CAD/CAM

UNIT-1 Fundamental of CAD/CAM

CAD: Computer aided design is the usew of computer to help in the creation, modification, analysis and optimization of a design. The computer system consist of special hardware and software to perform the spacial design fundtion.

CAM: Computer aided manufacturing can be defined as the use of computer systems to plan, manage and control the operation of a manufacturing plant through direct or indirect computer link with the plant raw materials and resources.

Automation:

Automation is defined as the process of performing a well defined sequence of operation with little or no human labour, using specialized sensor and actuator that control and monitor the sequence of operation being performed.

Mechanization:

Design Process: Design is defined as the process of creating a component to meet desired needs. It is a decision making process, in which the basic mathematics and engineering science are used to convert raw material to valuable productwhich satisfy our need.

There are six steps involve in the conventional design process;

1. Recognition of need
2. Problem Defination
3. Synthesis
4. Analysis & Optimization
5. Evaluation
6. Presentation.

1. Recognition of Need

In this step the designer identify the needs of the produc
The environment under which the product will work.

2. Defination of Problem

In this step the designer decide the shape of product, its space requirement and the material need to manufacture it.

3. Synthesis of Design

In this step a rough design/drawing of part is made, the different force which will act on it is calculated which help in deciding the approximate dimension of the product.

4. Analysis and Optimization

At this step the geometric shape and the dimension decided is checked for safe stresses and if it is not satisfactory, then the dimension of the product is recalculated. The part is also optimized so that it acquire minimum dimension, weight, volume and can be produce at low cost.

5. Evaluation

In this stage the product is compared with the problem defination phase ie the manufacturing and testing of model is done to check the operating peformance quality and reliability of product.

6. Presentation

In this step the component is represented along with necessary drawings in an attractive format required by the manufacturer to produce the product.

The application of computer for Design

The various design related task which can be performed by a computer aided design system can be grouped into four functional area :-

1. Geometric Modeling
2. Engineering Analysis
3. Design review and evaluation
4. Automated Drafting

Geometric Modeling: Geometric modeling is the computer compatible mathematical description of the geometry of an object. The mathematical description allow to CAD system to display the image of the product and can be edited on Graphic terminal. The basic form uses wire frame to represent the model of the product.

Engineering Analysis: It involves stress - strain calculation, heat transfer calculation etc. It help to findout the different properties such as dimension, surface area, weight, volume centre of gravity of the product to be made.

Design Review and Evaluation: This involves the analysis of product so that it should fit into the space provided, Most interesting feature of CAD system is kinematic analysis which provide the facility to animate the working of product.

Automated Drafting: This feature of CAD system help to automatic dimensioning of product, sealing of the drawing and in development of sectional view of product which help manufacturer in producing the product.

Benefits of CAD

- It improve design productivity
- It reduce manpower required to design a product.
- It is easy to modify a design according to user requirement in a CAD system.
- It reduce material wasteage.
- It provide different color option which help to customize design
- It help to design with high accuracy.

Limitation of CAD

- A cad system required larger memory and speed to run smoothly.
- The size of a CAD software package is larger.
- A CAD system required highly skilled personal to perform the work.
- It required high initial investment to setup a CAD system.

Computer configuration for CAD application :

A CAD system includes hardware component and CAD software package.

The hardware component include the following :-

1. Design Workstation
   a. Graphic Terminal
   b. Input Device
2. Graphical output device
3. Central processing unit
4. Secondary storage.

Design Workstation : The design workstation is the system on which design of a product is made. It provide interaction between operator and the CAD software package. The workstation perform following function;—

1. It must interact with the CPU.
2. It must generate a graphical image of the designed product
3. It must provide digital description of the graphic image.
4. It must translate computer commands into operation function

It consist of following hardware components :-

1. Graphical Terminal
2. Input Devices.

Graphical Terminal

The graphical terminal (also known as graphic display or VGA) enables the user to view image and to communicate with the displayed image by adding, deleting, blanking and moving graphic entities on the display screen.

There are three types of graphic terminals which is widely used in CAD system

1. CRT (Cathode Ray Tube) Display
2. Liquid Crystal Display
3. Plasma Panel Display.

Input Device

An input device is a piece of equipment used to provide raw data and control signals to the CAD system.

There are various type of input devices which is widely used in CAD system like mouse, keyboard, graphical taplets etc.

Graphic Output Device

- An output device is any piece of hardware equipment which convert information into a form in which human can read, see and understand it.
- A graphic output device is an output device which produce final drawing and documentation of the design

on paper.

- A printer and plotter is widely used as a graphic output device which provide hard copies (physical form) of text as well as figure of the design.

Central Processing Unit

- The CPU is the brain of entire CAD system.
- A CPU consist of controller (control unit), ALU (Arithmatic Logical Unit) and Internal registers.
- Functions of CPU are as follow :-
  a. To receive information from the workstation and display the output on the CRT screen.
  b. To read the data stored in the secondary memory storage unit.

Software

Software is a sequence of instruction design to direct a computer to perform certain function. It is a set of prewritten program / command.

Software is devided into two categories :-

1 System software
2. Application Software.

System Software : A system software is a type of software which is designed to manages the resource of computer system (Hardware).

Eg. Windows XP, Windows 10, Linux, Unix, Android, iOS.

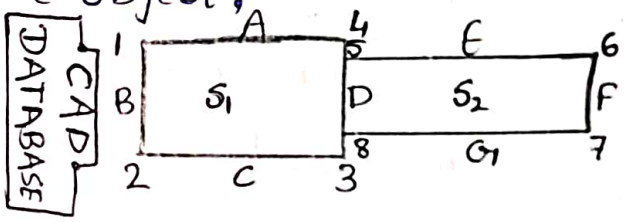
Application Software: It is design to perform a specific task from which it is created by using the resource of computer system through system software.

Eg. MS Office, AutoCAD, Solidworks.

CAD Database and Structure

- A CAD database is defined as the organised collection of graphical and non-graphical data stored on secondary storage in computer.
- A CAD data base structure is defined as the set of data elements that are related to each other by a set of relation and by applying these relation on elements will result in meaningful object.
- The complexity of database depends upon the types of model and information extracting capacity built into the CAD system.
- There are three type of Data structure which can be used to construct the object,

Corner 1,2,3,4,5,6,7,8
Edge ABCDEFG
Surface S_1, S_2.



Based on Edge/sides;

A	B	C	D	E	F	G

Based on corner
Based on Surfaces

Relation for corner

1 - A & B	2 - B & C	3 - C & D
4 - A & D	5 - D & E	6 - E & F
7 - G & F	8 - D & G	

Geometric Modeling:

Geometric modeling is defined as the mathematical description of the shape of an object. During geometric modeling process the computer selects the proper mathematical description according to the given command and thus display it as an image on the graphic terminal.

There are three type of geometric modeling which are as follow :-

1. Wireframe Modeling
2. Surface Modeling
3. Solid Modeling.

Wireframe Modeling :

A wireframe model of an object is the simplest form of geometric model that can be used to represent model mathematically in the computer. It is some time refers to as a stick figure or an edge refpresentation of the object.

The word wireframe only indicate that the object is formed by bending wire along the edge of the object.

Wireframe Entities :

A wireframe entities is defined as the smallest unit of a wireframe which is used to build the object but has its own identity is called wireframe entities.

A wireframe entities is devided into two categories :-

1. Analytic Entities
2. Synthetic Entities.

Analytic Entities / Analytic Curve :

This type of entities/curve can be represented by a simple mathematical equation such as circle or a line etc.

It has a fixed form and cannot be modified to achieve a shape that violtes the mathematical equation.

The analytic entities are ;-

1. Point
2. Line
3. Arc
4. Circle
5. Ellipse
6. Parabola
7. Hyperbola.

Synthetic Entities / Synthetic Curve :

These types of entities use approximation and interpolation technique to represent the entities.

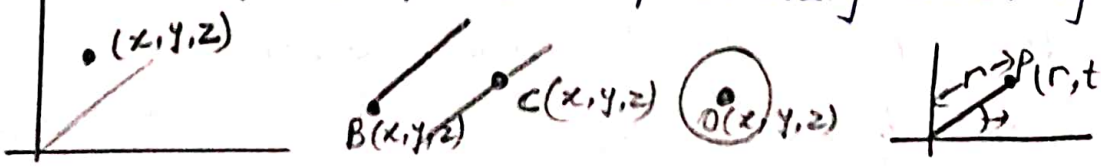
These curve have some limited flexibility in shape creation which is controled by given data points.

The synthetic curve are :-

1. Hermite cubic spine or parametric cubic curve or cubic spline.
2. Bezier Curve
3. B- spline

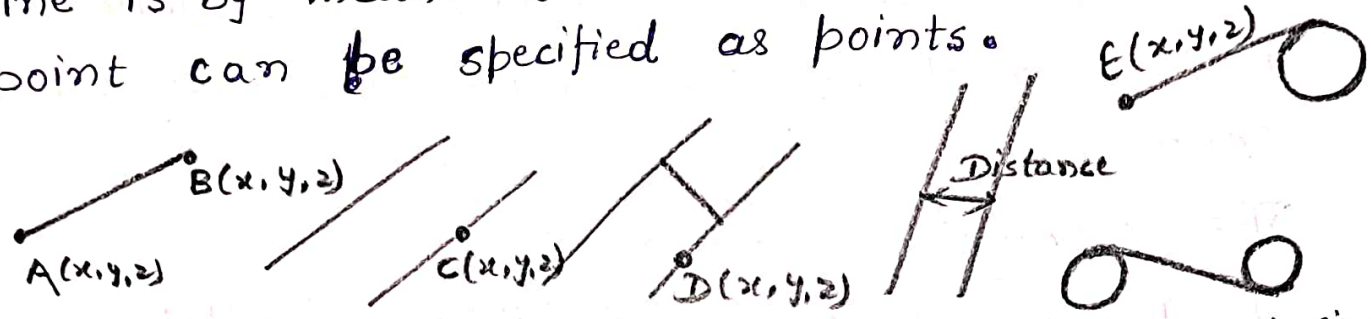
Point : A point is a notation that tell an exact location in space and has no length & width.

"In a CAD system a point is defined useing cartesian coordinate system or a polar coordinate system or can be defined from a previously existing point."



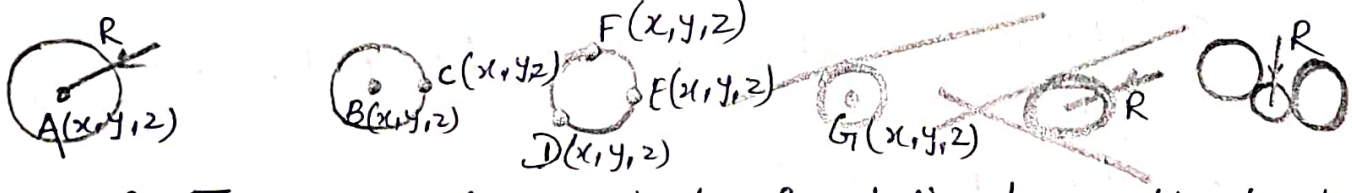
Line: A group of point which are moving in a straight path but in opposite direction froms a line. It has no width, no depth, but has length only.

"In a CAD system the simplest method of defining a line is by means of its two end points. The end-point can be specified as points.



