MANUFACTURING AND PRODUCTION SYSTEM

WALCHAND COLLEGE OF ENGINEERING
SANGLI.

METAL CASTING PROCESS

Casting: process of producing metal parts of desired shape by pouring the molten metal into the prepared refractory mold cavity and then permitting the molten metal to cool and solidify. The solidified piece of metal is called Casting.

Methods of metal casting processes

- Die Casting
- Sand Casting

DIE CASTING

- The molten metal is forced into the die under pressure and this pressure is maintained while the casting solidifies.
- Die is made in 2 halves
  - Stationary- cover die
  - Movable – ejector die
- Types of die casting:
  - Hot chamber die casting machine
  - Cold chamber die casting machine

HOT CHAMBER DIE CASTING PROCESS

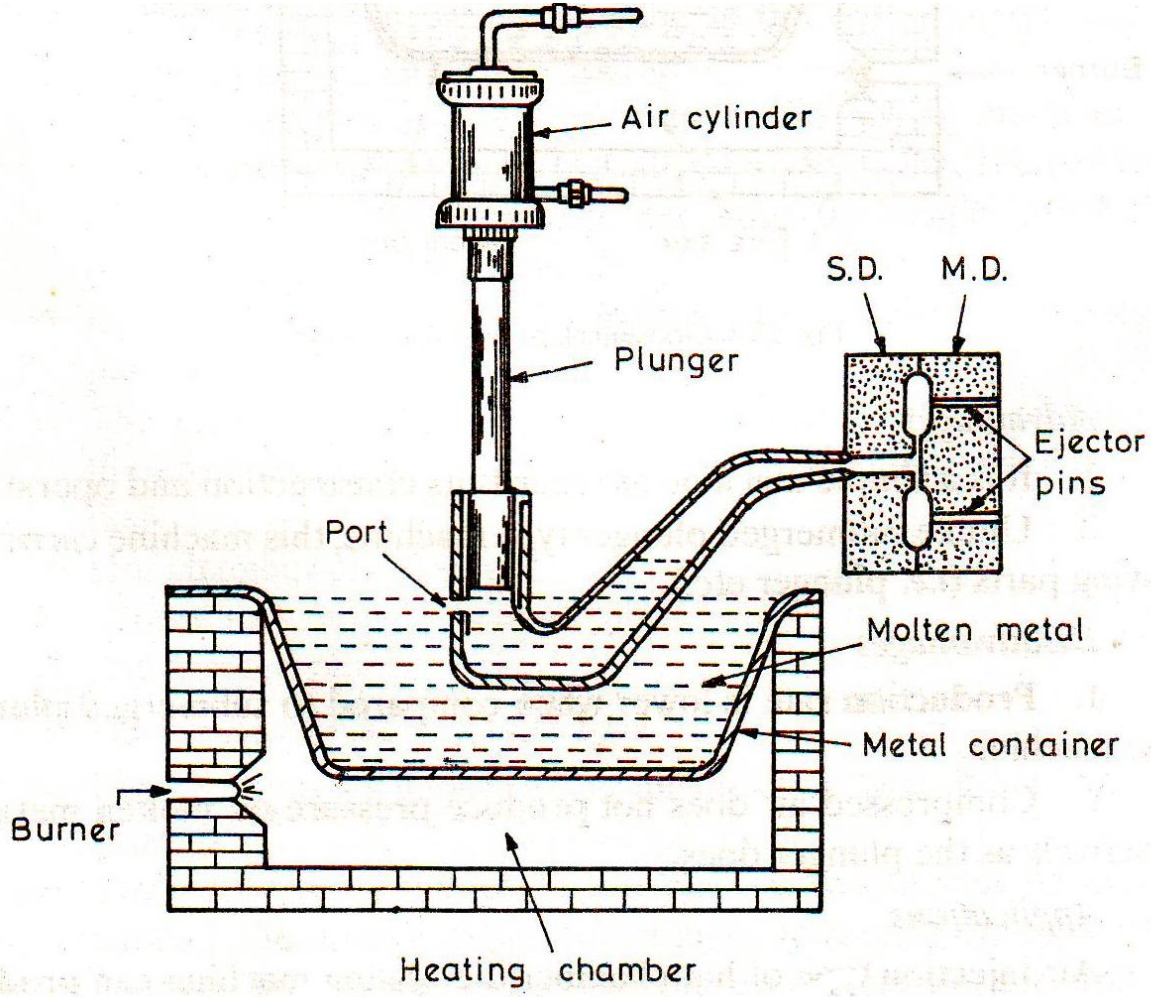


Figure: Hot Chamber Die Casting Machine

Hot Chamber Die Casting Machine

COLD CHAMBER DIE CASTING MACHINE

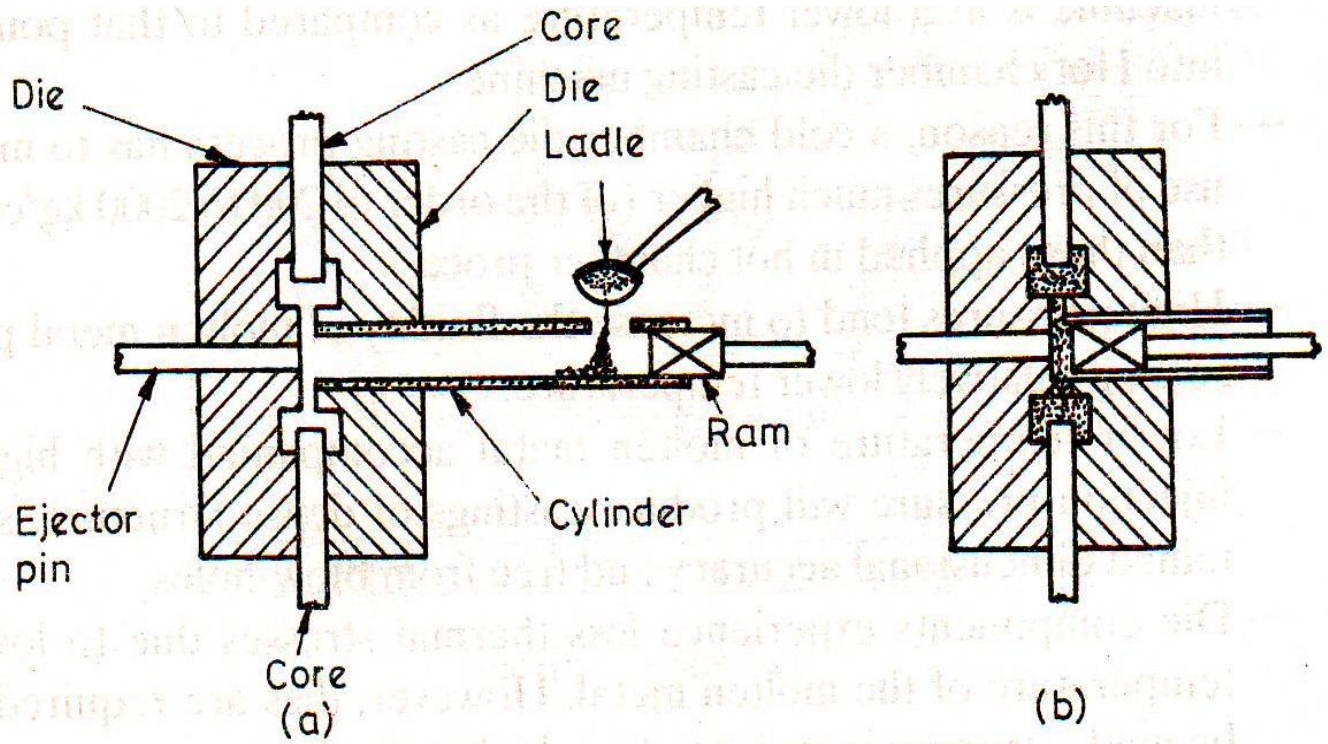


Figure: Cold Chamber Die Casting Machine

Cold Chamber Die Casting Machine

ADVANTAGES OF DIE CASTING

- Requires less floor space.
- High production rate is achieved.
- Greater surface finish is obtained.
- Labor cost is less.
- The die has a long life
- Die casting are less defective than sand casting.

