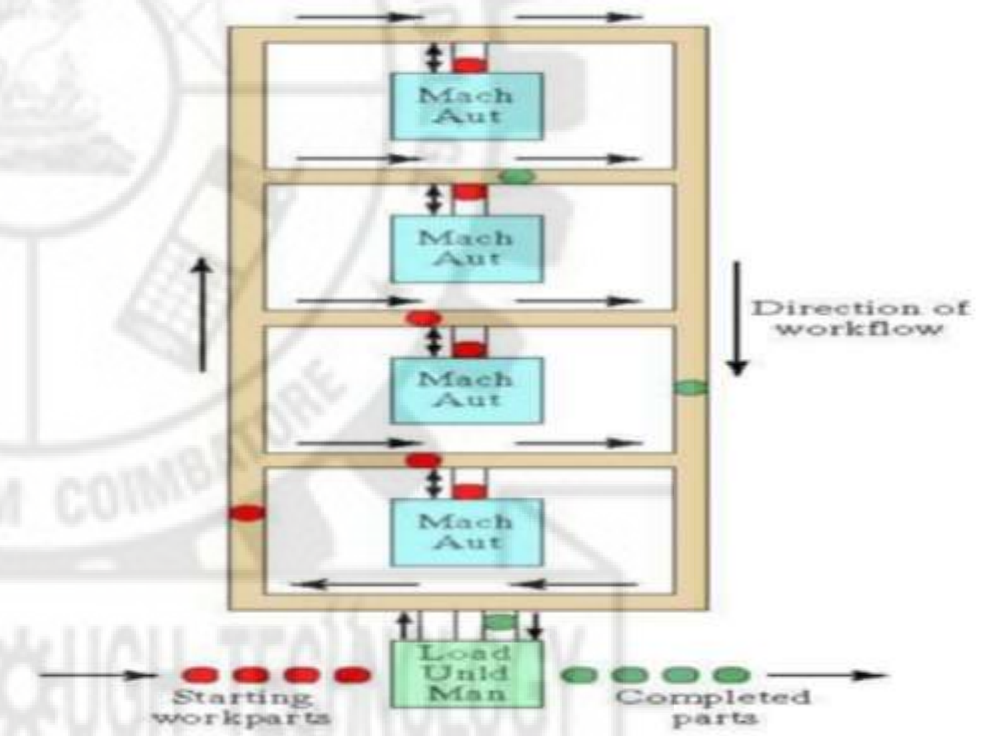
LOOP LAYOUT

- in this layout, the workstations are arranged in a loop. It is served by a part transport system in the same shape.
- Parts usually flow in one direction around the loop. The parts can be stopped and transferred to any station.
- A secondary handling system is used at each workstation.
- The loading/unloading stations are located at one end of the loop.



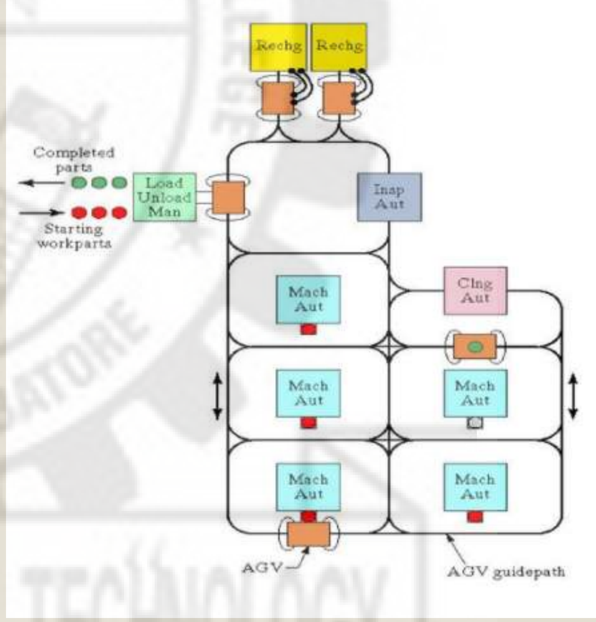
LADDER LAYOUT

- The ladder layout consists of a loop with rungs between the straight sections. Workstations are located on the rungs.
- The rung increases the possible ways of transporting work part from one machine to the next.
- It eliminates the need of a secondary handling system.
- This reduces average travel distance and minimizes jamming in the handling system.
- Thus transport time between workstations is considerably reduced.