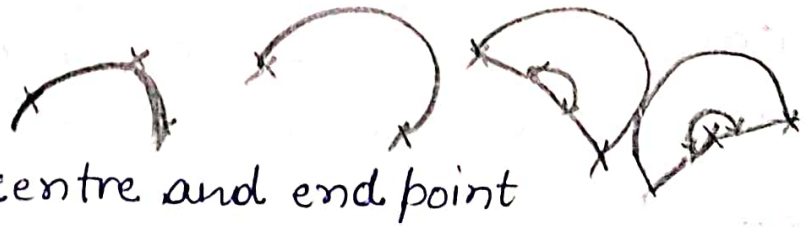
Circle: A circle is a closed two-dimensional figure in which the set of all the points in a plane is equidistant from a given point called "centre".

"In a CAD system the simplest method of defining a circle is by means of its centre A and radius R. These are various other method through which a circle can be define within a CAD system like circle passing through three collinear point."



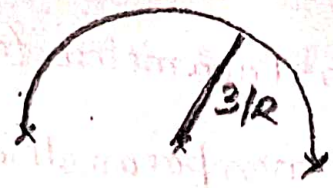
Arc: The arc of a circle is defined as the part or segment of the circumference of a circle or other curved line.

There are various method through which an arc can be defined in a CAD system which are as follows,



1. Three Point
2. Start point, centre and end point
3. Start point, end point & included angle.

4. Start point ; centre, included angle
5. Start point, end point & radius



Ellipse : An ellipse is a plane curve surrounding two focal point, such that for all point on the curve, the sum of the two distance to the focal point is constant.

"In CAD system ellipse can be defined by its centre, major & minor axis."

Representation of curve / Entities :

A curve in a CAD system can be represented in two form

1. Non- Parametric form
2. Parametric form

Parametric Form :

- In a parametric form the curve are represented using a parametric equation.
- Parametric equation is a type of equation which uses an independent variable called a parameter (often denoted by u or t) and in which dependent variable are defined as continuous function of the parameter.
- In parametric form, the curve is represented as

$$X = x(u)$$
$$Y = y(u)$$
$$Z = z(u)$$

where X, Y & Z are coordinate values on the space and the corresponding function x, y, z are the polynomial in parameter 'u'.

- The parametric form is most convenient for CAD & higher order curves. (Hyperbola, parabola)

Non-Parametric form:

- In non parametric form the curve are represented using a Non-parametric equation which has two form Implicit and Explicit form in which implicit form is widely used to represent analytic entities.
- Non-parametric equation uses dependent as well as independent variable to represent a curve and did not use or assign any other parameter to its current variable.

Implicit form:

- In an implicit form the curve is represented using implicit equation which has several variables, one of which is a function of the other set of variables.
- The implicit form is convenient for 2D curve of first order and second order. Typical curve that can be covered are line, circle and arc.

Explicit Equation	Implicit Equation
• Dependent variable 'y' is clearly stated in terms of 'x'.	• Dependent variable 'y' is not clearly stated in terms of 'x'.
• Explicit equation is denoted by $y = f(x)$.	• Implicit function is denoted by $f(x, y) = 0$
"$y = 3x^2 + 6x$"	"$3x^2 + 6x - y = 0$"

Representation of different curves;

1. Line:
   - Implicit form of a straigh line is given by

$$y = mx + c$$

Where x, y represent coordinate of cartesian 2D system and 'm' is the slope of the line.

• Parametric form of straight line is given by,

$$X = a_x u + b_x$$
$$Y = a_y u + b_y$$
$$Z = a_z u + b_z \quad \text{for } 0 \le u \le 1.$$

2. Circle :

• The implicit form of circle whose centre lies at origin of the coordinate is given by

$$x^2 + y^2 = r^2$$

• The parametric form of the circle whose centre lies at origin of the coordinate is given by

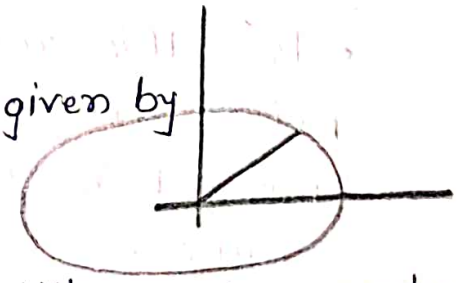
$$x = r\cos\theta$$
$$y = r\sin\theta$$

Where, $0 \le \theta \le 2\pi$
r is the radius of circle

$$x = r\left[\frac{1-u^2}{1+u^2}\right]$$
$$y = r\left[\frac{2u}{1+u^2}\right] \quad \text{for } -1 \le u \le 1.$$

3. Ellipse :

• The implicit form of ellipse is given by

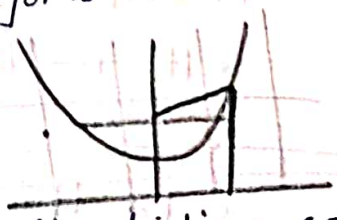


$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

• The parametric form of an ellipse whose centre lies at the origin of the coordinate system is given by

$$X = a\cos\theta$$
$$Y = b\sin\theta$$

Where 'a' and 'b' are semi-major & minor axes of ellipse.



4. Parabola :

A parabola has a focus and a fixed line called directrix, any point on the parabola is equidistance from the focus and directrix.

- The implicit form of a parabola is given by

$$y^2 = 4ax$$

- One of the parametric form of parabola is given by

$$x = au^2$$
$$y = 2au \quad \text{where } 0 \leq u \leq \infty$$

Curve Fitting :

- Curve fitting is the process of constructing a curve mathematical function such that it fit to a series of given data points so that a smooth curve can be generated.
- There are two methods used for curve fitting;
  1. Approximation method
  2. Interpolation Technique

Approximation Method

- In this method of finding the unknown data points from a given data point which is not exact but close enough to be used for construction of curve.
- In this method it is not necessary that the curve will pass throught all the given data points
- B-spline and Bezier curve are drawn using approximation method.

Interpolation Technique

- It is the technique of estimating any intermediate value of the function from the given data points.
- In this technique the curve produce will pass through all the given data points.

Interpolation Technique

- It is necessary that the curve produce will pass through all the given data points.
- Cubic spline & langranges interpolation methods are widely used to generate curves by interpolation method.
- The shape of the curve is greatly affected by changing a single data point and the change is unpredictable
- Cubic spline curves are made by this technique

Approximation Method (Best-fit Method)

- The curve produce will not pass through all the given data points but will be close to as many point as possible.
- Regression and least square methods are widely used to generate curve by approximation method.
- The shape of the curve is not greatly affected by changing a single data point and the change is predictable.
- Bezier Curve & B-spline are made by this technique.

UNIT-2 Surface and Solid Modeling

Surface Modeling:

- Surface modeling is the method of showing or presenting solid objects in a CAD system. Surface modeling uses planes, points, lines and curves to create a surface in 3D space.
- Surface modeling defines a component with greater mathematical description and create the surfaces with closed boundaries. It is particularly useful for modling objects, which can be modeled as shells (surfaces), such as car body, panels, fan blades etc.
- Surface modeling provides information on how the object edge is connected to form surface.

Surface Entities:

A surface entities is defined as the smallest unit of a surface modelling which build a surface model but has its own identity is called surface entities.

There two types of surface entities;

1. Analytic surface entities
2. Synthetic surface entities.

Analytical surface entities:

This type of entities can be represented by a simple mathematical equation such as Plane or tabulated cylinder.

The analytical surface entities are:-

1. Plane surface
2. Ruled surface
3. Surface of revolution

4. Tabulated cylinder/cylindrical surface
5. Spherical surface

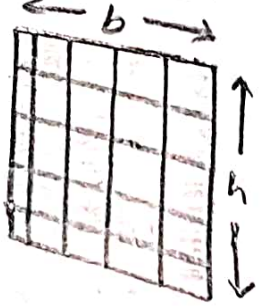
Synthetic Surface entities:

A synthetic surface entities is drawn by interpolating (approximating) the given data points and has a fixed form, according by the given data points

a. Bezier Surface
b. Coons Patches

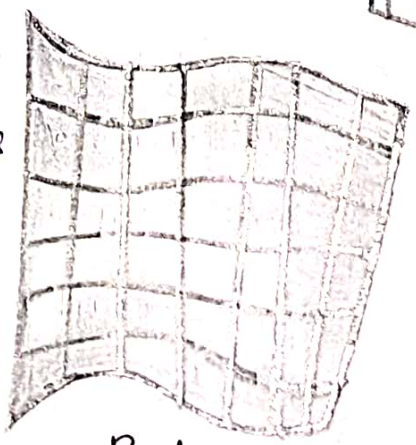
Plane Surface

This is the simplest surface. It required three noncoincident point to define an infinite plane. This plane surface can be used to generate a square or rectangular model and can also used to get cross-sectional view of a surface model by intersecting the model with a plane in required direction.



Ruled (Lofted) Surface

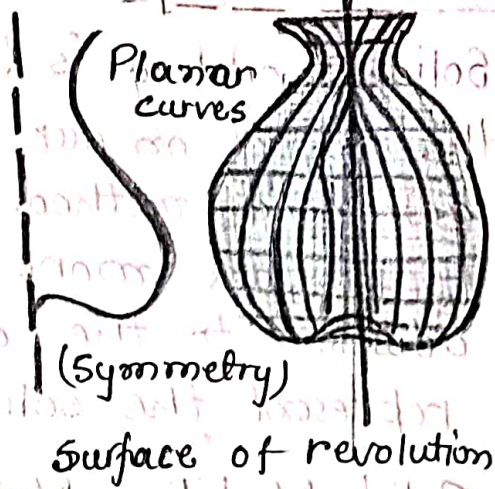
Ruled Surface are the surfaces that are generate using two curves (rails) with a straight line connecting each curves. It is a linear interpolation between two boundary curve known as rails which define the surface. Rails can be any wireframe entity.



• Ruled Surface

Surface of Revolution

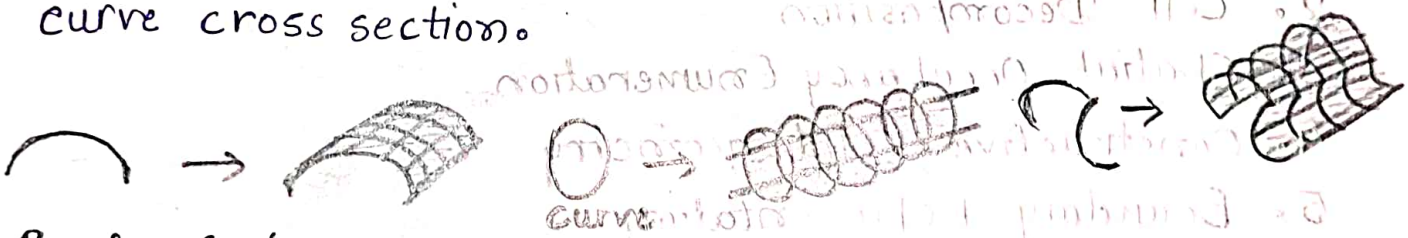
This is an axisymmetric surface that can used to model axisymmetric objects. It is generated by rotating a planer wireframe entity in space about the axis of symmetry at required angle.