LIMITATIONS OF DIE CASTING

- The size of casting is limited.
- The cost of the die and equipment is higher than sand casting.
- Ferrous alloys are not cast.
- The air in the die cavity gets trapped inside the casting and creates porosity.

APPLICATIONS OF DIE CASTING

- Automobile parts
- Marine parts
- Domestic appliances
- Instruments

SAND CASTING

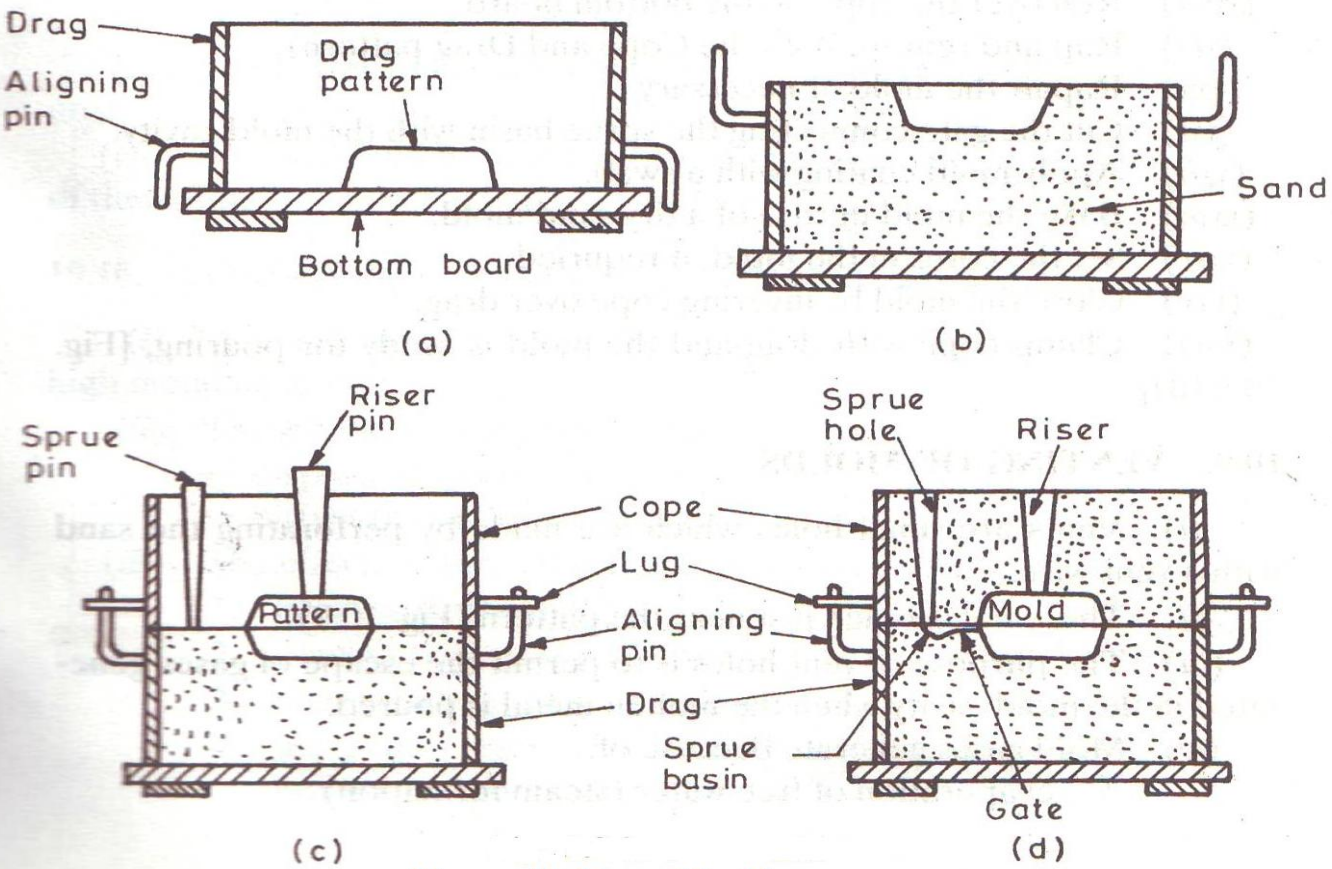


Figure: Making a Mould

SAND CASTING

Sand Casting1

Sand Casting2

Disa Moulding

METAL FORMING PROCESS

Forming: the process in which the desired shape and size are obtained through the plastic deformation of material.

- Forging
- Rolling
- Extrusion
- Drawing

Forging: The process in which the metal is first heated and then hammered to the required shape and size.

Types of forging operations:

- Open die forging operation
- Closed die forging operation

OPEN DIE FORGING OPERATION

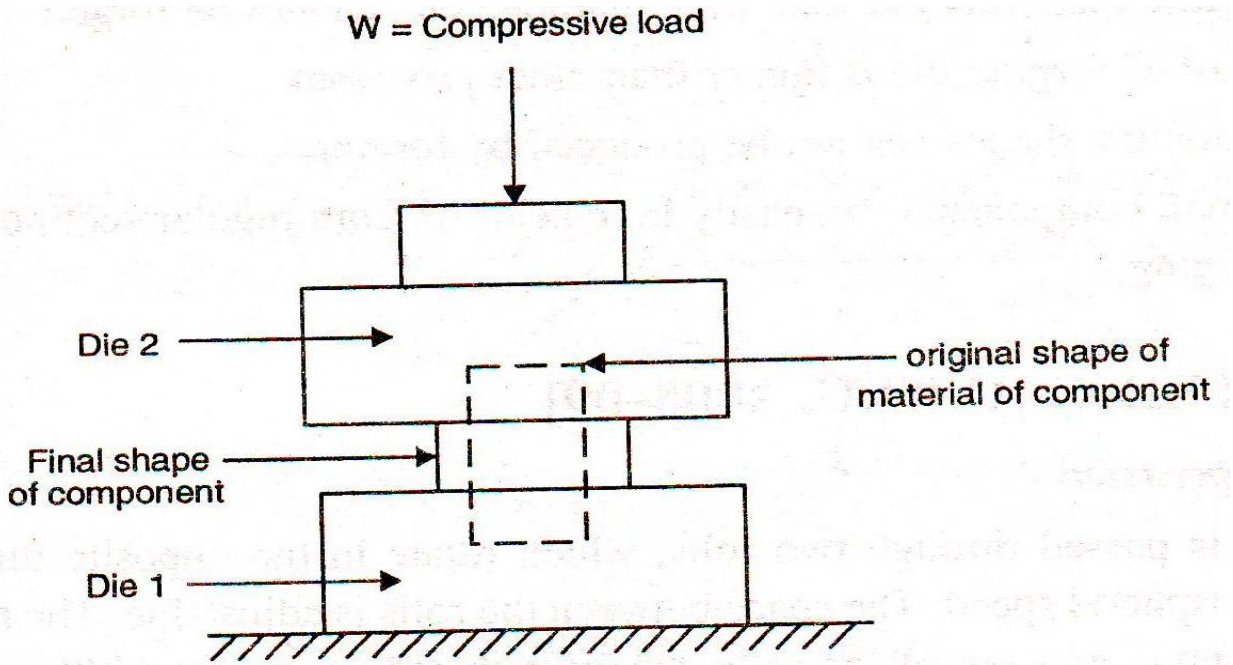


Fig. 2.1 Open die forging (Upsetting Operation)