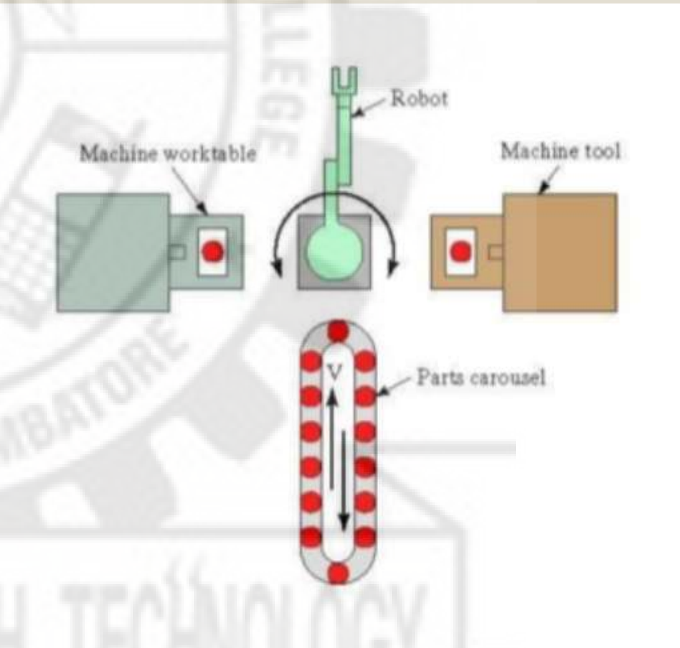
OPEN FIELD LAYOUT

- This layout consists of multiple loops and ladders.
- This type of layout is appropriate for processing a large family of parts. The number of different machine types may be limited.
- The parts are routed to different workstations depending on which one becomes available first.



ROBOT CENTERED CELL LAYOUT

- In this layout, one or more robots are used as the material handling system.
- Industrial robots can be equipped with grippers for the handling of rotational parts.
- This type of layout is often used to process cylindrical or disk shaped parts.



AUTOMATED GUIDED VEHICLE (AGV)

- It is a computer controlled, self propelled and driverless vehicle meant for transporting raw materials, work-in-progress and finished products from one station to another work station.
- The vehicle is powered by on-board batteries, which allows the vehicle to run continuously for several hours (upto 16 hours).

- Working of AGV
  - ❖ Vehicle guidance and routing.
  - ❖ System management.
  - ❖ Traffic control and safety.
  - ❖ Vehicle dispatch.
  - ❖ System monitoring.

- Vehicle guidance and routing
  - ❖Defining the path way for the movement of vehicle guidance and making the vehicle to move in the defined path way is known as routing.

      - ✓Embedded wire system.
      - ✓Paint strip system.

- Embedded wire system
  - ❖In embedded wire system 2 guide wires are embedded under the floor.
  - ❖When electric supply is given to the wire, magnetic field is created around the wire.
  - ❖The on-board sensor on the AGV detect the magnetic field and the AGV is guided along the path of magnetic field.
  - ❖Thus the vehicle is guided along the defined path.

- Paint strip method
  - ❖In this method, the path to be followed by the vehicle is coated with special paint on the floor.
  - ❖This paint is reflective type and emit fluorescent light.
  - ❖The optical sensor fitted on the AGV defect and absorb this light and the AGV is guided along the paint strip.

- Traffic control and safety
  - ❖Ensuring the smooth movement of AGVs along the define path without any collision is known as Traffic control and safety.
- Vehicle dispatch
  - ❖Making the vehicle to reach the different destinations at the correct time is known as the vehicle dispatch.
    - ✓On-board dispatch
    - ✓Remote operation
    - ✓Using computer control

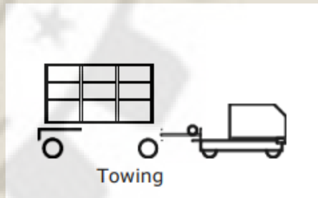
- System monitoring
  - ❖Location of vehicle within the system.
  - ❖Location of inoperative vehicle.
  - ❖Status of vehicle, either loaded or unloaded.
  - ❖Amount of time spent at each stop.
  - ❖Amount of time taken between stops.
  - ❖Status of battery, that is charging/discharging/charged etc….