Surface of revolution

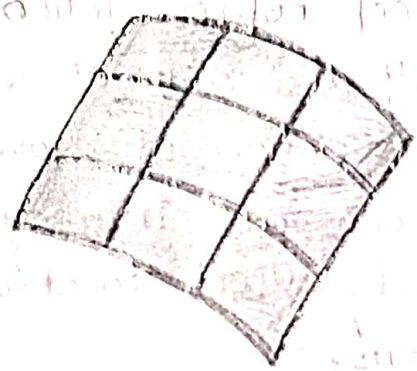
Tabulated Cylinder

This is surface generated by moveing a planer curve along a certain specified direction. The plane of the curve is perpendicular to the axis of specified direction. It is used to generate surface that have uniform curve cross section.



Bezier Surface

This is a surface that is made by approximating a given point data. It is a synthetic surface and the curve does not pass through all given points. It is a free form surface that permit twist and kinds.



Composite Surface

A composite surface is the collection of connected surfaces. The composite surface can consist of different type of curves but they must join at the ends with tangent of curvature continuity. Composite surfaces are composed of a set of surfaces but are treated as a single entity. The orientation of the composite surface is determined by checking the orientation of the first surface.

Solid Modeling

Solid modeling is the representation of the solid parts of the object on our computer. Solid modeling is the most advanced method of geometric modeling in three dimension. It provides more surfaces & volume characteristic in addition to the geometrical information which helps to represent the solid without any confusion.

Solid Modeling Methods

There are different method through which a solid modeling can be done or a solid model can be created within CAD system which are as follows':-

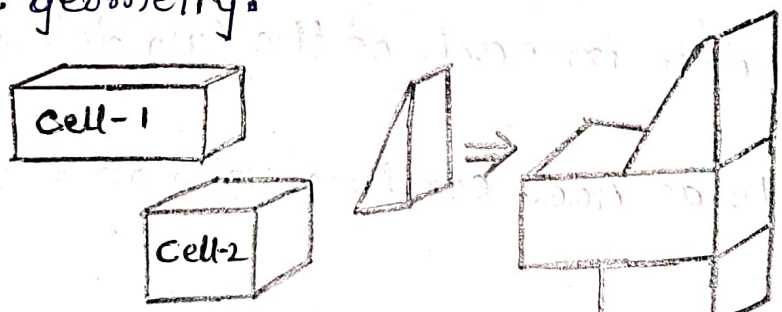
1. Sweep Representation
2. Cell Decomposition
3. Spatial Occupancy Enumeration
4. Constructive Solid geometry
5. Boundary Representation

Sweep Representation

- Sweep representation is useful in creating two and a half dimensional models. The sweeping is based on the motion of moving a given surface along a given path.
- There are two types of sweep method which is widely used to create a solid model which are as follows;-
  1. Linear sweep
  2. Non-linear sweep.
- In linear sweep representation the solid model is created is created by sweeping a surface along a linear direction in space.
- In non-linear sweep representation the solid model is created by sweeping a surface along a curve path which is described by a higher order equation.

Cell Decomposition

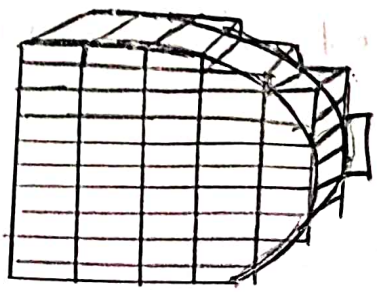
- In this representation technique the object can be represented as the sum of cells into which it can be decomposed.
- Cell decomposition consists of a single operator 'Glue' which restricts the cell to be "non-intersecting".
- The adjoining cells may touch each other but must not share any interior point.
- By joining simple cells using the glue operator complex solid can be modeled easily.
- This modeling technique is easy but due to single operator sometimes its tedious.
- Cell decomposition is not versatile as constructive solid geometry.



Spatial Occupancy Enumeration

- In this type of representation system the solid is represented by the sum of spatial cells that is occupies. These cells (also called voxels or volume elements) are cubes of fixed size that lies in a fixed spatial grid.
- The smaller the size of the cube, the more the curve object can be represented.

- The model is unique and easy to validate.
- This technique is used to represent volumetric data obtained from sources such as CAT scan.



Spatial Occupancy Enumeration

- In this

Constructive Solid Geometry

- In this type of solid representation method the physical object are created by combination basic elementry shape (known from of shapes / premitive shape) using Boolean Operation.
- The different types of Boolean operation which is used are as follow :—

1. Union
2. Intersection
3. Difference

Union

- The sum of all points in each of the two defined sets is union.
- It also referred to as Add, combine, join or merge.

Intersection

- Those points which are common to each of the two defined sets is the intersection, hence in modeling the common volume will be remained after this operation.
- It is also refered to as common or conjoin.

Difference

- The points in a source set minus the points common to a second set.
- It is also referred to as subottraction, remove, cut.

Advantages of CSG

- Data to be stored is less, so the memory required is less.
- CSG models are complete.
- It creates a fully valid geometric solid model.
- Complex shapes can be made relatively quicker.
- It required less skill.
- It can be converted to the corresponding boundary representation

Disadvantages of CSG

- It required more computational work.
- Getting tapered shape in the model is difficult.

Boundary Representation (B-rep)

- In this type of representation method the solid model is defined by its enclosing surfaces or boundaries.
- It consist of geometric information about the faces, edges and vertices of an object with topological data on how these are connected to form a model.
- A B-rep model is created by using euler operation.
- The basic elements of a boundary representation are :-

i. For closed Polyhedra

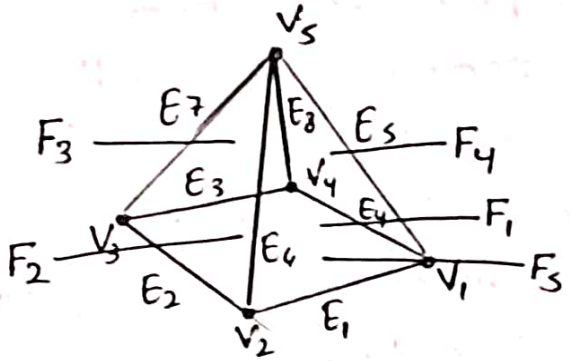
a. Simple Polyhedra
b. Polyhedra with faces of inner loop
c. Polyhedra with not through holes
d. Polyhedra with handles (through holes)

ii. For Open Polyhedra

a. Wire polyhedra
b. Lamina polyhedra
c. Shell polyhedra
d. Open - three dimensional polyhedra

Boundary representation and its data structure

- B-rep is done by storing face, edge and vertices as nodes with pointers or branches between the nodes to indicate connectivity.



Vertex	Coordinates
V_1	$x_1\ y_1\ z_1$
V_2	$x_2\ y_2\ z_2$
V_3	$x_3\ y_3\ z_3$
V_4	$x_4\ y_4\ z_4$
V_5	$x_5\ y_5\ z_5$

Edge	Vertices
E_1	$V_1\ V_2$
E_2	$V_2\ V_3$
E_3	$V_3\ V_4$
E_4	$V_4\ V_4$
E_5	$V_1\ V_5$
E_6	$V_2\ V_5$
E_7	$V_3\ V_5$
E_8	$V_4\ V_5$

Face	Edge
F_1	$E_1\ E_4\ E_5$
F_2	$E_2\ E_4\ E_7$
F_3	$E_3\ E_7\ E_8$
F_4	$E_4\ E_5\ E_8$
F_5	$E_1\ E_2\ E_3 E_4$.

UNIT-3. NC Control production systems

Numerical Control Production system :—

A numerical control production system uses numerical control to control and manage the machine tool which is used within a production system.

Numerical control

- Numerical control of a machine tool is a method of programmable automation in which various function of the machine tool are controlled by letter number or symbols (known as command & the sequence of command known as programme).
- In simple words we can say that a NC machine tool runs on a programme given to it.

In NC machine tool following function is automatic

1. Starting and stopping of machine tool spindle.
2. Controlling the spindle speed.
3. Positioning the tool tip at desired location.
4. Controlling the rate of movement (feed rate).
5. Changing of tool in the spindle.

Basic element of NC system

A numerical control system consist of the following three basic elements :-

1. Program of Instrction
2. Controller unit, also called a machine control unit (MCU)
3. Machine tool (NC tooling)

Program of Instrction

- The program of instruction is the detailed step by step set of direction which tell the machine tool what to do. It is coded in numerical or symbolic form on

a input medium that can be read by
unit.

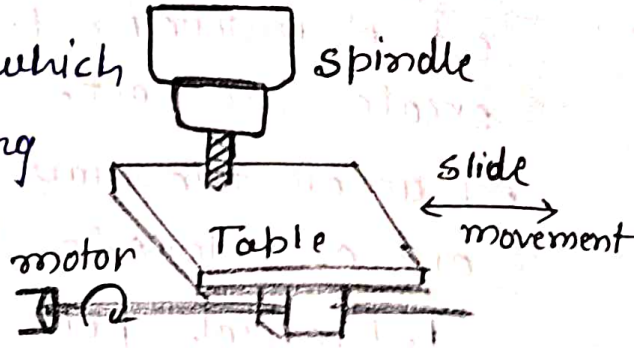
- The most common input medium is 1 inch wide punched tape but some other forms like magnetic tape and punched card can also be used.
- There are two other methods of input to the NC system ie manual data input (MDI) and by means of computer directly linked with NC system also called direct numerical control (DNC).

Controller Unit

- The second basic component of the NC system is the controller unit. This consists of the electronics and hardware that read the programme of instruction and convert it into mechanical action of the machine tool.
- The element of a NC controller unit are tape reader, a data buffer and signal output channel machine tool, feedback channel from the machine tool and the control console.
- The tape reader is an electromechanical device for winding and reading the punched tape containing the program of instruction.
- The data buffer store the input instruction in logical block of information.
- The signal output channel are connected to the servomotors and other controls in the machine tool.
- The control console contains the dials and switches by which the machine operator runs the NC system.

Machine Tool

- The third basic component of NC system is the machine tool. It is the part of the NC system which perform usefull work.
- A most general NC system which is design to perform machining operation contains a machine tool which has a workable and spindle as well as the motor and controls neccessary to drive them. It also includes the cutting tools and other auxiliary equipment needed in machining operation.



NC Procedure

To utilize numerical control in manufacturing, the following steps must be followed :-

1. Process Planning
2. Part Programming
3. Tap verification
4. Tap Preparation
5. Production

Process Planning

- At this step a route sheet is prepared. i.e a list of the sequence of operation which must be performed on the workpart is made.
- The basic information required to made the route sheet like part geometry, cutting process parameter and cutting tool to be used is decided by the operator according to product design.

Part Programming

- In this step the operator plan the sequence of machining step to be performed by NC and create the part program (part program manuscript) which contains the set of instruction to be followed by the NC machine to create the part.
- There are two ways to create the program for NC which are as follows :-
  1. Manual part programming
  2. Computer assisted part programming

Tape Preparation

- A punched tap is prepared by the operator according to the part programming.
- In manual part programming the punched tape is prepared directly from the part program manuscript on a typewriter like device known as flexowriter.
- In computer aided part programming the computer automatically generate the tap once the part geometry and other parameter feed into the it, which save a lot of time and used for complex geometry.

Tape ~~Prepar~~ Verification

- After the punched tape has been prepared, it is checked by running it through a computer program which plot the various tool movements on paper.
- Programming errors are common and it may require about three attempts before the tap is correct and ready touse.

