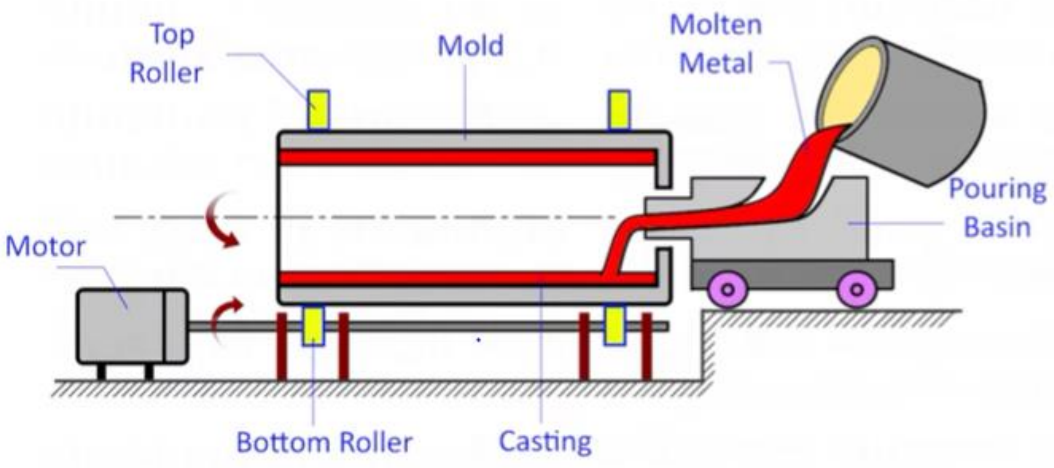
CASTING OPERATION

CASTING

- Casting is a manufacturing process by which the required shape and size of final product is obtained by pouring a molten liquid material into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify.
- The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process.
- Casting materials are usually metals.
- Almost all metals can be cast.
- Casting is most often used for making complex shapes that would be otherwise difficult to make by other methods.

Centrifugal casting



The mold is set up and rotated along a vertical (rpm is reasonable), or horizontal axis.

2. The mold is coated with a refractory coating.

3. While rotating molten metal is poured in.

4. The metal that is poured in will then distribute itself over the rotating wall.

5. During cooling lower density impurities will tend to rise towards the center of rotation.

6. After the part has solidified, it is removed and finished.

➢Centrifugal Casting produces:

- ➢Good quality.
- ➢Accurate casting.
- ➢Saves material.
- ➢Dense product & have fine grained structure with uniform & high physical properties.
- ➢Less subjected to directional variation than static casting.

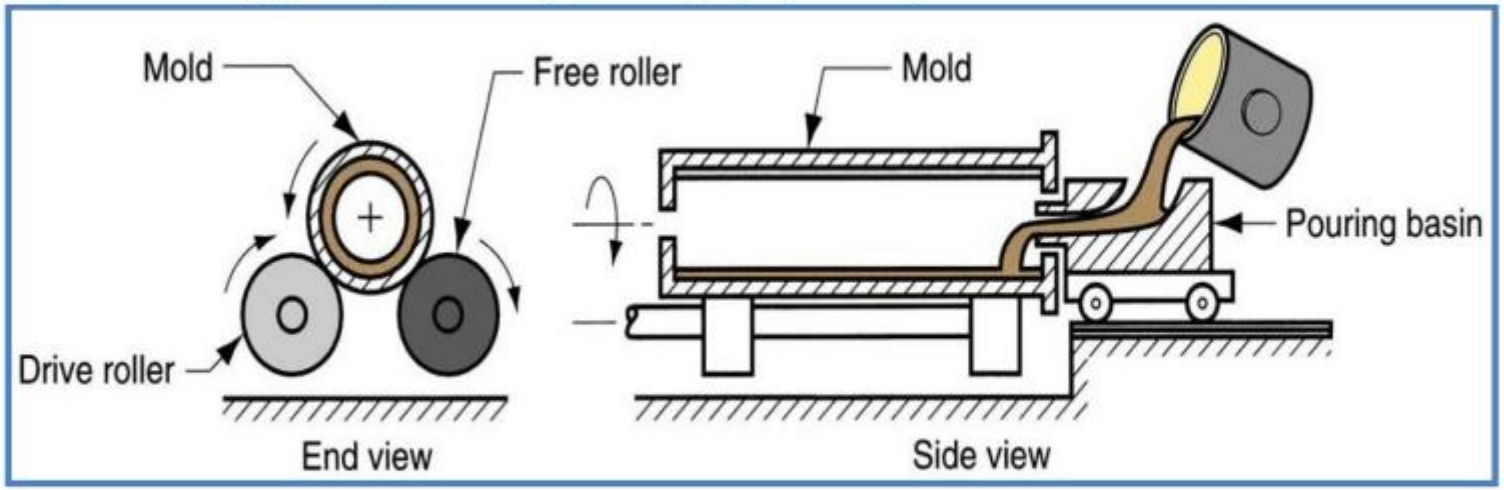
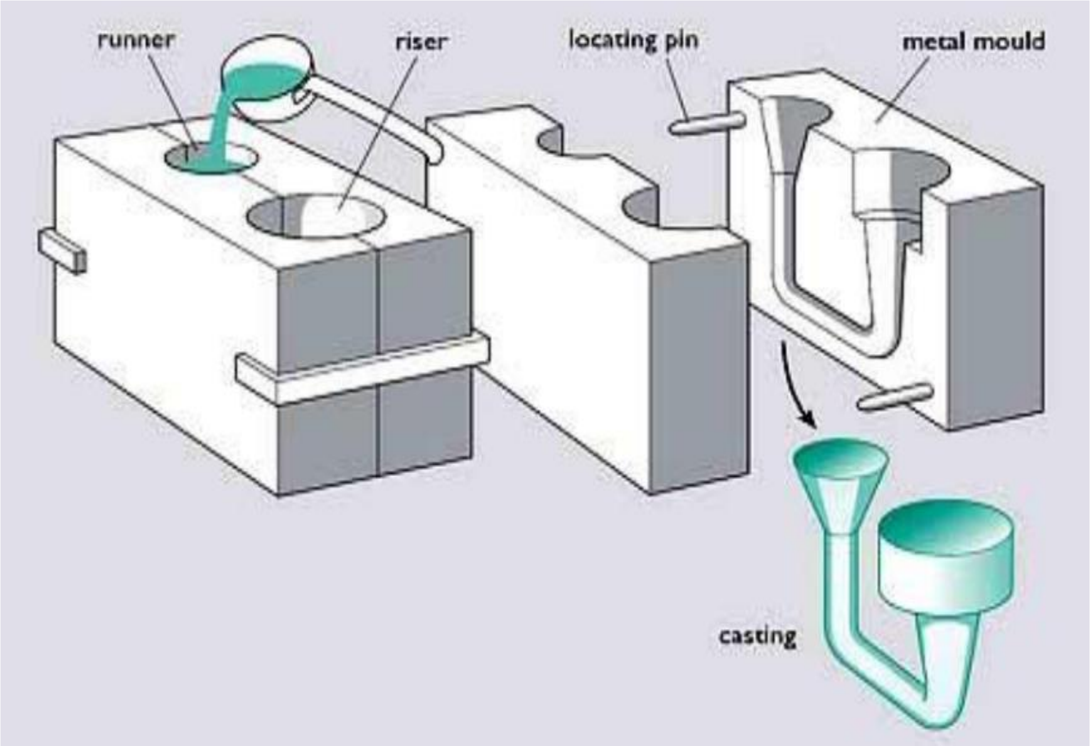


Fig. (14): Setup for true centrifugal casting.

Permanent mould casting (gravity die casting)



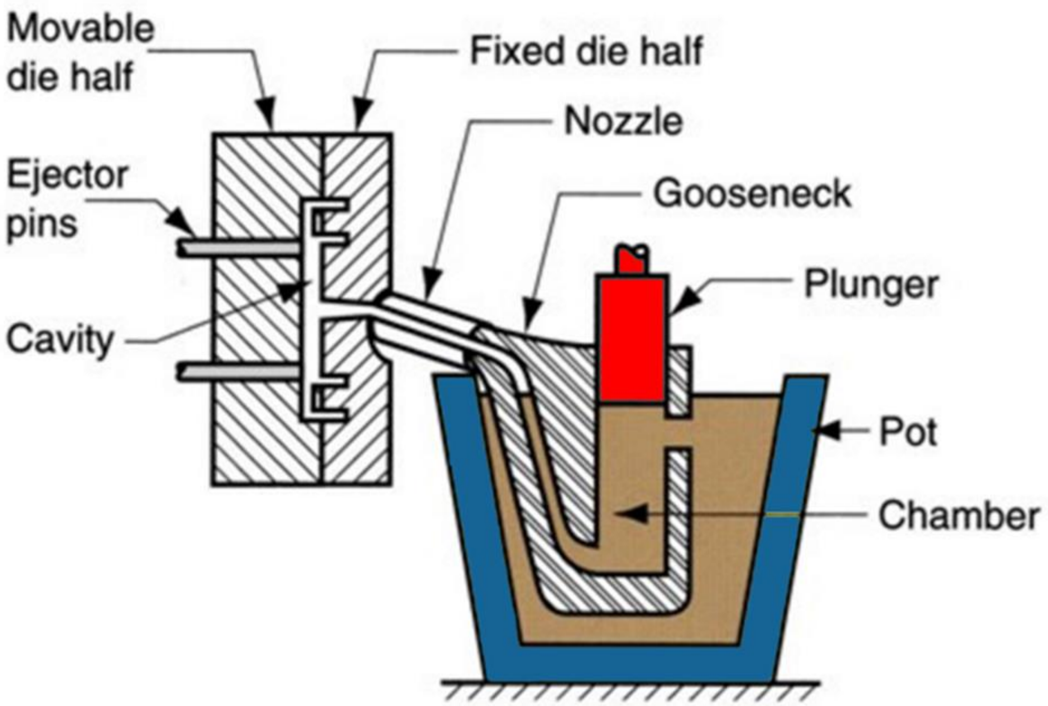
- A casting produced by pouring molten metal in a metallic mould is known as permanent mould casting
- These moulds are generally made in two halves
- The sprue, riser, runner, gates and vents are machined into the parting surface of mould halves
- The process is generally used for non ferrous metals and their alloys
- Hydraullic brake cylinders, oil pump bodies, carburetor bodies etc are made by this process

The casting is called gravity die casting because molten metal is poured into mould under gravity only , no external pressure is applied to force the liquid metal into mould cavity (opposite to die casting).

The casting is called permanent mould casting because it uses the mould which is permanent i.e. the mould can be used many times before it is discarded or rebuilt.

SPECIAL CASTING PROCESS

Hot chamber die casting process

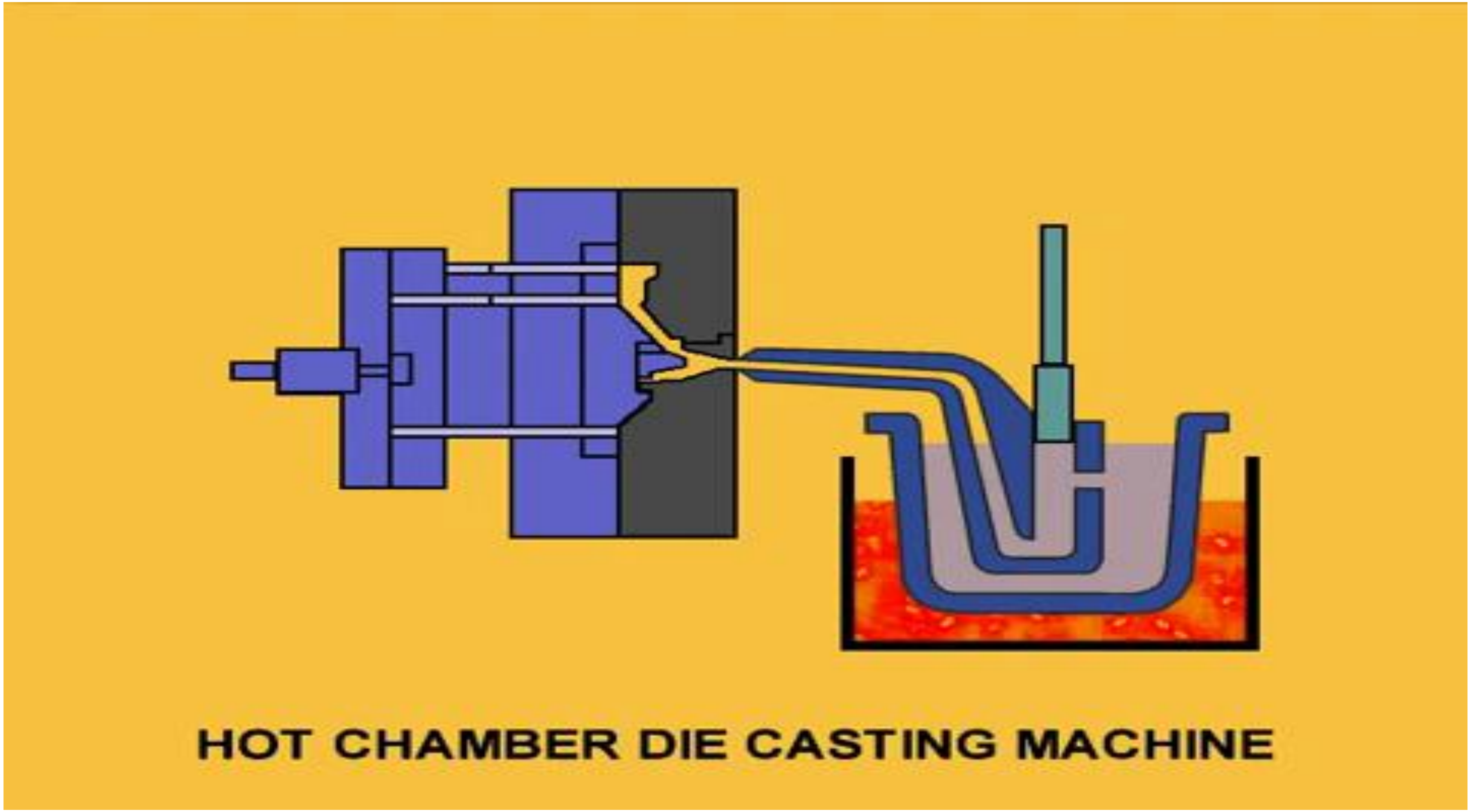


- Hot chamber die casting is a type of die casting that uses alloys with low melting temperatures (i.e. Zinc, some Magnesium alloys.