TYPES OF AGVs

- There are 6 types of AGVs
  - ✓Towing vehicle.
  - ✓Unit load vehicle.
  - ✓Pallet trucks.
  - ✓Fork trucks.
  - ✓Light load vehicles.
  - ✓Assembly line vehicles.

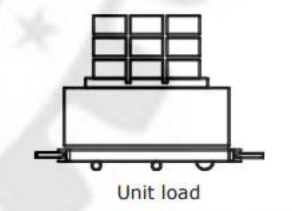
TOWING VEHICLE

- It consists of one ore more trailers to form a train. It is generally used for moving very large load over large distances in warehouses or factories.



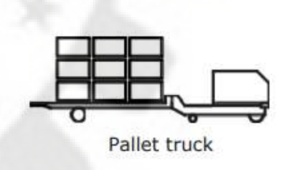
UNIT LOAD VEHICLE

- These are used to move unit loads from one station to another. They are equipped with powered rollers, moving belts or mechanized lift platforms. The unit load carriers are used for moving high volumes over moderate distances.



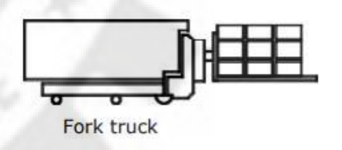
PALLET TRUCKS

- Pallet trucks are used to transport palletized loads from floor level. The capacity ranges up to several thousand kilograms. Some trucks are capable of handling two pallets.



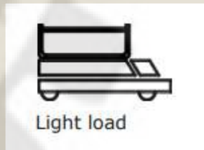
FORK VEHICLE

- Fork trucks have the ability to service palletized loads both at floor level as well as on stands. They may also be able to stack the loads when required. These are generally used where the heights of load transfer vary.



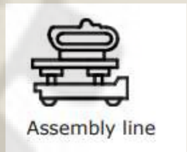
LIGHT LOAD VEHICLE

- Light load AGV is a relatively small vehicle with corresponding light load capacity in the order of 250 Kg or less.



ASSEMBLY LINE VEHICLE

- It is the adoption of light load vehicles for serial assembly processes. It carries a partially completed subassemblies through a sequence of assembly workstations.



ROBOT

- Robot is a programmed multi-function manipulator designed to move material, parts, tools or special devices for the performance of variety of tasks.

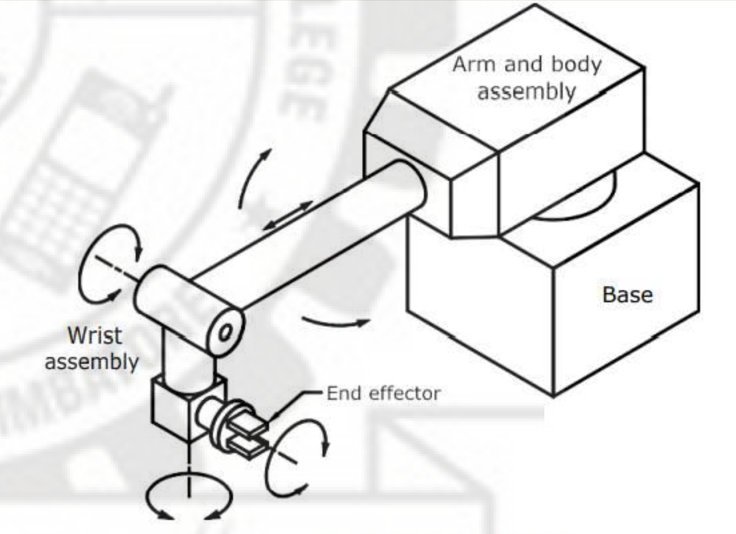


Fig.4.11 Elements of robot

TYPES OF FMS

1. Flexible Turning Cell (FTC)

- ❖ It consists of one CNC turning centre combined with a parts storage system.
- ❖ The availability of C-axis and the live tools in the turret enable the machine to perform operations like turning, milling, off- centre drilling, tapping, helical groove cutting, etc.
- ❖ It means that all operations to produce a component can be carried out in one set up itself.
- ❖ It is provided with facilities like automatic part changer, automatic tool changer, tool breakage sensors, automatic tool length compensation, in-process gauging, automatic chuck changing, etc.
- ❖ The idle time of the machine can be considerably reduced with the help of these facilities. The productivity and flexibility of CNC turning center's can be improved by using these facilities.