Production

- At this step the tap is loaded into the machine as well as raw material and then the NC system takes over the control and machines that part according to the instruction on tape.
- When the part is completed the machine stops and the operator remove finished part from the machine and loads the next raw material and reinsert the tap for the next round of machining.

Types of NC Machine based or feed back control system

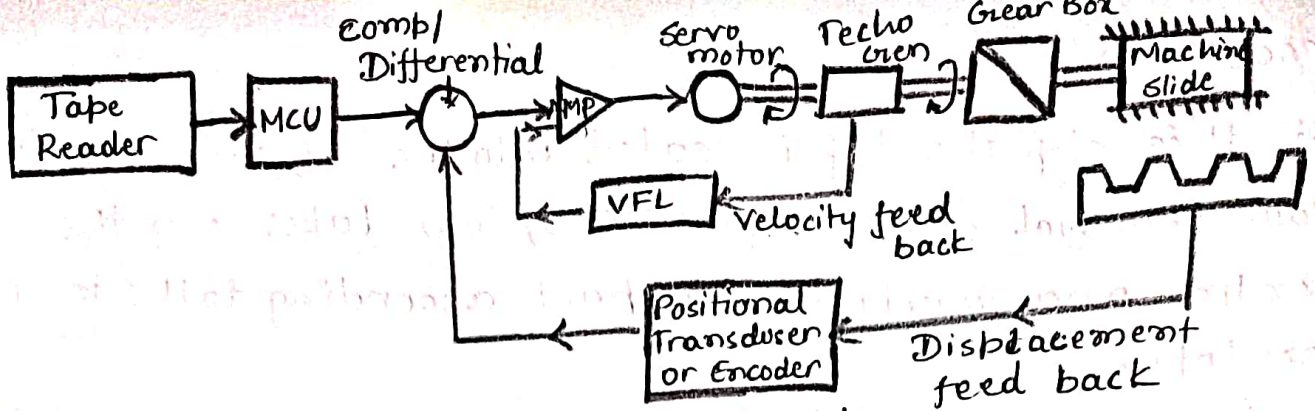
1. Open loop system
2. Closed loop system

1. Open loop system

- A control system in which the final output value is not directly measured and checked with the input value is known as open loop system.
- In open loop system, there is no feed back device to measure the actual position of tool and work table, hence it cannot be verified with the input value give in command.

2. Closed loop system

- A control system in which the final output value is not directly measured and checked with the input value is knows as open loop control system.
- In closed loop system there is feed back devices (sensor) to measure the actual position of tool and work table and verify it with the input valve and if any difference is present then it take corrective measure to correct it.



Type of Motion Control System in NC

There are following types of motion control system in NC machine

1. Point to Point control
2. Straight Line control
3. Contouring / Continuous path control

1. Point to Point Control

- In this system the machine tool head reaches a particular fixed co-ordinate point by the shortest possible path at rapid speed.
- The speed or path by which this movement from one point to another is achieved is not important.
- This is suitable for drilling, reaming, punching, tapping etc.

2. Straight line control

- In this system the machine tool head moves parallel to the X and Y axis as per program.
- The cutting motion in this system is along straight line and the feed rate is controlled by command from the NC program.
- The NC machine which is capable of straight cut movement is also capable of point to point movement.

3. Contouring / Continuous Path control

- It is the most complex, the most flexible and the most expensive type of machine tool control.
- In this system the machine tool head is capable to move at any angle and along curved path.
- The method by which it moves from one point to other point is called interpolation.
- It uses three types of interpolation :-

1. Linear Interpolation — straight line
2. Circular Interpolation — Arc and Circle
3. Parabolic Interpolation — Any free curve

Method of listing Co-ordinate of point

There are two method of listing of co-ordinate of a point in NC.

1. Asolute co-ordinate method or Absolute Positioning System
2. Incremental co-ordinate method or Incremental Positioning System.

1. Absolute Co-ordinate Method

- The system in which all the measurement are taken from a fixed origin with co-ordinate $X=0, Y=0$ and $Z=0$ is known as absolute co-ordinate method.
- This origin serves as datum position from which all the distance are measured.
- The origin can be defined in two ways :-
  a. Fixed Zero : Origin is at lower left corner of the workpiece.
  b. Floating Zero : Origin at the centre of the workpiece (when it is symmetric in nature)

2. Incremental Co-ordinate System

An incremental system is one in which all measurements for the next position are calculated in the form of distance from the point at which the tool was resting previously.

Direct Numerical Control

- Direct Numerical control machine tool can be defined as a NC system in which number of machine are controlled by computer through direct connection with computer in real time.
- The part program is transmitted to the machine tool directly from the computer memory instread of using a tape reader.

Components of DNC system

- Central Computer
- Bulk Memory
- Telecommunication lines
- Machine tools

Computer Numerical control

- A computer numerical control is a NC system that uses a dedicated computer to perform all the basic numerical control function.
- Earlier days it uses a tape reader for original loading of the part program and then stored in computer themory but now a days program can be directly written over it using some computer language.

Axis Identification

- It real world space is designated by 3-dimension and there are three axis of movement identified X, Y & Z in NC machine.

- Certain rules are followed for designating these axes for applying it to different types of NC machines.
- All the machine tool make use of cartesian co-ordinate system for simplicity and right thumb rule is used as guide for designating these axis.
- First axis to be identified is the Z-axis and then remaining two axis is identified.
- Z-axis is always kept parallel to the spindle axis and when tool move away from the work hold surface is designated as positive Z-axis.

NC Part Programming

The NC part programming is the method of write part program. ie it is a sequence of instruction which describe the motion of the tool needed to perform to generate the required part.

- The part programming can be done in two ways, which are as follow : —

1. Manual Part Programming
2. Computer Aided Part Programming

Manual Part Programming

- To prepare a part program using the manual method the programmer write the machine instruction on a special form called part programming manuscript.
- The manuscrip is a listing of the relative tool and workpiece location. It also include other data, such as preparatory commands and speed/feed specification.
- Each horizontal line in a manuscript represent a block of command which specify certain function required for production of product.

- The programe manuscript is then used to produce a punched tape with the help Hexo-writer or tele typewriter which is finally feed into the NC machine for production.
- Manual Part programming job can be divided into two categories :-
  a. Point to Point jobs
  b. Contouring jobs
- Manual Programming is ideally suited for point to point application.

Computer Aided Part Programming

- Most part machine on NC system are considerably more complex. In the more complicated point to point and countouring job, manual part programming become extremely difficult and subjected to error, in this situation computer help is used to generate part programe.
- The computer uses a high level language such as APT (automatically programmed tool) ADAPT, SPLIT etc for writting a computer programme which has english like statement which is then processed by the computer to prepare the tape.
- The computer automatically punches the tape in the paper tape format for the particular NC machine.

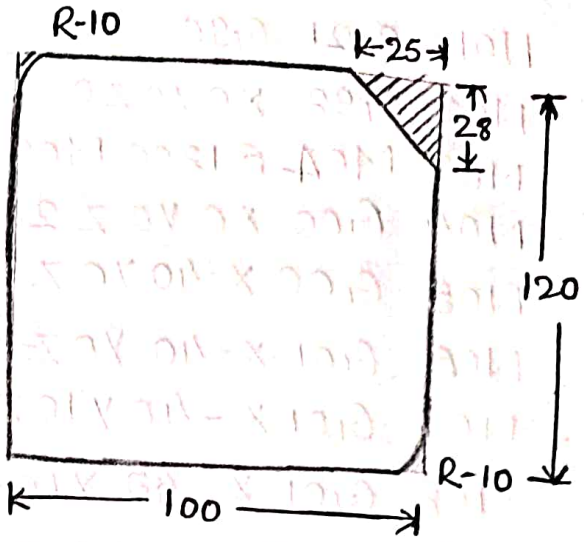
Computer Added Design / Computer Added Manufacturing :

UNIT-3

Code	Function
M02	Programme Stop
M03	Programme start clockwise
M04	Programme start Anti-clockwise
M05	Spindle stop
M06	Tool change
M08	Coolant ON
M09	Coolant OFF
M30	Programme stop & tape rewind.
G 00	Rapid Traverse
G 01	Linear Interpolation
G02	Circulation Interpolation clockwise
G03	circulation Interpolation Anti-clockwise
G04	Dwell
G05	Hold / Delay
G06	
G17	XY Plane designation
G18	ZX Plane designation
G19	YZ Plane designation
G20	Inch
G21	mm
G33	Thread cutting
G40	Cutter compensation cancel
G41	Cutter compensation Left
G42	Cutter compensation Right
G63	Thread cutting cycle
G70	Dimensioning in inch unit
G71	Dimensioning in metric unit
G80	Canned cycle cancel
G81-89	Canned cycles

G90	Absolute dimensioning
G91	Increamental dimensioning
G94	Feed rate mm/min
G95	Feed rate mm/rev
G92	Zero preset
G98	Return to the initial level after each canned cycle operation.

Qn. Prepare CNC part programming for milling using ISO codes for component shown in figures. All dimensions are in mm.



1st ....

CNC Milling Code

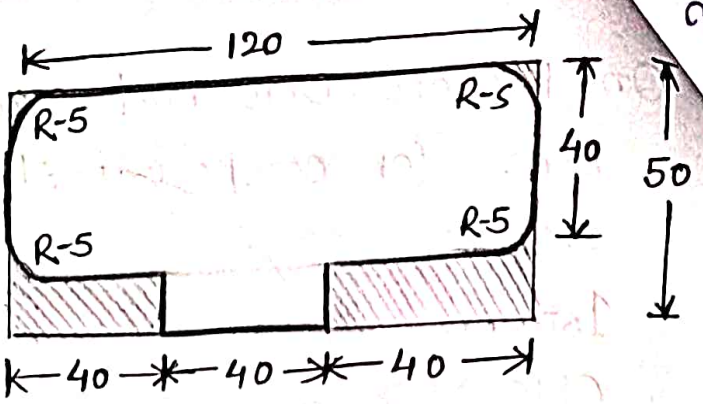
N01 G21 G90
N02 G98 X0 Y0 Z0
N03 M03 S1000 M08 G41
N04 G00 X0 Y0 Z5
N05 G01 X0 Y0 Z-3 F150
N06 G01 X0 Y110 Z-3
N07 G02 X10 Y120 Z-3 R10
N08 G01 X75 Y120 Z-3
N09 G01 X 100 Y92 Z-3
N10 G01 X 100 Y10 Z-3
N11 G02 X 90 Y0 Z-3 R10
N12 G01 X0 Y0 Z-3
N13 G01 X0 Y0 Z0
N14 G00 X0 Y0 Z0 M09
N15 G00X0 Y0 Z0 M02.

Codes

G21 - measure in mm
G90 - Absolute dimensioning
G98 - Back to Initial lvl
M03 - Programme Start CW
M08 - Coolant On
G00 - Rapid Traverse
G01 - linear Interpolation
G02 - Circular Interpolation CW
M09 - Coolant off
M02 - Programme stop.
G41 - Cutter Compensation Left

2nd ...