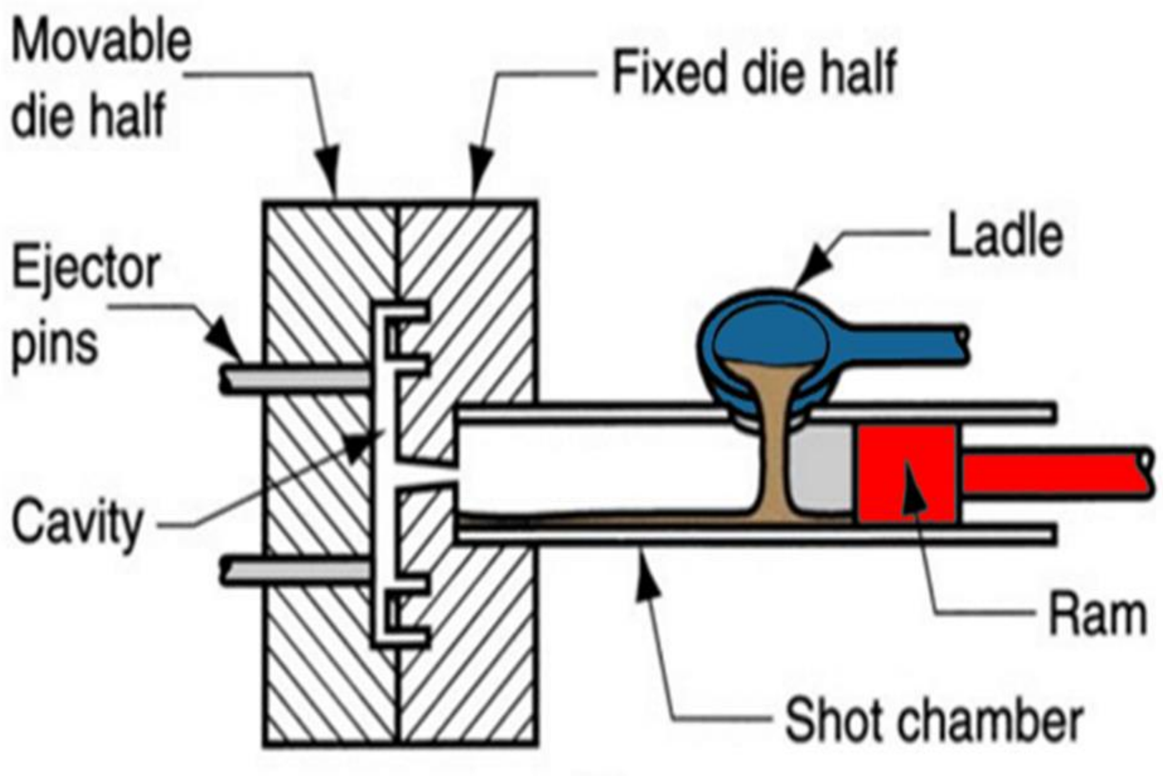
- In a hot chamber die casting machine, the fixed die half is called a cover die, which is mounted to a stationary plate and aligns with the nozzle of the gooseneck.

- The movable die half is the ejector die and is mounted to a movable platen, which slides along tie bars
- The metal is contained in an open holding pot, which is placed in the furnace and melted to the needed temperature.
- When the plunger is in the "up" position, the molten metal flows into the shot chamber.
- As the plunger moves down, it forces the molten metal through a gooseneck and into the die at injection pressures ranging from 1,000 – 5,000 psi.
- The machine pushes the moving platen towards the cover die and holds it closed with great pressure until the molten metal is injected.
- The plunger remains in the "down" position to hold the pressure while the casting "cools off." After solidification, the plunger is retracted and the cast part is either ejected, manually removed from the machine or pushed off the cover die.
- This ejection system, which includes an ejector die and ejector pins, allows the casting to be pushed out while releasing the die halves

HOT CHAMBER DIE CASTING



Cold chamber die casting



- Cold chamber die casting is a type of die casting that is used for alloys with high melting temperatures
- As a contrast from hot chamber die casting here melting unit is separate .
- Molten metal is ladled from the furnace into the shot chamber through a pouring hole
- The plunger forces metal through the shot chamber into the die at pressures ranging from 2,000 and 20,000 psi.
- The plunger holds the pressure and retracts after solidification.

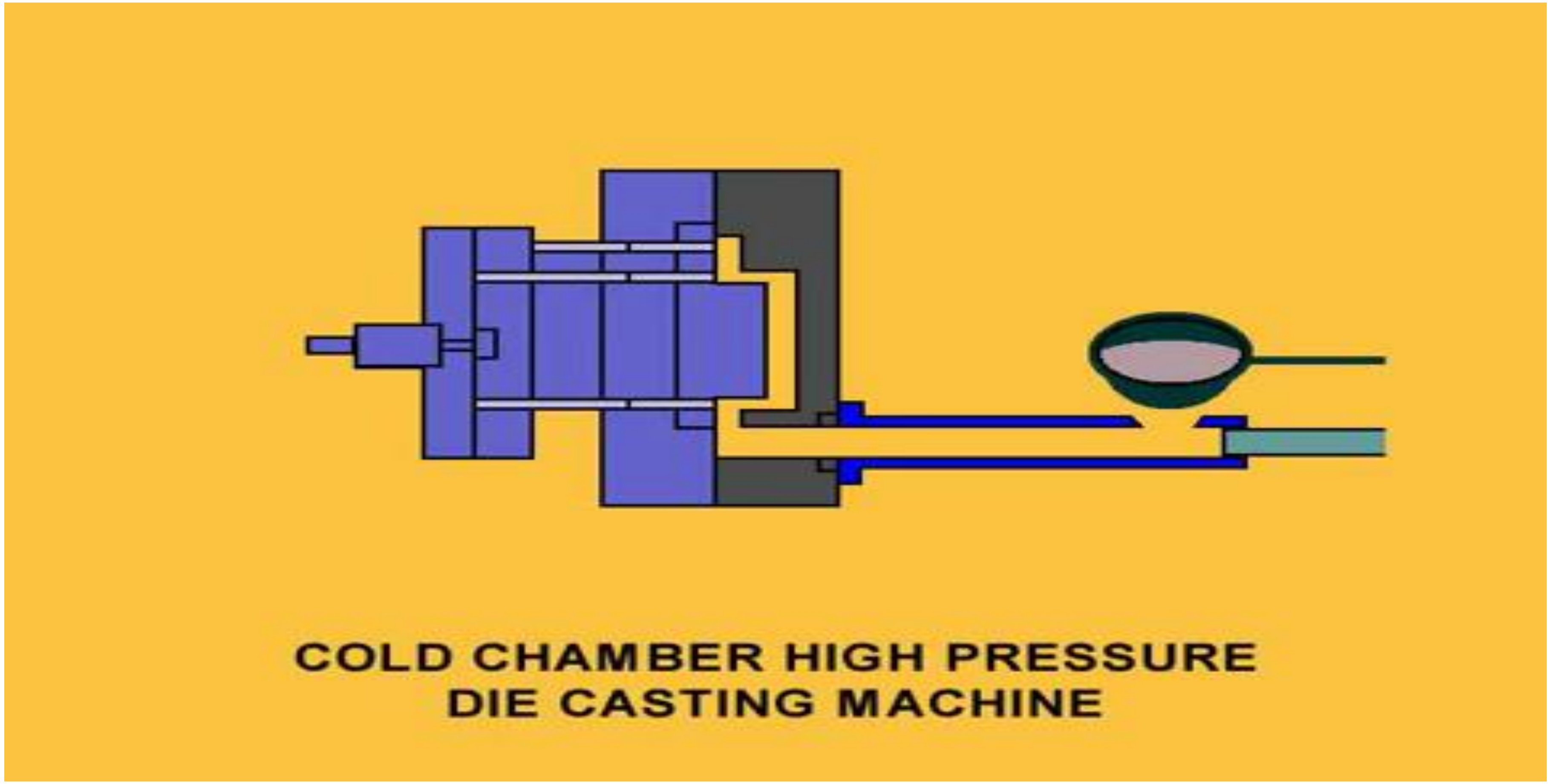
Advantages of die casting

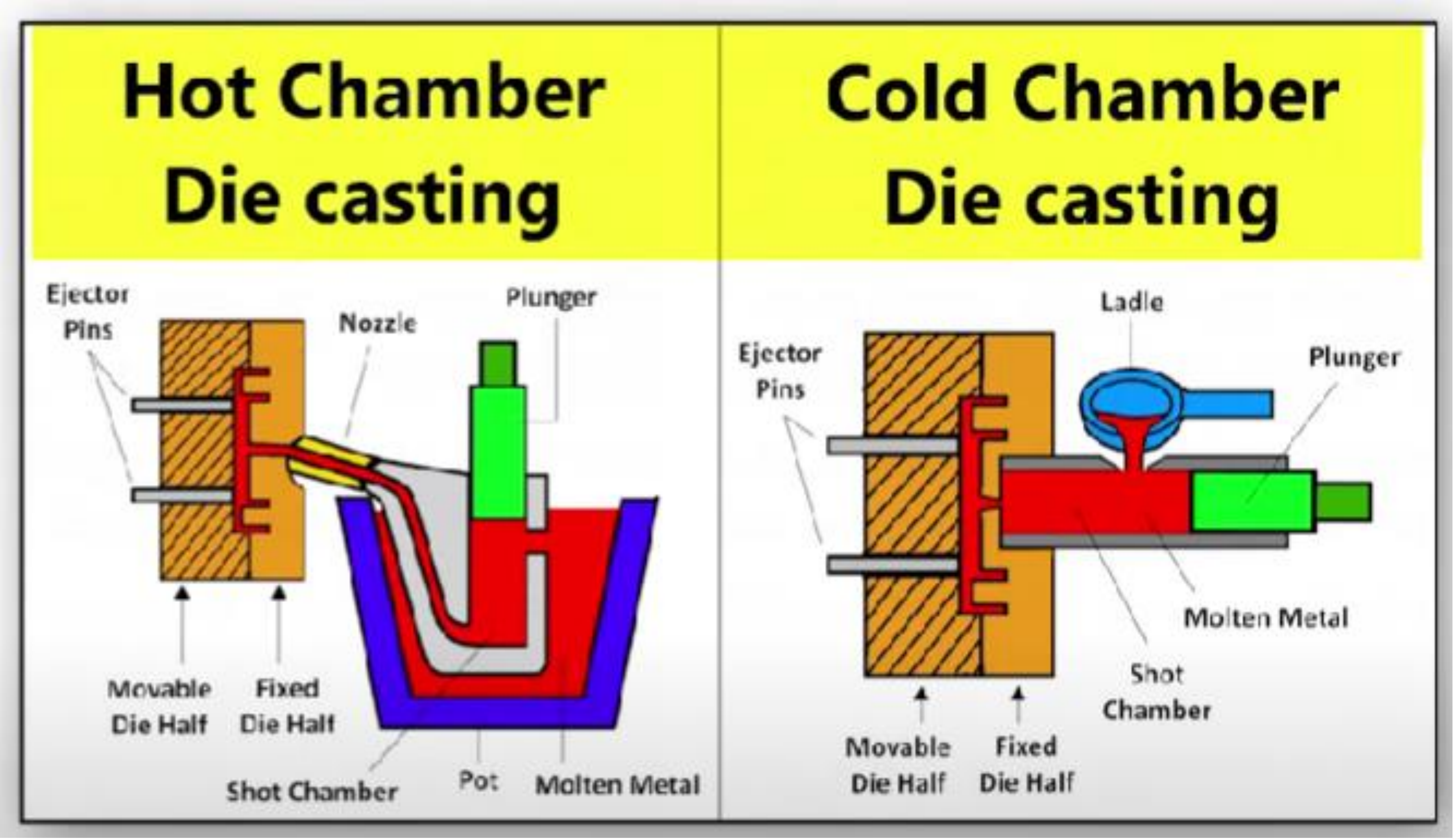
1. Production rate is high
2. Better surface finish and details
3. Close dimensional tolerance can be obtained
4. Thin section can be cast easily
5. Labour cost per casting is low

Disadvantages of die casting

1. Die costing units are costly
2. Not economical for small runs
3. All metals and alloys cannot be die cast

Cold Chamber Die Casting

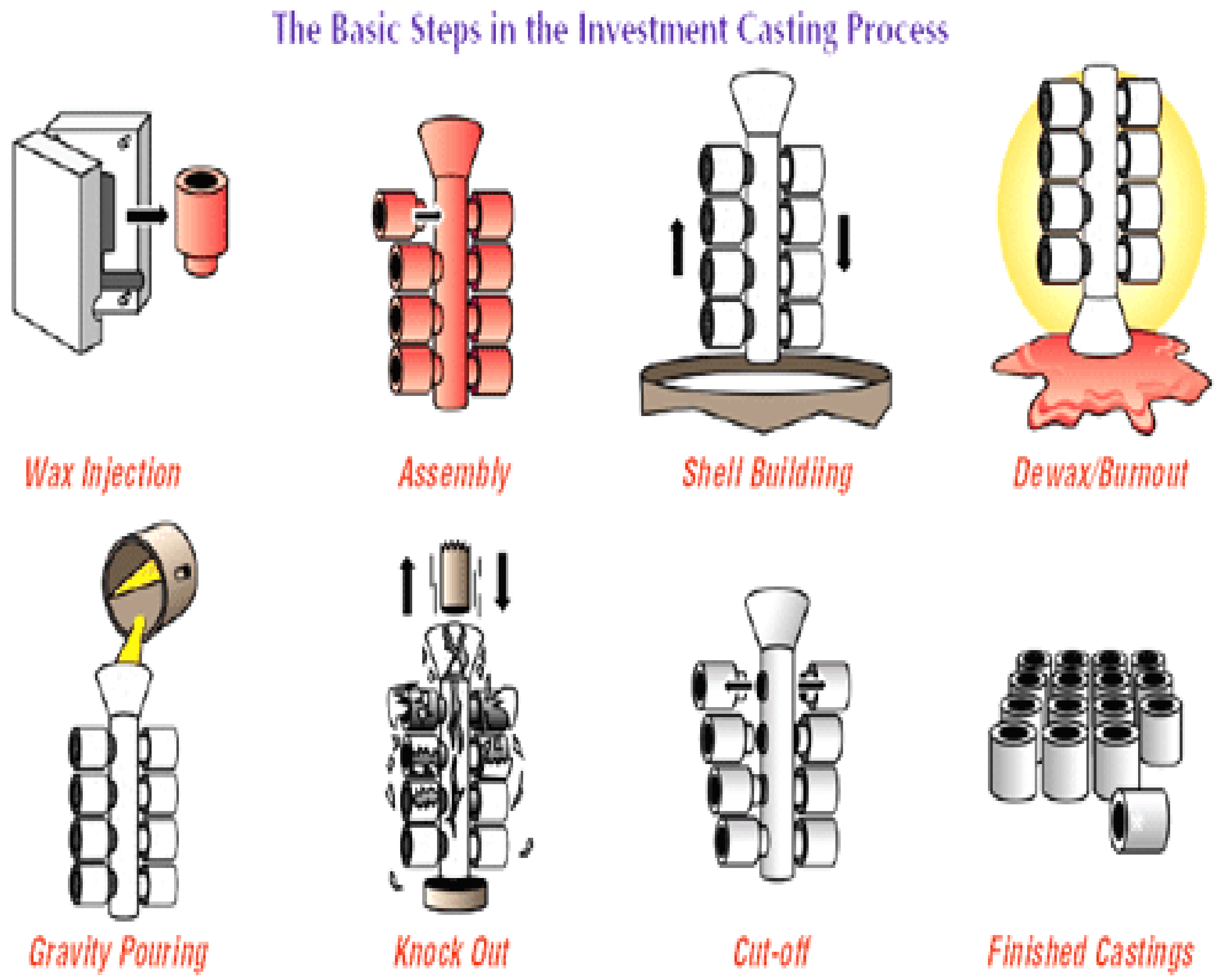



Hot Chamber
Die casting
Ejector
Pins
Nozzle
Plunger
Movable
Die Half
Fixed
Die Half
Shot Chamber
Pot
Molten Metal
Cold Chamber
Die casting
Ladle
Ejector
Pins
Plunger
Molten Metal
Shot
Chamber
Movable
Die Half
Fixed
Die Half