2. Flexible Manufacturing Cell (FMC)

- ❖ It consists of two or three CNC machine tools interfaced with automated material handling and automatic tool changers.
- ❖ Flexible manufacturing cells are capable of automatically machining a wide range of different work pieces.
- ❖ They are usually employed in small batch production.
- ❖ Examples of flexible manufacturing cell include :
- ✓ A turning centre fitted with a gantry loading and unloading system and pallets for storing work pieces and finished parts.
- ✓ One or two horizontal machining centers with modular fixturing, multiple pallets, advanced tool management system, automatic tool changer, automatic head changer, robots, etc.

UNIT 5 - CONCURRENT ENGINEERING, QUALITY FUNCTION DEPLOYMENT, PRODUCT DEVELOPMENT CYCLE, AUGMENTED REALITY.

Concurrent Engineering: Concurrent engineering is a work methodology emphasizing the parallelization of tasks, which is sometimes called simultaneous engineering or integrated product development using an integrated product team approach.

Sequential engg vs Concurrent engg:

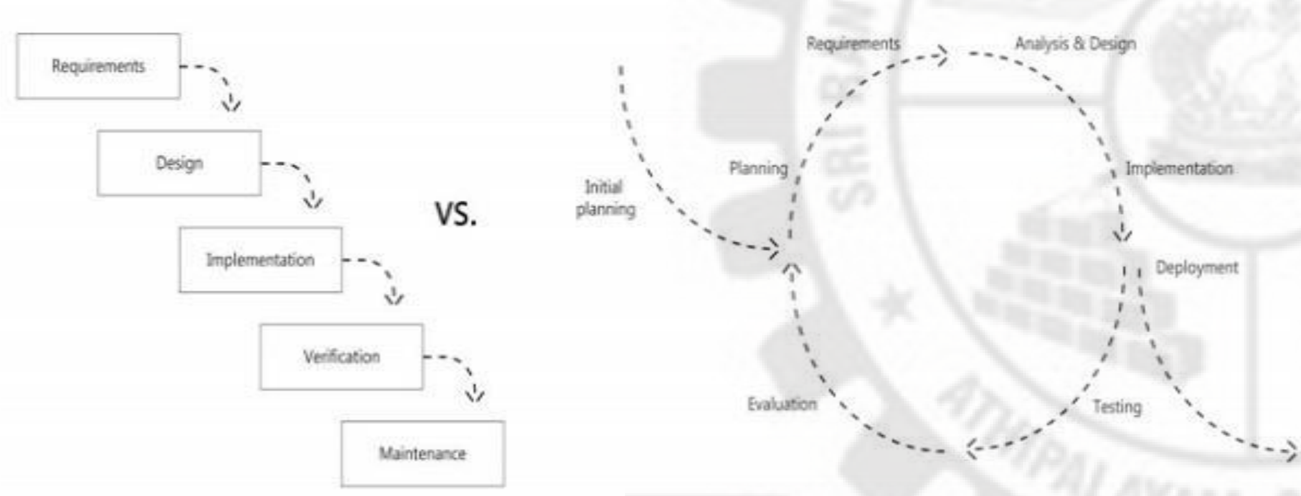


Fig. 1.3. Sequential Vs Concurrent Engineering

Table 1.1. Sequential Vs Concurrent Engineering

Sequential Engineering	Concurrent Engineering
Sequential engineering is the term used to explain the method of production in a linear system. The various steps are done one after another, with all attention and resources focused on that single task.	In concurrent engineering, various tasks are handled at the same time, and not essentially in the standard order. This means that info found out later in the course can be added to earlier parts, improving them, and also saving time.
Sequential engineering is a system by which a group within an organization works sequentially to create new products and services.	Concurrent engineering is a method by which several groups within an organization work simultaneously to create new products and services.
The sequential engineering is a linear product design process during which all stages of manufacturing operate in serial.	The concurrent engineering is a non-linear product design process during which all stages of manufacturing operate at the same time.
Both process and product design run in serial and take place in the different time.	Both product and process design run in parallel and take place in the same time.
Process and Product are not matched to attain optimal matching.	Process and Product are coordinated to attain optimal matching of requirements for effective quality and delivery.
Decision making done by only group of experts.	Decision making involves full team involvement.

