Systems in Mechanical Engineering

Unit V

Introduction to Manufacturing

A. Y. 2020-21

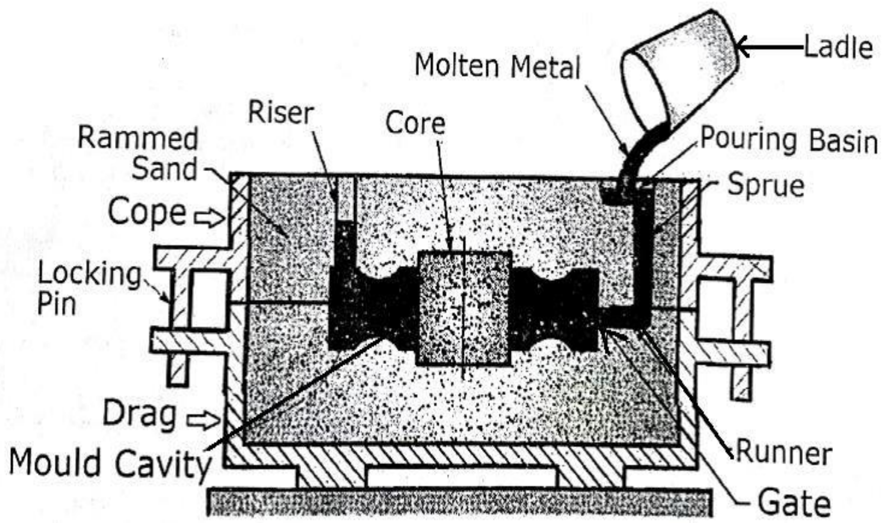
Manufacturing Process

- **Manufacturing Process**-Manufacturing Process is a process of converting Raw Material into Finished Products using machines.
- **Classification of manufacturing process**:

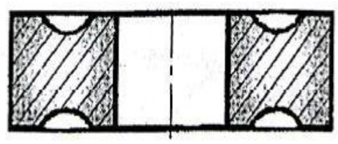
Conventional Manufacturing Processes:

A. Casting: Molten metal is poured in cavity and allowed to cool and solidify.
B. Metal forming/ Metal working: Raw material is shaped to plastic deformation.
C. Sheet metal working: Making component from sheet metal.
D. Machining/ Metal cutting: Material removing form workpiece by cutting tool
E. Surface finishing: Negligible amount of material is removed by using surface finished tool.

A. Casting



Casting Setup



Final Component

- **Principle:** Casting is a manufacturing process in which part of desired shape is obtained by pouring molten metal into cavity of required shape.
- **Steps in Sand Casting:**

1. Pattern Making: Pattern is replica of the part to be casted. Initially pattern has to be made using different manufacturing process other than casting. Commonly used materials for pattern making are- Wood, Plastic and metal.

2. Mould Making: Mould is a container made from green sand and which has cavity in which molten metal can poured. Mould box has two halves, the upper halve is called cope and lower halve is called drag. Arrangement for metal pouring has to be made inside the mould.
3. Core Making: Core is a predetermined shape in sand placed in mould to form hollow interior. Hollow interior includes holes and spaces.
4. Melting and Pouring Metal: The raw material is melted in furnace. The molten metal is poured into mould using ladle molten metals flow through specific channel; Pouring basin, sprue, runner, gate, mould cavity and riser.
5. Cooling and Solidification: Metal is allowed to cool to room temperature. During solidification the metal shrinks and the extra metal required compensate this shrinkage is obtained from the riser.
6. Cleaning and Inspection: Undesired part like riser has to be cut from main casting. The casted surface is cleaned and finished. Then it is inspected to check defects in products.

- **Advantages :**

i. Complicated shapes can be produced.
ii. Very small to very large size can be produced.
iii. Almost all types of alloys and metals are used.
iv. Economical for small as well as mass production.
v. Special Casting processes like, die casting give good dimensional accuracy and surface finish.
vi. Low cost manufacturing

- **Disadvantages:**

i. Component of thickness less than 6mm difficult to produce.
ii. Melting of metal involves high energy consumption.
iii. Requires large and skilled man power and large space.
iv. Environmental pollution is high.
v. Blow holes, gas cavities and non-metallic inclusions reduces strength of component.
vi. Mechanical properties, porosity, poor dimensional accuracy and surface finish.

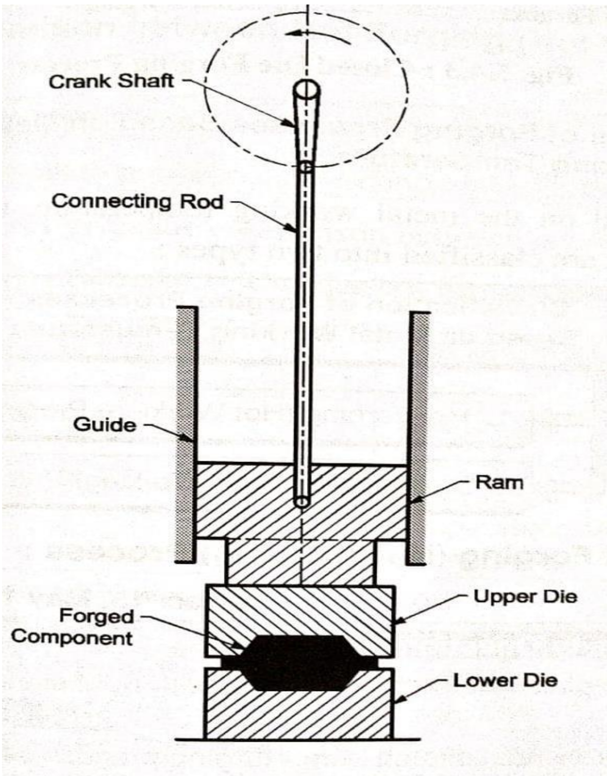
- **Applications:**

Gear box housing, machine tool bed, machine tool frame, gear, bearing housing.

B. Metal Forming / Metal working

- Metal Forming is a process in which the component of desired size and shape is produced through plastic deformation of metal under the action of external force (tensile, compressive or combination of them).
- Metal forming processes can be carried out on metal in hot or cold conditions.
- Types of metal forming processes:
  1. Forging: Production of metal parts
  2. Extrusion: Production of metal bars/ rod
  3. Wire drawing: Production of metal wire
  4. Rolling: Production of metal sheet
  5. Sheet metal forming: Production of sheet metal parts

1. Forging



- **Principle:**

i. Forging is the process in which metal or metal alloy is first heated and then plastically deformed to desired size and shape by application of compressive force using hand hammer or a press.

ii. In forging process material is heated to a temperature beyond the elastic limit so that it is plastically deformed in required size and shape.

- **Working:**

i. In forging process, the material is deformed into desired shape between two parts called as dies. The shape of the dies matches with desired shape of forged component.

ii. The forging press consist of lower die fixes to frame while upper die is connected to ram. The hot material is kept on lower die.

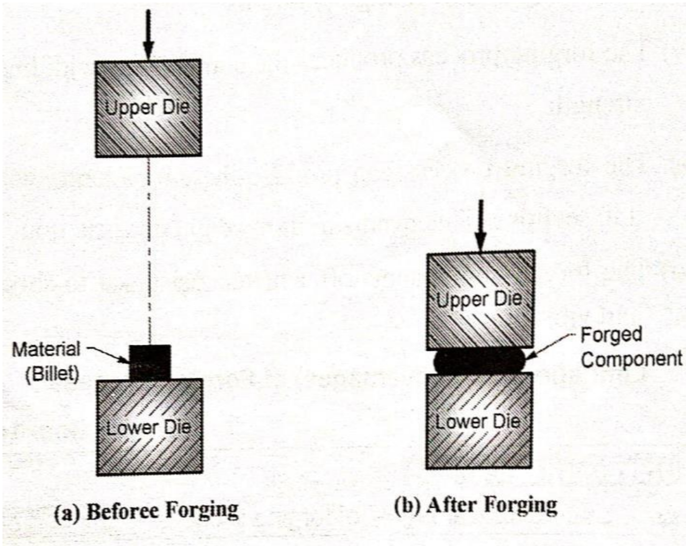
iii. During downward stroke of ram, the upper die exerts compressive force on hot material. Due to sudden compressive force, hot material is converted into desired shape.

iv. The forging press can be mechanical press or hydraulic press.

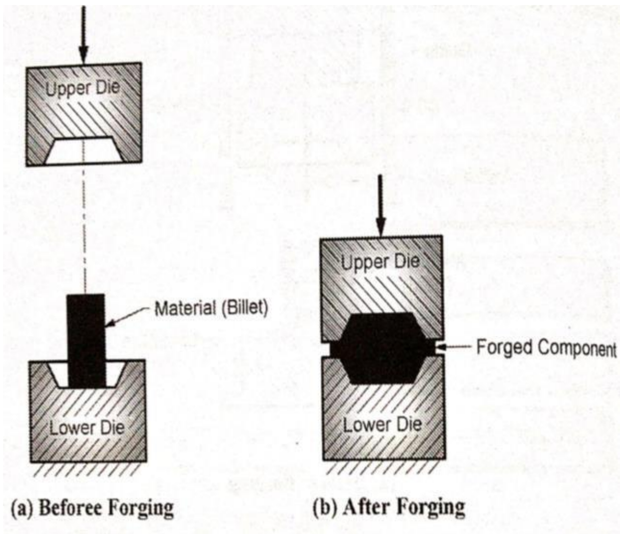
v. In mechanical press, ram is driven by electric motor through the crankshaft and connecting rod. In hydraulic press ram is driven by hydraulic oil.

vi. Material used for forging: Ductile material like low or medium carbon steel, alloy steel, stainless steel, copper alloy, aluminium alloy.

- **Types of Forging:**
    1. Open die forging
    2. Close die forging



Open die forging



Close die forging

- **Open die forging:**

In open die forging process, the material or workpiece is deformed in two flat dies or dies of very simple shape.

- **Close die forging:**

In close die forging process, the material or workpiece is deformed between two dies which have impressions of desired shape. When two dies are closed the cavity form is of desired shape.

- **Comparison of open and close die forging:**

Sr. No.	Parameter	Open die forging	Close die forging
1	Principle	Workpiece is compressed between two flat dies	Workpiece is compressed between two die halves that form cavity of shape to be produced.
2	Cost of die	Low	High.
3	Process type	Simpler	Complex
4	Dimensional accuracy	Not very exact	More exact dimensions
5	Machining	Required	Not required
6	Use	Used for low production and simple parts	Suitable for mass production and complex parts

- **Advantages of Forging process:**

i. High dimensional accuracy.
ii. Gives good surface finish.
iii. Stronger/ tougher than casted part.
iv. Better mechanical properties, strength, and toughness.
v. Better resistance to shock and vibrations.
vi. It can be welded.