INVESTMENT CASTING

- Investment casting is a manufacturing process in which a liquid material is poured into a ceramic mold, which contains a hollow cavity of the desired shape, and then allowed to solidify.
- The solidified part is the casting, which is broken away from the ceramic mold to complete the process.
- The steps within the investment casting process are as follows:

Investment casting



- **Create wax pattern**: A pattern that replicates the finished part geometry is made using a wax injection die
- **Wax Assembly**: Next, the wax patterns are assembled onto runners and into a finished tree which is ready to be dipped.
- **Slurry Coating**: The assembly is then dipped into a high-grade ceramic slurry to build a ceramic shell around the wax tree.
- **Stuccoing**: After the slurry coating is done, particles of sand are dropped onto the surface of the wet tree assembly. This helps to thicken and strengthen the layer of coating on the wax assembly surface..
- **Dewaxing:** The wax inside the newly built shell is now removed. Dewaxing is done using a steam-dewaxing **autoclave or flash fire furnace.**
- **Casting:** Now the desired molten metal is poured into the pre-heated mold cavity.
- **Cooling**: The mold then sits to allow the molten metal to cool and solidify which then becomes the final casting.
- **Shell Removal:** The shell material is then removed through processes hammer knockout, vibration, and steel grit blasting.
- **Cut Off:** The finished parts are then cut free from the gating and runner system.
- **Finishing**: Various finishing techniques are then employed including grinding, sand blasting and coating to achieve the final surface needed.

Investment casting

Slush Casting:

- Slush Casting is a special type of permanent mold casting to create a hollow casting without using cores. In the process the material is poured into the mold and allowed to cool until a desired wall thickness is obtained, the not yet solidified molten metal is poured out. It is a relatively inexpensive process.
- This is useful for making hollow ornamental objects such as candlesticks, lamp's holder, statues etc.
- The thickness of the shell is controlled by the amount of time allowed before the mold is drained as shown in Fig. (3) above.
- Low-melting-point metals such as lead, zinc, and tin are used.
- The exterior appearance is important, but the strength and interior geometry of the casting are minor considerations.

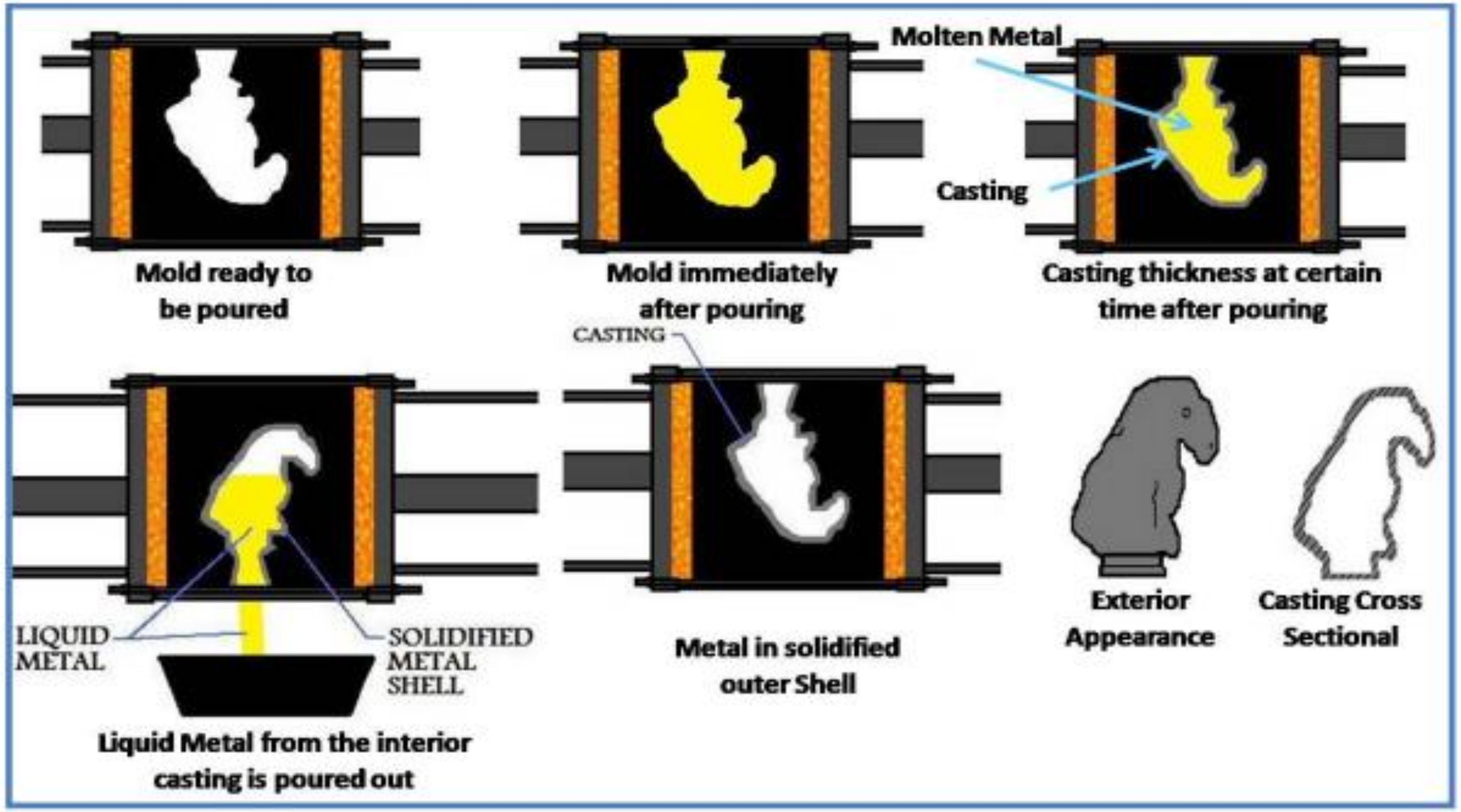


Fig. (2): The steps to form a Slush casting.

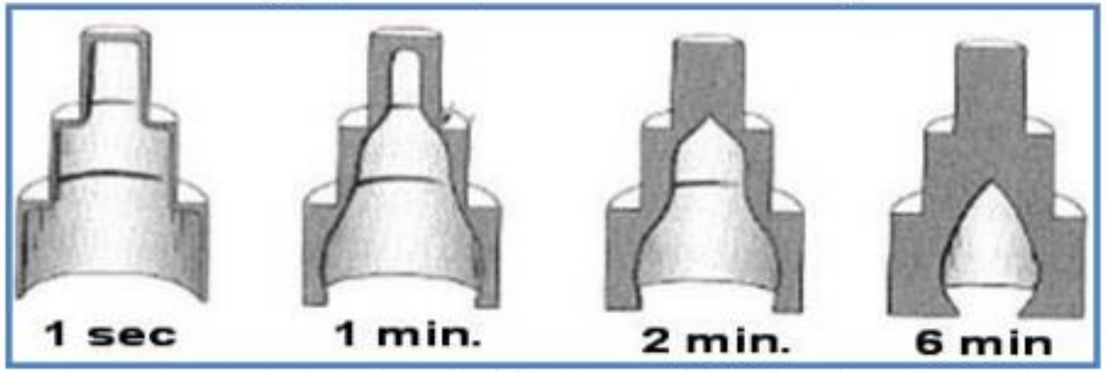
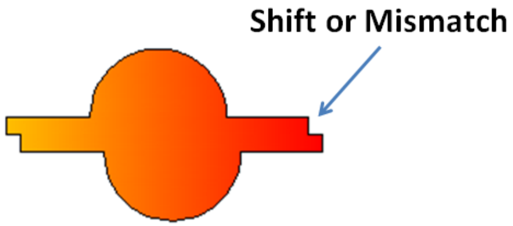


Fig. (3): Variation of the Shell thickness with time of solidification.

Casting Defects

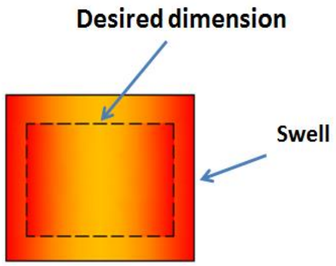
1. Shift or Mismatch

The defect caused due to misalignment of upper and lower part of the casting and misplacement of the core at parting line.



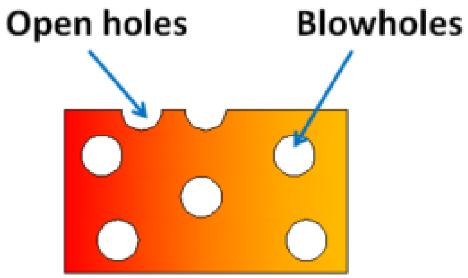
2. Swell

It is the enlargement of the mold cavity because of the molten metal pressure, which results in localised or overall enlargement of the casting



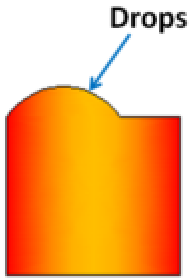
3. Blowholes:

When gases entrapped on the surface of the casting due to solidifying metal, a rounded or oval cavity is formed called as blowholes. These defects are always present in the cope part of the mold.



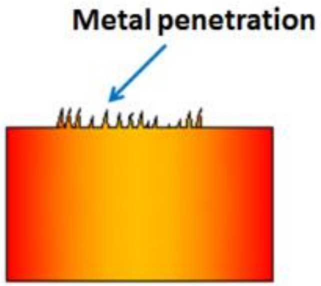
4.Drop

Drop defect occurs when there is cracking on the upper surface of the sand and sand pieces fall into the molten metal.



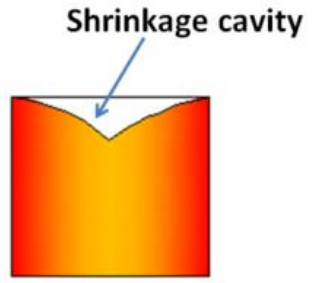
5. Metal Penetration

These casting defects appear as an uneven and rough surface of the casting. When the size of sand grains is larges, the molten fuses into the sand and solidifies giving us metal penetration defe



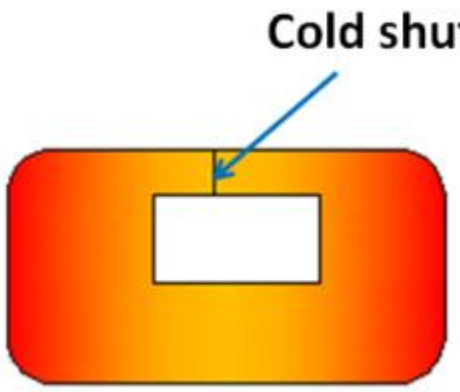
6. Shrinkage Cavity

- The formation of cavity in the casting due to volumetric contraction is called as shrinkage cavity.



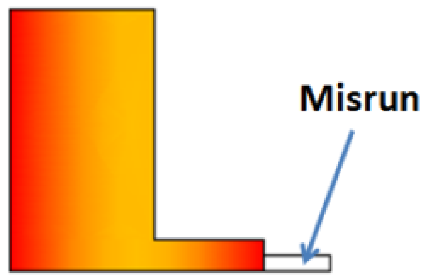
7. Cold Shut

When the molten metal enters into the mold from two gates and when these two streams of molten metal meet at a junction with low temperatures than they do not fuse with each other and solidifies creating a cold shut (appear as line on the casting). It looks like a crack with round edge



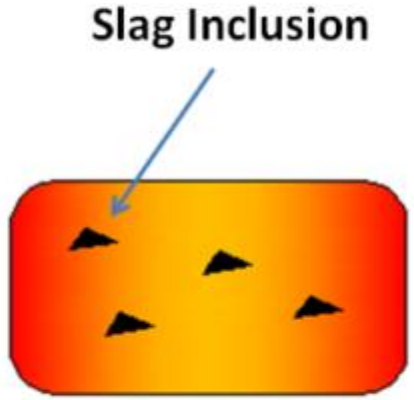
8. Misrun

When the molten metal solidifies before completely filling the mold cavity and leaves a space in the mold called as misrun.



9. Slag Inclusion

This defect is caused when the molten metal containing slag particles is poured in the mold cavity and it gets solidifies.



- Mechanical working of a metal means the plastic deformation of a metal under the action of externally applied forces.

- Mechanical working (plastic deformation) of metals above the recrystallisation temperature (lower critical temperature) but below the burning point is termed as hot working and the working below recrystallisation temperature is termed as cold working.

- During the plastic deformation of a metal the existing grains or crystals are distorted or broken out. The refining of metal is done by heating the metal, leading to the formation of new grains with undistorted space lattice (crystal). This is called "recrystallisation". The temperature at which recrystallisation takes place, i.e .new grains are formed in the metal is called recrystallisation temperature.

COLD WORKING OF METALS

- The mechanical working of metals below recrystallisation temperature is called cold working. The cold working is normally done at room temperature.

Advantages

- Accurate dimensional control can be obtained by cold working process.
- No surface oxidation results in the process.
- Better surface finish is obtained.
- Strength and hardness of the metal is increased.
- This is a possible method to increase the hardness of those metals which do not respond to heat treatment.