CNC Milling Code



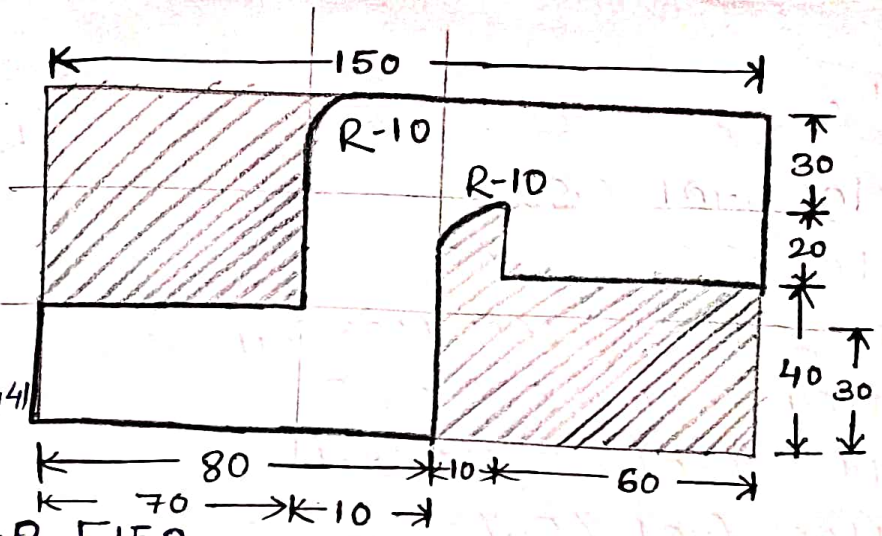
N01 G21 G90
N02 G98 X0 Y0 Z0
N03 M04 S1200 M08 G42
N04 G00 X0 Y0 Z2
N05 G00 X-40 Y0 Z2
N05 G01 X-40 Y0 Z-2 F150
N07 G01 X-40 Y10 Z-2
N08 G01 X-35 Y10 Z-2
N09 G03 X0 Y15 Z-2 R5
N10 G01 X0 Y45 Z-2
N11 G03 X-5 Y50 Z-2 R5
N12 G01 X-115 Y50 Z-2
N13 G03 X-120 Y45 Z-2 R5
N14 G01 X-120 Y15 Z-2
N15 G03 X-115 Y10 Z-2 R5
N16 G01 X80 Y10 Z-2
N17 G01 X80 Y0 Z-2
N18 G01 X40 Y0 Z-2
N19 G00 X0 Y0 Z0
N20 G00 X0 Y0 Z0 M09 M02.

Codes

G21 - measure in mm
G90 - Absolute dimensioning
M04 Programme Start ACW
M08 - Coolant On
G00 - Rapid traverse
G01 - linear Interpolation
G03 - Circular Interpolation ACW
M02 - Programme stop
M09 - Coolant off.
G42 - Cutter compensation Right

3rd ..

CNC Milling Code




```
N01 G21 G90
N02 G98 X0 Y0Z0
N03 M03 S700 M08 G41
N04 G00 X0 Y0 Z4
N05 G01 X0 Y0 Z-2 F150
N06 G01 X0 Y30 Z-2
N07 G01 X70Y30 Z-2
N08 G01 X70 Y80 Z-2
N09 G02 X80 Y90 Z-2 R-10
N10 G01 X 150 Y 90 Z-2
N11 G01 X 150 Y40 Z-2
N12 G01 X 90 Y 40 Z-2
N13 G01 X 90 Y 60 Z-2
N14 G03 X 80 Y 50 Z-2 R-10
N15 G01 X 80 Y 0 Z-2
N16 G01 X 0 Y 0 Z-2
N17 G01 X0 Y0 Z 0
N18 G00 X0 Y0 Z0 M09 M02.
```

Codes

G21 - measure in mm
G90 - Absolute dimensioning
M03 - Programme start CW
M08 - Coolant on
G41 - Cutter compensation left
G00 - Rapid traverse
G01 - linear Interpolation
G02 - Circular Interpolation CW
M02 - Programme stop
M09 - Coolant off.

UNIT-4 Group Technology & Computer Aided Process Planning

Group Technology :

- Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in manufacturing and design so as to reduce the overall manufacturing cost.
- Similar parts are arranged into a single group (data base) known as part families.

Advantages of Group Technology

- It allows similar design to be easily modified from the existing design with less efforts.
- Standard process plan can be developed for their group.
- A standard setup procedure and tooling can be developed for the grouped product.
- It allows faster production.
- There will be less work in process inventory.
- Material Handeling and movement is reduced.

Disadvantages of Group Technology

- The cost of implemeting group technology is high and need outside consultant.
- It may not be possible for factory with very large variety of product.
- The entire production of a company cannot be put under group technology.
- There are various way of grouping and not a single grouping system suits all application.
- If the product changes the group technology system will also changes based on the product.

Part Families :

- A part family is a collection of parts which are similar either because of geometric shape and size or because similar processing stops are required in their manufacturing.
- The parts within a family are different but their similarities are close enough to put them as a member of same families.
- There are three general method for grouping parts into families
  1. Visual Inspection
  2. Production flow Analysis (PFA)
  3. Parts classification and Coding System

Visual Inspection

- The visual inspection method is the simple and least expensive method of grouping parts into families.
- In this method the parts is grouped into different families by looking at either the physical parts or photographs and arraging them into similar grouping.
- This method is less acurate as compare to other method.

Product Flow Analysis (PFA)

- Product flow analysis method was developed by J.L. Burbidg
- In this method the part is grouped into families by identifying the associates machine tool being used using the route sheet for parts produced in a given shop.
- In this process the parts having similar operation sequences and machine routing are grouped together in one part families.
- It is done in following steps;-
  1. Data collection
  2. Sorting of Operation
  3. Prepration of PFA chart
  4. Data analysis.

Part Classification and Coding System

- In this method the parts is grouped into families through examination of the individual design and manufacturing similarities.
- It uses coding system which define the manufacturing sequence and design steps to be followed in a particular part.
- The classification and coding system have been developed but none of them has been universally adopted because classification and coding system is custom engineered for a given company or industry which may not suited for other industry.
- The classification and coding may be carried out on the entire list of parts manufactured within the plant or a sampling process may be used to establish the part families.
- Types of Part Classification and coding system :-
  a. Optiz System
  b. MIDCLASS System
  c. CODE System

Optiz Classification and coding system

- This part classification and coding system was developed by H. Opitz of the University of Aachen in West Germany.
- The Optiz coding system uses the following digit sequence

  12345 6789 ABCD

- The basic code consist of nine digit, which can be extended by adding four more digits.
- The first nine digits are intended to convey both design and manufacturing process data, in which the first five digit 12345 are called "form code" and describe the primary design attribute of the part while the next

four digit "6789" are called "supplementary code" which is Some other details about manufacturing like dimension, work material, starting workpiece shape and accuracy.

- The extra four digit "ABCD" are known as "secondary code" which indicate production type and sequence. This code can be designed by the manufacturer for its own purpose if needed.

The MICLASS Part classification and coding system

- MICLASS stands for metal institute classification system and was developed by TNO, the Netherland Organization for Applied Scientific Research.
- The MICLASS classification number can range from 12-30 digits. The 12 digit are a universal code that can be applied to any part, while the 18 additional digits can be used to code data that are specific to the particular company or industry.
- It is difficult to code the part manually so a computer program (software) has been design based on MICLASS system in which to classify a given part design, the user has to answer series of questions asked by the compute program and on the basis of the responses the computer assign a code number to the part.
- The number of question will depends upon the complexity of the part. For a simple part maximum Seven question are needed while for average part. the number of question ranges between 10 to 20.

The CODE part classification and coding system

- The code part classification and coding system developed and marketed by Manufacturing Data System Inc. of Ann Arbor, Michigan.
- It is widely used in design engineering for retrieval of part design design data and also used in manufacturing process planning, purchasing tool design and inventory control.
- The code number has eight digits. For each digits there are 16 possible values (zero trough 9 and A through F) which are used to describe the parts design and manufacturing details.
- The 1st digit position indicates the basic geometry and principal manufacturing process process of the part.
- The 2nd and 3rd digit provided additional information concerning the basic geometry and principle manufacturing.
- Digit 4, 5 and 6 specify secondary manufacturing process such as threads, grooves, slots.
- Digit 7 and 8 are used to indicate the overall size of the part like diameter, length etc and so on.

Cellular Manufacturing

- Once part have been grouped into ~~part~~ families and all machines that are required for complete manufacturing has been identified, it is necessary to organise these all machines into a cell.
- A cell (machine cell) is where all the parts of a group are completely manufactured and all the machine are arranged in proper layout so that material and parts smoothly move through the cell. Manufacturing with GT cells (also known as machine cell) is called

cellular manufacturing.

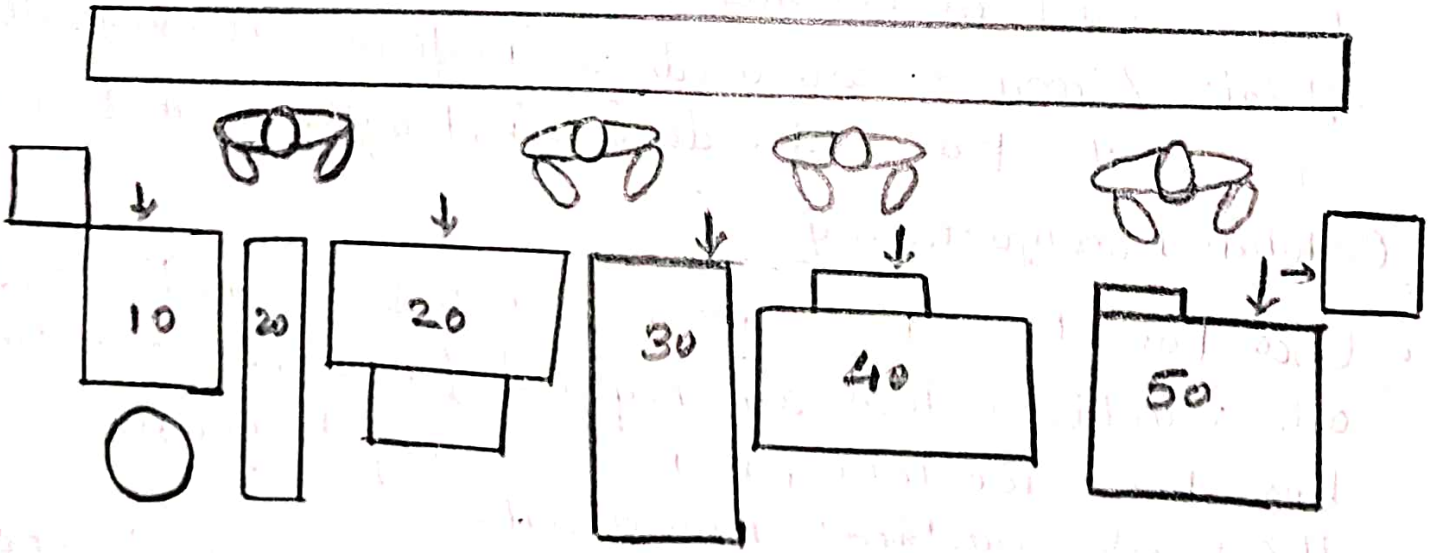
Machine cell design

There are three types of machine cell design which is widely used in a GT cell.