Benefits of concurrent engineering

Concurrent engineering deals with factors that directly affect a company's profitability and market share: lead time, unit cost, product quality and design. Here are other benefits of this method:

Innovative solutions

It's common for skills within different departments or among employees to overlap. This allows teams to address joint tasks with similar backgrounds while bringing unique perspectives. Even employees in the same department can have different viewpoints depending on their skill sets.

Since projects are open to collaboration in concurrent engineering, each team member with a specialty adds value. Cross-department meetings can identify possible setbacks and create unanimously accepted solutions. By applying these insights, organizations may prevent significant mistakes.

Early modifications

The initial stages of concurrent engineering may be challenging because new projects may lack a steady pace. However, this means they're open to alterations early on, which can be helpful. Concurrent engineering focuses on identifying and resolving issues in the initial stages. Much iteration may take place to achieve goals like actively reducing scrap production, manufacturing lead times and the number of future changes. This helps give project teams better control over the characteristics of the final product.

Minimized risk of loss

Since multiple teams or departments take part in concurrent engineering, many people have relevant information about the project and its development cycle. This can dramatically reduce any negative impact on the product's overall success if a team member has to step away from the project. It's also easier to add new members because of the unlimited access to information concerning the project.

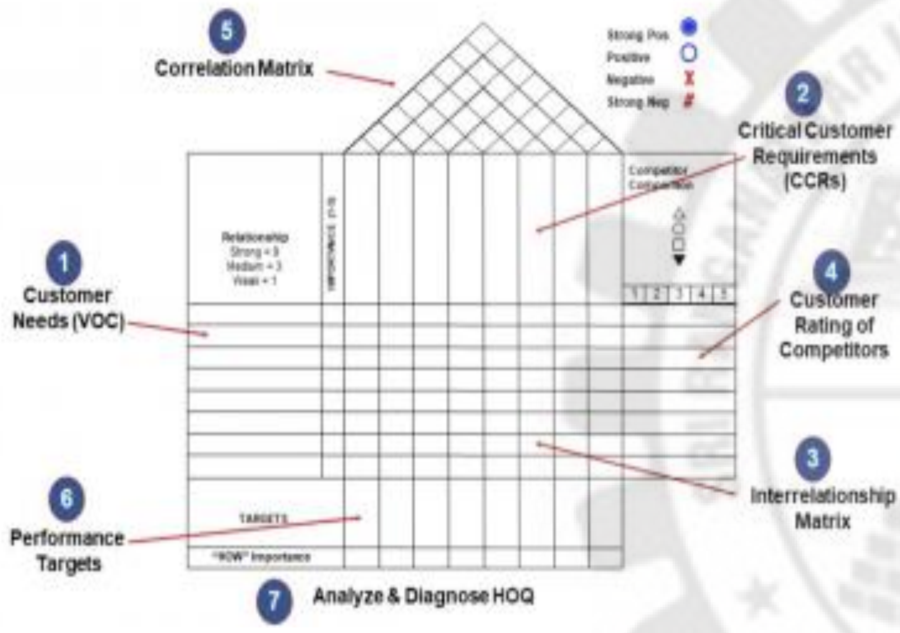
Reduced time to reach the market

The most significant benefit of concurrent engineering is reducing the project's duration, so the product reaches the market quickly. Working on multiple stages of the project simultaneously reduces the time spent on it. The result is a massive advantage over competitors since companies can enter new markets with innovative products before anyone else.

QUALITY FUNCTION DEPLOYMENT:

HOUSE OF QUALITY:

- **Customer needs:** For each critical customer segment, capture customer feedback and VOC input consisting of your customer’s needs and the priority or weight of each need.
- **Customer critical requirements:** The top row of the house contains the critical customer requirements (CCRs), also referred to as critical to customer (CTC).
- **Interrelationship matrix:** Evaluate the relationship between your customer needs and CCRs. Determine the relative importance of each CCR.
- **Customer rating of your competitors:** How does your customer perceive the marketplace and your competition’s ability to meet each of their requirements?
- **Correlation matrix:** Compare CCRs to determine if they are in conflict with each other, leveraging each other, or have no effect on each other.
- **Performance targets:** Determine the necessary performance targets (specs) for each CCR.