Disadvantages

- Higher presure and heavier equipment are needed.
- Only small sized components can be easily cold worked.
- Only ductile metals can be shaped through cold working
- Grain structure is not refined; residual stresses have harmful effects on certain properties of metal

COLD WORKING OPERATIONS

The various widely used cold working operations are

- Drawing
- Squeezing
- Bending
- Extrusion
- Shearing

1. **DRAWING**

It is the process of producing various cross-sections by forcing of metal through a die by means of a tensile force. Bars and sheets of any cross-section or composition may be cold drawn. Some of the drawing operations used are

- Wire drawing
- Deep drawing
- Stretch forming
- Tube drawing
- Metal spinning

2. Wire drawing:

All the metal wires are produced by cold drawing, through the die. This process consists of forcing a large diameter rod through a die, there by reducing its cross sectional area of the rod. Raw material for wire drawing is hot rolled bars. The bars are first cleaned to remove scale and rust, and then coated with some lubricants to avoid corrosion and oxidation. The wire is drawn by pulling the rod, through several dies of decreasing diameters to obtain the wire of the desired diameter.

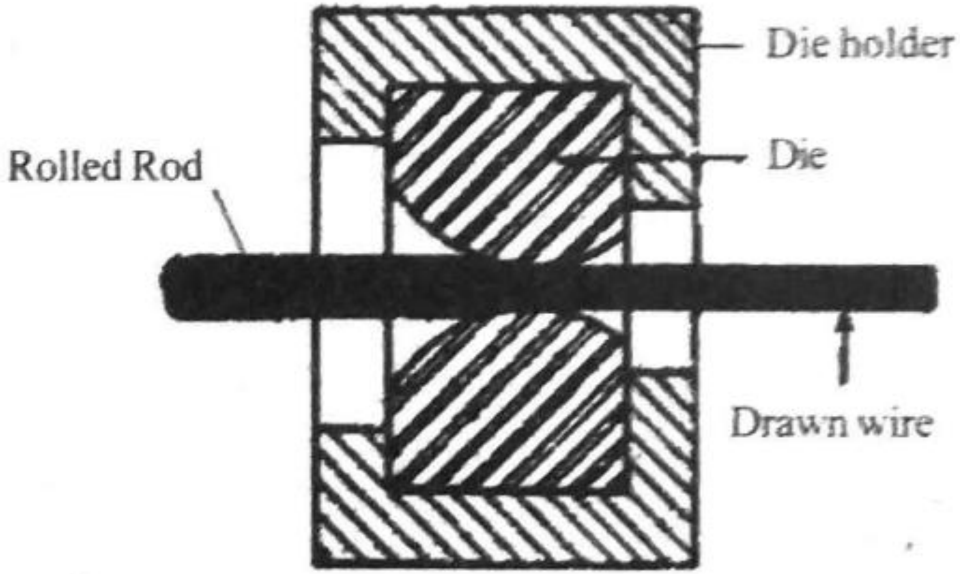


Fig. 2.6 Wire drawing process

Tube drawing: Seamless and welded tubes, produced through hot working are further cold drawn for providing a good surface finish & better dimensional accuracy. The tube is pulled through the die over a fixed mandrel. The out side diameter of the tube is controlled by the opening of the die and the inside bore (diameter) by the mandrel. (Refer fig. 2.7)

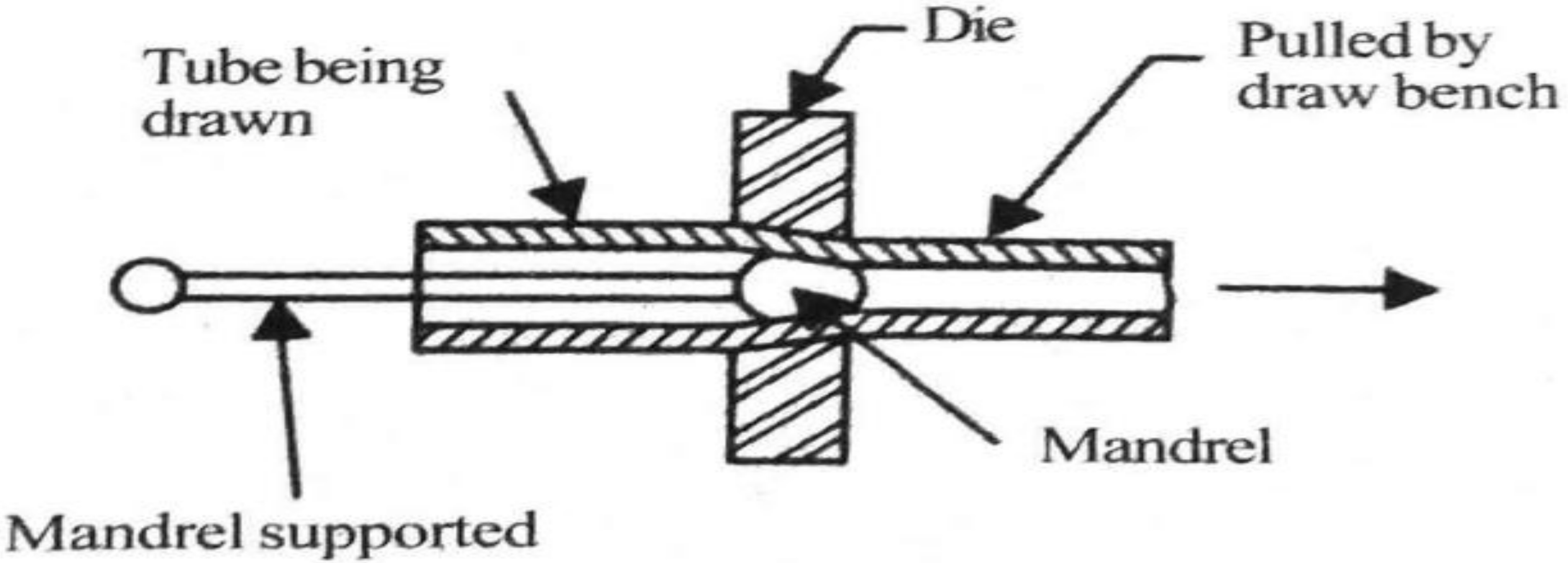


Fig. 2.7 Cold drawing of tubes

Deep drawing: This process involves the production of a dish or cup from a flat sheet metal. This process causes the flow and displacement of metal, to give desired shape with satisfactory finish. fig, 2.8 shows the drawing of a shallow cup from a blank.

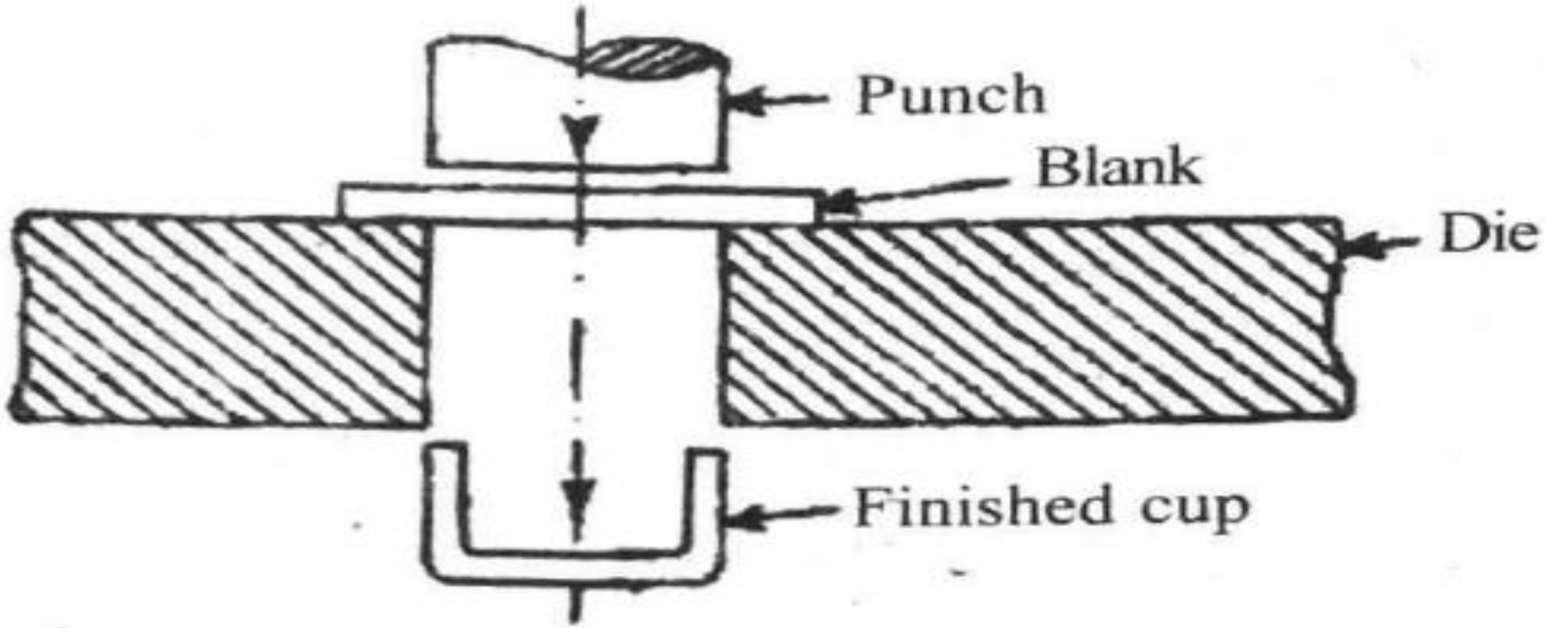


Fig. 2.8 Deep drawing

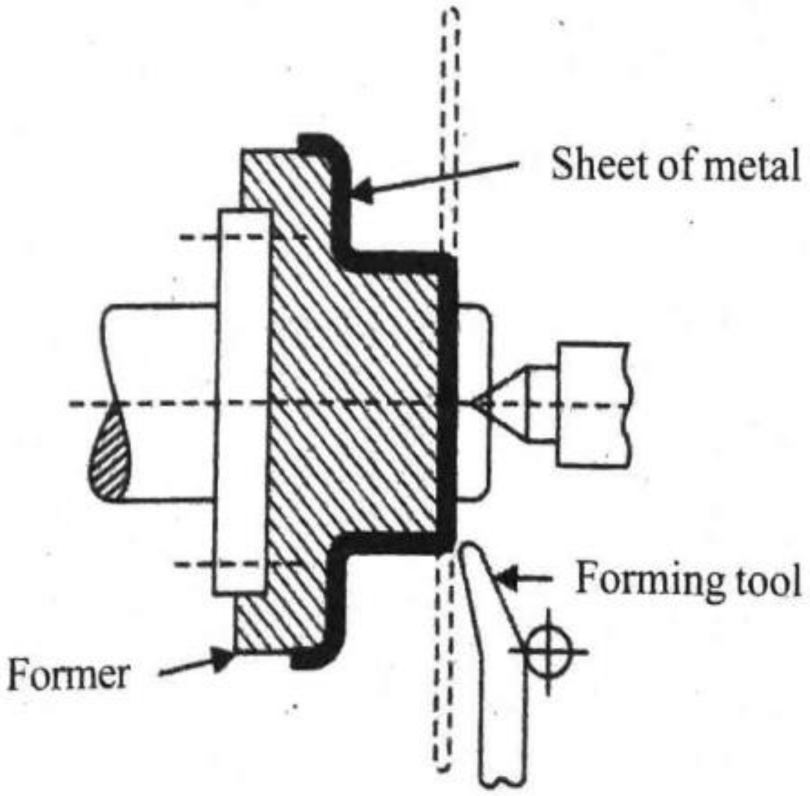


Fig 2.9 Cold spinning

Metal spinning (Cold spinning):

Metal spinning is an operation of shaping sheet metal by pressing against a form while it is rotating. Fig. 2.9 shows a cold spinning operation. The operation is performed on a speed lathe. A circular blank is cut and positioned against the metallic or wooden form by an adopter. A spinning tool with blunt edge is used and while the lathe rotates, the blank is forced to the shape of the form. Aluminum and other soft metals are suited for cold spinning. Kettles, cooking utensils & light reflectors can be produced by this method.

Stretch forming: This process consists of gripping a sheet metal at each end in suitable jaws, and stretching it over a die made to the required contour until complete forming is achieved. In this process, the sheet get stretched beyond the elastic limit while conforming to the die shape. This is accompanied by slight thinning of sheet.

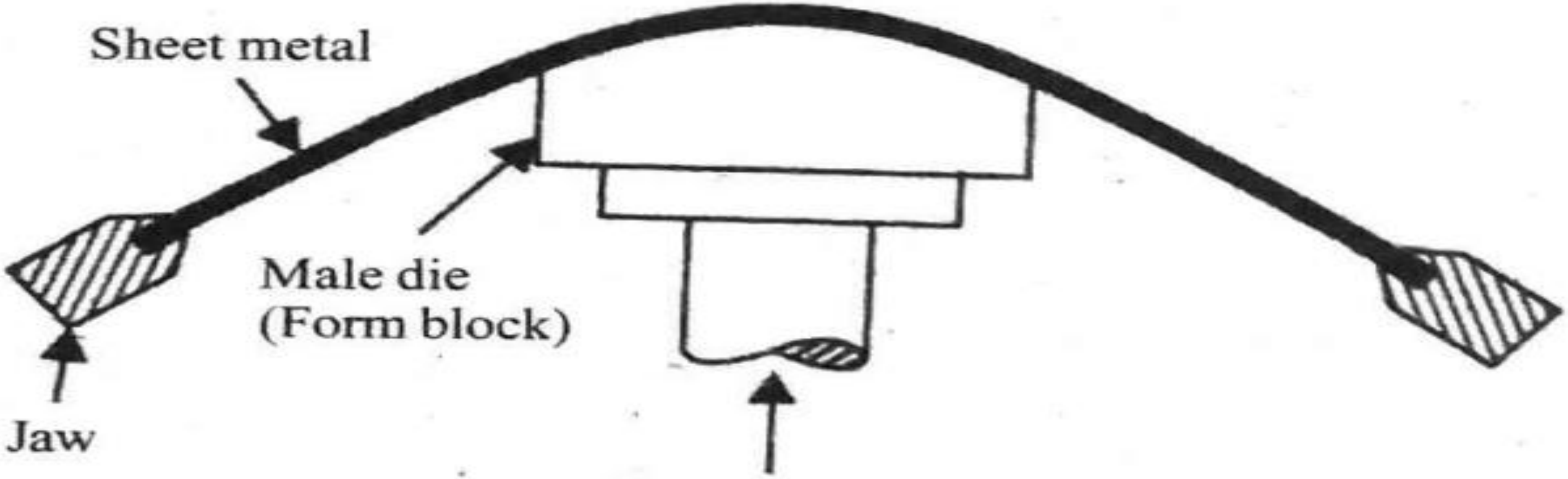


Fig. 2.10 Stretch forming

BENDING

This process is also known as forming. The bars, rods, structural shapes and sheet metals may be bent to many shapes in cold conditions Mechanical working of metals Ram 2.25 through dies. The bending can be done on a ram type machine or rotary type of machine. In ram type machine (Fig 2.11) two pressure dies are mounted in fixed position on the frame of the machine and are free to rotate about their mounting pins. The form is mounted directly to the piston rod of the hydraulic cylinder