- **Disadvantages of forging process:**

i. Brittle material like cast iron, high carbon steel cannot be forged.
ii. Complex shapes cannot be forged.
iii. Very large size part cannot be forged.
iv. Dies are costly.
v. Noise and Vibration is more

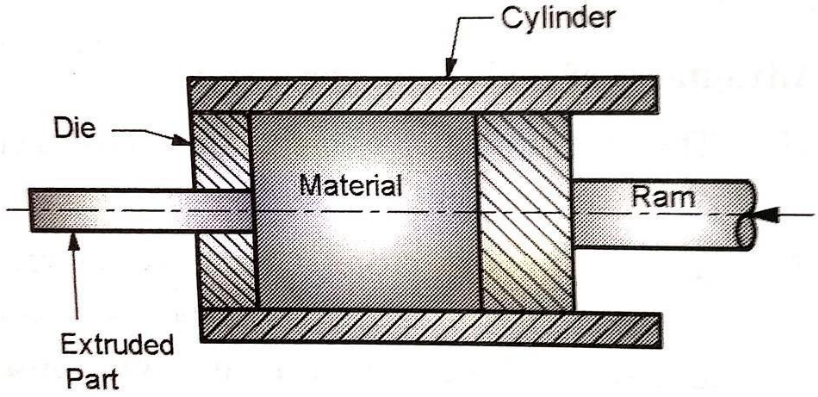
- **Applications of forging process:**

  Connecting rod, crankshaft, propeller shaft, rocker arm, knife, war equipment's, swords, protective armour, helmets.

- **Comparison of Casting and forging:**

Sr. No	Parameter	Casting process	Forging process
1	Definition	Casting is a manufacturing process in which part of desired shape is obtained by pouring molten metal into cavity of required shape.	Forging is the process in which metal or metal alloy is first heated and then plastically deformed to desired size and shape by application of compressive force using hand hammer or a press.
2	Suitability of material	All metal, alloy and plastic can be cast	Only ductile material can be forged
3	Size of component	No restriction on size	Large size component difficult to forge
4	Shape of component	Very complex shape components can be cast	Very complex component cannot be forged
5	Suitability	Economically suitable for small or large production.	Economically not suitable for small job production.
6	Initial investment	Less	High
7	Cost of component	Very less	High
8	Dimensional accuracy	Less	High
9	Toughness	Poor	Good
10	Resistance to shock	Poor	Good
11	Quality of product	Shrinkage, cavities, blow holes occurs in component	No shrinkage, cavities, blow holes occurs in component
12	Space requirement	Large	Comparatively less
13	Pollution	Produces air pollution	Produces noise pollution

2. Extrusion



- **Principle:** Extrusion is metal forming process used for manufacturing the long and straight rods or bar of fixed cross sections.
- **Material used:** Steel, Aluminium alloy, magnesium, thermoplastic etc.
- **Working:**

i. In extrusion process material is placed in the form of billet is kept inside the cylinder and forced to flow through the die of desired cross section using ram. As a result part or component of desired cross section in produced.
ii. In extrusion process ram is driven by electric motor or hydraulic cylinder.
iii. If the material is extruded at a temperature above recrystallization temperature so that forcing or pushing material is so easy then it is called as **hot extrusion.**
iv. If material is extruded at a temperature below its recrystallization temperature then it is called as **cold extrusion.**

- **Advantages of Extrusion process:**

i. Component produced by extrusion have high accuracy and good surface finish.
ii. Cost of component produced by extrusion process is low.
iii. Extrusion process can produce a component of large length.
iv. High rate of production.
v. Metal as well as plastic part can be produced.

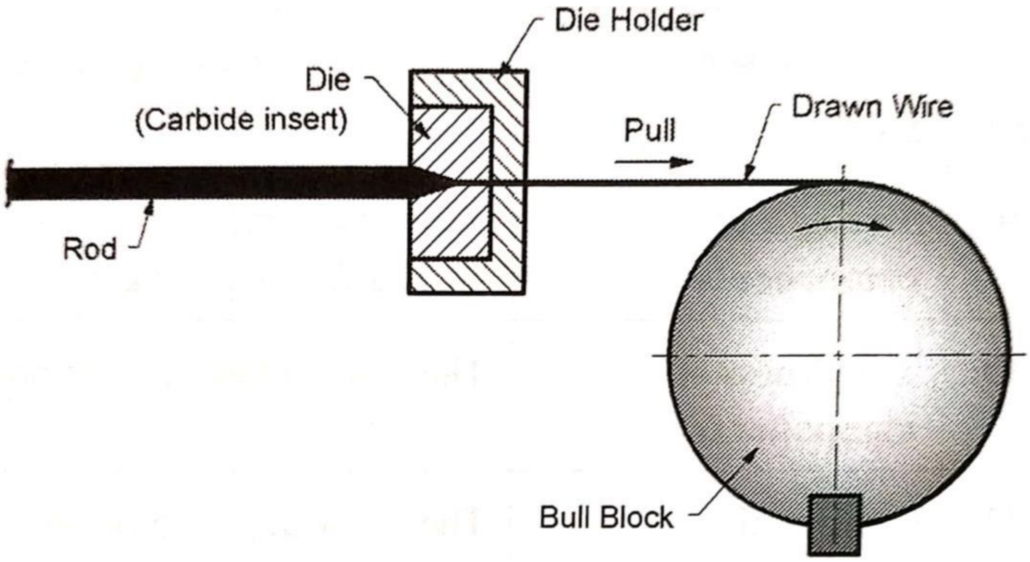
- **Limitations of Extrusion process:**

i. High initial cost of set up.
ii. Extrusion cannot produce components of varying cross section.

- **Application of Extrusion process:**

Collapsible tube, Aluminium cans and cylinders, Bars, Tubes, Gearblank

3. Wire drawing



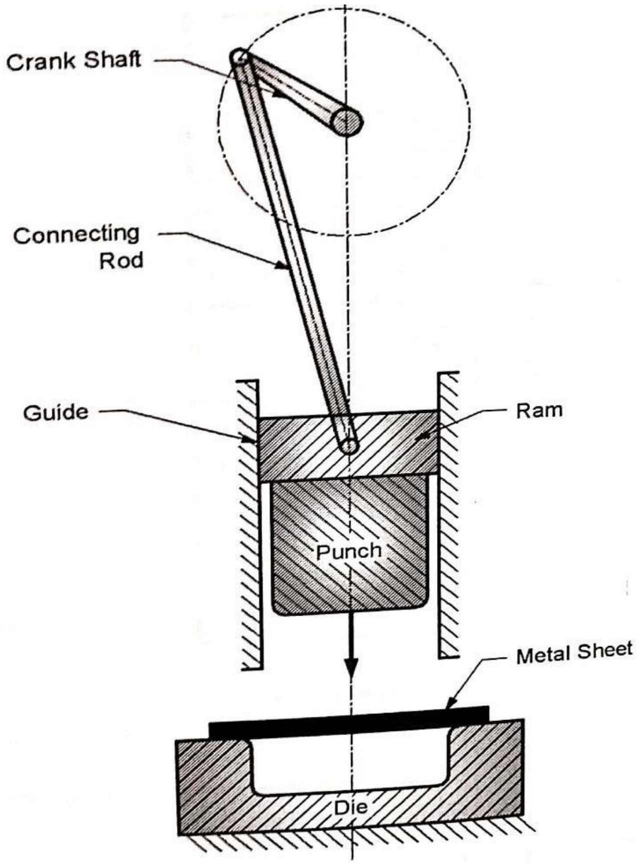
- **Principle:** Wire drawing is cold working process of producing wire from rod through the successive reduction of diameter.
- **Material used:** Steel, Copper, Aluminium alloy.

- **Working**:
  i. In wire drawing process metal is pulled through a die. A tensile force is applied to the metal on the exit side of the die for pulling purpose.
  ii. There is gradual reduction of cross section area inside die. Due to this, as the tensile force is applied to a metal exit side of die, the die exerts radial compressive force on the metal. This causes plastic flow of metal.
  iii. For obtaining significant change in size multiple passes are required.
  iv. For wire drawing process, material must have good ductility.

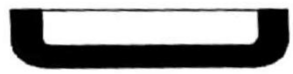
- **Advantages:**

  Wire drawing process gives excellent dimensional accuracy.

4. Sheet Metal Forming/ Sheet metal working/ Press working



Sheet metal working



Final component

- **Principle:** Sheet metal working is process of manufacturing of components or parts from sheet metal of thickness ranging from 0.1 mm to 8 mm. the sheet metal working carried out with machine tool called as press. So it is also called as press working.
- **Construction and Working:**
  i. Press: The tool used on press for carrying out the sheet metal working are die and punch.
  ii. Die: It is stationary part which forms shape of desired component. It is fixed to bed of press.
  iii. Punch: It enters in die cavity to carrying out operation. Small clearance is kept between die and punch for thickness of metal sheet. Punch is attached to ram. Ram is driven by crankshaft through connecting rod. The piece of metal sheet which is to be given shape is kept on die. The force is applied through the punch.

- **Advantages of Sheet metal working:**
  i. Components produced by sheet metal working are light in weight.
  ii. Components produced by sheet metal working are cheap.
  iii. In sheet metal working rate of production is high.
  iv. Gives high dimensional accuracy and better surface finish

- **Disadvantages of Sheet metal working:**

i. Thickness of metal sheet used is limited

ii. Low strength of components.

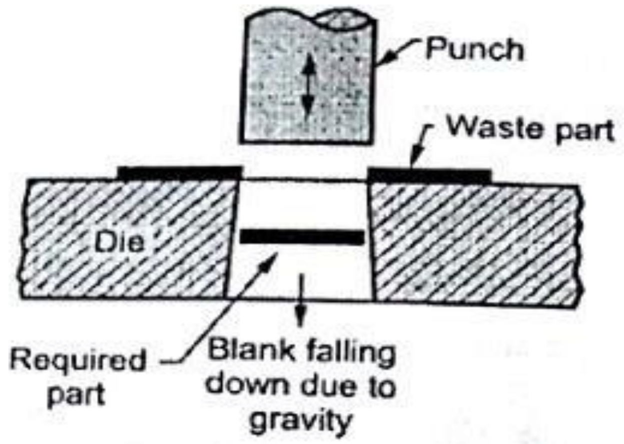
- **Applications of Sheet metal working:**

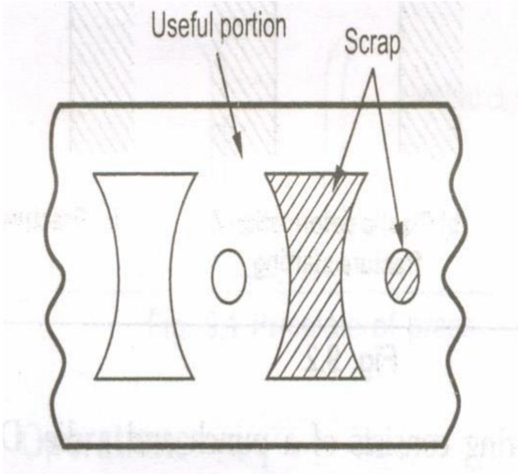
  Automobile and truck body parts, Airplanes body parts, railway-locomotives bodies, Steel furniture, Farm and construction equipment, Appliances bodies, Beverage cans, Utensils, etc.

- **Types of Sheet metal working:**
  a. **Sheet metal cutting or shearing processes**
  b. **Sheet metal forming processes:**

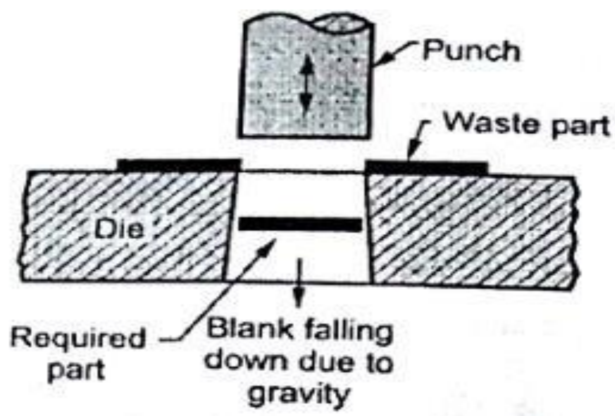
a. **Sheet metal cutting or shearing processes:** Sheet metal is stressed beyond the ultimate limit.