CLOSED DIE FORGING OPERATION

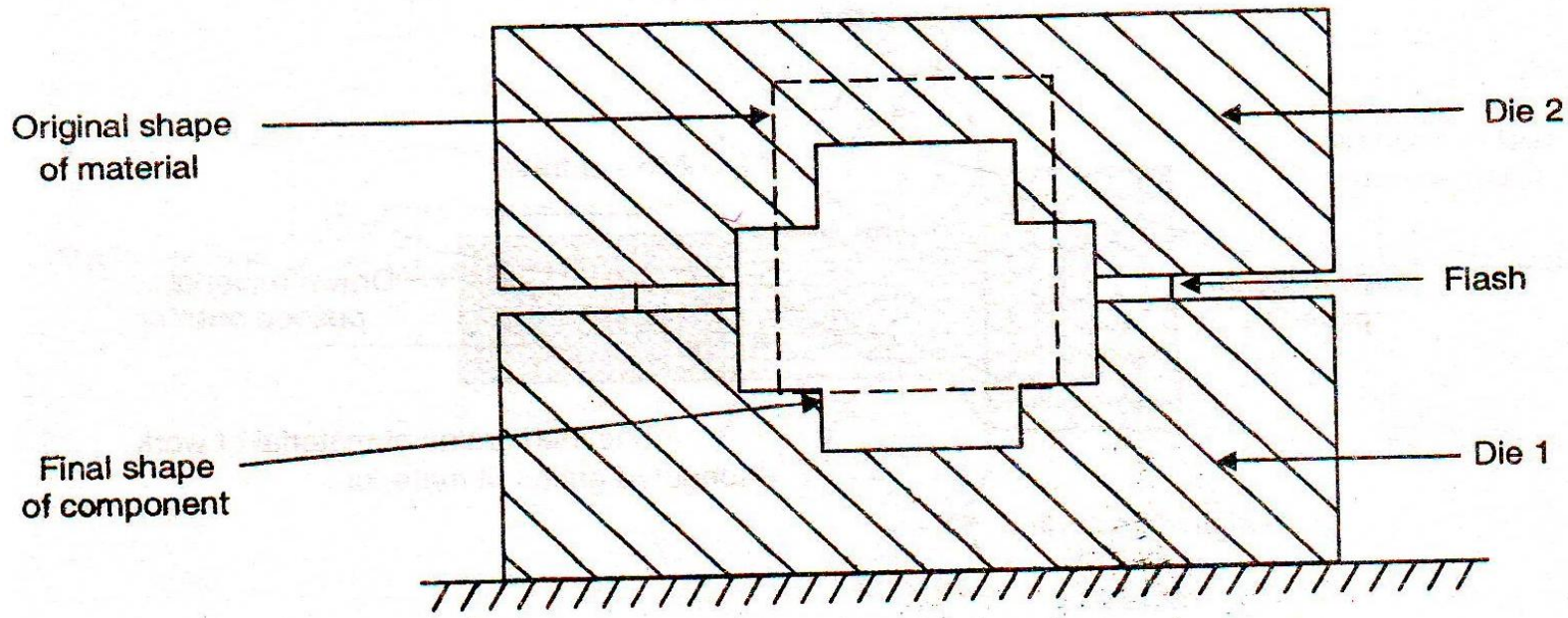


Fig. 2.2 Closed die forging

Open Die forging

Closed Die Forging

ADVANTAGES OF FORGING

- Strength and toughness is increased.
- Forge components have the ability to withstand the higher loads during service.
- Components can be produced to close tolerances.
- Machining time after forging is reduced.

DISADVANTAGES OF FORGING

- Brittle materials like cast iron, diamond etc. cannot be forged.
- Complex shapes cannot be produced by forging.
- Small components can easily be machined from regular sections and not by forging.
- Cost of forging die is higher than other processes.

Rolling: it is the most rapid method of forming metal into desired shapes by plastic deformation in between rolls.

Types of Rolling:

- Hot rolling
- Cold rolling

HOT ROLLING

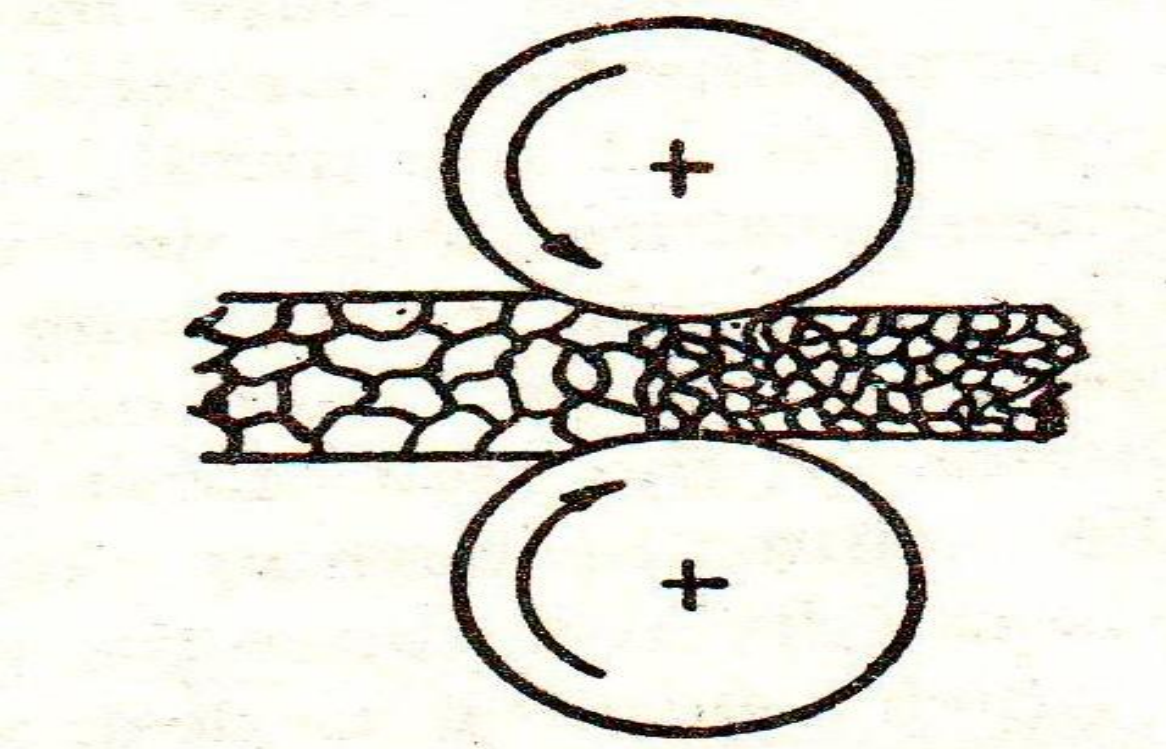


Figure: Hot Rolling

COLD ROLLING

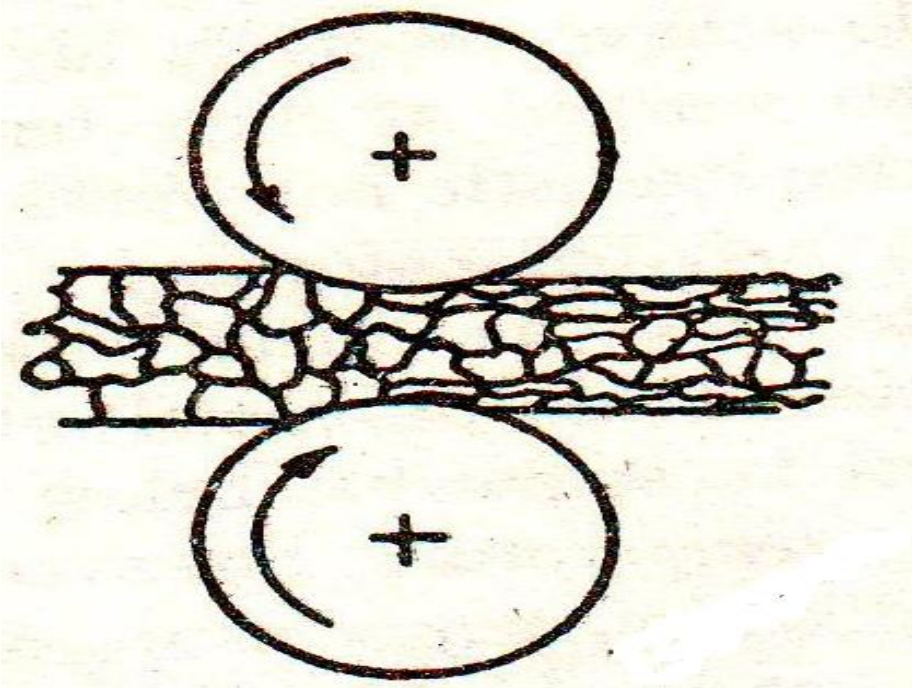


Figure: Cold Rolling

Rolling

ADVANTAGES OF ROLLING

- High production cost
- Suitable for large reduction
- Wide range of shapes like billets, slabs, sheets, bars, tubes etc. can be produced.