1. Straight trough cell or inline layout
2. U-shaped cell
3. L-shaped cell

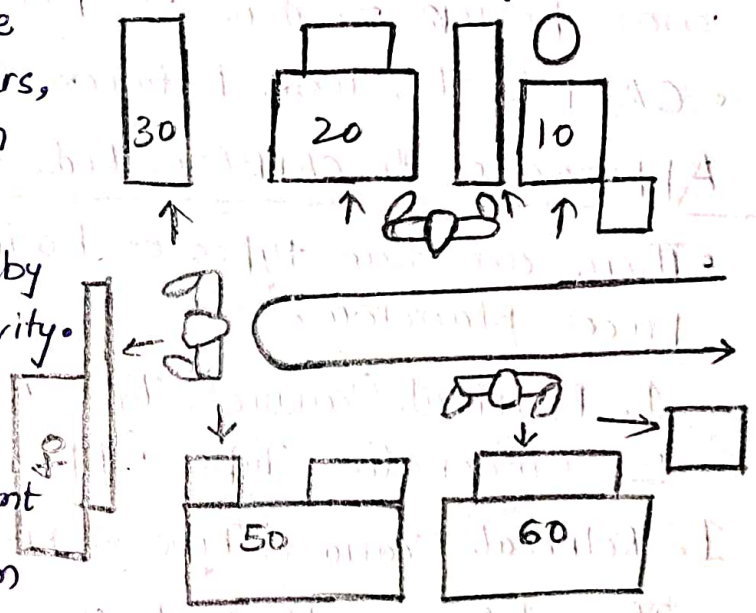
Straight trough cell or Inline Layout

- In this type of machine cell design machines are arranged in a line and generally integrated with simple material handling device like conveyor belt for the movement of material during processing from one machine to other. This type of layout is easy to understand, control and schedule the parts and labour operating the machines. It has easy access from both sides and have a single delivery station for finished part.



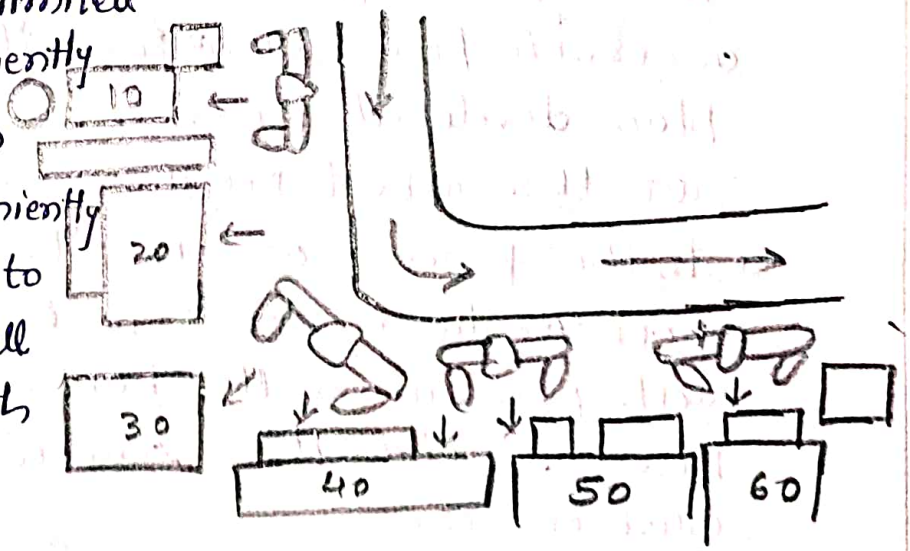
U-Shape Cell

- The more common arrangement in group technology cells is the U-shape cell. In this arrangement, the work-in and work-out points is the same which allows easy loading and unloading of the parts. All the workers are inside and thus they can help each other when necessary. When the number of machines in the cell is small, it may be provided with only manual work holding arrangemen while with large number of machines, it can be provided with conveyar belt for material handling. Since the machines are in close proximity to the workers, it is possible to assign multiple machines to an individual worker, thereby improving the productivity.



L-Shape Cell

In this type of arrangement lengthy series of operation can be easily fitted into limited space. It canbe conveniently located at the points in the shop that are conveniently from the raw material to come to the cell as well as feed other cells with the finished parts.



Computer Aided Process Planning (CAPP)

- Process Planning is concerned with determining the sequence of manufacturing operation needed to produce a given part or product.
- The operation sequence once findout in written on a form known as route sheet.
- Computer aided process planning is means of automatically develop the process plans (route sheet) from the geometric image of the component thus reduce the man power needed to perform it manually.
- CAPP is the link between CAD and CAM.

Approaches to CAPP (methods to implement CAPP)

- There are two types of basic approaches to computer aided process planning :-
  1. Retrival (Variant) Type Approach
  2. Generative Type Approach

1. Retrival (Variant) Type Approach

- This type of approach uses group technology code to select a generic process plans from the exiting master process plan developed for each part faimily and edit it to suit the current requirement of the part.
- In this process at first the master process plan for each part families is stored in Comper files and when a new work part arrives the part code is inserted into CAPP program which then search to determine if a match exist or not.
- If a match exist, the statement operation sequence are retrive from the computer file and displayed to user on scree
- If an exact match is not found, the user search the operation sequence file for similar part that can used to develop the plan for new part.

2. Generative type Approach

- In the generative type approach a process plan is created from scratch for each component without human intervension
- In this system it create plan by means of decision logic, formulas geometry based on data and other logical process.
- The computer uses a set of algorithms to progress through various technical and logical decision towards the final plan for manufacturing.
- After retriving these information the computer generate the required process sequence for the work part.
- A pure generative type system can produce a complete process plan from design data available.

Machinability Data System

- In process planning for particular part the cutting parameter like speed, feed and depth of cut needed to be predetermined according to the geometry and sequence of operation so in order to get a proper speed, feed and depth of cut of a particular operation machinability data system is used.
- The objective of a machinability data system is to select cutting speed and feed rate when the following characteristics of the operation has been defined.
  a. Type of machining operation
  b. Machine tool
  c. Cutting tool
  d. Work part
  e. Operation parameter other than feed & speed.
- The various ways through which a proper feed, speed & depth of cut can be obtained are :-
  1. Experience and judgement of process planner, foreman or machine operator.

2. Handbook recommendations
3. Computerized machinability data system.

Material Requirement Planning (MRP)

- MRP stands for material requirement planning is system of planning to get the right materials to the right place at the right time minimising the inventory cost.
- Material requirements planning is a computerized system that allows manufacturers to plan, manage and control their inventories more effectively.
- MRP helps the producer analyze various factors to prepare the demand forecasts. It calculates the inventory schedules the production, and ensures that finished products reach the right place at the lowest possible cost at right time.

Material Requirements Planning Steps

1. Identify the product type
2. Estimate the demand and volume
3. Explore required raw material and components
4. Evaluate existing inventory levels
5. Examine the manufacturing capacity
6. Plan the production and cost
7. Shedule the delivery.

Benefits of Material Requirements Planning—

- It help^ to easily identify the volume of raw material required
- It maintain a balance betweendemand and sopply chain.
- It increase the productivity.
- It maintain optimum maintaining inventory level.
- It reduce inventory handling cost.
- It prevent Wasteage of inventory and stocs
- It reduce lead time.

Dis-advantages

- It is an expensive system to apply.
- Incorrect data can lead to incorrect demand.
- Wrong input can delay production and shipment.

UNIT-5 Flexible Manufacturing System & Automated Inspection

Flexible Manufacturing System

- A flexible manufacturing system (FMS) is a highly automated Group technology cell, consisting of one or more processing stations (usually CNC machine tools), interconnected by an automated material handling and storage system and controlled by a computer system.
- The reason the FMS is called flexible is that it is capable of processing a variety of different part style simultaneously at the various workstations and the different type of part styles and quantities of production can be adjusted according to changing demand patterns.

Equipment of Flexible Manufacturing System

FMS has three basic component :-

1. Workstation
2. Material handling and storage system
3. Computer control system

Workstation

- They are typically consist of different type of processing or assembly equipment used in a FMS which depends upon the type of workpart required to be manufactured.
- Following are the types of workstations typically found in an FMS :-
  a. Load/Unload Station
  b. Machining Station/ Machining center
  c. Assembly station
  d. Inspection station
- The load/unload station act as a physical link between the FMS and the rest of the factory. It is where raw material enter the system and finished part exit the system. Loading and unloading can be accomplished either manually (the most common method) or by automated handling systems.

• Machining station or maching center is the CNC machin which perform the required machining operation on the raw part. It is equiped with automatic tool changing & tool storagewhich is connected with the FMS part-handlin system.

Material handling & storage system

• They are used transport workparts from one workstation to another workstation and since each station has a small queue, it is sometime required to store the part temporar so a storage system is also required.

• The handling system also include locations for load/ unload stations.

Computer control system

• It is used to coordinate the activities of the different workstation and the material handling system in the FMS.

• It also distribute the control instrction to different workstation.

• A computer control system consists of a central computer and microcontroling the individual machines and other components.

Types of FMS Layouts

There are four types of FMS layout which are as follow:-

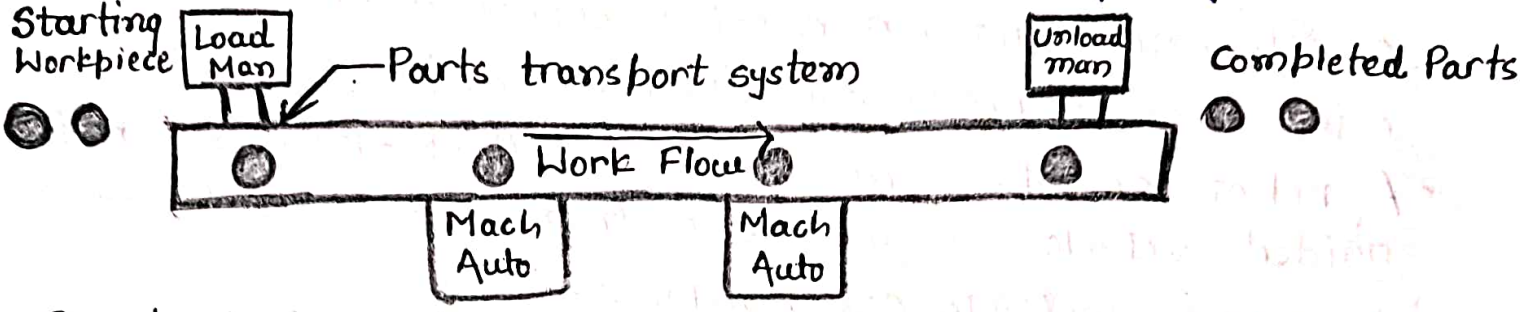
1. In-line layout
2. Open field layout
3. Loop layout
4. Robot - centered layaut/cell.

1. In-line layout

• It is the simplest form of layout in which the machine and handling system are arranged in a straight line.

• The parts moves from one workstation to the next in a predefind sequence with work always moving in one direction and no back-flow occur.