Steps in Failure Modes and Effects Analysis (FMEA):

Step 1: Identify potential failures and effects

• Step 2: Determine severity

• Step 3: Gauge likelihood of occurrence

• Step 4: Failure detection

• Risk priority number (RPN)

Step 1: Identify potential failures and effects The first FMEA step is to analyze functional requirements and their effects to identify all failure modes. Examples: warping, electrical short circuit, oxidation, fracture. Failure modes in one component can induce them in others. List all failure modes per function in technical terms, considering the ultimate effect(s) of each failure mode and noting the failure effect(s). Examples of failure effects include: overheating, noise, abnormal shutdown, user injury.

Step 2: Determine severity Severity is the seriousness of failure consequences of failure effects. Usual practice rates failure effect severity (S) on a scale of one to 6 where one is lowest severity and 10 is highest. The following table shows typical FMEA severity ratings and their meanings:

Rating	Meaning
1	No effect, no danger
2	Very minor – usually noticed only by discriminating or very observant users
3	Minor – only minor part of the system affected; noticed by average users
4	Moderate – most users are inconvenienced and/or annoyed
5	High – loss of primary function; users are dissatisfied

6	Very high – hazardous. Product becomes inoperative, customers angered. Failure constitutes a safety hazard and can cause injury or death.

Step 3: Gauge likelihood of occurrence Examine cause(s) of each failure mode and how often failure occurs. Look at similar processes or products and their documented failure modes. All potential failure causes should be identified and documented in technical terms. Failure causes are often indicative of weaknesses in the design.

Step 4: Failure detection After remedial actions are determined, they should be tested for efficacy and efficiency. Also, the design should be verified and inspections procedures specified. 1. Engineers inspect current system controls that prevent failure mode occurrence, or detect failures before they impact the user/customer. 2. Identify techniques used with similar products/systems to detect failures. These steps enable engineers to determine the likelihood of identifying or detecting failures. Then, each combination from steps one and two is assigned a detection value (D), which indicates how likely it is that failures will be detected, and ranks the ability of identified actions to remedy or remove defects or detect failures. The higher the value of D, the more likely the failure will not be detected

Risk priority number (RPN) After the foregoing basic steps, risk assessors calculate Risk Priority Numbers (RPNs). These influence the choice of action against failure modes. RPN is calculated from the values of S, O and D as follows:

RPN = S * O * D (or RPN = S x O x D)

RPN should be calculated for the entire design and/or process and documented in the FMEA. Results should reveal the most problematic areas, and the highest RPNs should get highest priority for corrective measures. These measures can include a variety of actions: new inspections, tests or procedures, design changes, different components, added redundancy, modified limits, etc. Goals of corrective measures include, in order of desirability:

• Eliminate failure modes (some are more preventable than others)

• Minimize the severity of failure modes

• Reduce the occurrence of failure modes

• Improve detection of failure modes When corrective measures are implemented, RPN is calculated again and the results documented in the FMEA.

VALUE ENGINEERING:

Value engineering identifies the areas of excessive or unnecessary expenses and attempts to improve the value of the product. It provides the base for better performance at a lower cost while reducing neither necessary quality, reliability nor maintainability.

Value Analysis is a technique of cost reduction based on systematic and organised examination of every item of cost which goes into the manufacture of the industrial product in terms of the value or customer satisfaction it adds to the product.

Another definition of Value Analysis is **“the systematic examination of all factors which contribute to the cost of a product, part or a material with the object of uncovering these possibilities of cost reduction which will not in any way reduce the quality, performance or any other attribute of the product which is sought by the customer.”**

Value Analysis means the organised and exhaustively critical study of a product in terms of the design, functions and costs with the object of cost reduction.

Types of Values:

1. Cost Value:
It is the cost of manufacturing a product or component.

2. Use Value:
It considers work done, functions performed or service rendered and efficiency/effectiveness of the product.

3. Esteem Value:
It involves the qualities and appearance of the product which attracts persons and creates a desire in them to posses the product.

4. Exchange Value:
It considers the properties or qualities which will remain attractive enough to other people to permit market resale in the future.

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1. Basic (or Primary) Functions:
These are the functions without which the product would virtually lose all of its value, and in some cases even its identity. For example, if lead is removed from an ordinary wooden lead pencil, it would not only eliminate its basic function of pencil but will leave us with not more than a stick.