LIMITATIONS OF ROLLING

- High equipment cost
- Suitable for producing large sections
- Poor dimensional accuracy and finish

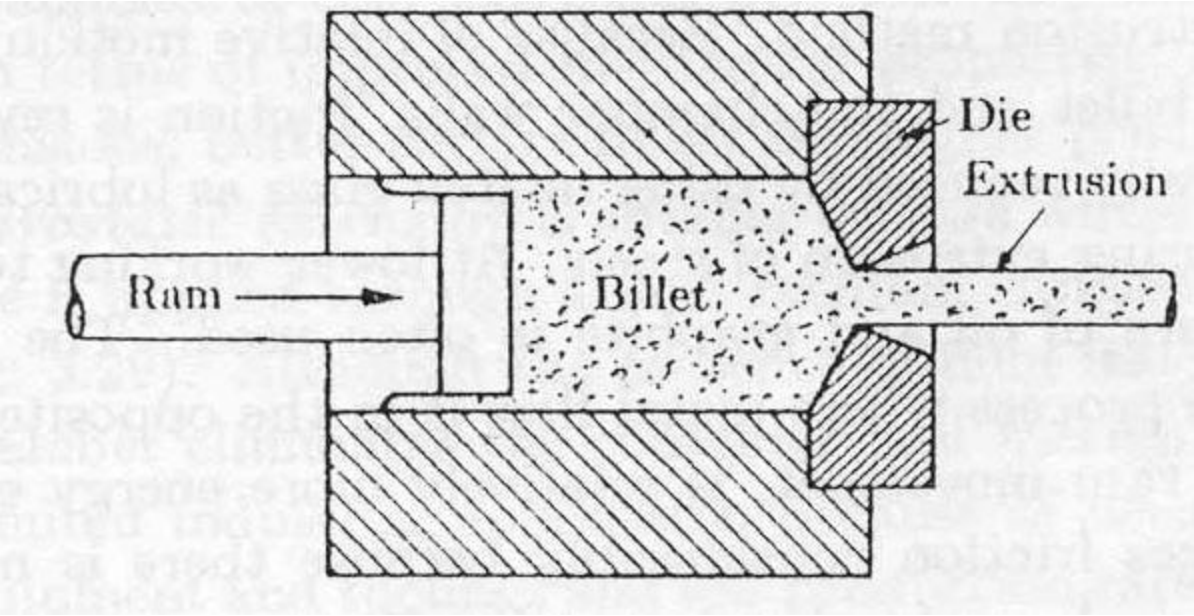
Extrusion: a process in which a heated billet or slug of metal is forced by high pressure through orifice that is shaped to provide the desired form to the finished part.

Types of extrusion:

- Direct or forward extrusion
- Indirect or backward extrusion
- Impact extrusion
- Hydrostatic extrusion

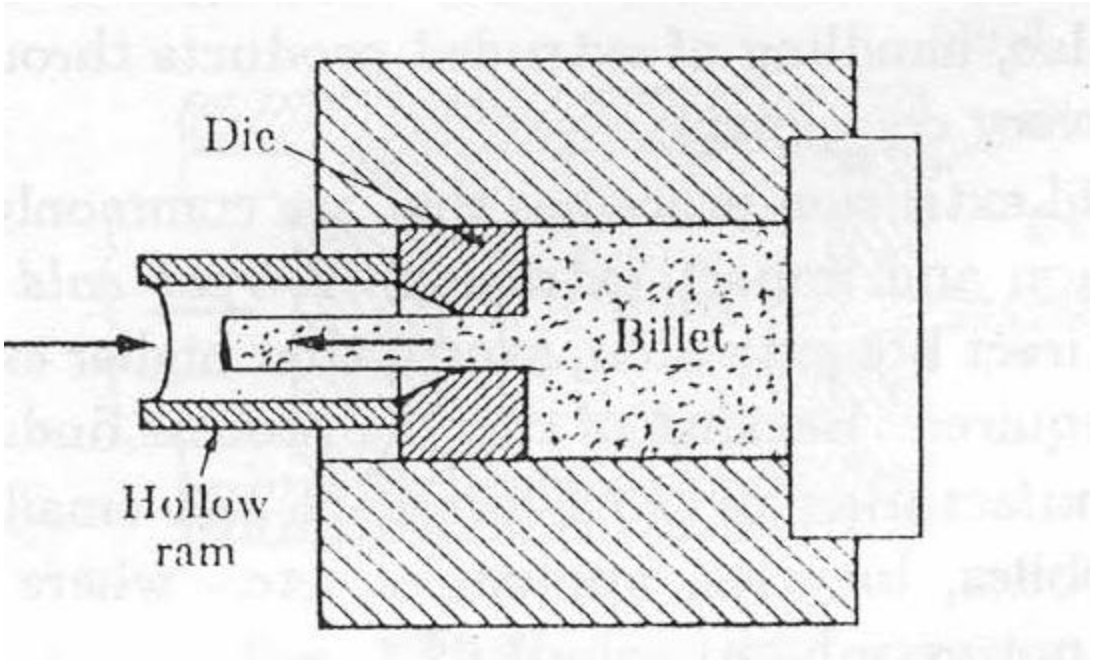
Direct or forward extrusion:

- Metal flows in the same direction as that of ram.



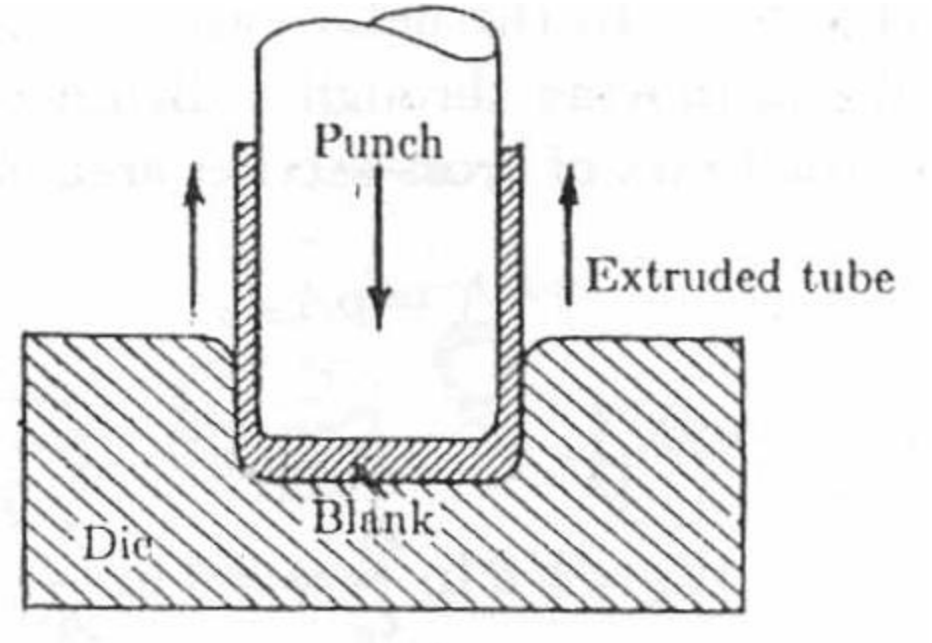
Indirect or backward extrusion:

- Metal flows in the opposite direction of the ram.
- It is more efficient since it reduces friction losses considerably.