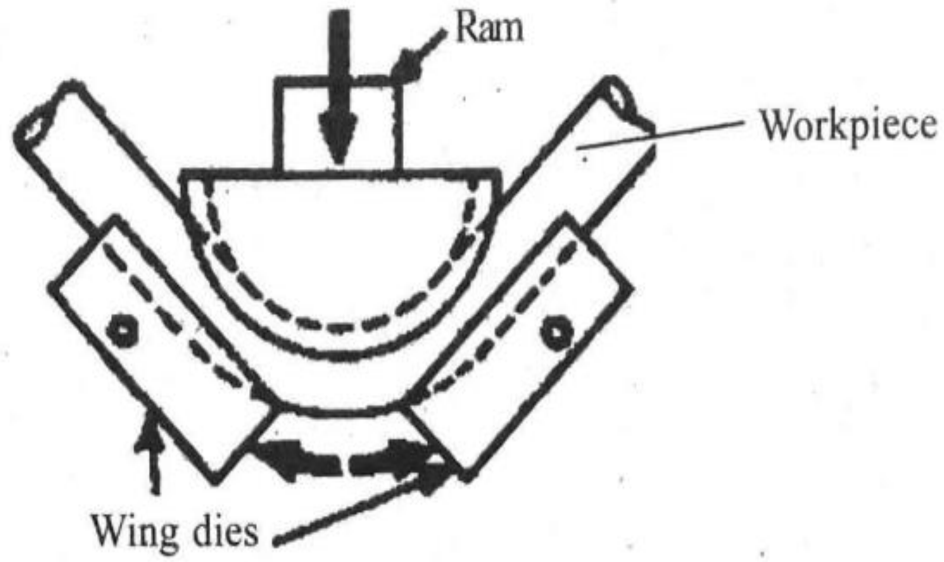


Fig. 2.11 Bending using ram type machine

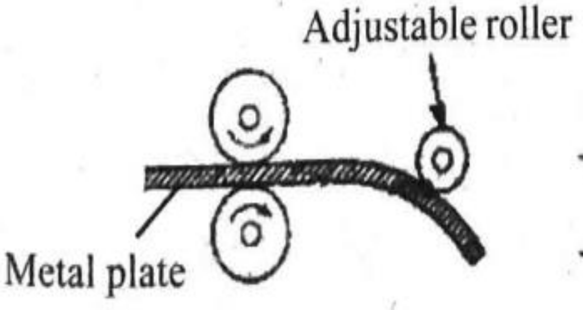


Fig. 2.12 Roll bending

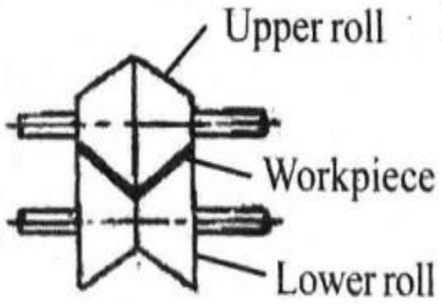


Fig. 2.13 Roll Forming

- A rotary type, roll bending machine is shown in fig.2.12.
- It is employed for bending metal plates and strips into cylindrical shapes.
- This machine is made with three rollers of similar diameter, two of them are fixed and one is adjustable. As the metal enters and passes through the rolls, its final curvature is determined by the position the adjustable roll.
- Another type of roll forming is shown in fig. 2.13. While designing dies and punches spring back of metals in bending should be considered.

SQUEEZING

It is a quick and widely used way of forming ductile metals. In squeezing, the metal is made to flow with in the cavity of die and punch, to attain the desired shape. This process requires a great amount of pressure and is usually performed in hydraulic presses. Some ofthe important squeezing operations are

(1) cold rolling

(2) Upsetting

(3) coining,

(4) cold heading.

(5) Hobbing

(6) shot peening. etc.

Cold rolling (squeeze rolling): In this process the metal is passed through a number of rollers thereby producing reduction in area until the required thickness is obtained. This process is mainly used for wrought iron products to give better surface finish, impart better tolerances and to improve surface properties.

Upsetting: It is a squeezing operation in which the metal is subjected to reduction in height or length with a corresponding increase in the cross sectional area.

Coining: Coins, medals and other similar articles are produced by this process. This operation is carried out in dies in which the metal is confined and restricted its flow in the lateral direction.

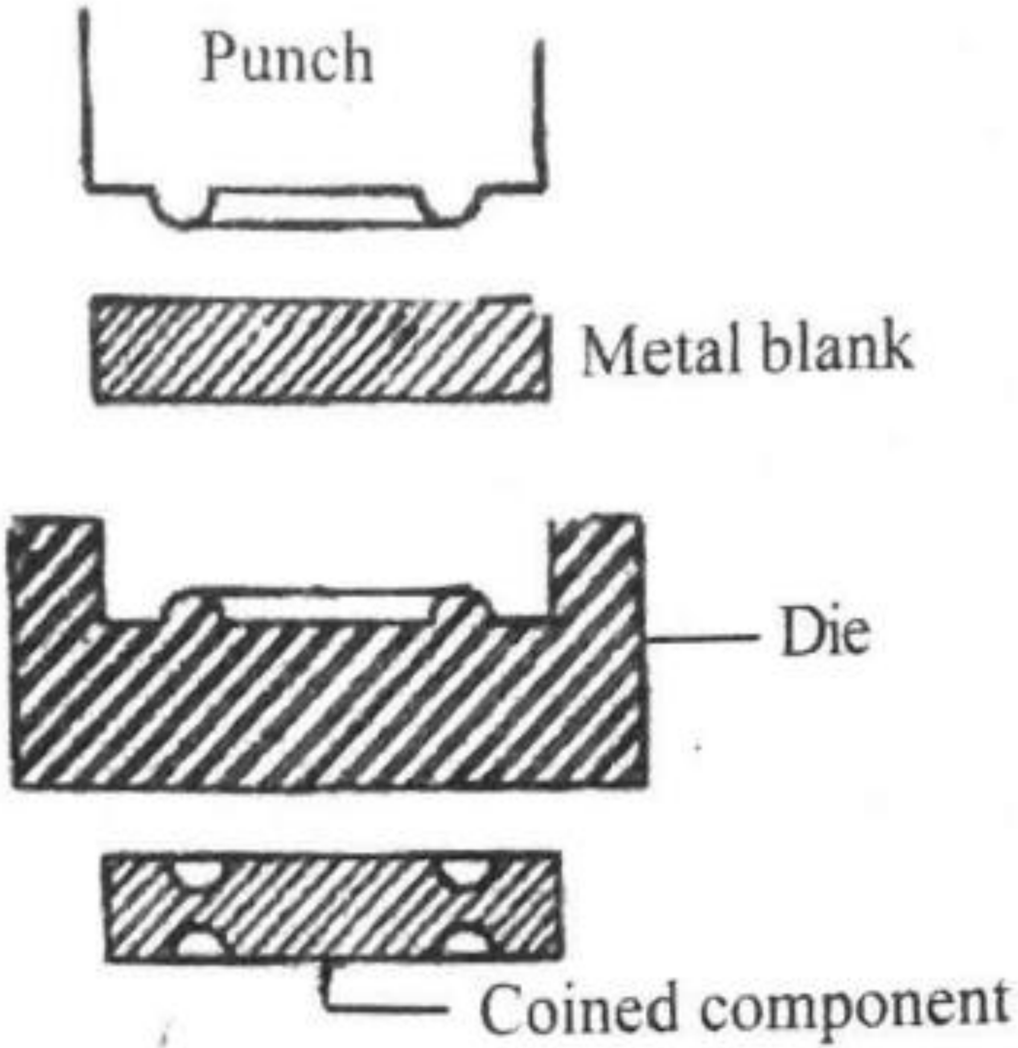


Fig. 2.14 (a) Coining

Embossing: In this process sheet metal is stretched to shape under pressure by means of a punch and die. A large number of ornamental wares, such as plates in sheet metal are produced by embossing. Refer fig. 2.14(b)

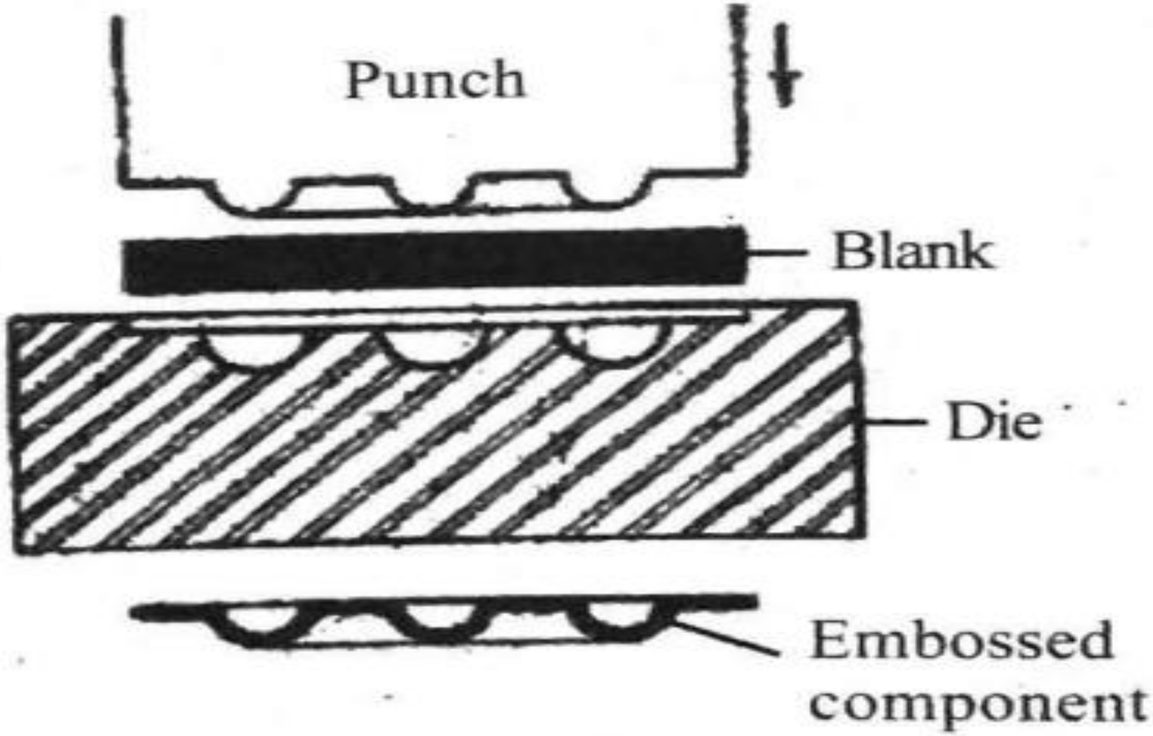


Fig. 2.14 (b) Embossing

Cold heading (Cold forging)

It is a form of swaging operation extensively used for making bolts, rivets, and other similar headed parts. A ductile metal rod having standard length is fed on to the machine, where it is held in a pair of jaws and subjected to two or three blows to form the head roughly. It is then repositioned in another die for final shaping and sizing.

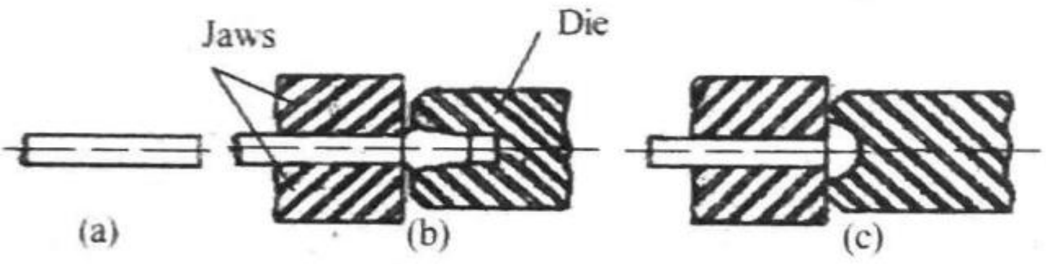


Fig. 2.15 Formation of a rivet head

Hobbing: It is a process of producing cavities in softer metals by forcing a hardened steel form or Hob. During the operation, a heavy retainer ring is placed around the metal blank. This process is extensively used in plastic and die casting industries. Refer fig 2.16.