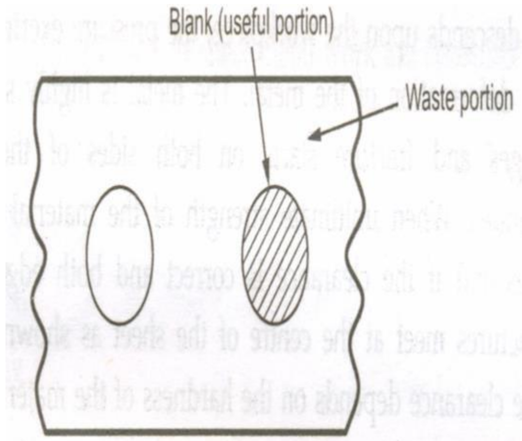
i. **Punching:** It is the operation of producing a circular hole in metal sheet using a punch and a die. In punching, the metal sheet with hole is required component while the material punched out to form hole is waste part.



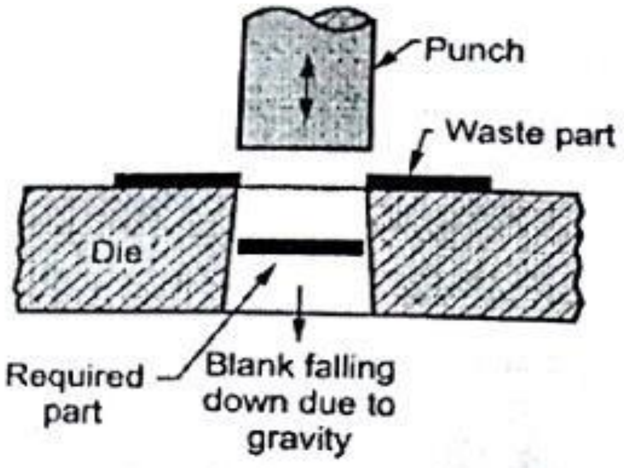


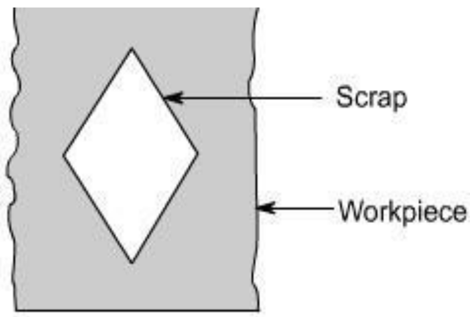
ii. **Blanking:** It is the operation of cutting out a piece of the required shape from a metal sheet using a punch and a die. In blanking, the metal sheet with hole is waste while the material cut out to is required part.





iii. Piercing: It is operation of producing a hole of any desired shape in a metal sheet by using a punch and a die. In piercing metal sheet with the hole is required component while punched cut out to form hole is the waste portion.



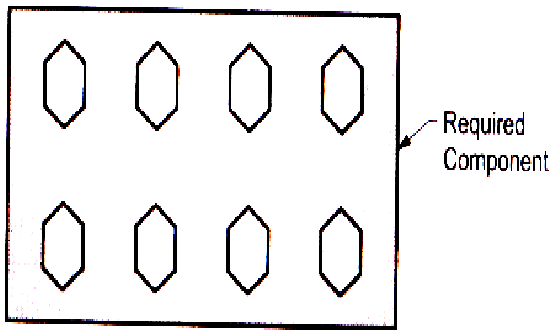


iv. Perforating: It is the operation of Producing/ Cutting evenly spaced holes of any shape in regular fashion.

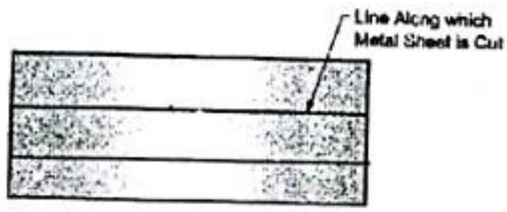
v. Slitting: It is the operation of cutting a metal sheet in a straight line along the length.

vi. Lancing: It is the operation of cutting and bending the cut portion of sheet metal.

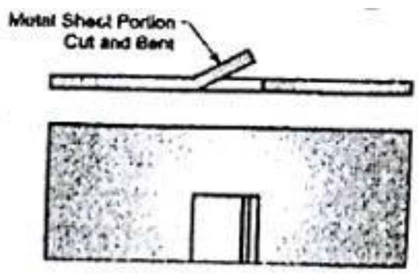
vii. Notching: It is the operation of removal of small part of the metal sheet of desired shape from edge of metal sheet.



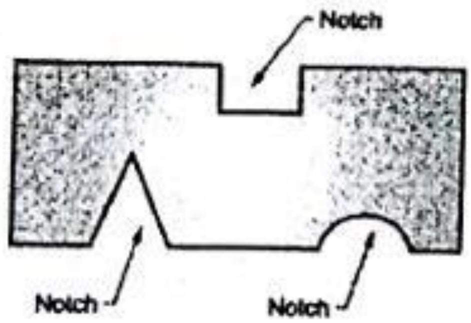
Perforating



Slitting



Lancing



Notching

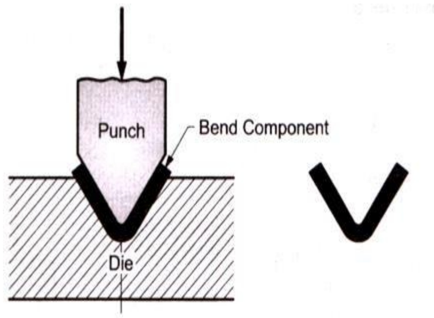
b. Sheet Metal Forming Processes: Sheet metal is stressed beyond the elastic limit and less than ultimate limit.

i. Bending: Bending is a metal working process by which a straight length is transformed into a curved length. Both tensile and compressive stresses are developed in bend region.

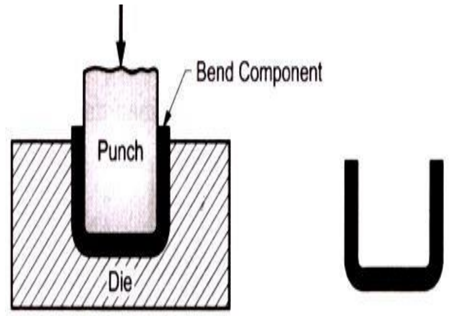
Ex. Producing angles and channels

Types of bending:

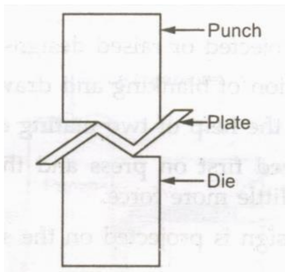
i. **V- bending: Metal sheet is bend in V-shape**
ii. **U-bending: Metal sheet is bend in V-shape**
iii. **Angle bending:** the metal sheet bent to sharp angle.
iv. **Curling/ rolling:** The edges of metal sheet are curled or rolled.



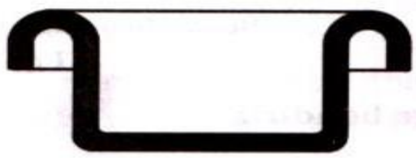
V- Bending



U-bending



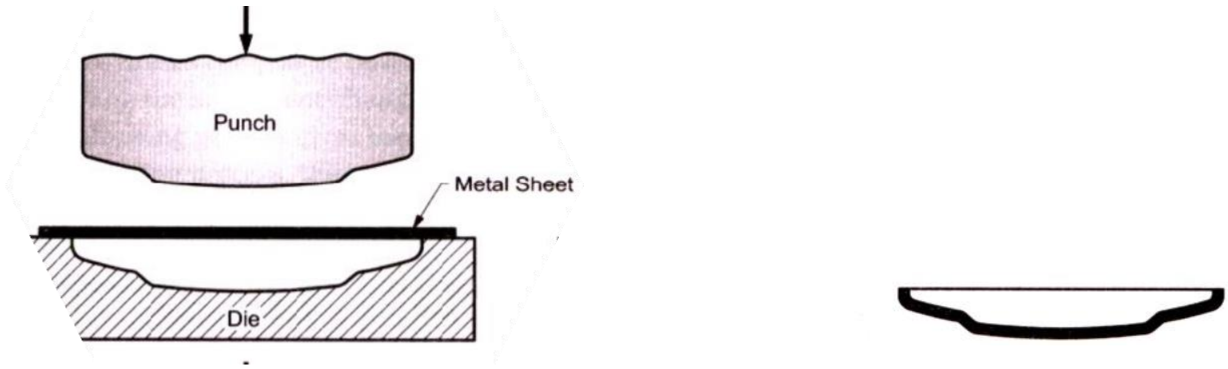
Angle bending



Curling

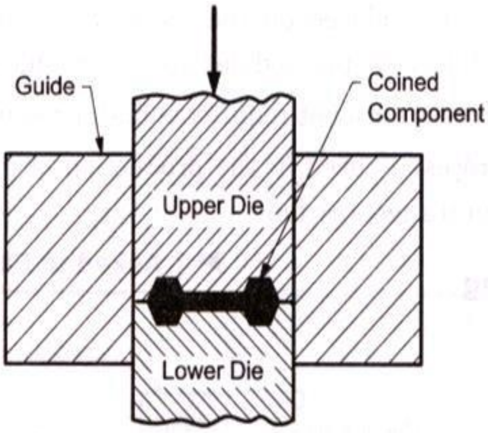
ii. Forming: Sheet metal plastically deforms to take the shape of cavity formed between punch and die.

Ex. Auto and Aircraft body panels, Steel furniture, Toys.



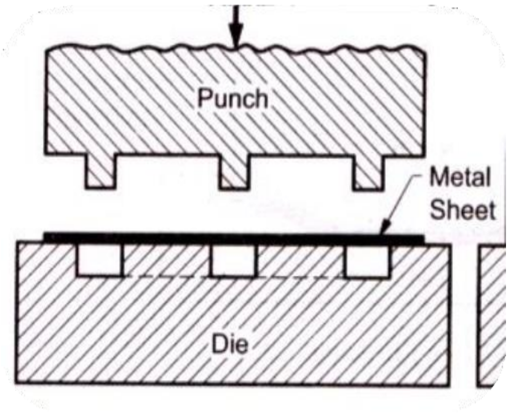
iii. Coining: Coining is the process in which under High compressive load, metal flows into cavity of the punch and die. Metal blank of proper size is placed on lower set and large pressure is applied on the blank by upper die.

Ex. Manufacturing of coins, Medals, Ornamental parts.