Impact extrusion:

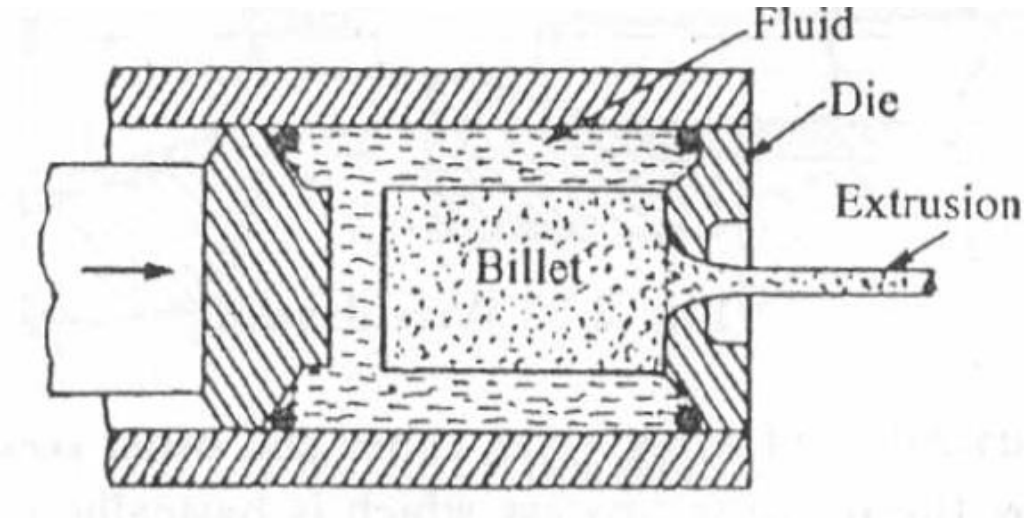
- Similar to indirect extrusion
- The punch descends rapidly on the blank which gets indirectly extruded on to the punch and to give a tubular section.



EXTRUSION

Hydrostatic extrusion:

- The friction between the container wall and billet is eliminated.
- Limited application in industry due to specialized equipment and tooling and low production rate due to high set up time.



ADVANTAGES OF EXTRUSION

- Shapes not possible by rolling, can be extruded easily.
- Better dimensional accuracy is achieved than rolling.
- Unlimited range of items can be extruded.
- Very large reduction is possible.

DISADVANTAGES OF EXTRUSION

- 18-20% wastage of material.
- Inhomogeneity in the structure of material.
- Shorter service life of extruded parts.
- High tooling cost

APPLICATIONS OF EXTRUSION

- Plastic and nonferrous alloys can be extruded easily.
- Complex shapes can be obtained easily.
- Suitable for medium and small batch production.
- High dimensional accuracy may be obtained.

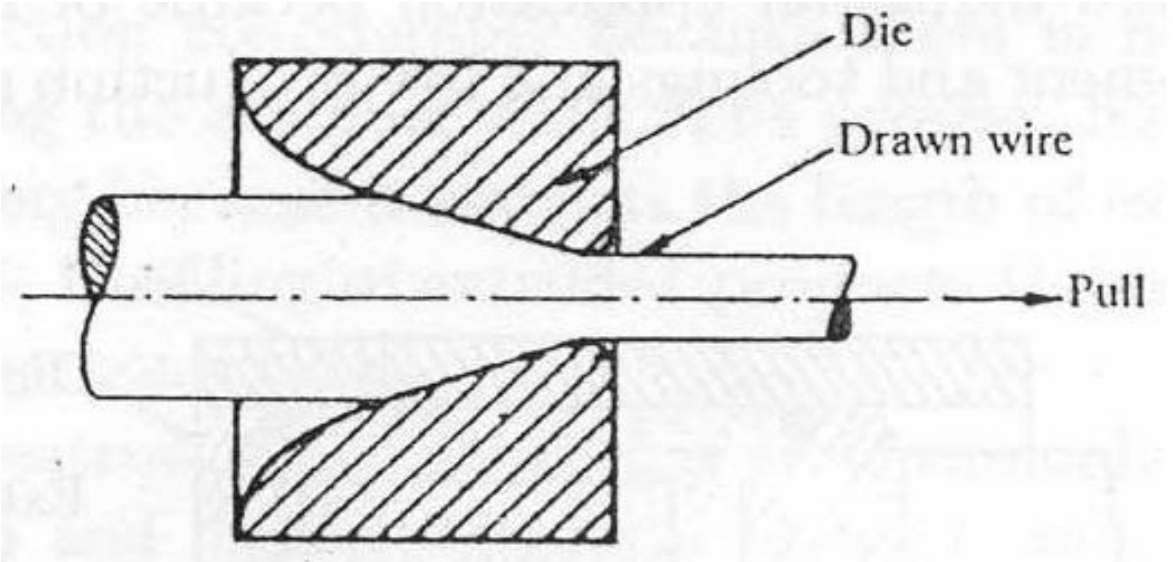
Drawing: process for making of cup shaped parts from flat sheet metal blanks.

Types of Drawing:

- Wire drawing
- Tube drawing
- Deep drawing

WIRE DRAWING

Wire drawing: In this process the material is pulled through a die in order to reduce it to the desired shape and size.

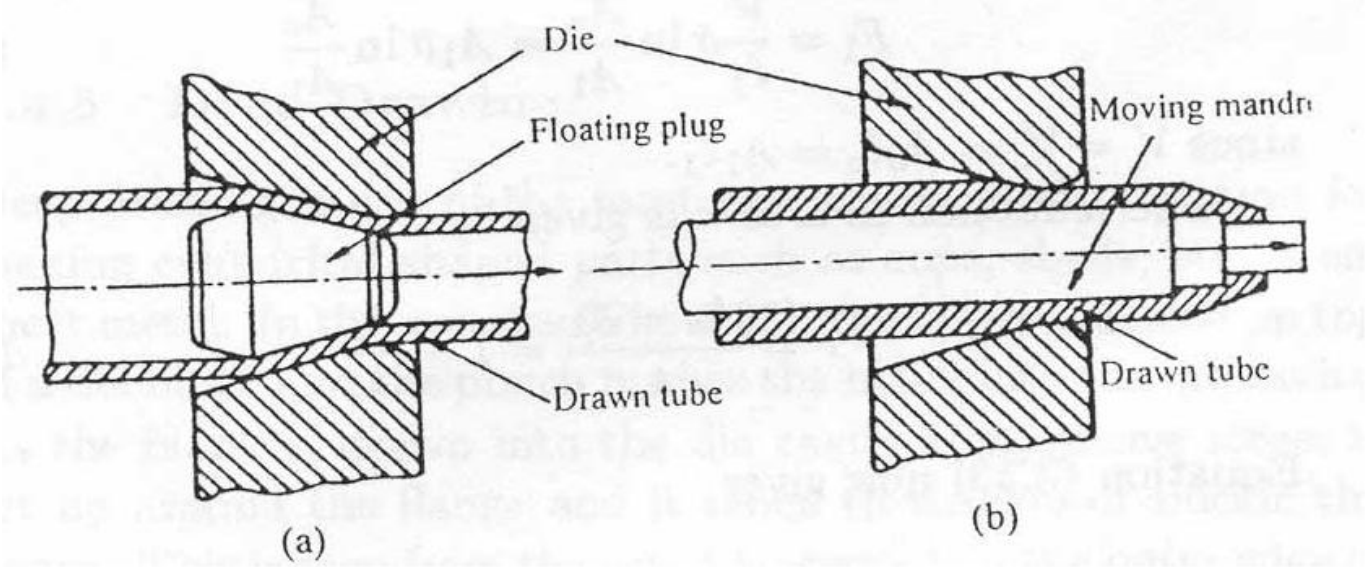


TUBE DRAWING

Tube drawing:

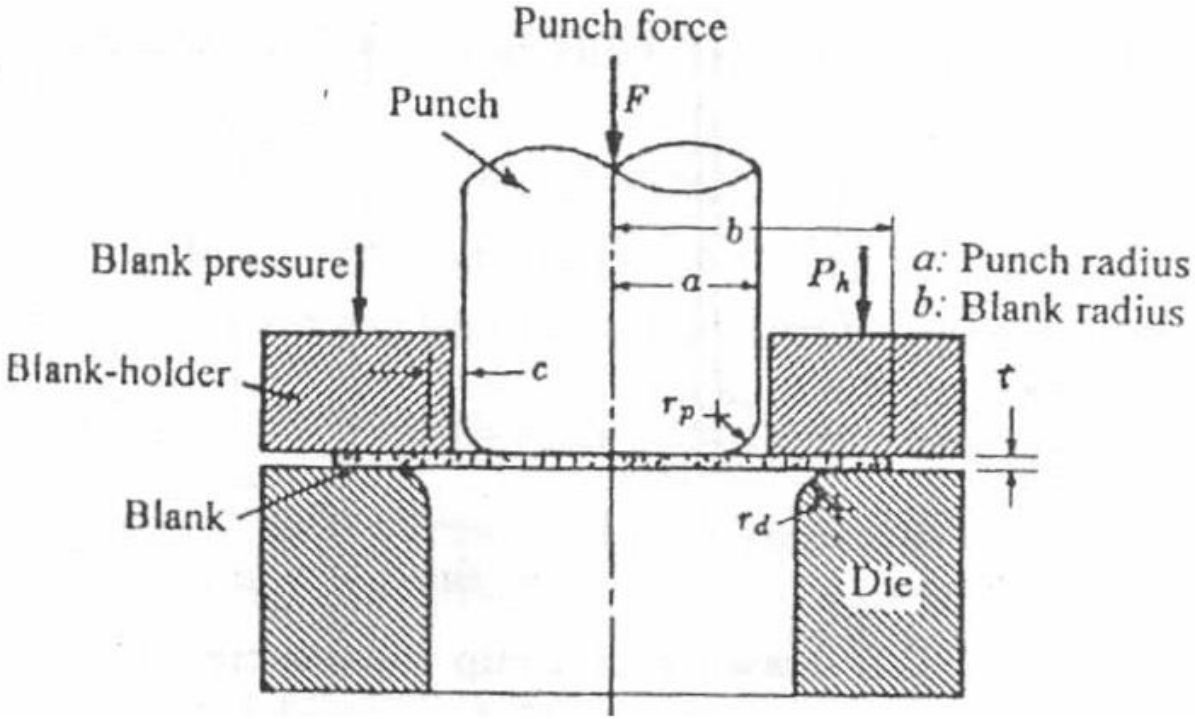
It is similar to wire drawing except that a mandrel of appropriate diameter is required to form the internal hole.

The process reduces the diameter and thickness of the tube.



Deep Drawing:

Used for making cylindrical shaped parts such as cups, shells etc. from sheet metal.



- **Advantages of drawing:**
  - Low equipment and tooling cost.
  - High production rate.
  - Good surface finish and dimensional accuracy.
- **Disadvantages of drawing:**
  - Deformation limited to small reductions.
  - Production of constant cross-sections only.
  - Lubrication is necessary.

METAL CUTTING OPERATIONS

Cutting is the collection of processes where in material is brought to a specified geometry by removing excess material using various kinds of tooling to leave a finished parts that meets the specifications.

- Metal cutting operations:

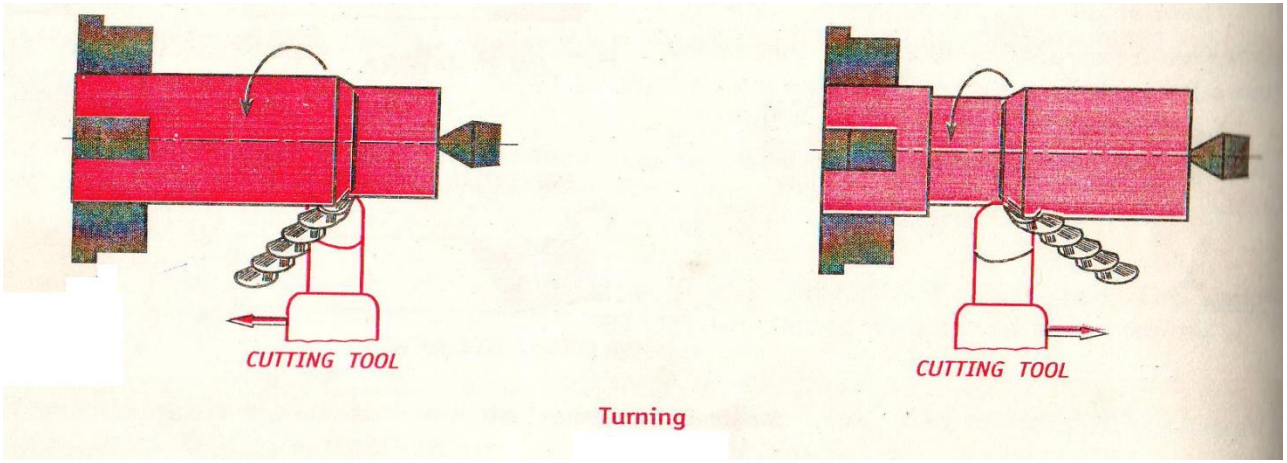
i. Turning
ii. Drilling
iii. Milling
iv. Boring
v. Reaming
vi. Shaping

i. Turning: is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted materials.

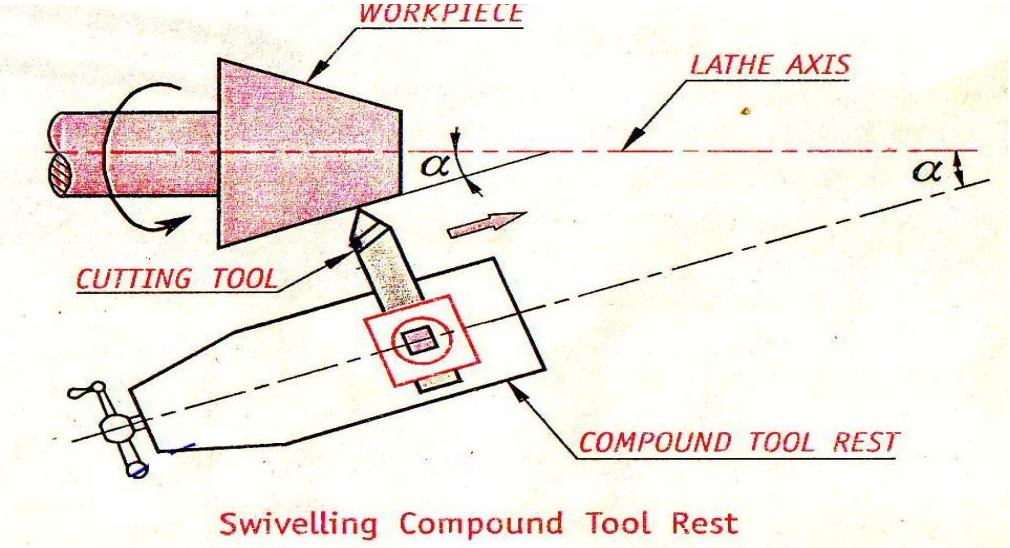
- Types of turning:
  - Plain turning
  - Taper turning

- Plain turning: the work piece is supported in between two centers which permits the rotation of work piece.

  This method of machining operation in which the work piece is reduced to the cylindrical section of required diameter.



- Taper turning: is an operation on a lathe to produce conical surface on the work pieces.



Swivelling Compound Tool Rest

It is accomplished either

- With the work piece mounted coaxial with the axis of the lathe centers and the cutting tool being moved linearly inclined to it.
- The work piece itself is mounted so as to have its axis inclined to the axis of lathe centers and the cutting tool being moved linearly parallel to the axis of the lathe bed.

- All types of materials can be turned.
- Low tooling cost.
- Large components can be turned.
- Most versatile machine capable of producing external and internal circular profiles and flat surfaces.

Advantages of Turning

- Requires skilled labor.
- Low production rate.
- Close tolerances and fine finish cannot be achieved.

Disadvantages of Turning

ii. Drilling: is a metal cutting process carried out by a rotating cutting tool to make a circular holes in a solid materials.

the tool which holds the material is called drill.

- Inexpensive tooling and equipment.
- Most suitable for producing round holes of various sizes.
- High production rate.