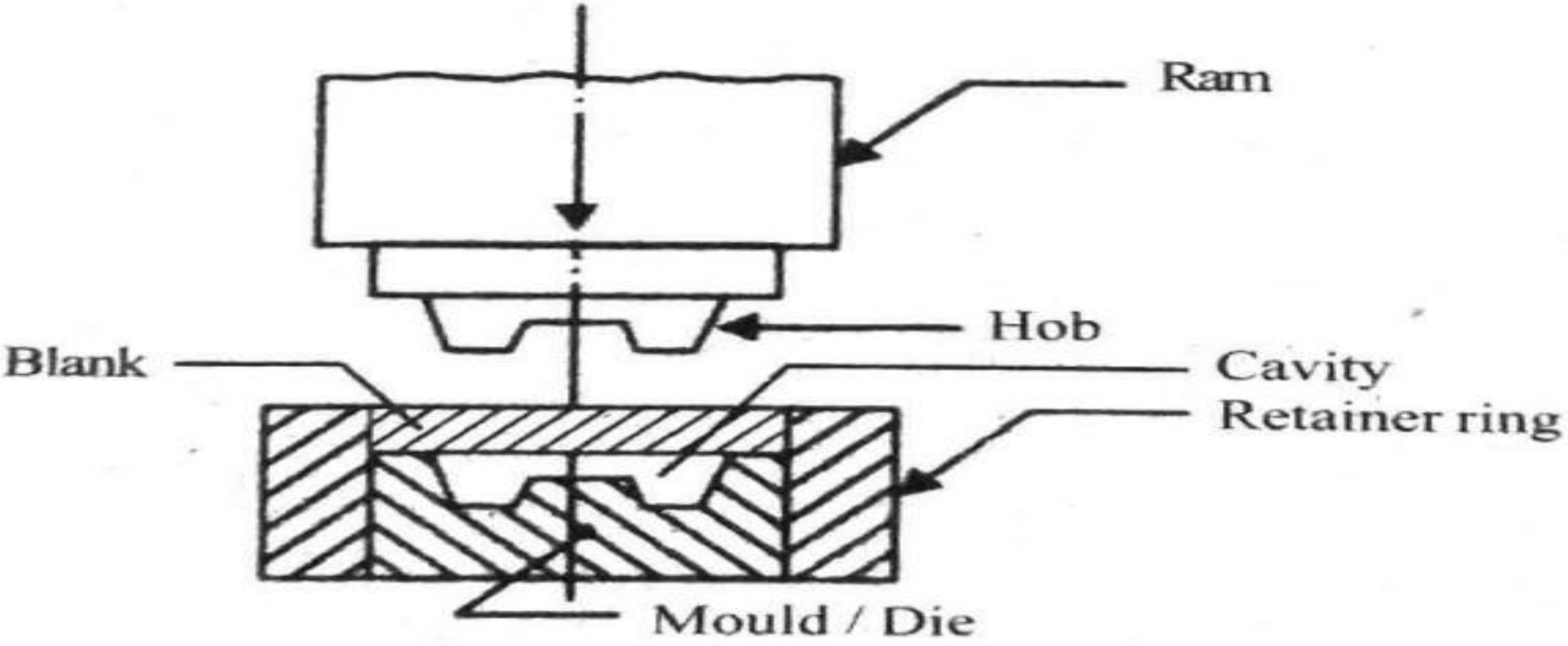


Fig. 2.16 Hobbing

SHEARING

This is a process of cutting the metal using the punch and die. The metal to be cut is placed between the punch and die as shown in fig. The punch descends upon the metal piece causing the shearing action. Some of the shearing operations are

(a) trimming

(b) punching and

(c) blanking. etc.

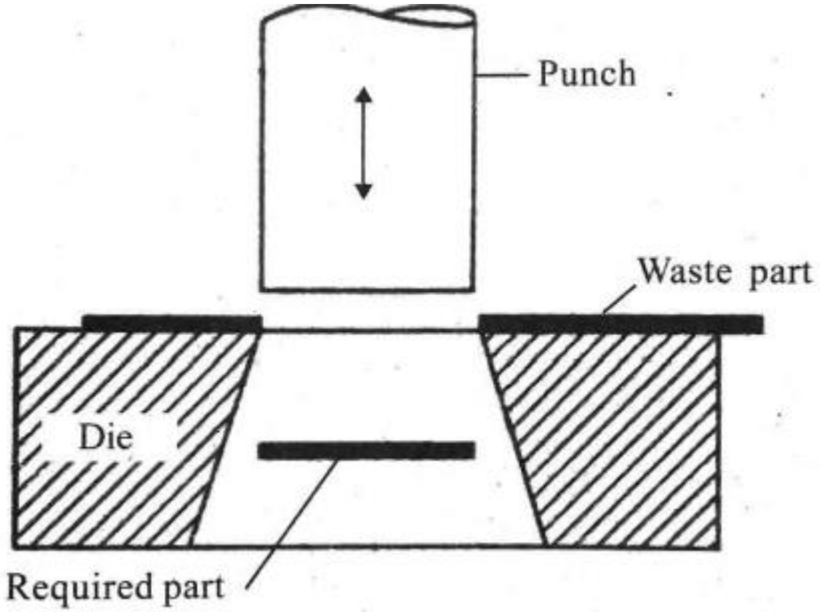


Fig. 2.17 Shearing operation

Trimming: It consists of removal or cutting away of excess material, left around the parting lines, in different operations. It is similar to blanking and is done on special type of trimming dies.

Punching (Piercing): It is an operation of cutting holes in a sheet metal using punch and die. The metal punched out goes as waste and the sheet with hole is the required product. Refer fig. 2.18 (a)

Blanking: It is an operation of cutting of flat sheet to the desired shape. The metal punched out is the desired product and the sheet with the hole left on the dies goes as waste. Refer fig. 2.18 (b).

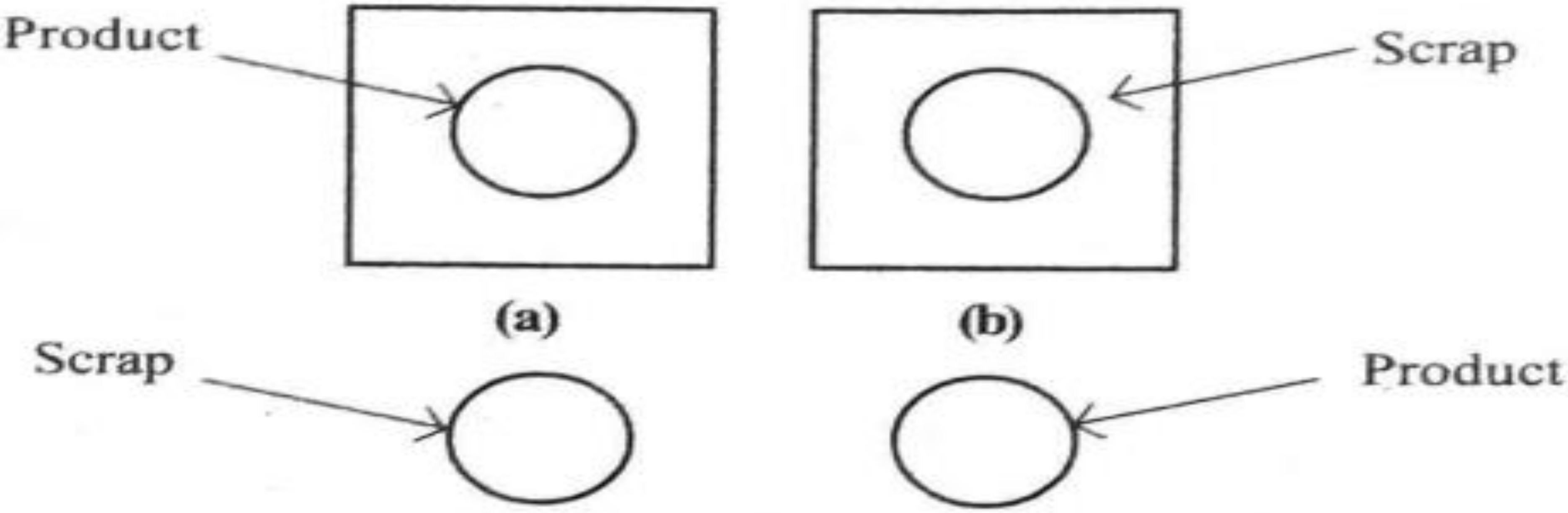


Fig. 2.18 (a) Punching (b) Blanking

COLD EXTRUSION

- The process of extrusion involves the flow of metal in its plastic state through a shaped die under pressure. The most common cold extrusion process is impact extrusion.
- Impact extrusion:- In this process of extrusion the working material is placed in to a blind hole of the die and a punch with clearance is forced in to the die which causes the metal to flow plastically around the punch. When the punch moves up, compressed air or stripper is used to separate the component from the punch. The application of the process are limited to soft and ductile materials such as lead, tin, aluminum, zinc and some of their alloys. The main advantages of this process is its speed, product uniformity and low scrap yield. This process is used for the manufacture of collapsible tubes, (for shaving cream, tooth paste, medicines. etc) condenser cans and other similar thin walled products.

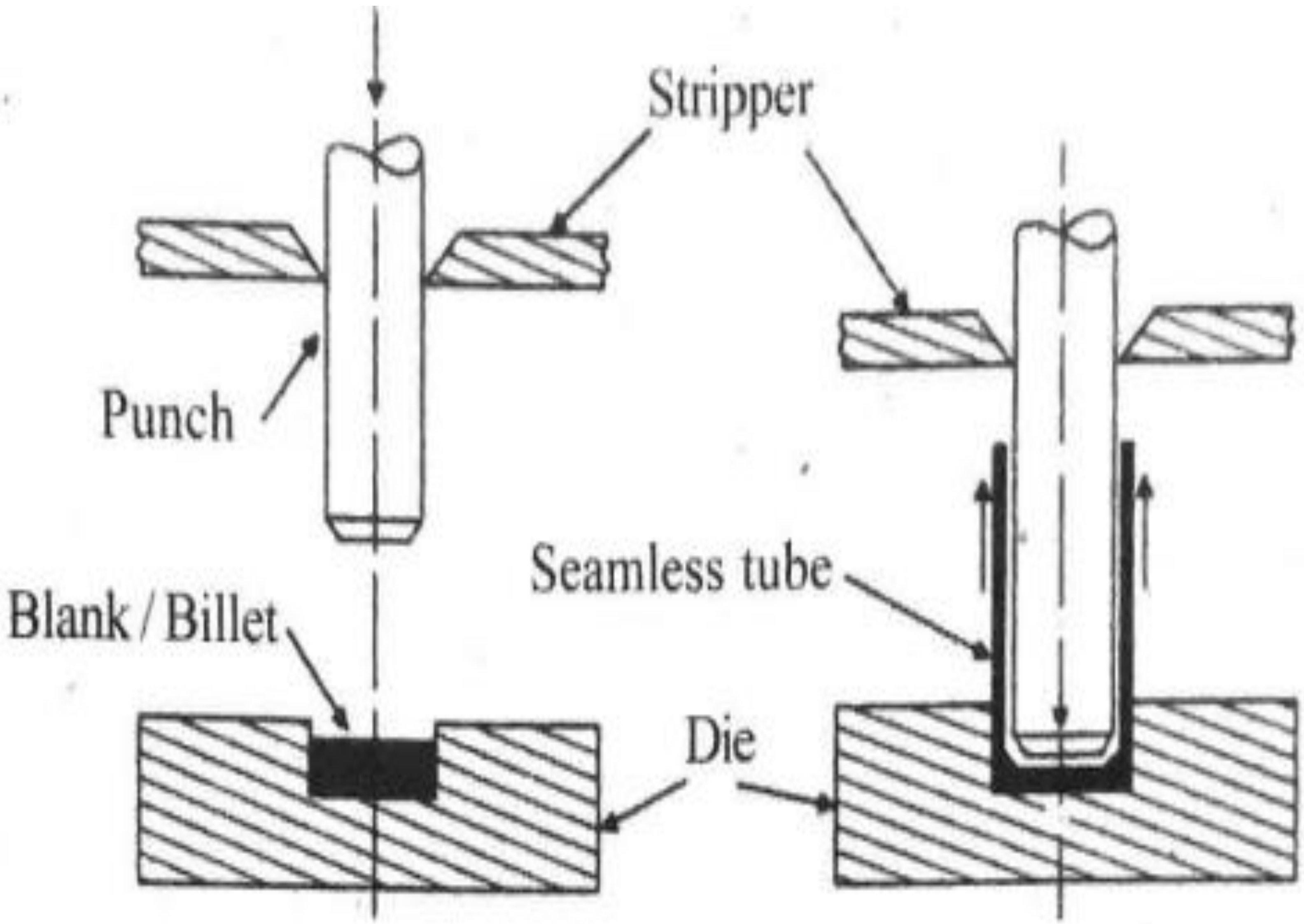


Fig. 2.19 Impact extrusion

HOT WORKING OF METALS

- Mechanical working of metals above recrystallisation temperature is termed as 'hot working'. Hot working combines the deformation and recrystallisation. In addition to mere change of shape, hot working effects the metal characteristics and properties. The changes in structure from hot working improve mechanical properties such as ductility, toughness, elongation percentage, reduction of area percentage, and resistance to shock and vibration.

Advantages

- Porosity of the metal is mostly eliminated
- Since the metal is worked above recrystallisation temperature refinement of grains (crystals) occurs.
- Impurities in the form of inclusions are broken up and distributed through the metal.
- Physical properties are generally improved due to refinement of grains.
- Energy required to change the shape is less compared to cold working.
- It is a rapid and economical process.

Disadvantages

- Close tolerances cannot be maintained.
- Tooling and handling cost is high.
- Rapid oxidation or scale formation takes place on the metal surface, leading to poor surface finish.
- Tool life is reduced as the tools have to work at high temperatures

HOT WORKING PROCESSES

The following are some of the important hot working processes.

(a) Hot rolling

(b) Hot piercing

(c) Hot drawing

(d) Hot extrusion

(e) Hot spinning

a) HOT ROLLING

Rolling is the most economical and rapid method of converting large sections in to desired shapes .The forming of bars, plates, sheets, rails, angles, I-beams and other structural sections are made by hot rolling.

The process of rolling consists of passing the hot billets through at least two rolls rotating in opposite directions at a uniform speed as shown in fig. 2.20.

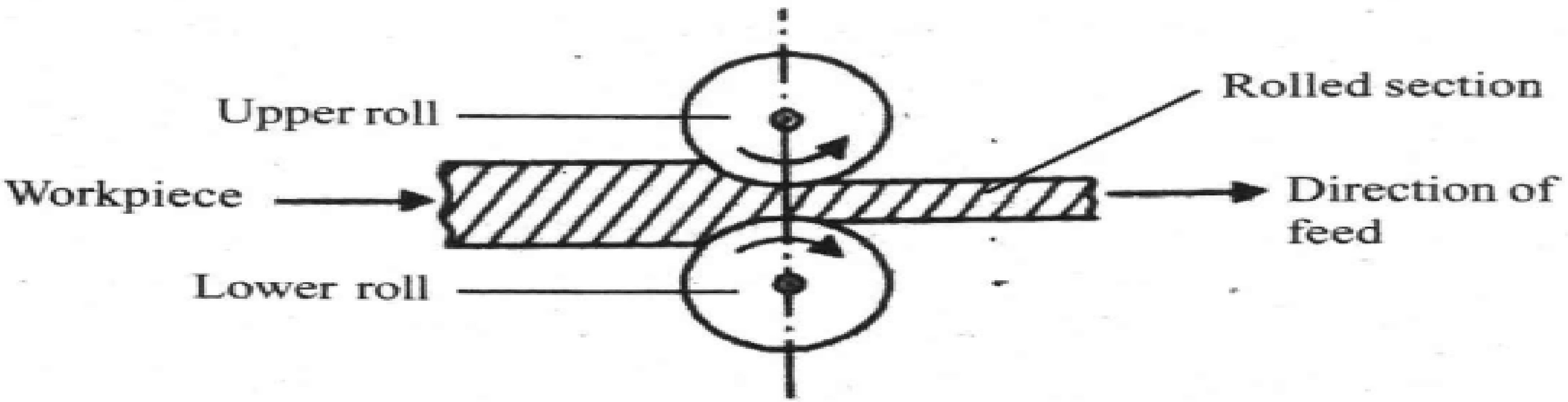


Fig. 2.20 Principle of Hot Rolling (Two high mill)

2.12 HOT DRAWING

It is mostly used for the production of thick-walled seamless tubes and cylinders. The process consists of two stages. The first stage consists of drawing a cup out of a hot circular plate with the help of a die and punch as shown in fig. 2.24 (a).