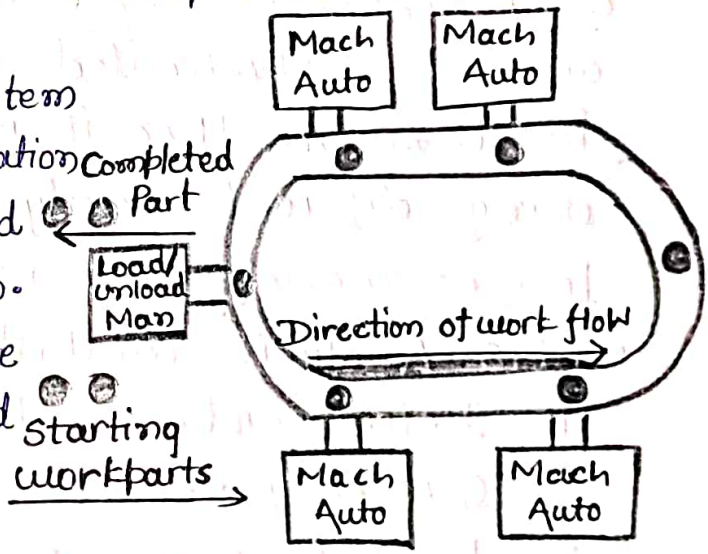
• The in-line layout can be combined with an integrated parts-storage system so that it can be used for "light out" operation ie the worker load the part in during day shift and the FMS operates unattented during night shift.



2. Loop Layout

• In the loop layout, the workstations are organized in a loop that is served by a partshandling system in the same shape. The parts move in one direction around the loop and has the capability to stop and be able to transferred to any station.

• A secondary handling system is provided at each workstation to allow parts to move around the loop without obstruction. The load/unload station are typically located at one end of the loop.



3. Open Field Layout

• The open field layout consists of multiple loops and branches, and may include side movement of the work part. This type of layout is generally used for processing large families of parts. The number of different machine type may be limited, and parts are routed to different workstations depending on which one becomes available first

• It uses automatic guide vehicle for material handling purpose.

4. Robot Centered Layout

- The robot-centered layout uses one or more robotes as the material handling system. Industrial robots can be equipped with grippers that make them capable for the handling of rotational parts, and robot-centered FMS layouts are often used to process cylindrical or disk-shaped parts.
- A robot can be mounted on a floor-installed rail-guided vehicles or suspended from an overhead crane to service multiple CNC machines.

Analysis Methods of FMS.

- Flexible manufacturing system (FMS) is a highly automated manufacturing system. The relation between its components is very complex. Also the FMS components are very sophisticated and costly. If FMS has to be implemented then it is better to analyze its results using different analysis method which involves no loss of money and resources.
- FMS Analysis method can be classified as
  1. Deterministic model
  2. Queueing model
  3. Discrete event simulation

Deterministic model

- Deterministic models are useful in obtaining starting estimates of FMS performances. It is useful in the beginning stages of FMS design to provide rough estimates of system parameters such as production rate, capacity and utilization.
- Deterministic models do not permit evaluation of operating characteristics such as the buildup of queues and other dynamics that can affect system performance.

- Deterministic models tend to overestimate FMS performance
- If actual system performance is much lower than the estimates provided by these models, it may be a sign of either poor FMS design or poor mangement of FMS operations.

Queueing Models

- Queueing models can be used to describe some of dynamics not accounted in deterministic approaches.
- These models are based on the mathematical theory of queues. They permit the inclusion of queues, but only in a general way and for relatively simple system configurations.
- The performance measures that are calculated are usually average value for steady state operation of the system. Probably the most well known of the FMS queueing models is CAN-Q.

Advantages of FMS

- It improve capital utilization.
- It decrease the labour cost by reducing number of labours required for production.
- It give better quality due to automated control of process.
- It increases the productivity of the manufacturing plant.
- It reduce error repair and rejection of parts.

Disadvantage of FMS

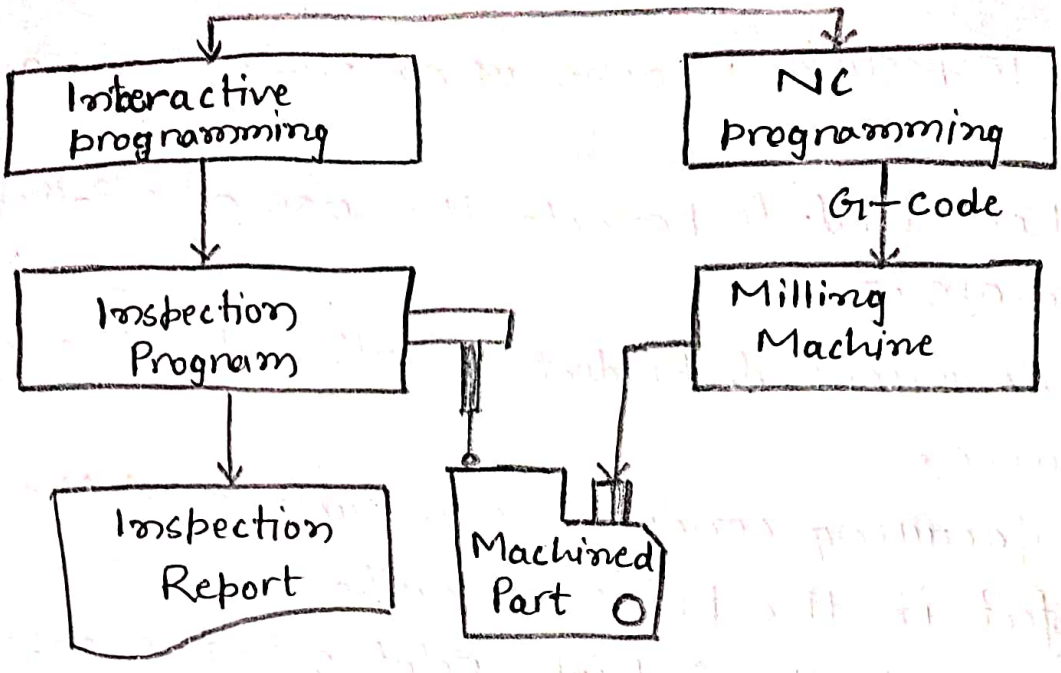
- It has a limited ability to adapt to change in product.
- It required large capital for its implementation.
- It required proper analysis of manufacturing process before implementation of FMS.

Computer Aided Quality Control (CAQC)

- Computer aided quality control is when computers are used to inspect and test products that are being manufactured within a plant.
- It is an engineering application that can observe the operations of machinery and ensure everything is being produced as per required standards.
- It allows for a digital inspection of the quality products being produced and putting in place statically process control and producing necessary documentation.
- It include computer aided inspection and computer aided testing.

Objectives of computer aided quality control :-

- It increase productivity in inspection process.
- It increase overall productivity.
- It reduce lead time
- It reduce wastage due to scrap or rework.
- It automatically maintain and create record of parts and raw material.



Computer Aided Quality Control

Automated Inspection

Automated inspection is defined as the automation of one or more steps involved in inspection procedure. It user computer sensors and scanners which helps to inspect the part which is being produce within a manufacturing plant and identify the error if exists. It also maintain the record of the product related to its final dimension.

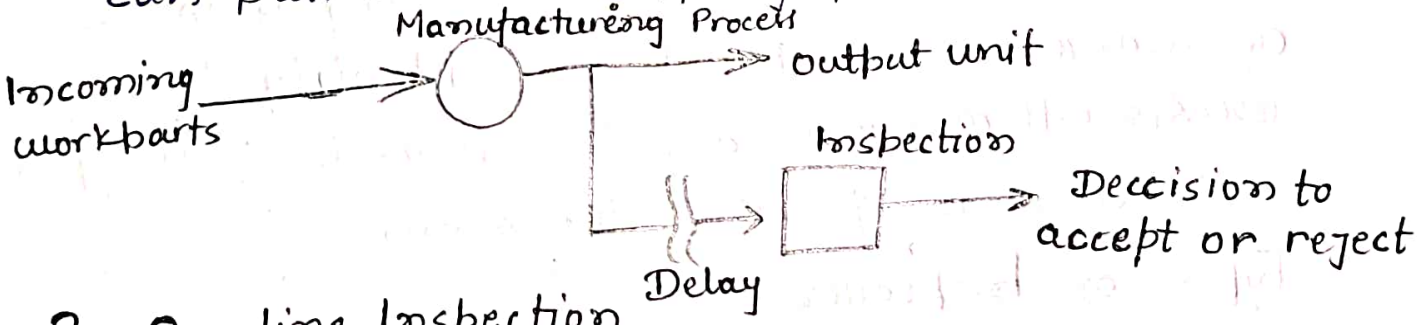
Types of Inspection

1. Off-line Inspection
2. On-line Inspection
3. Contact inspection
4. None contact inspection

1. Off-line inspection

- Off-line inspection is performed away from the manufacturing process and there is generally a time delay between processing and inspection.

- Off-line inspection is done using statistical sampling method.
- Factor that tends to promote the use of off-line inspection are :-
  a. The manufactured product is well within the design tolerance.
  b. Manufacturing conditions are stable and the risk of defect in the process is small.
  c. cost of inspection is high relative to the cost of a few detective parts.
- The disadvandage of off-line inspection is that the parts have already been made by the time poor quality is detected. When sampling is used, an addition disadvantage is that defective parts can pass due to sampling procedure.



2. On-line Inspection

- The alternative to off-line inspection is on-line inspection performed when the parts are made either as an integral step in the processing or assembly operation or immediatly afterward.
- There are two methods of on-line inspection which are as follow :-
  1. On-line In-process inspection/ In-process inspection
  2. On-line Post process inspection/Post-process inspection.

a. On-line In-process inspection

- On-line in-process inspection is achieved by performing the inspection procedure during the manufacturing operation. As the part are being made, the inspection procedure simultaneously measures their demand and other features.
- The benefit of in-process inspection is that it may be possible to control the operation that is making the current part, thereby correcting the quality before the part is completed. When on-line in-process inspection is performed manually, it means that the worker who is performing the manufacting process is also performing the inspection procedure.
- Techniqually, automated on-line in-process inspection of the product is usually difficult and expensive to implement.

b. On-line Post-Process Inspection

- On line post-process inspection, the measurement procedure is done immediately after the production process. Even though it done after the production process, it is still considered an online method because it is integrated with the manufactring workstation, and the results of the inspection can be used to immediately control the production operation.
- The limitation of on-line/post process inspection is that the part has already been made, and it is therefore impossible to make corrections if needed in that particular part. The best that can be done is to correct the production of the next part.

- On-line post-process inspection can be performed as either a manual or an automated procedure. When done manually it can be accomplished using either sampling or 100% inspection. When on-line process inspection is automated, it is typically performed on a 100% basis.

Contact Inspection

- Contact inspection involves the use of mechanical probe or other device that makes contact with the object required to inspect. The purpose of the probe is to be measure the object in some way.
- Contact inspection is used to measure physical dimensio of the part. These techniques are widely used in the manufacturing industries, specially in the production of metal parts. Contact inspection is also used in the ~~manufacturing~~ electrical circuit testing.
- The principal contact inspection machines are:
  a. Conventional measuring instruments
  b. Coordinate measuring instrument/machine (CMMs) and related techniques to measure dimensions.
  c. Stylus-type surface texture measuring machine to measure surface characteristics such as roughness & waviness.

Non-Contact Inspection Method

- Non-contact inspection methods uses a sensor located at a certain distance from the object to measure the desired features like dimension and surface properties.
- The noncontact inspection technologies can be classified in two categories:
  a. Optical
  b. Non optical

- Optical inspection technologies use light to perform measurement process. The most important optical technology is machine vision; however, other optical techniques are important in certain industries.
- Nonoptical inspection technologies uses energy forms other than light to perform the inspection. These other energies include electrical fields, radiation (other than light) and ultrasonics.
- Noncontact inspection offers certain advantages over "contact inspection" which are as follow:-
  a. They avoid damage to the part surface that might result from contact inspection.
  b. Inspection cycle times are faster because non-contact methods use a stationary probe that does not need repositioning for each part.
  c. Non contact methods can be done on the production line without the need for any additional material handling system.