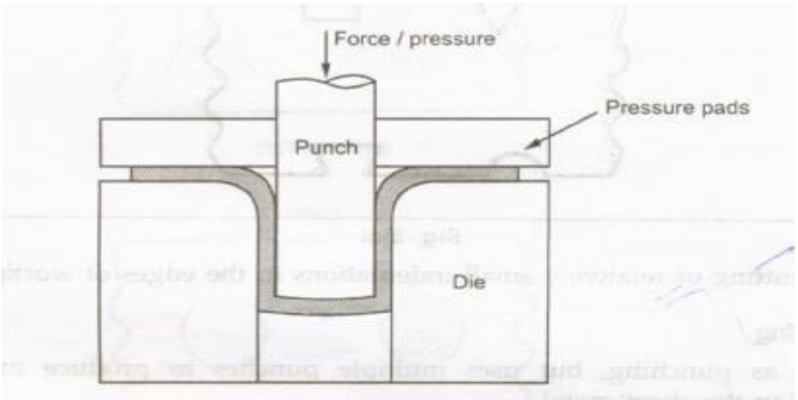


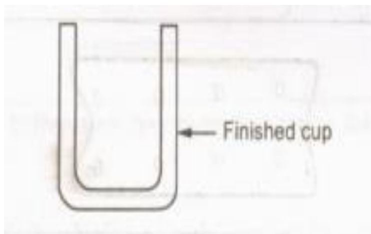
iv. Embossing: It is process of producing impressions of letters, numbers or design on metal sheet. Metal sheet is placed on die and force is applied by punch, Final component have depressed details on one side and raised details on other side.

Ex. Name plates, Part number, badge.



v. Drawing: Producing cup shape part from flat sheet metal. It is called as Deep drawing when length (Depth) of formed cup is greater than diameter.

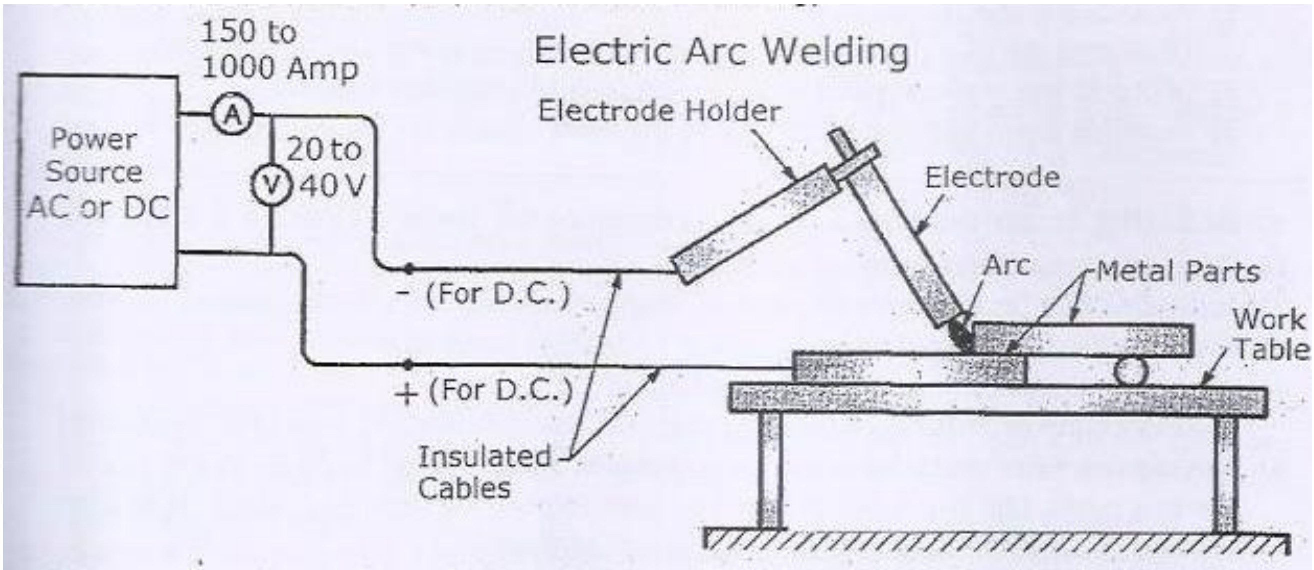




C. Metal Joining Process

- **Welding** is a metal joining Process in which two similar metals are permanently joined together by localized fusion with suitable application of heat and pressure.
- Welding process needs 3 inputs: Heat (Essential), pressure (Optional), filler material (Optional)
- **Classification of Welding:**
  1. **Pressure welding (Plastic welding):** Two metal parts are joined together are heated to a plastic stage and forced together by external pressure to make the joint. The process does not required filler material. It is classified as,
     - **i.** Forge welding (hand forging)
     - **ii.** Resistance welding (Spot welding, seam welding, projection welding)
     - **iii.** Pressure Thermit welding
  2. **Non- pressure welding (Fusion welding):** Two metal parts are joined together are locally heated to molten stage and allowed to solidify to make the joint. External pressure is not applied (not require). Filler material required for better bonding. It is classified as,
     - **i.** Electric Arc Welding (SMAW, TIG, MIG, Carbon arc welding)
     - **ii.** Gas welding
     - **iii.** Non pressure Thermit

Shielded metal arc welding (SMAW)



- **Principle:** Heat is generated by an electric arc struck between an electrode and the work piece.
- **Working:**

i. The external pressure is not applied. Filler metal is used.

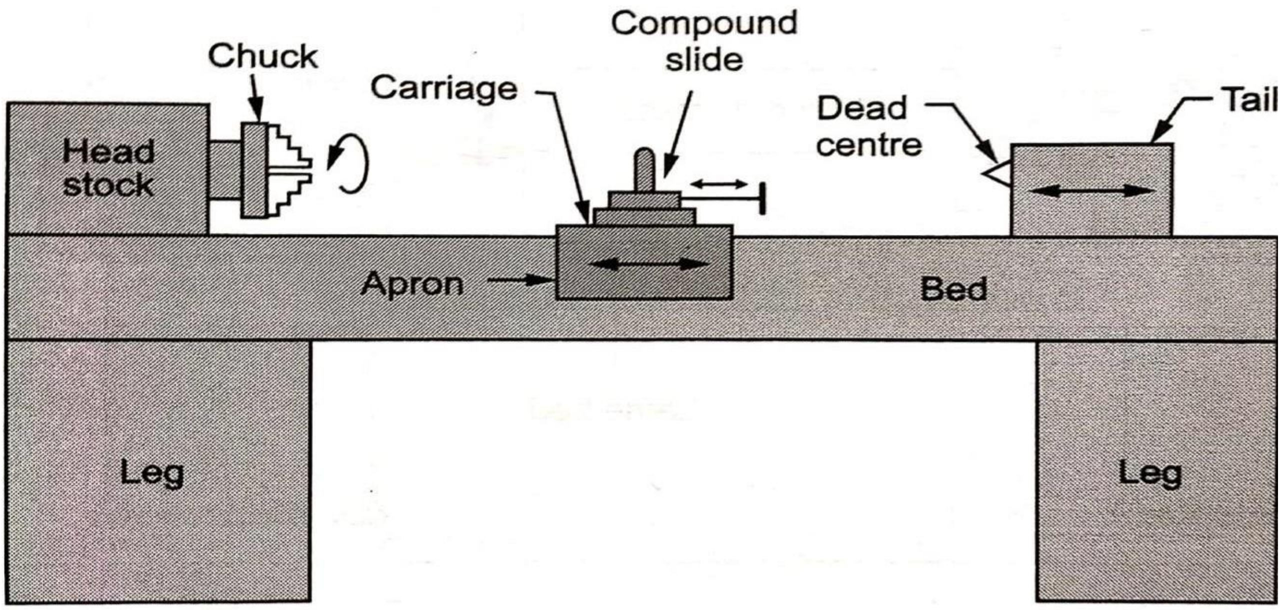
ii. In the process Low voltage (20 to 40 V) and high Current (150 to 1000 A) DC or AC supply is used.
iii. One terminal is attached to an electrode and other is attached to workpiece.
iv. In D.C. Positive terminal is connected to workpiece and negative terminal is connected to electrode.
v. The electrode is allowed touch the workpiece to form an electric circuit and then separated to maintain gap of 3 to 6 mm.
vi. Large current tries to flow through air gap in the form of arc which produces necessary heat. (2400^0 C to 4000^0 C).
vii. This heat is sufficient to melt base metal at the joint region. The additional metal is supplied by Filler material.
viii. The electrode is moved along the length of work piece to be welded.

- **Advantages of Electric arc welding:**
  i. The equipment is portable and less expensive.
  ii. Can be used for thick and thin section.
  iii. Complicated part can be weld.
  iv. Welding can be done in any position of parts.
  v. Can produce good quality with better strength.
- **Disadvantages of Welding:**
  i. Process require filler material.
  ii. It is slow process because if consumable electrode is used process get interrupted.
  iii. Welding control is difficult.
  iv. Quality of weld depends on skill of operator.
- **Application of Electric arc welding:**
  i. Ship building, Bridge construction.
  ii. Manufacturing of transmission Tower, Electric tower.
  iii. Manufacturing of steel furniture, window grill, window door/ frame.
  iv. Manufacturing of boiler, pressure vessel, storage tank, Pipe lines.
  v. Complicated structural parts, fabrication jobs.

D. Metal cutting process

- Metal cutting process is the process of removing the material from the work piece in the form of chips by means of cutting tools so as to give desired shape and size to the component.
- Metal cutting machine Tool: Lathe machine, drilling machine

Lathe machine



- **Working Principle:** Lathe m/c is used to machine **cylindrical surfaces**. Work piece is clamped in chuck or face plate. Cylindrical workpiece is held between two rigid & strong centers (Dead center and live center). Workpiece revolves about its own axis (Which is same as spindle axis). Cutting tool is rigidly held & supported in a tool post. The tool is fed against the revolving workpiece in longitudinal, cross or angular direction.
- **Elements of Lathe machine:**

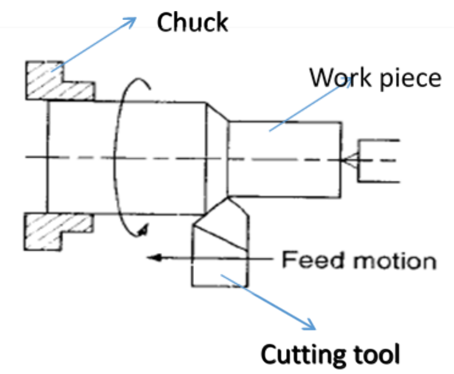
1. **Bed:** It is the foundation part of lathe and supports all its parts. It is a heavy & rigid casting made in one piece to resist deflection and vibrations. The top of the bed is have guides or ways. Function of the Bed is to It holds or supports all other parts, that is, head stock, tailstock & carriage.
2. **Headstock: It is** Located on left hand end of the lathe. It is live centre because it turns with the workpiece. It is housing for the main drive (driving pulleys, back gears & spindle).
3. **Tailstock: It is l**ocated on Right side of the lathe machine. It carries dead centre. Tailstock is mounted loosely on guide ways can be moved and locked in position. It support the free end of the long work piece. The tools of drilling, reaming, tapping operations are hold by tailstock.

4. **Carriage**: It is located in between the headstock & tailstock is the carriage. It is moves on the bed ways. **Function of carriage is** to hold cutting tool and Impart either longitudinal or cross feed. **It has five major parts:**
    i. **Tool post-** It is mounted on the compound rest & slides in a T-slot. Function is to hold the tool.
    ii. **Compound rest–** It is mounted on top of the cross-slide. It can be clamped to remain at any angular setting. It is used for taper turning operation.
    iii. **Cross slide –** Mounted on top of saddle. Provides cutting tool motion perpendicular to the Centre line of the lathe. So it gives cross motion to carriage or cutting tool. The cross feed movement controlled by manual or automatically.
    iv. **Saddle –** It is mounted on lathe bed. Saddle slides along the ways of the lathe bed. It Supports the cross-slide, compound rest & tool post.
    v. **Apron –** It is bolted to the saddle. The hanging part in front of the carriage. It contains the gear, clutches, & levers for operating the carriage by hand and power feeds.