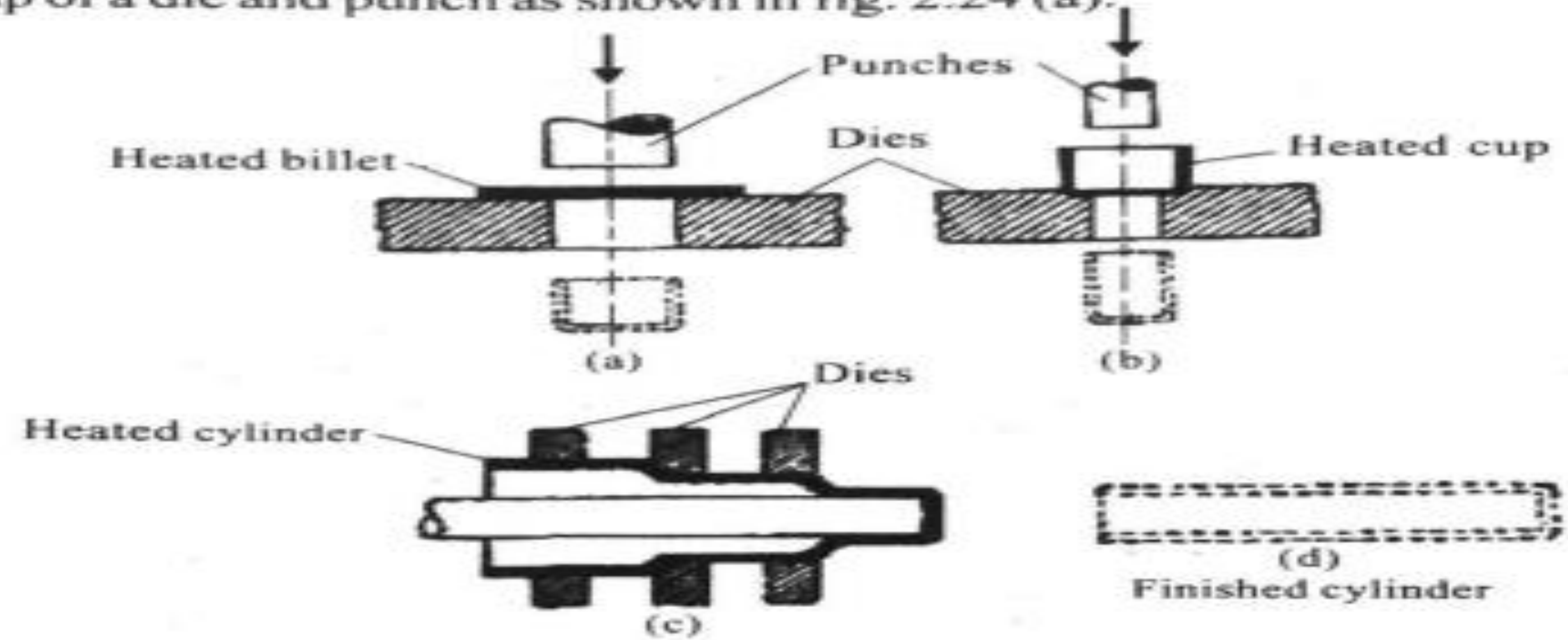


Fig. 2.24 Principle of hot drawing

The second stage involves repeated heating and drawing of this cup The drawing operation continued through a series of successively smaller dies arranged in horizontal draw bench to obtain seamless tubes and cylinders as shown in figures 2.24 (b), (c) and (d).

HOT EXTRUSION

It is the process of pushing a heated billet of metal through an orifice provided in to the die, thus forming an elongated part of uniform cross- section. The pressure applied is mechanically or hydraulically.

Zinc, lead, aluminum, copper, magnesium, nickel and their alloys are used for extrusion.

Methods of Extrusion

The extrusion processes can be classified as

1. Direct or forward extrusion
2. Indirect or backward extrusion
3. Tube extrusion

Direct or forward extrusion

In this case the raw material used is a billet. The heated billet is pushed by the press by operating a ram in the cylinder (container) through a small restricted opening of the die. The length of the extruded part will depend upon the size of the metal billet and cross- section of the die. The direct extrusion method is the most popular method, the extrusion press being mechanically simpler. For example solder wire is made by this method. Refer fig. 2.25.

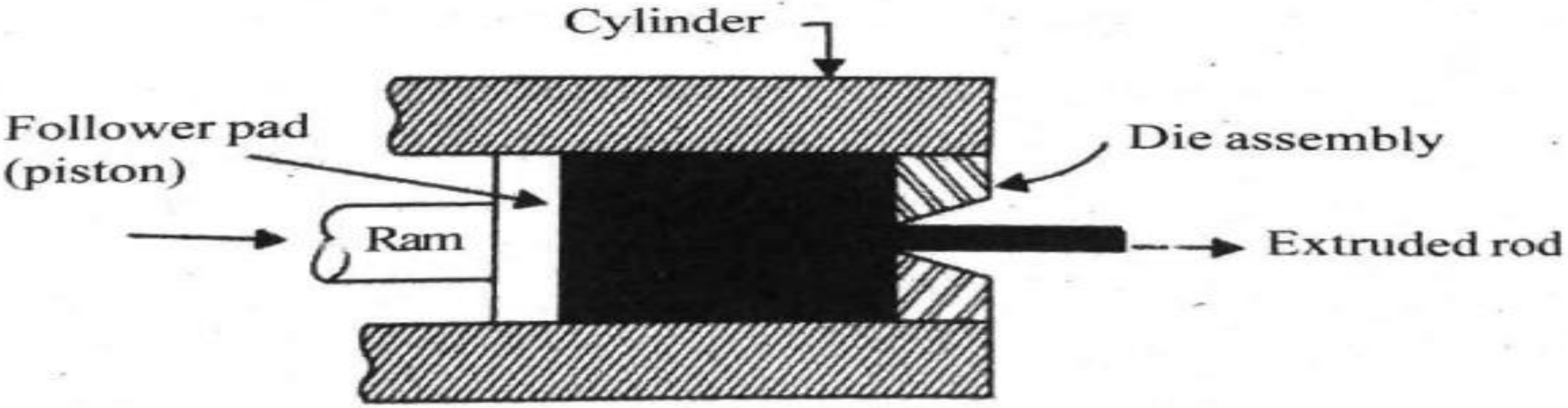


Fig. 2.25 Direct (forward) extrusion

Indirect or backward extrusion

It is similar to forward extrusion with the difference that the extruded metal is forced through the hollow ram as shown in fig. 2.26. In this case the force required to compress the metal is less but the equipment used is more complicated. The limitations of this method are weakening of the ram and impossibility of providing adequate support for the extruded part. This process provides a better quality product.

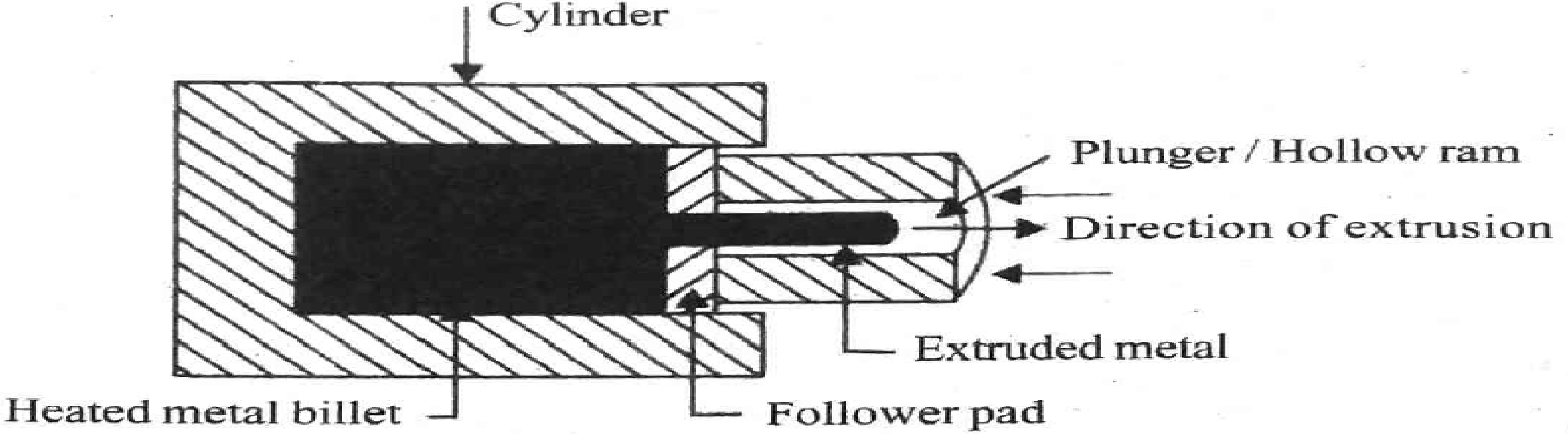


Fig. 2.26 Indirect or backward extrusion

Tube extrusion

This is a form of direct extrusion, but uses a mandrel to shape the inside of the tube. First the mandrel attached to the ram is pushed through the centre of the heated billet and the die,

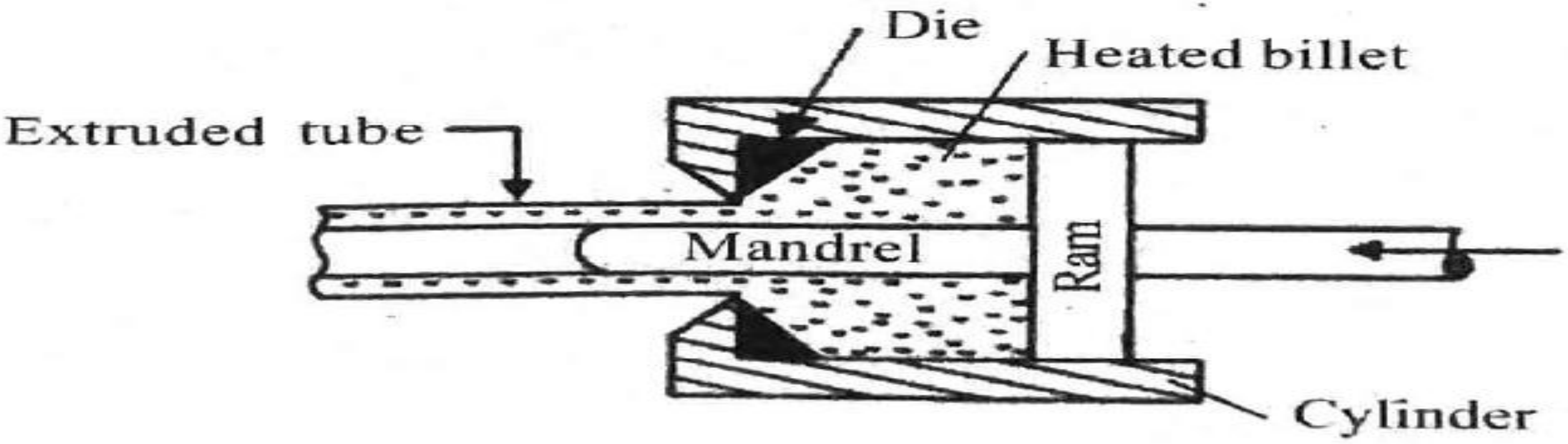


Fig. 2.27 Tube extrusion

followed by applying pressure on the billet by advancing the ram. The metal flows through the opening between the die and the mandrel. Refer fig 2.27. The method is used to produce seamless tubes.

HOT SPINNING

Hot spinning is the proces of shaping sheet metal by pressing against a form, while it is rotating. Fig 2.28 shows a hot spinning operation. A heated blank is pressed against a metallic form attached to the lathe head stock, by an adapter. A spinning tool with blunt edge is used and while the lathe rotates, the blank is forced to the shape of the form. Metals like aluminum, copper, brass and mild steel are suitable for hot spinning. The articles like kettles, cooking utensils, liquid containers and light reflectors are produced by this method.

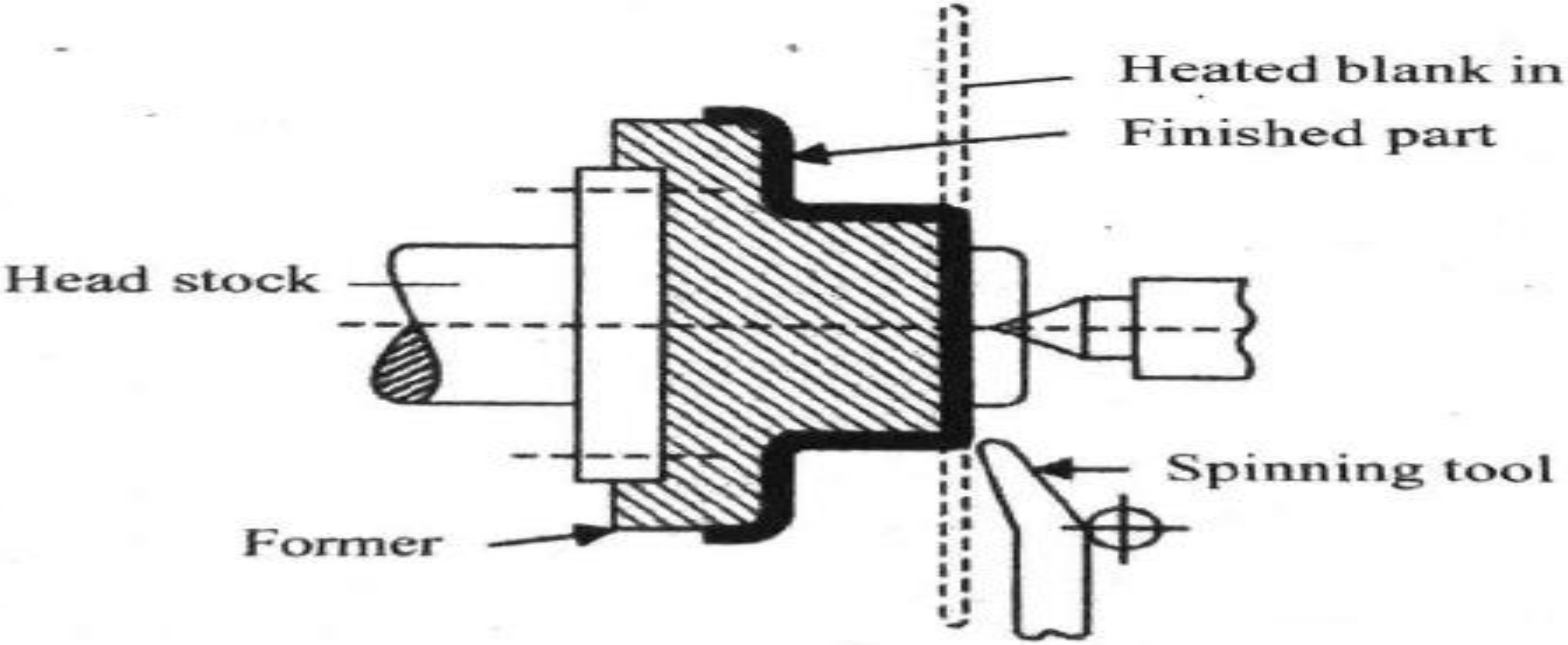


Fig. 2.28 Hot spinning

2.11 HOT PIERCING (ROLL PIERCING)

It is the process to produce seamless tubes. In this process cylindrical billets are passed between two conical shaped rolls. Fixed mandrel, assists in the piercing and controls the size of the hole as the billet is forced over it. This operation produces a longer tube with specified wall thickness. The process is carried out in hot conditions. It is also known as roll piercing.