2. Secondary Functions:
These functions support the basic functions, although they may or may not be essential functions. For example, pencil without lead may still remain the esteem value by just being seen in the pocket.

GUIDE LINES OF DESIGN FOR MANUFACTURE AND ASSEMBLY (DFMA):

Design for Manufacture and Assembly (DfMA) is a design approach that focuses on ease of manufacture and efficiency of assembly. By simplifying the design of a product it is possible to manufacture and assemble it more efficiently, in the minimum time and at a lower cost.

Traditionally, DfMA has been applied to sectors such as the design of automotive and consumer products, both of which need to efficiently produce high quality products in large numbers. More recently, construction contractors have begun to adopt DfMA for the off-site prefabrication of construction components such as concrete floor slabs, structural columns and beams, and so on.

DfMA combines two methodologies – Design for Manufacture (DFM) and Design for Assembly (DFA):

Design for Manufacture (DFM)

DFM involves designing for the ease of manufacture of a product's constituent parts. It is concerned with selecting the most cost-effective materials and processes to be used in production, and minimising the complexity of the manufacturing operations.

Design for Assembly (DFA)

DFA involves design for a product's ease of assembly. It is concerned with reducing the product assembly cost and minimising the number of assembly operations.

Both DFM and DFA seek to reduce material, overhead, and labour costs.

DfMA principles

In a similar approach to lean construction, applying DfMA enables the identification, quantification and elimination of waste or inefficiency in product manufacture and assembly. It can also be used as a benchmarking tool to study the products of competitors.

The main principles of DfMA are:

- Minimise the number of components: Thereby reducing assembly and ordering costs, reducing work-in-process, and simplifying automation.
- Design for ease of part-fabrication: The geometry of parts is simplified and unnecessary features are avoided.
- Tolerances of parts: Part should be designed to be within process capability.
- Clarity: Components should be designed so they can only be assembled one way.
- Minimise the use of flexible components: Parts made of rubber, gaskets, cables and so on, should be limited as handling and assembly is generally more difficult.
- Design for ease of assembly: For example, the use of snap-fits and adhesive bonding rather than threaded fasteners such as nuts and bolts. Where possible a product should be designed with a base component for locating other components quickly and accurately.
- Eliminate or reduce required adjustments: Designing adjustments into a product means there are more opportunities for out-of-adjustment conditions to arise.

Advantages of DfMA

Some of the main advantages of DfMA include:

Speed

One of the primary advantages of DfMA in construction is the significantly reduced programme on-site through the use of prefabricated elements.

Lower assembly cost

By using fewer parts, decreasing the amount of labour required, and reducing the number of unique parts, DfMA can significantly lower the cost of assembly.

Higher quality and sustainability

A highly automated approach can enhance quality and efficiency at each stage.

There may be less waste generation in the construction phase, greater efficiency in site logistics, and a reduction in vehicle movements transporting materials to site.

Shorter assembly time

DFMA shortens assembly time by utilising standard assembly practices such as vertical assembly and self-aligning parts. DFMA also ensures that the transition from the design phase to the production phase is as smooth and rapid as possible.

Increased reliability

DfMA increases reliability by lowering the number of parts, thereby decreasing the chance of failure.

Safety

By removing construction activities from the site and placing them in a controlled factory environment there is the possibility of a significant positive impact on safety

Product Development Cycle:

The product development cycle is the process of taking a product from an idea through its market release and beyond. This cycle involves many departments in a company: product managers, developers, designers, QA testers, and others.

What Are the Product Development Cycle Stages?

There is no universal definition of the product development cycle. Businesses disagree about how many stages the cycle includes. Even those who agree on the number of steps disagree about where one ends and the next starts.

Another point of disagreement: Some teams believe the cycle goes only as far as the product launch. Other companies—including ProductPlan—believe the cycle continues beyond the product's market release and includes improvements to the product over time.

Here is how we define what we view as the seven stages of the product development cycle. You can use these steps as a guide to creating your own product development strategy.

Stage 1: Develop the idea.

This is the brainstorming stage. The product team looks for ways to solve problems for their user personas. During this phase, the team will generate several product ideas.

Stage 2: Validate the idea.

By the end of the first stage, the team will have a long list of product concepts. The goal now is to narrow the list to one product or feature worth pursuing. There are several ways of screening ideas to learn which are the most viable.