5. **Lead screw**: It is a long threaded shaft driven by feed drive which runs longitudinally. Lead screw gives mechanized or automatic motion to the carriage for cutting threads on the work piece. The rotation of lead screw moves the carriage to and fro longitudinally during thread cutting operation. Rotary motion of the lead screw is converted into linear motion of the split nut, carriage, tool post, cutting tool.

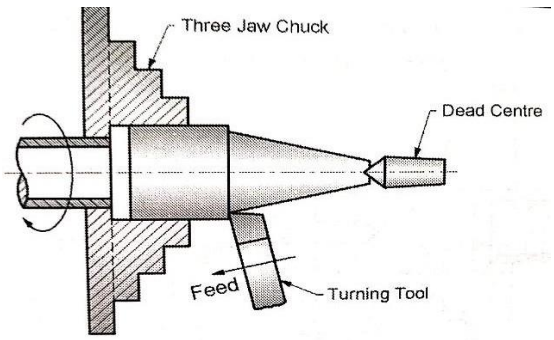
6. **Main drive**: It is used to drive the spindle (Chuck-Work piece) and can change the spindle speed through gear box. Main drive is powered by electric motor. It transmits the power from main drive to lead screw. Machine Tools are power driven machines.

- **Lathe machine operations**:

1. **Turning:** 	**Tool Used:** single point cutting tool. **Direction of the tool motion:** Parallel to axis **Process Description:** Work piece reduced to cylindrical section of required diameter. Tool is fed perpendicular to the axis of work piece to a known depth and then moved parallel to axis of work.

<table>
<tr><td>

2. Taper turning:

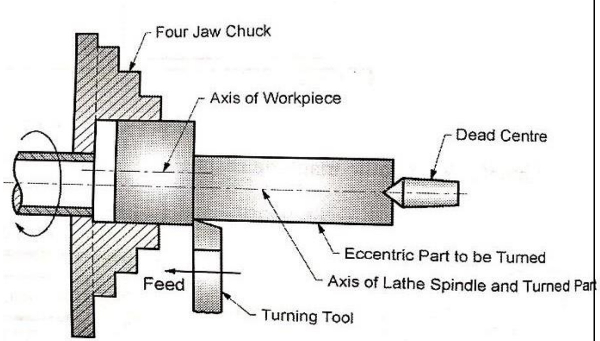


</td><td>

It is the process of uniformly reducing the diameter of workpiece along its length.
In taper turning, the cutting tool moved at an angle to the axis of workpiece by using compound slide.

</td></tr>
<tr><td>

3. Eccentric turning:

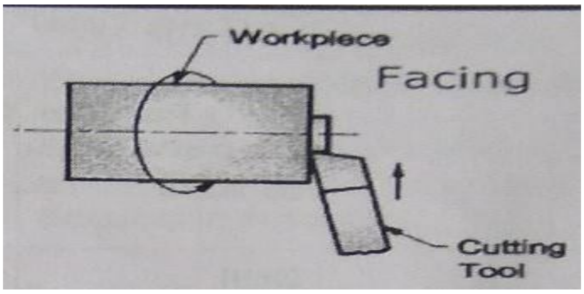


</td><td>

It is the process of removing material from cylindrical surface of workpiece to reduce its diameter about an axis offset from the axis of the workpiece.

</td></tr>
<tr><td>

4. **Facing –**

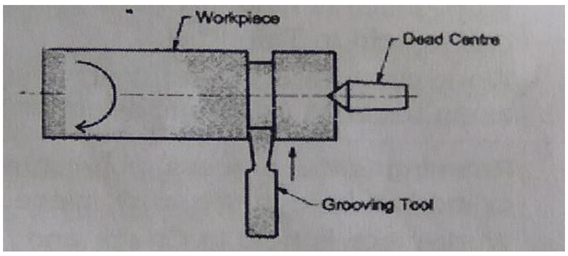


</td><td>

Tool Used: single point cutting tool (Facing tool).
Direction of the tool motion: Perpendicular to axis
Process Description: Process of removing material from end surface of workpiece to produce flat surface.
Tool is fed perpendicular to the axis by cross slide.

</td></tr>
<tr><td>

5. Grooving –

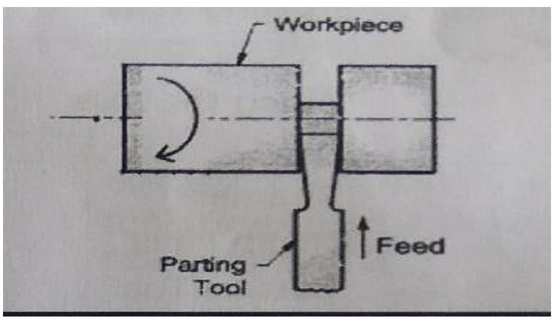


</td><td>

Tool Used: Multi point cutting tool (grooving tool).
Direction of the tool motion: Perpendicular to axis
Process Description: Process of producing narrow groove on cylindrical surface of workpiece.

</td></tr>
<tr><td>

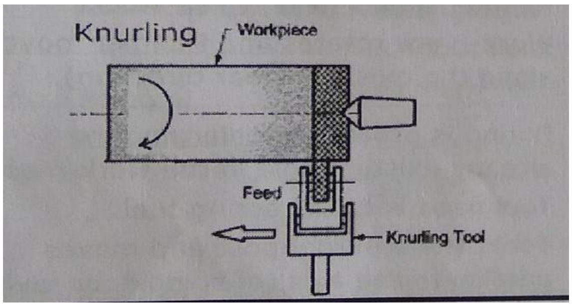
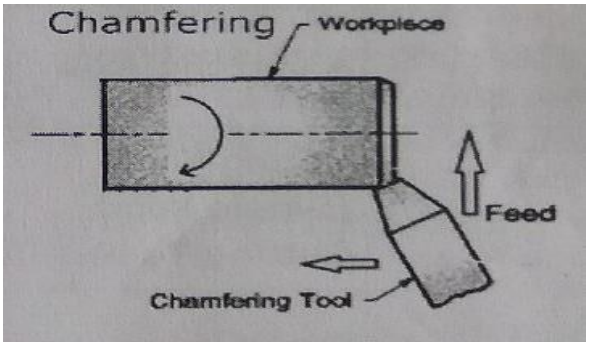
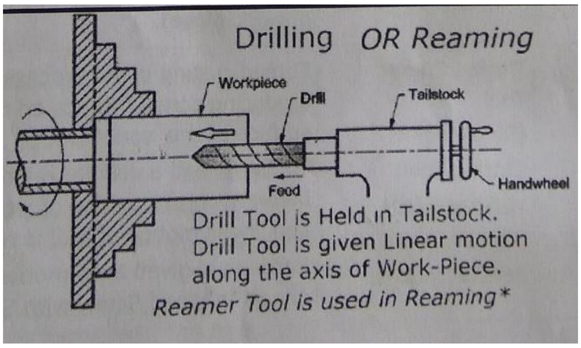
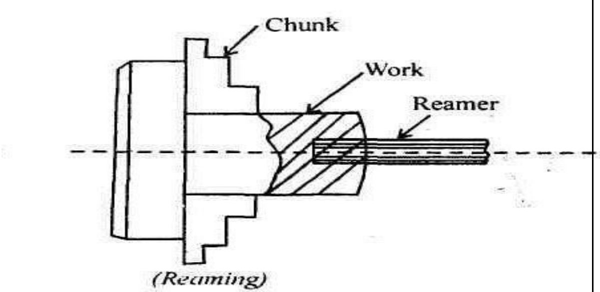
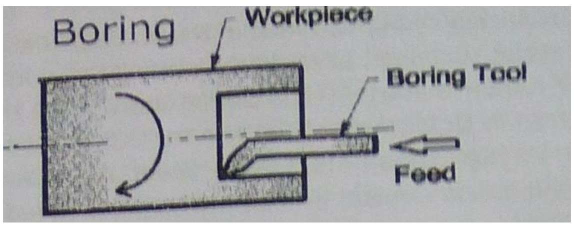
6. **Parting –**



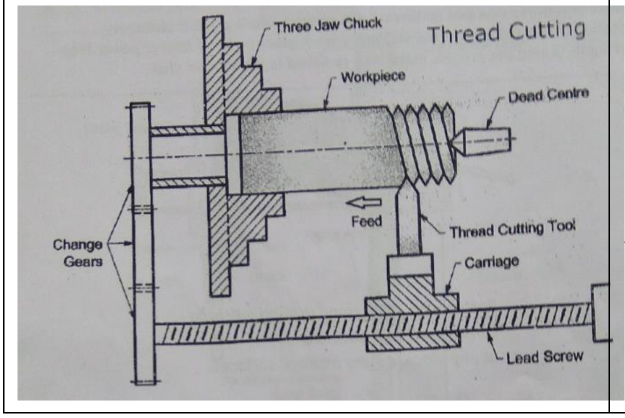
</td><td>

Tool Used: Multi point cutting tool (parting tool).
Direction of the tool motion: Perpendicular to axis
Process Description: Process of cutting workpiece into two parts.

</td></tr>
</table>

7. Knurling: 	**Tool Used:** Multi point cutting tool (knurling tool). **Direction of the tool motion:** Parallel to axis **Process Description:** Process of embossing a diamond shaped regular pattern on surface of workpiece. Knurling provides non slip surface to workpiece.
8. Chamfering: 	**Tool Used:** Multi point cutting tool (chamfering tool). **Direction of the tool motion:** Both Parallel and perpendicular to axis **Process Description:** Process of beveling the sharp end of workpiece.It enhances aesthetic look and avoids injuries while handling workpiece.
9. Drilling: 	**Tool Used:** Multi point cutting tool (Drill tool). **Direction of the tool motion:** Along the axis **Process Description:** Process of producing cylindrical hole in the workpiece. Workpiece is held in chuck and drill tool is held in tailstock. Workpiece rotates and drill moves along axis.
10.Reaming: 	**Tool Used:** Multi point cutting tool (reamer tool). **Direction of the tool motion:** Along the axis **Process Description:** Process of finishing the cylindrical hole in the workpiece. Workpiece is held in chuck and reamer tool is held in tailstock. Workpiece rotates and reamer moves along axis.
11. Boring: 	**Tool Used:** Single point cutting tool (Boring tool). **Direction of the tool motion:** Parallel the axis **Process Description:** Process of enlarging the already existing hole in workpiece.