Advantages of Drilling

- Requires semi-skilled labor.
- Basically a rough machining operation.

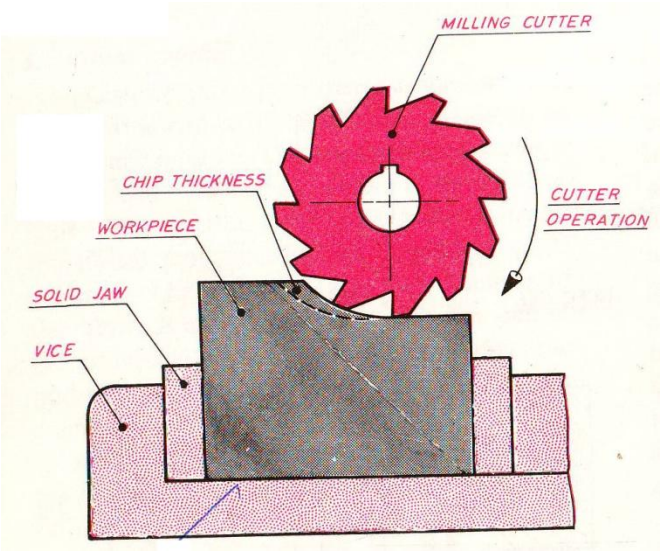
Disadvantages of Drilling

iii. Milling: is a metal cutting operation in which the operating tool is slow revolving cutter having cutting teeth formed on its periphery.

- Methods of Milling:
- Up milling or Conventional milling
- Down milling or Climb milling

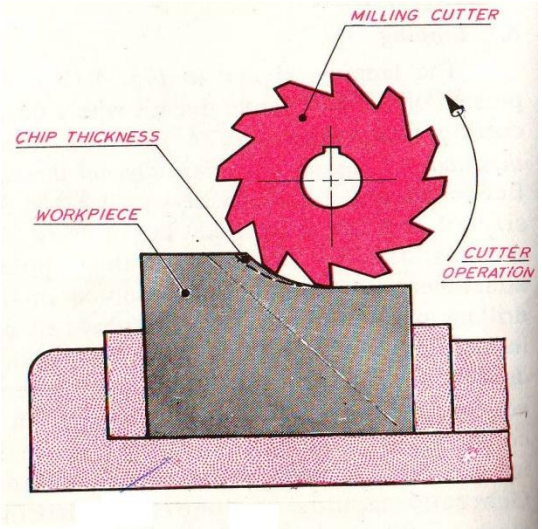
Up or Conventional milling:

- When the work piece is fed in opposite direction to the cutter tooth at the point of contact, the process is known as conventional milling.
- In this process the work piece is advances against the rotating cutter, the chip that is removed gets progressively thicker.



Down or Climb milling:

- When the work piece is fed in the same direction as that of the cutter tooth at the point of contact, the process is called climb or down milling.
- In this process, the cutter enters the top of the work piece and removes the chip that gets progressively thinner as the cutter tooth rotates.



- Variety of shapes including flats, slots and contours can be obtained.
- Versatile operation with wide variety of tooling and attachments.
- Suitable for low and medium production rate.
- Better dimensional control and surface finish.

Advantages of Milling

- Requires skilled labor.
- Tooling relatively more expensive.

Limitations of Milling

iv. Boring: is done to ensure correct location of hole by making it concentric with the axis of rotation of spindle.

Boring is also used to increase the diameter of drilled hole.

The process of boring can be done on the lathe or drilling machine or on special machine or on special machine tools.

- All types of material can be bored.
- Low tooling cost.
- Large components can be bored.
- Provides better dimensional control and surface finish.
- Variety of internal circular profiles can be obtained.

Advantages of Boring

- Requires skilled labor.
- Low production rate.
- Suitable for internal profiles only.

Limitations of Boring

v. Reaming: is an operation to improve the surface finish of previously drilled hole.

The tool used in reaming is known as reamer.

- Types of reamer:
- Rose reamer
- Fluted reamer
- Rose reamer: is an heavy bodied tool with end cutting edges.
- Fluted reamer: cut metal on periphery and remove only 0.004 to 0.08 inch (0.1 to 0.2 mm) on the bore.

vi. Shaping: is a type of machine tool that uses linear relative motion between the work piece and single point cutting tool to machine a liner tool path.

- Operations performed on a shaper:
  - Horizontal cutting
  - Vertical cutting
  - Angular cutting
  - Irregular cutting

- Horizontal cutting: a horizontal flat surface is produced by feeding the work in horizontal direction under the reciprocating cutting tool.
- Vertical cutting: the tool is fed downward in a vertical cutting such short of tool feed is also used in cutting grooves, keyways etc.
- Angular cutting: the work piece is clamped on tapered parallel vice or by swiveling the head of the shaper, angular cutting can be done.
- Irregular cutting: a formed tool whose surface forms the contours of the required surface is used.

- Suitable for producing flat and contour profiles on small work pieces.
- Suitable for low production rate.
- Low tooling and equipment cost.

Advantages of Shaping

- Requires skilled labor.
- Large size work piece cannot be used.
- Only simple profiles can be obtained.
- Close tolerance and fine finish cannot be obtained.

Disadvantages of Shaping

INTRODUCTION TO MACHINES

1. **Lathe machine**: a lathe is a machine tool employed generally to produce circular objects.

Major parts of a lathe and their functions:

i. Bed
ii. Main drive
iii. Cone pulley and back gear
iv. Head stock
v. Tail stock
vi. Lead screw
vii. Feed rod
viii. Carriage assembly

i. Bed:

- The bed is a foundation part of a lathe and supports all its other parts.
- The top of the bed is formed by precision machined guide ways. There are 2 sets of guide ways viz. outer ways and inner ways.
- The head stock and tail stock are mounted on the inner ways which keep them perfectly aligned with each other.
- The outer ways guides the longitudinal movement of the carriage assembly and align it with the center line of the lathe.

ii. Main Drive:

- An electric motor mounted in the left leg of lathe in conjunction with the transmission system like belt or gear drive from the motor to the spindle that form the main drive of the lathe.

iii. Cone pulley and back gear:

- The cone pulley which drives the main spindle through belting is driven by motor.
- Various speeds can be obtained by shifting the belt on the different steps of the cone pulley.
- Spindle speeds can be further varied using a back gear arrangement.

iv. Head stock:

- The housing comprising of the feed gear box and the cone pulley is called the head stock of the lathe.
- The main spindle projects out from the headstock.
- The headstock will be rigidly mounted on the lathe bed at its left end.

v. Tail stock:

- Tail stock is the movable part on the lathe that carries the dead center in it.
- The main function of the tailstock is to support the free end of the long work pieces.
- It is also used to clamp the tools like twist drills and reamers for making holes and taps and dies for cutting threads.
- Tailstock is mounted loosely on the lathe bed ways and can be moved and locked in any desired position.

vi. Carriage assembly:

- The carriage assembly serves to support the tool and rides over the bed ways longitudinally between the headstock and tailstock.
- It is composed of five main parts.

a) Saddle b) Cross slide c) Compound rest d) Apron

e) Tool post

a) Saddle: is a H shaped casting slides over the outer set of the guide ways and serves as the base for the cross slide.

b) Cross slide: is mounted on a saddle and enables the movement of cutting tool laterally across the lathe bed by means of cross feed hand wheel. It also serves as the support for compound rest.

c) Compound rest: is mounted on the top of the cross slide and supports the tool post. It can be swiveled to any angle in the horizontal plane to facilitate the taper turning and threading operation.

d) Apron: is mounted at the front of the saddle beneath it and houses the carriage and the cross slide mechanisms. The apron hand wheel moves the carriage assembly manually by means the rack and pinion gears.

e) Tool post: is mounted on the T slots of the compound rest. The tool post clamps the tool in the proper position for machining operation.

vii. Lead Screw: is a screw rod which runs longitudinally in front of the lathe bed. The rotation of the lead screw moves the carriage to and fro longitudinally during thread cutting operation.

viii. Feed Rod: is stationary rod mounted in front of the lathe bed and facilitates longitudinal movement of the carriage during turning, boring and facing operation.

ix. Feed gear box: is mounted on the left side of the lathe bed and below the head stock. It houses the necessary gears and other mechanisms that transmits various feed gear ratios from headstock spindle to either the lead screw or the feed rod.