For example, the team can weigh each product idea according to a consistent set of criteria. One way to do this is with the weighted scoring feature in Product Plan's

The team should also screen its product concepts by speaking with its ideal customer user personas. These are the people likely to buy a product from the company, so their view on the list of ideas should carry weight.

Stage 3: Build a prototype.

For a company that develops software, the engineering team can create a very simple mockup of the application. They could even develop only a wireframe.

If the business manufacturers physical products, the team might want to build a physical prototype and give it to a focus group or small group of customers for their feedback.

Stage 4: Create the messaging.

In parallel with building and sharing the prototype, the product team will be working with the marketing department to create the product's market strategy. This will include:

- Developing the product's value proposition
- Creating tools and materials for the sales department
- Building marketing and advertising campaigns

Note: The marketing team can work on the product's messaging and materials simultaneously as the developers build the prototype or mockup. But the product team should share their focus-group feedback with marketing as soon as possible. For example, they should let marketing know what these early users found most useful about the product.

Stage 5: Build the product.

After gathering focus-group feedback about its prototype or mockup, the team is now ready to build a minimum viable product (MVP).

This does not need to be the full-featured product the team envisioned during its brainstorming session. The team will have time to build out the product. The goal now is to ship an MVP as quickly as possible. The sooner the company puts a working version of its product into users' hands, the sooner it can receive useful feedback to improve the product.

Stage 6: Release the product.

After developing and testing its MVP, the company is now ready to launch it to the public. The MVP will help the company gain several important insights at once, including:

- The level of market interest (and whether it is higher or lower than the company's research suggested).
- The types of buyer or user personas signing up for the product (and whether or not these are the people the product team anticipated would show the most interest).
- How real users react to the product (and whether or not this data aligns with the company's assumptions).

Stage 7: Improve the product.

Finally, the product team will take real-world feedback from its early users to improve the product.

In fact, the team will likely take this user data and repeat several of the stages above. For example, they might return to Stage 5 (build new functionality or fix existing functionality), then move to Stage 6 (release the updated product and analyze user feedback), and then return to Stage 7 (apply that feedback to make the product still better).

This is why we believe the product development cycle does not end once the product first hits the market. Product teams should be continuing to develop their products well after launch.

Augmented Reality

- Augmented reality (AR) involves overlaying visual, auditory, or other sensory information onto the world in order to enhance one's experience.
- Retailers and other companies can use augmented reality to promote products or services, launch novel marketing campaigns, and collect unique user data.
- Unlike virtual reality, which creates its own cyber environment, augmented reality adds to the existing world as it is.
- Augmented reality continues to develop and become more pervasive among a wide range of applications. Since its conception, marketers and technology firms have had to battle the perception that augmented reality is little more than a marketing tool. However, there is evidence that consumers are beginning to derive tangible benefits from this functionality and expect it as part of their purchasing process.
- For example, some early adopters in the retail sector have developed technologies that are designed to enhance the consumer shopping experience. By incorporating augmented reality into catalog apps, stores let consumers visualize how different products would look like in different environments. For furniture, shoppers point the camera at the appropriate room and the product appears in the foreground.
- Elsewhere, augmented reality's benefits could extend to the healthcare sector, where it could play a much bigger role. One way would be through apps that enable users to see highly detailed, 3D images of different body systems when they hover their mobile device over a target image. For example, augmented reality could be a powerful learning tool for medical professionals throughout their training.
- Some experts have long speculated that wearable devices could be a breakthrough for augmented reality. Whereas smartphones and tablets show a tiny portion of the user's landscape, smart eyewear, for example, may provide a more complete link between real and virtual realms if it develops enough to become mainstream.
- **Augmented Reality vs. Virtual Reality**

- Augmented reality uses the existing real-world environment and puts virtual information on top of it to enhance the experience.

- In contrast, virtual reality immerses users, allowing them to "inhabit" an entirely different environment altogether, notably a virtual one created and rendered by computers. Users may be immersed in an animated scene or an actual location that has been photographed and embedded in a virtual reality app. Through a virtual reality viewer, users can look up, down, or any which way, as if they were actually there.

APPLICATIONS OF AR:

AR software is used for training, work and consumer applications in many industries including healthcare, public safety, gas and oil, tourism and marketing. Augmented reality gaming software is probably the most common type of AR app, in particular since the popularity of the Pokémon GO game for smart phones.