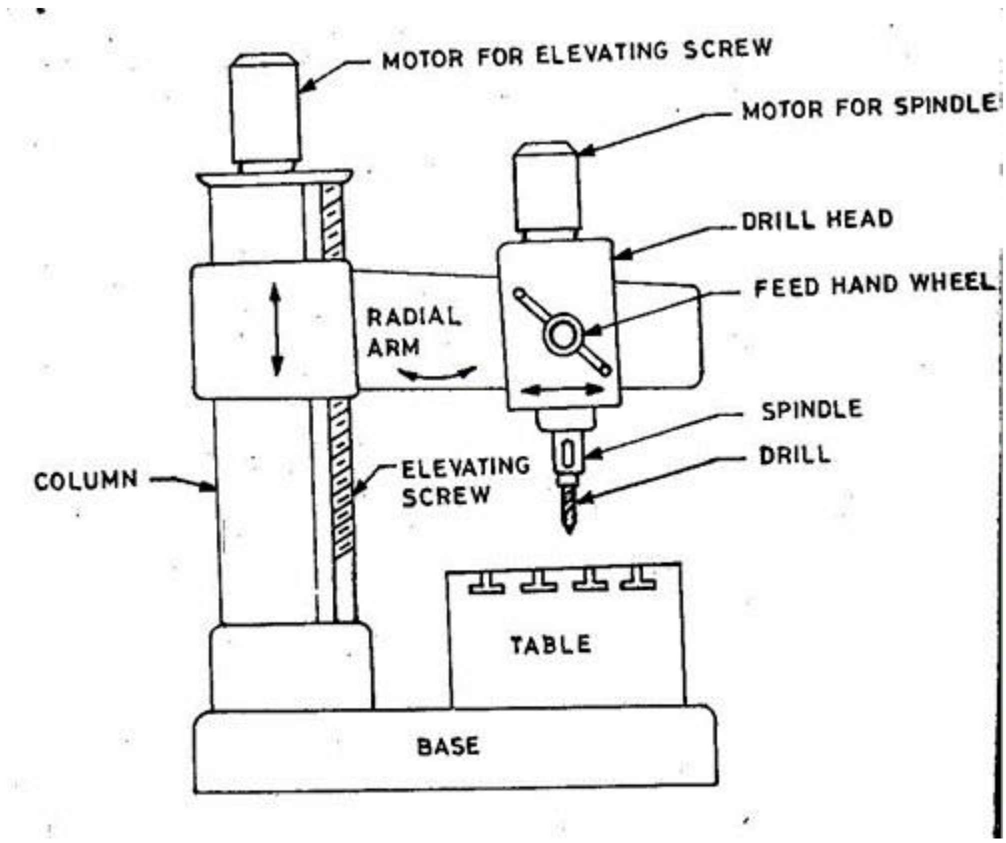
12. Thread cutting:



- **Tool Used:** Single point cutting tool (Thread cutting tool).
- **Direction of the tool motion:** Parallel the axis

Process Description: Process of producing screw threads on cylindrical surface of workpiece. Carriage is given auto-motion by engaging Lead screw with split nut.

Drilling Machine

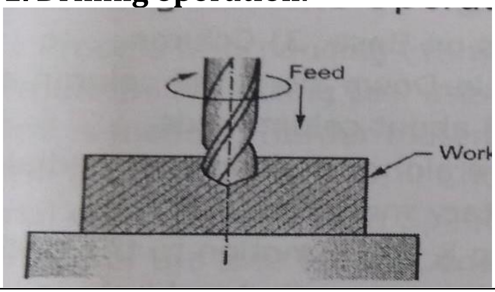
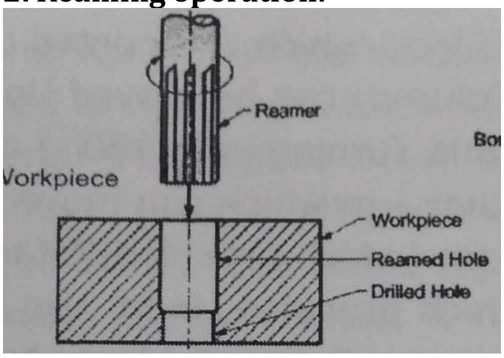
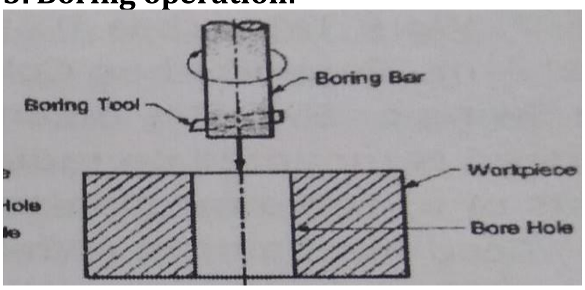


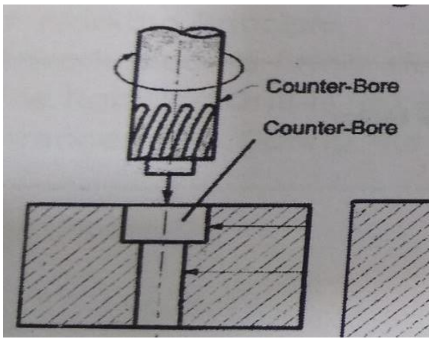
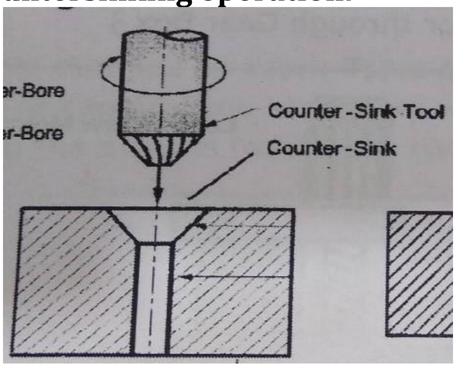
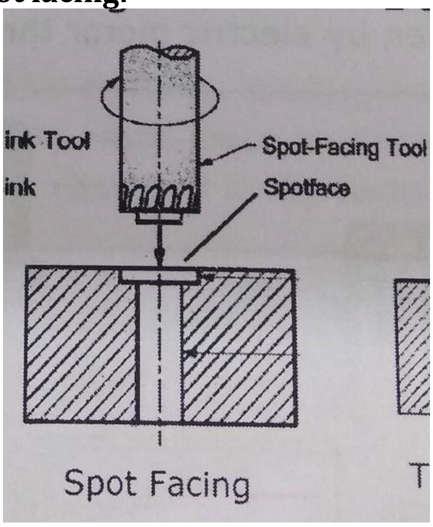
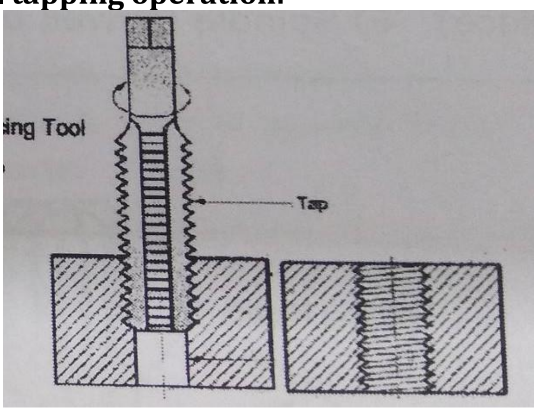
- **Working principle:** A workpiece is firmly clamped on work table or base. Work piece is stationary. The rotating drill is fed against the stationary workpiece by hand feed or power feed arrangement. During the process material is removed in the form of chip.
- **Drill:** A multi point cutting tool used to make cylindrical hole in work piece. Drill is made of harder material (HSS) than that of worpiece. Drill is press fitted in Drill chuck. End shape of drill tool is conical to initiate hole in material.
- **Material of Drill:** HSS, Alloy steel, High carbon steel.

- **Components of drilling machine:**

1. **Base –** It is a part of the machine on which the vertical column is mounted.
2. **Column –** It is the vertical member of the drilling machine. It supports table and the head including driving mechanism.
3. **Table –** It is mounted on the column. ‘T’ slots are provided on it to clamp the work piece on it. The table may be of circular or rectangular in shape. The position of the table can be adjusted vertically on the column to hold the work piece at different height below the drill tool.
4. **Head –** It is mounted on the top of the column. It consists of driving and feeding mechanism for the spindle.
5. **Radial arm-** It is supported on column can be moved up and down along the column axis and swing (turn upto 180 ^{0}) about column axis.
6. **Spindle –**Spindle is a vertical shaft which holds the chuck and drill. Rotary motion of the spindle is given directly to the tool to cut the material from the work piece.

- **Operations performed on drilling machine:**

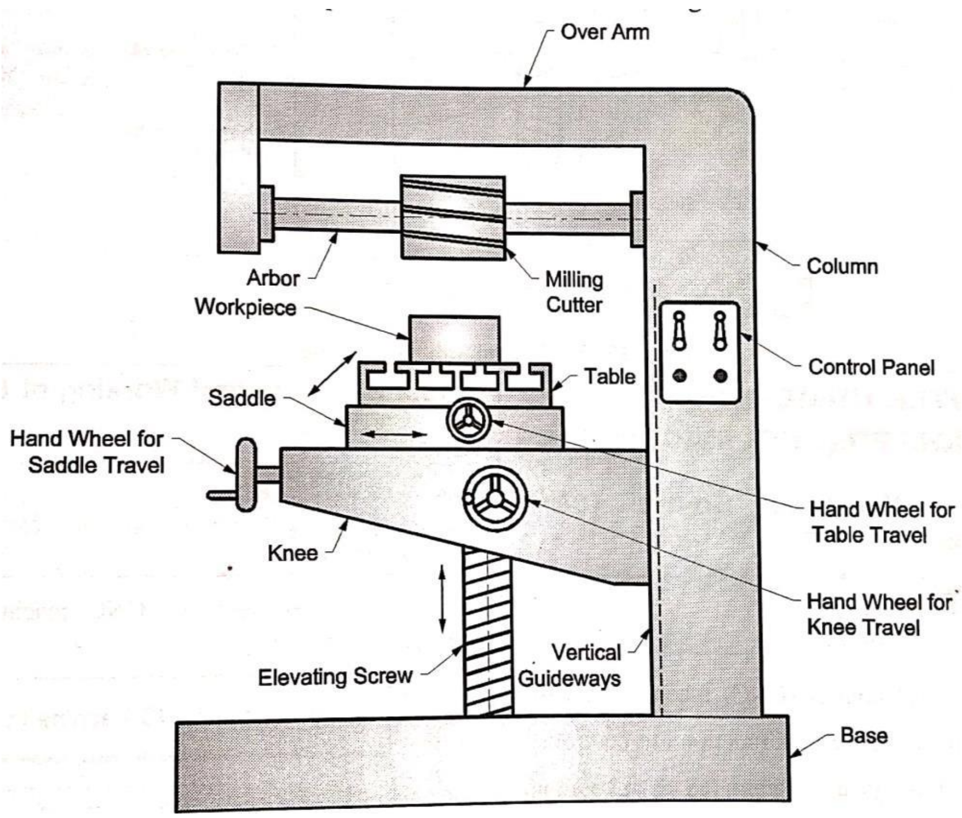
1. Drilling operation: 	**Tool used:** Drill (Conical end-multipoint cutting tool) **Process description:** producing Cylindrical hole in workpiece is called as drilling. Before drilling the **centre of the hole is located** on the work piece by puch.
2. Reaming operation: 	**Tool used:** Reamer (Flat end-multipoint cutting tool) **Process description:** Accurate sizing and finishing a hole which has been previously drilled by removing small amount of metal. Reaming is done after drilling. In order to finish a hole and to bring it to the accurate size, the hole is drilled slightly undersize.
3. Boring operation: 	**Tool used:** Boring (Single point cutting tool) **Process description:** operation of **enlarging already drilled hole.** It brings hole to the required size and have a better finish.