2. **Drilling Machine:** a power operated machine tool, which holds the drill in its spindle rotating at high speeds and when manually actuated to move linearly simultaneously against the work piece produces a hole, is called a drilling machine.

Types of Drilling Machine:

i. Portable drilling machine
ii. Bench drilling machine
iii. Pillar drilling machine
iv. Radial drilling machine
v. Multiple spindle drilling machine
vi. Gang drill

BENCH DRILLING MACHINE

- It consists of a vertical main column mounted over a base.
- The vertical column carries a moving head housing in it a speed gear box and spindle feeding mechanism and a job mounting table, called work table which can be also raised or lowered.
- A electric motor is mounted at the top end of the vertical column on its rear side.
- The power is transmitted to the main spindle through the stepped cone pulley drives and gearing systems.

- A drill chuck for small sized drills is fitted in the spindle at its lower end. For bigger sizes the drill itself will fitted directly in the spindle.
- The work piece will be mounted on the work table and is clamped to it.
- The work table can be moved up and down over the arm and locked in required position.
- The center of the hole to be drilled will be punched with a mark initially on the work piece.

3. **Milling Machine:** is a power operated machine tool in which the work piece mounted on moving table is machined to various shapes when moved under a slow revolving serrated cutter.

Types of Milling Machine:

i. Plain or horizontal type milling machine.
ii. Vertical milling machine.
iii. Universal milling machine.
iv. Planer type milling machine.
v. Profile cutting type milling machine.

HORIZONTAL MILLING MACHINE

Parts of horizontal milling machine:

a) Column
b) Arbor
c) Knee
d) Saddle
e) Table

The horizontal milling machine has its cutter axis horizontal.

a) Column: the column which is usually combined with the base into the single casting. The column houses the spindle, transmission system from the electric motor to spindle and it enables to mount the table control and lifting mechanisms.

b) Arbor: is a horizontal shaft provided with a straight body and tapered shank. On the straight portion of the arbor rotary cutters are mounted. The tapered end of the arbor fits into tapered hole of the spindle. The other end of the arbor is mounted in a bearing housed in the projecting over arm.

c) Knee: is a casting mounted on the front of vertical slide of the column and is moved up and down by an elevating screw. The upper face of the knee is provided with guide ways so as to mount the saddle.

d) Saddle: is a casting provided with two slides one at the top and other at the bottom which are exactly at 90 degrees to each other. The lower slide fits within the guide ways on the top of the knee and the upper slide receives the dovetail guides provided on the bottom of the table.

e) Table: is mounted on the top of the saddle. The bottom of the table has a dovetail slide which fits in the slide ways on the top of the saddle. The top of the table is machined with several full length T slots for mounting vices or other work holding fixtures.

4. **Shaping machine:** is a type of machine tool that uses the linear relative motion between the workpiece and a single point cutting tool to machine a linear tool path.

Main parts of shaper:

i. Ram
ii. Shaper head
iii. Column
iv. Cross rail
v. Saddle and table
vi. Base
vii. Tool head

i. Base: is a heavy robust cast iron structure that supports the all the other parts of the shaper machine.

ii. Column: works as a housing for the electrical circuits and operating mechanism of a shaper. It also support as ram, cross rail, heads etc.

iii. Cross rail: is a heavy cast iron attached to the column of the shaper machine and is used for two purposes for elevating the table and for cross traverse of the table.

iv. Table: holds and supports the workpiece during operations. It can be move horizontally by a cross rail mechanism to provide feed to the workpiece. The table mounted on the saddle.

v. Ram: is reciprocating part of the shaper . It gets its drive from the quick return mechanism which is fitted inside the column to change its position relative to the job.

METAL JOINING PROCESSES

Metal joining processes:

- Soldering
- Brazing
- Welding
- Riveting

1) Soldering: is a method of uniting two thin metal pieces using a dissimilar metal or an alloy by the application of heat.

Types of soldering:

i. Soft solder
ii. Hard solder

i. Soft solder: the alloy of lead and tin called soft solder, is used in varying proportions for sheet metal work, plumbing work and electrical junctions.

The soldering temperature of soft solder ranges from 150 to 350 degree centigrade.

ii. Hard solder: an alloy of copper, tin and silver known as hard solder and is used for stronger joints. The soldering temperature of hard solders ranges from 600 to 900 degree centigrade.

Application of soldering:

- used extensively in electronics industry.
- Used to join various metals and thicknesses. Manual operation requires skilled worker, soldering speed can be high with automated equipments.

2) Brazing: is a joining process in which filler metal is placed at or between the facing surfaces to be joined and the temperature is raised to melt the filler metal but not the workpieces.

- The melting temp. of the filler metal is above the 450 degree centigrade but below the melting point of the metals being joined.

- Almost all metals can be joined by some type of brazing metals.
- Process is ideally good for dissimilar metals.
- Process can be performed quickly and economically.
- Thinner and complex assemblies can be joined easily.

Advantages of Brazing

- Subsequent heating of the assembly can cause inadequate melting of the braze metal, weakening or destroying the joints.
- They enhanced susceptibility to corrosion with braze joints.

Disadvantages of Brazing

3) Welding: may be defined as the metallurgical joining of two metal pieces together to produce essentially a single piece of metal.

Types of Welding:

i. Pressure welding
ii. Fusion welding

i. Pressure Welding: in the pressure welding or plastic welding, the parts to be joined are heated only upto the plastic state and then fused together by applying the external pressure.

types of pressure welding are: forge welding, resistance welding, gas welding, thermit welding.

ii. Fusion Welding: also known as non-pressure welding, the joint of two parts is heated to the molten state and allowed to solidify.

the different types of fusion welding are: arc welding, gas welding, thermit welding.

- A good welded joint is as strong as the base metal.
- Welding equipments are not much costly.
- Portable welding equipments are available in the market.
- Both similar and dissimilar metals/alloys/ thermoplastics can be joined easily.
- The process can be mechanized.

Advantages of Welding

- Welding gives out harmful fumes, radiation and spatter.
- Residual stresses and distortion in the products are induced.
- Jigs, fixtures are required to hold and support the work.
- The structure of weld is not same as that of the parent metal.
- Edge preparation and skilled worker are needed for good welding.

Disadvantages of Welding

Application of welding:

- Structural building and bridges.
- Aircraft and automobile construction.
- Pressure vessel and storage tank.
- Rail, road equipment.
- Piping and pipe lines.
- Household and office furniture.
- Earth moving machinery and cranes.
- Repair and maintenance work.

4) Riveting: the process of forming another rivet head after the rivet is placed in the hole previously drilled or punched through the plates, is called riveting.

Types of riveting:

- Cold riveting: riveting is done at ambient temp.
- Hot riveting: rivets are initially heated before applying force. After riveting is done the joint is heat treated by quenching and tempering.

Riveted joints: rivets are used to fasten permanently two or more plates or pieces of metal. Joints made with rivets are called riveted joints.

Types of riveted joints:

- Lap joint
- Butt joint

i. Lap joint:

- In lap joint, the plates to be connected overlap each other.
- Rivets are inserted on overlapping portion.
- Single or multiple rows of rivets are used to give strengths to the joints.
- Depending on the no. of rows the riveted joints may be classified as single riveted lap joint, double or triple riveted lap joint.

ii. Butt joint:

- In butt joint, the plates are brought to each other without forming any overlap.
- Riveted joints are formed between each of the plates and one or two cover plates.
- Depending upon the number of cover plates the butt joints may be single strap or double strap butt joint.

Disadvantages of riveted joints:

- More metal is removed while making of the holes.
- Weight of the rivets increases the weight of the riveted members.

Application of riveted joints:

- Used in structural work such as bridges, roof trusses.
- In construction of pressure vessels such as storage tanks, boiler etc.
- Used when non-metallic and metallic parts are to be connected together.