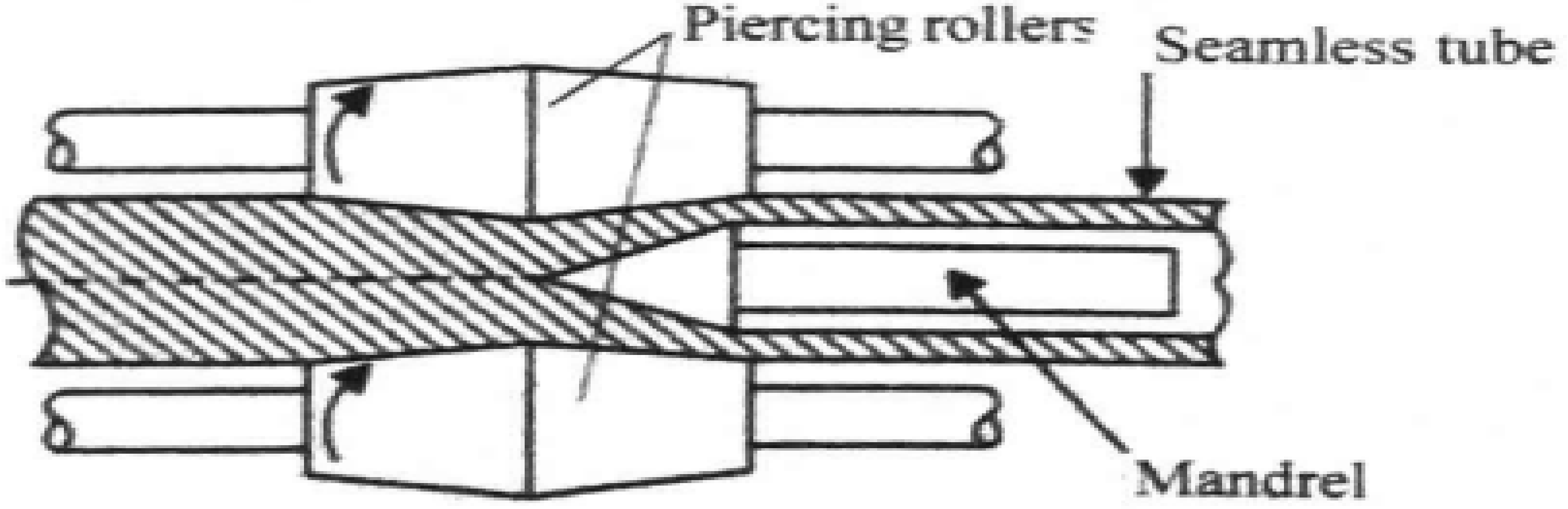


Fig. 2.23 Piercing process

2.11 POWDER METALLURGY

Powder metallurgy is the process by which fine powdered materials are blended, pressed in to the desired shape, and then heated in a controlled atmosphere to attain strength and other properties. It is one of the cheapest mass production process for manufacturing high quality, high strength, complex parts with a high degree of accuracy.

Basic steps in powder metallurgy process

The production of a component by powder metallurgy involves the following four steps.

1) Powder manufacture
2) Mixing and blending
3) Compacting
4) Sintering

Processing Stages of Powder Metallurgy

- First the primary material is powdered and divided into many small individual particles.

- Two or more metal and or non metals are mixed or blended together to form a homogeneous mixture.

- The blended mix is introduced into a mold cavity or a die and pressed to produce a weak cohesive mass called as green compact.

- The green compact is then subjected to very high temperature and pressure for a known time to get a hardened mass.

Steps involved in PM technique

1. Preparation of powders: very fine powders are obtained using various techniques.

2. Blending of powders: The fine powders are mixed along with a lubricant. The lubricant helps in imparting good fluidity to the powders.

3. Compacting: The blended powder is compacted in a mold or die.

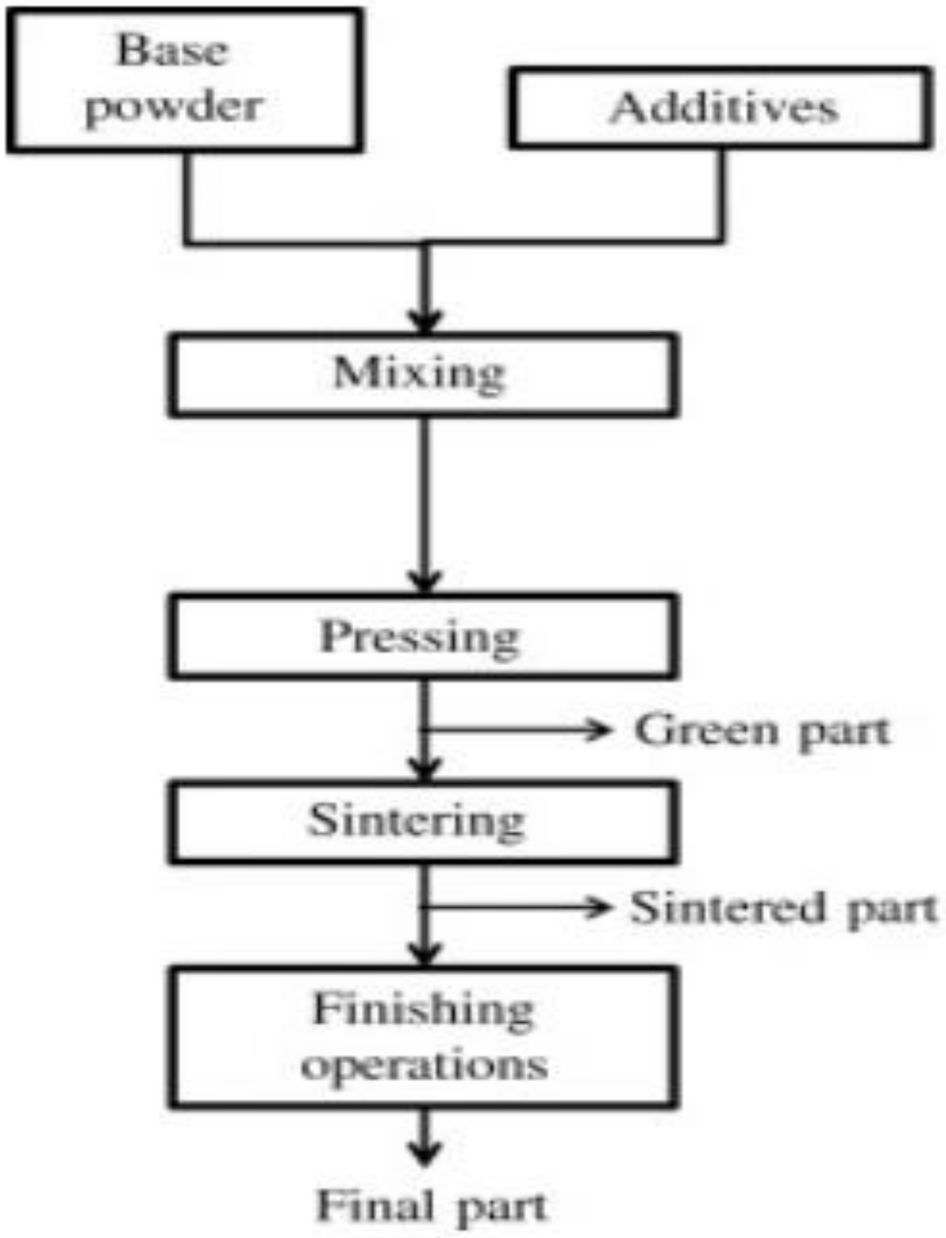
4. Sintering: The compacted mass is sintered at a high temperature in a furnace in a controlled atmosphere.

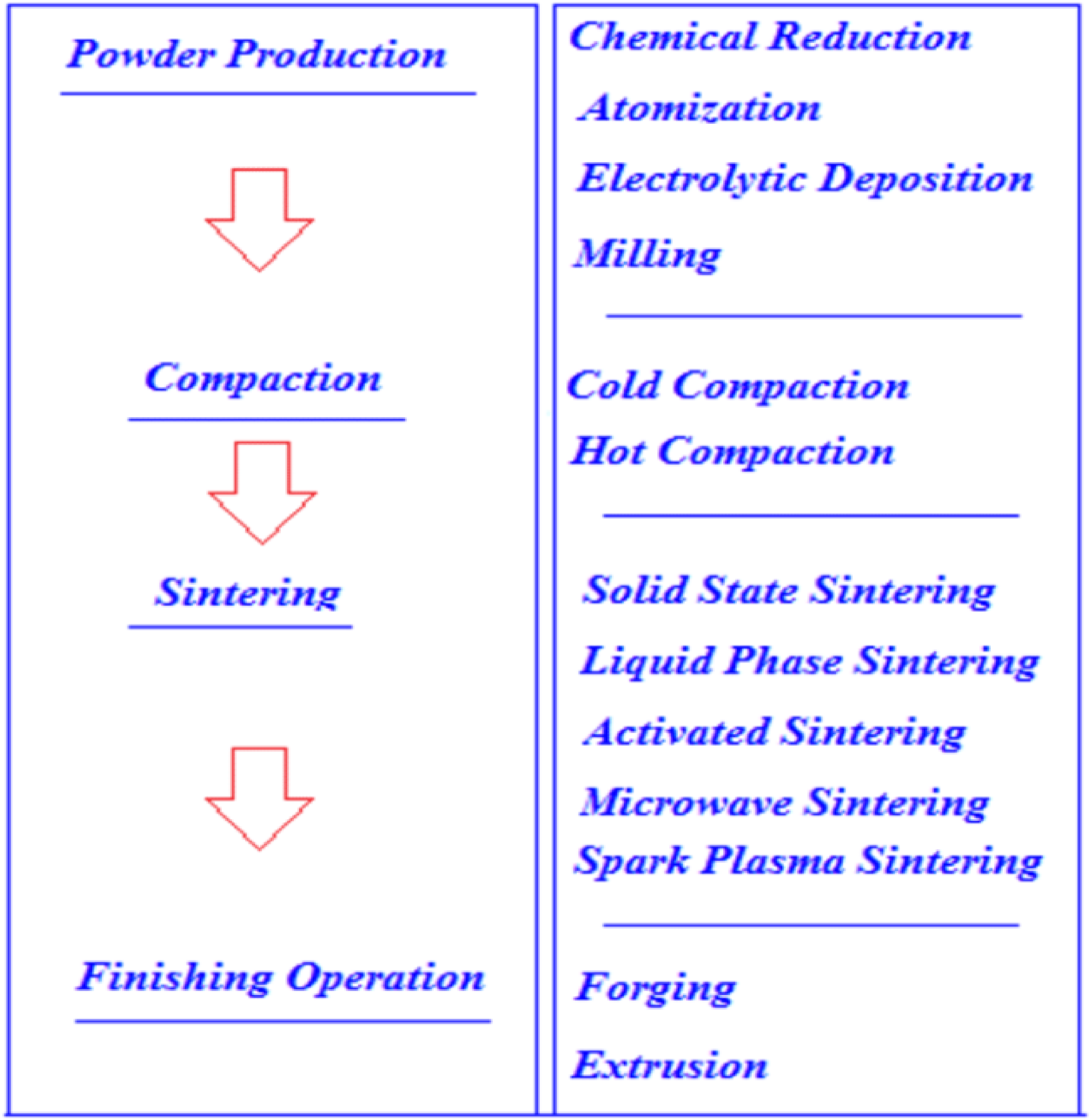
5. Sizing: The sintered component is passed in a mold or dies to trim the component and achieve high dimensional accuracy.

6. Machining: If required final machining is done on some specific locations including drilling very small holes.

7. Treatment: Parts are subjected to deburring and tumbling to remove any small projections and other treatments like oil impregnation tec., are given.

8.Inspection: Finally parts are inspected to check the quality .


Base powder
Additives
Mixing
Pressing
Green part
Sintering
Sintered part
Finishing operations
Final part


Powder Production
Compaction
Sintering
Finishing Operation
Chemical Reduction
Atomization
Electrolytic Deposition
Milling
Cold Compaction
Hot Compaction
Solid State Sintering
Liquid Phase Sintering
Activated Sintering
Microwave Sintering
Spark Plasma Sintering
Forging
Extrusion

- Advantages
  - Elimination or reduction of machining
  - High production rates
  - Complex shapes
  - Wide variations in compositions
  - Wide property variations
  - Scrap is eliminated or reduced
- Disadvantages
  - Inferior strength properties
  - High tooling costs
  - High material cost
  - Size and shape limitations
  - Dimensional changes during sintering
  - Density variations
  - Health and safety hazards

Some applicationsPM are as follows

- Used to produce porous parts e.g filters.
- Some components of tungsten employed in jet engines are made by powder metallurgy.
- Auto mobile components such as clutch plates, connecting rods, cam shafts and piston rings etc.
- Many types of hard and soft magnetic components.
- Grinding wheels are manufactured by using steel and diamond powder.
- Nozzle for rockets and missiles are made using silver infiltrated tungsten.
- It is used to produce complex shaped parts which require machining when produced by other methods e.g. gears.
- Electrical bushes for motors are made by combining metallic and non metallic material.
- Some parts used in clocks, type writers, calculators, permanent magnet etc. are made by powder metallurgy

THANK YOU