4. Counter boring Operation: 	**Tool used:** Counter Boring (Flat end-multipoint cutting tool) **Process description:** It is operation of enlarging limited portion of hole. The enlarged hole forms a square shoulder with the original hole. Provides space for the heads of bolts, studs and pins.
5. Countersinking operation: 	**Tool used:** counter sunk (Conical end-multipoint cutting tool) **Process description:** It is the operation of enlarging the end of hole in **conical shape.** Provides recess for a flat head screw. Standard countersinks have **60°, 82° included angle.**
6. Spot facing: 	**Tool used:** Spot Facing/ Counter boring tool (Flat end-multipoint cutting tool) **Process description:** It is process of finishing and squaring the surface around the hole. It provides smooth seat for washers, nuts and bolts.
7. tapping operation: 	**Tool used:** Tap (A set of 3 Tap-multipoint cutting tool) **Process description:** It is the operation of cutting internal threads in already produced hole by means of cutting tool called as a tap.

E. Metal finishing Process

Metal finishing is the process of imparting high surface finish and high dimensional accuracy to the already machined component with negligible removal of material.

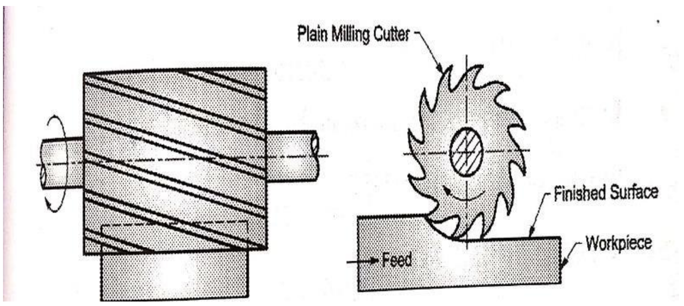
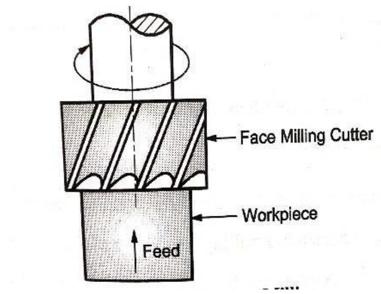
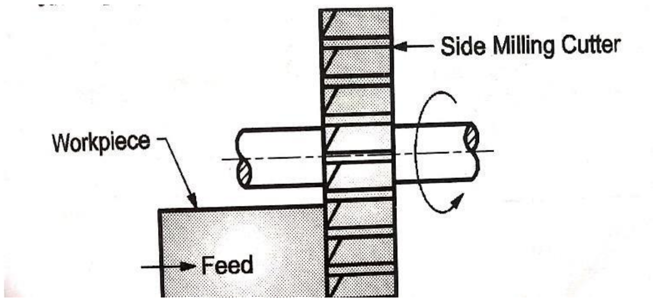
Milling Machine

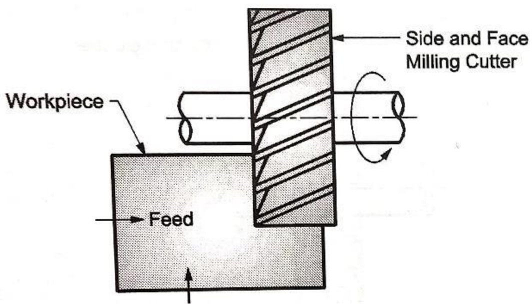
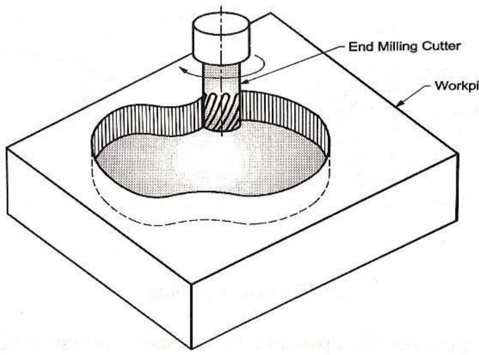
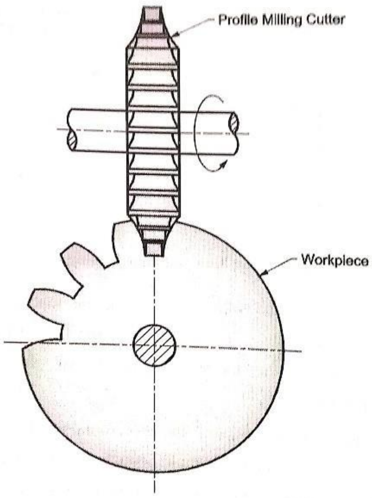
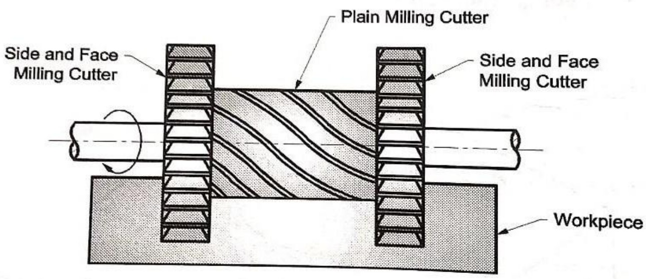


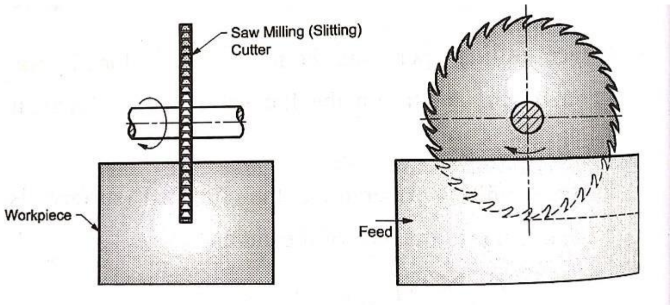
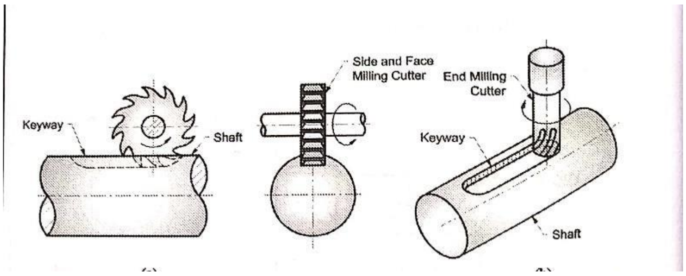
- Milling is process of removing excess material from work piece with a multi-tooth rotating cutter.
- Flat or curved surfaces of many shape can be machined by milling with good finish and accuracy.
- **Principle of operation:**
  i. In a milling machine, the work piece is firmly clamped on the work table.
  ii. The multipoint cutting tool, called milling cutter is mounted on the spindle of milling machine.
  iii. The spindle and hence milling cutter rotate at the desired speed.
  iv. The workpiece is fed against the rotating milling cutter in X, Y and or Z direction by hand feed or power.
  v. As milling cutter is made of harder material than workpiece, it removes material from workpiece I the form of chips so as to produce desired shape.
- **Components of Milling machine:**
  i. Base: Base is lowermost part of machine which supports the entire structure.
  ii. Column: It is vertical part fixed on base. It supports all other elements of milling machine. It consist of all the motors and drive mechanisms for the spindle and the table feed.

iii. Knee: The knee is supported on elevating screw. It slides up and down along the vertical guide ways on column face with the help of elevating screw.
iv. Saddle: Saddle is mounted on knee. It supports table and provides the cross feed to table.
v. Table: Table is mounted on saddle. The table travels longitudinally in guide ways provided on the saddle. It supports the work table. It has T-slot to clamp the workpiece.
vi. Over-arm: The top of column supports overhanging arm called over-arm.
vii. Spindle: Spindle is hollow shaft driven by electric motor through the belts and gears. In some milling machine, milling cutter is directly mounted on the spindle.
viii. Arbor: It is accurately machined shaft which is used for holding and driving the milling cutter. It is driven by spindle.

- **Operation performed on Milling machine:**

1. Plain milling: 	The machining is done by the cutter having teeth located on the cylindrical surface of the cutter. In plain milling operation, the finished surface is parallel to the axis of the cutter.
2. Face milling: 	In face milling operation, machining is done by the teeth on the flat end of cylindrical cutter. In face milling operation, finished surface is perpendicular to axis of the cutter.
3. Side milling: 	In side milling operation, the machining is done by the cutter having teeth located on the flat surface of the cutter.

4. Side and Face milling: 	In side and face milling operation, the machining is done by cutter having teeth on the flat surface as well as on the cylindrical surface on the cutter. In this operation horizontal and vertical surfaces are machined simultaneously. In side and face milling operation, one surface is parallel and other is perpendicular to axis of cutter.
5. End milling: 	In end milling, the machining is done by cutter having teeth on the end as well as periphery of cutter. End milling is used or tracer controlled machining of complicated profile.
6. Profile/ Form milling: 	In profile milling operation, machining is done with curved teeth having outline same as that of the shape of the profile to be cut is used. Gear teeth are cut by profile milling operation.
7. Gang milling: 	In gang milling two or more milling cutter are mounted on arbor so that each cutter will produce in own distinctive surface as the workpiece is fed to it. In this all horizontal and vertical surfaces are machined simultaneously.

8. Saw (Slitting): 	In saw milling operation, thin milling cutter is used for cutting deep narrow slots or for cutting off operation. Thickness of saw milling cutter is usually in the range of 0.75 and 5 mm.
9. Keyway Milling: 	The keyways of rectangular cross section are milled either on horizontal milling machine by using side and face milling cutter or on vertical milling machine by using end milling cutter.

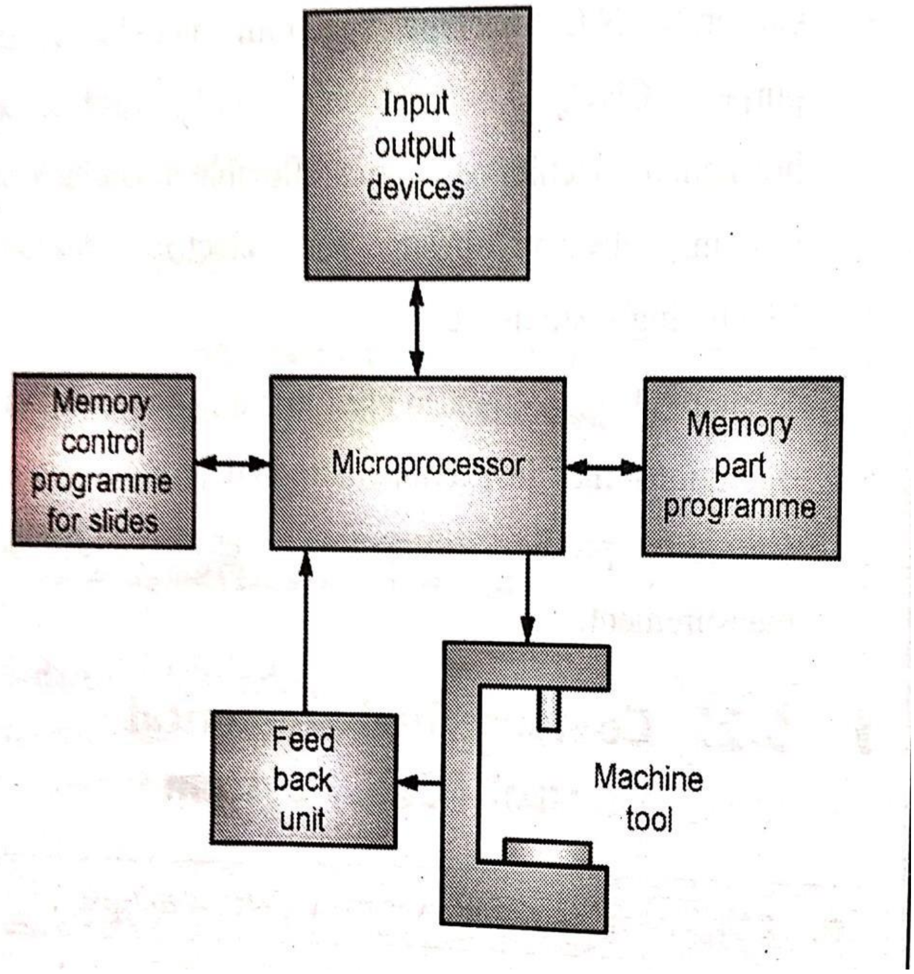
Non- Conventional manufacturing processes:

1. Computer numerical controlled machines
2. Micromachining
3. Additive manufacturing
4. Rapid prototyping
5. Reconfigurable manufacturing system
6. Internet of things

1. Computer Numerical Controlled (CNC) Machine

- **Principle:**

1. Computer Numerical Controlled (CNC) machines are the machine tools of which various function are controlled by computer through a program fed to it, without human operator.
2. CNC machine requires dedicated computer as machine control unit. In CNC machine entire program is entered and stored in computer memory. The machining cycle for each component is controlled by program contained in computer memory.
3. The stored part programme listing can be used for future production also.