Coordinate measuring machine (CMM)

- A coordinate measuring machine (CMM) is a measuring device that measures the geometry of object by establishing coordinates points on a physical surface using a contact probe.
- The machine will specify the probe's position in terms of displacement from an origin point in a three dimensional coordinate system (XYZ axes).
- A CMM can measure object dimension with high accuracy, record the measured data.

A coordinate measuring machine has the following main elements in order to properly function.

1. High precision mechanical structure
2. Probing system
3. Machine control unit
4. CMM Software

1. High Precision Mechanical structure

- It is the main operating unit of a CMM which has the ability to move the sensor probe to the desired position on the part to be measured. It is made very rigid to provide the necessary accuracy for the measurement.

2. Probing System

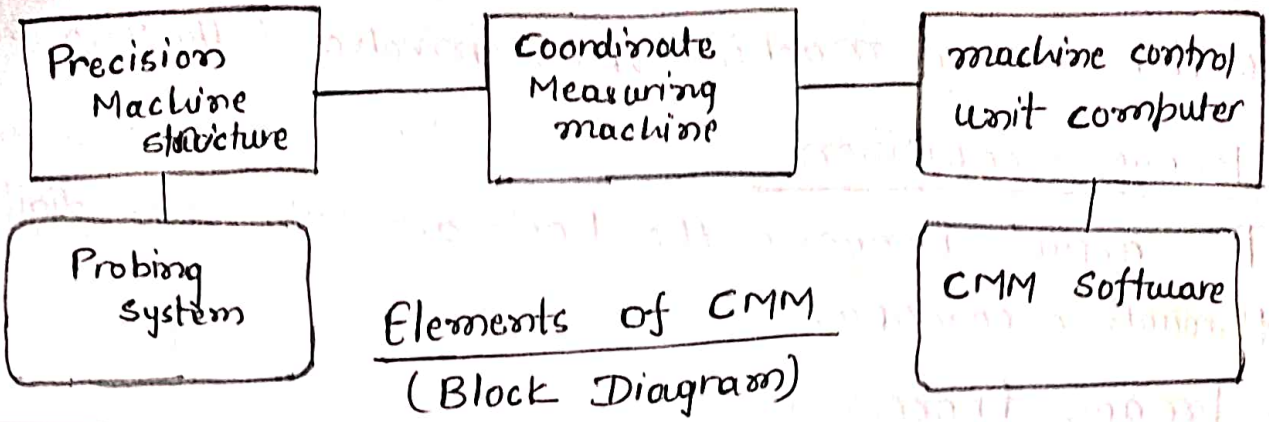
- The touch trigger probe is used to collect the basic information such as x, y & z axis coordinate of point where the probe touch the part to be measured.
- It is a mechatronic device help to record a number of points to the part surface which is needed to quickly measure.

3. Machine Control Unit

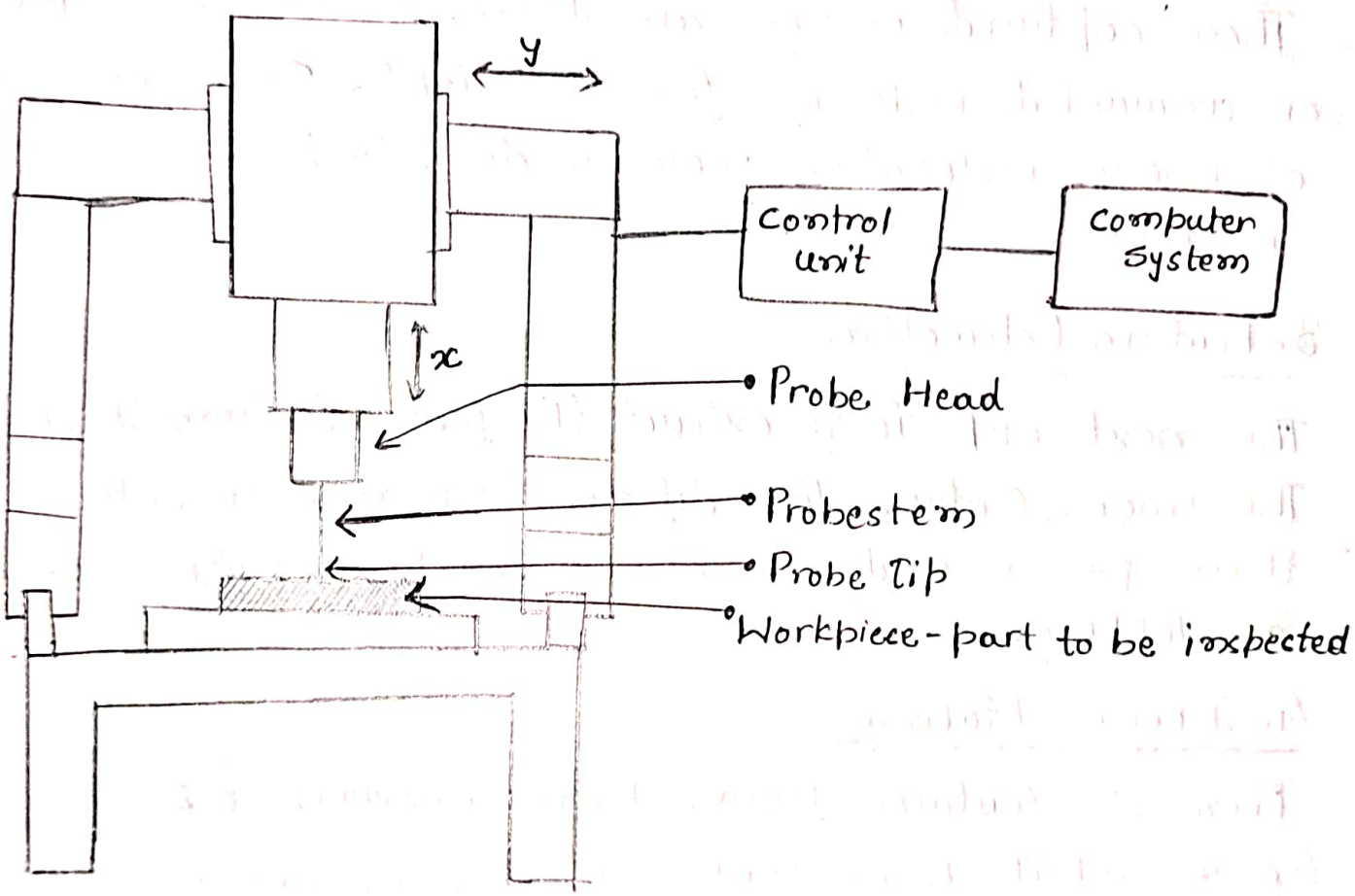
- It is a computerised system that control the probe positioning as well as getting the data in terms of coordinate which are then used by software.

4. CMM Software

- A CMM software is a metrology operating system which perform the necessary calculation using the coordinate value it receives from MCU and display the final dimension of the object.



Elements of CMM
(Block Diagram)



Machine Vision

- A machine vision system of inspection is highly popular in now days.
- A machine vision system consist of camera, a digital computer and an interface between them that act as postprocessor.
- The combination of above element capture the picture and analyzes the image by comparing it with data stored in memory. The data are often in the form of model on the objects which are to be inspect.

Inspection using machine vision involves following steps

1. Image Acquisition

- The actual image of the parts are capture in digital form through a camera.

2. Image Processing_

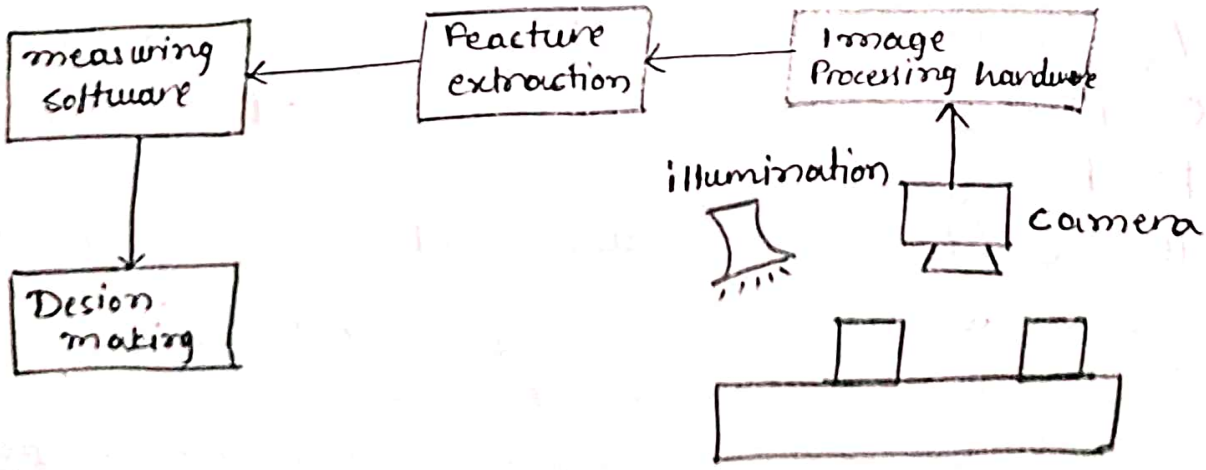
These captured images are filtured to remove background or unwanted reflections from the light. Some ammount of image restoration may be done to improve image quality.

3. Feature Extraction

The next step is to extract the features from the image. The image features like different surface, curve, line there position and size are extracted by taking care of overlapping.

4. Decision Making_

From the features found in the previous step, the feature which is necessary for measurement is extracted which is then matched with a computed description with some known model of the image (region or object) and thus inspection is done.



Computer Integrated Manufacturing

- CIM is the integration of tota manufacturing enterprise through the use of integrated systems and data communications coupled with new manageral philosop that improve organizational and personal efficiency.
- Computer-integrated manufacturing is the manufacturi approach which uses a computer system for the total integration of each individual concepts such as CAD CAM, CAPP into one large system known as computer Integrated manufacturing.
- CIM basically involves the integration of all the function of a manufacturing plant.

Difference between Off-line and On-line inspection

Off line Inspection	On-line Inspection
• It is perform away from the manufacturing location.	• It is perform at the manufacturing location.
• It required extra floor space for the setup of inspectio machine and tools.	• It do not required extra floor space for the setup of inspection machine & tools.
• Extra material handling system is required to move the part from manufacturing location to inspection location.	• It do not required extra material handling system.
• The part may be damaged while moving for inspection	• There is no change of part to get damage while inspection.

Contact Inspection

- In this type of inspection method physical contact is needed between the machine and the object to be inspected.
- Due to regular physical contact the machine instrment wear out after some time and needed to be replace.
- It is difficult to made it auto matic.
- It is done away from the manufacturing location & required extra floor space.
- Measuring using scale, measuring tape, vernier is a contact type inspection method.

Non-Contact Inspection

- In this type of inspection method physical contact is not needed between the machine and the object to be inspected.
- The inspection machine uses either light, electric fields ultrasonic wave or ether form of energy for inspection
- It can be easily made automatic.
- It can be done during manufacturing and do not need extra floor space.
- Measuring using machine vision is a non-contact inspection method.