- **Elements and working of CNC machine:**

1. **Input/ Output devices:** The data is fed to CNC machine through keyboard.
2. **Memory:** The memory consists of RAM and ROM. The memory stores programs and other machine tool control information.
3. **Microprocessor/ Control system:** It is brain of CNC machine tool. It receives the data stored in memory as part program. The data is converted into instructions to machine tool.
4. **Machine tool:** The machine tool is operated by machine control unit. In CNC machine tool following functions may be automatic:
    i. Starting and stopping of machine tool spindle
    ii. Controlling the spindle speed
    iii. Positioning of tool tip at desired location and guiding it along depth.
    iv. Controlling the feed rate
    v. Changing the tools.
5. **Feedback unit:** The feedback mechanism takes feedback from machine tool and send it to microprocessor for corrective action.
6. **Interfaces:** It provides connection between microprocessor, machine tool and other elements.

- **Advantages of CNC machine tool:**

i. Manufacturing of complex component quickly and accurately.
ii. It produces component with high degree of accuracy.
iii. Uniform quality products are produced so inspection time requirement is very less.
iv. High accuracy eliminates human errors, scrap and wastage.
v. Greater operator safety.
vi. Less human effort gives greater operator efficiency.
vii. It requires less space.

- **Limitations:**

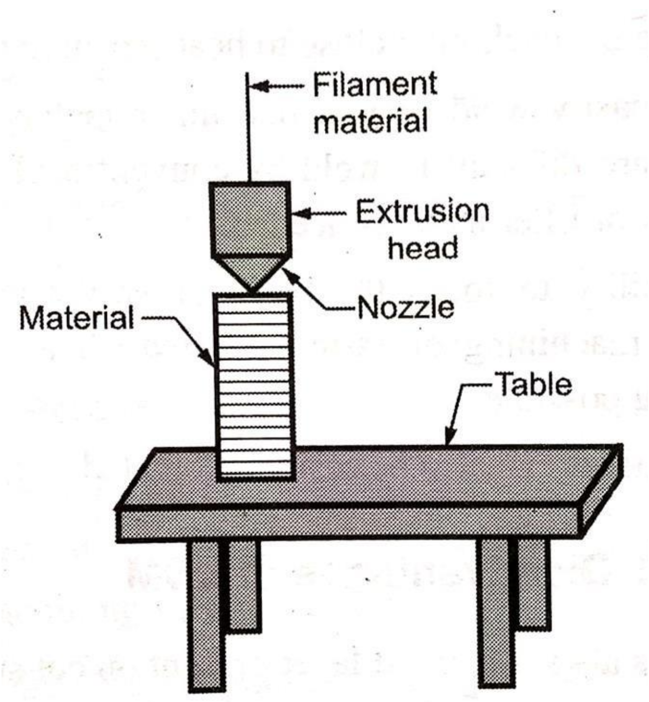
i. High initial cost because of sophisticated technology.
ii. Spares of CNC machines are costly so high maintenance cost.
iii. High operational cost: It requires high skilled labour and trained personnel for looking after the part programming and machine operation. Hence operation cost is high.

- **Application:**

i. CNC turning Centre
ii. CNC Drilling machine
iii. CNC Milling machine
iv. CNC machining centre
v. CNC welding and cutting machine
vi. CNC laser cutting machine
vii. CNC die casting machine
viii. CNC Grinding machine
ix. CNC gear shaper

- **Introduction of G- Code and M-Code:**
- **G-Code:** G-codes are CNC programming language codes used by programmer to instruct CNC machine controller to perform various operations/ functions during machining process. Each G-code tells CNC machine to perform particular operation. Ex. G00 is G-code for fast tool travel
- **M- Code:** M-codes are CNC programming language codes used by programmer to instruct CNC machine controller to perform various miscellaneous functions. Each M-code tells CNC machine controller to perform particular miscellaneous function. Ex. M05 is M-code for stoping spindle rotation.

2. Additive Manufacturing

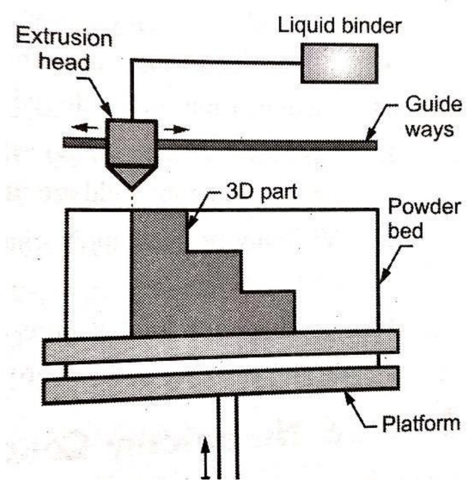


- Additive manufacturing is the technology where material is being added in the convection manufacturing, major work was done by removing the material but in additive manufacturing a 3 D subject is built by adding material in the form of a layer upon layer of material.
- The material used in additive manufacturing are metals, plastics, concrete.
- The basic requirements of additive manufacturing are computer, CAD (Computer aided design software) or 3D modelling software well equipped machines and material to be used for layering.
- The general additive manufacturing procedure is to prepare a CAD drawing first.
- The CAD drawing is modelled by a 3D modelling software, which is ready by additive manufacturing machine or by its part to analyse the data received from CAD file.
- At last different layers of the liquid are lays down one over other in some cases inside of liquids powder or sheet material is also used to form a layer one over other to manufacture a 3D object.
- Ex. Rapid prototyping

Rapid Prototyping

- Rapid Prototyping (RP) is family of fabrication methods to make engineering prototypes in minimum time by using Computer Aided Design (CAD) model of the part.

3. 3 D printing:



i. The term 3 D printing is process that deposits a binder material onto a powder bed with inkjet printer heads layer by layer.
ii. In this process material is joined or solidified under computer control to create 3 D object, with material being added together layer by layer.
iii. In 3 D printing liquid binder is applied to bond powder particles.
iv. The printer spreads a layer of powder from feed box to cover the surface of the build platform and then prints the binder solution onto the loose powder, forming cross section of the part.
v. When the binder is printed, the powders particles are glued together. The remaining powder is loose and supports the part as it is being printed. When cross section is completed the build platform is lowered slightly, and a new layer is spread over its surface. The process is repeated until the whole model is completed.

- **Advantages:**

i. Prototype can be produced in short period of time
ii. 3 D printing reduces cost of making prototypes.
iii. Complex part can be manufactured in in less cost and time.
iv. Reduces the material waste.
v. New product is launched in market in short duration.
vi. Feedback of customer can be incorporated in the product design almost on real time basis.

- **Limitations:**

i. Product is poor in strength.
ii. 3 D printing machines are expensive.
iii. Low cost machine cannot build parts with high accuracy.

- **Application:**

Production of replacement parts, dental crowns, artificial limbs

4. Reconfigurable Manufacturing Systems

- Reconfigurable manufacturing system is the system which is used by manufacturers that emphasizes on the importance of the adaptivity towards the change and to develop speed in order to achieve its production, capacity and functionality.
- Whenever there are changes in market the Reconfigurable manufacturing system changes the response which allows the company to manufacture its products in a manner which is efficient one.
- There are six characteristics of reconfigurable manufacturing system:

i. **Modularity:** All the machines, equipment controls, tools and other parts of the manufacturing system should be modular i.e. they can be accommodated to manufacture the different item or products with existing setup easily.

ii. **Integratability:** System should be such that they are able to integrate modules speedly and more efficiently. It is applicable to machinery level and system level.

iii. **Customized Flexibility:** The system should be flexible enough to accommodate new model or able to update the existing one.

iv. **Scalability:** It is rearrangement of the manufacturing system for the addition of new product.

v. **Convertibility:** It is ability of existing system to transfer it so that new production line can be designed.

vi. **Diagnosability:** If there are some errors, defects or problems in system it should be able to automatically read and analyse it.

- **Advantages:**
    1. It can respond to unforeseen changes in product demand.
    2. It improves productivity
    3. It avoids obsolesce of manufacturing system.

- **Disadvantages:**
    1. It can be used in only limited variation of product design.
    2. Modular design affects the accuracy of system.

5. Internet of Things (IoT)

- Industrial IoT is the interconnection of sensors, instruments and other devices of system which are connected together with the help of networked computer.
- Industrial energy management and manufacturing are the basic application of industrial IoT. Because of this connectivity data exchange, analysis, collection are done quickly.
- The end result of IIoT is to improvement in productivity and efficiency which ultimately results into economic improvement.
- IIoT allows for a high degree of automation by using cloud computing to optimize the control of different processes.
- IIoT is the digital transformation in manufacturing industry.
- IIoT uses the network of sensors to collect critical production data which are used by the cloud software.
- The outcome of IIoT is that it helps in cost reduction.
- It also helps to utilize manufacturing more efficiently.
- It also reduces the product cycle time by using industrial IoT we can do mass customization by making available a source of real time data for shop floor scheduling industrial IoT helps to ensure the safety of operator.
- IIoT changing the way of production system:

i. Visibility on shop floor and operations performed on field are improved.
ii. Visibility on the supply chain manufacturing are improved.
iii. Visibility on outsourced operations and the remote operations are improved.

6. Micromachining

- Micromachining is a technique of producing or machining technique of producing or machining the features with dimensions ranging from few microns to a few hundred microns.
- In micromachining, the component to be machined are 2D or 3D components and may have a size of few mm. Features to be machined are in the range of few microns to few hundred microns.
- In medical field, diagnosis and surgery without pain can be achieved through miniaturization of medical equipment. This techniques are used for producing miniaturized medical equipment and implant.

- **Components produced by micromachining:**

  i. Biomedical implant
  ii. Microsurgical equipment's
  iii. Aerospace components
  iv. Micro scale pumps
  v. Microscopic holes for fibre optics
  vi. Micro scale fuel scale

- **The various micromachining processes:**

  i. Micro-turning
  ii. Micro-milling
  iii. Micro-drilling
  iv. Micro laser machining
  v. Micro EDM (Electro-discharge machining)