MODULE-II

1.0 Solidification of Casting

After the molten metal/alloy is poured into the mould, a series of events takes place during the solidification of casting. The material is cooled down to ambient temperature. During cooling of casting the following events take place.

* Liquid shrinkage - Due to cooling of liquid ~~at~~ metal at higher temp. to m.p.

* Solidification shrinkge - During phase change from liquid at m.p. to solid at m.p.

* Solid shrinkage - Due to cooling of solid from mp to room temperature.

* Due to solidification of liquid metal dissolved gasses will try to escape from the casting through mould wall.

* These events greatly influence the

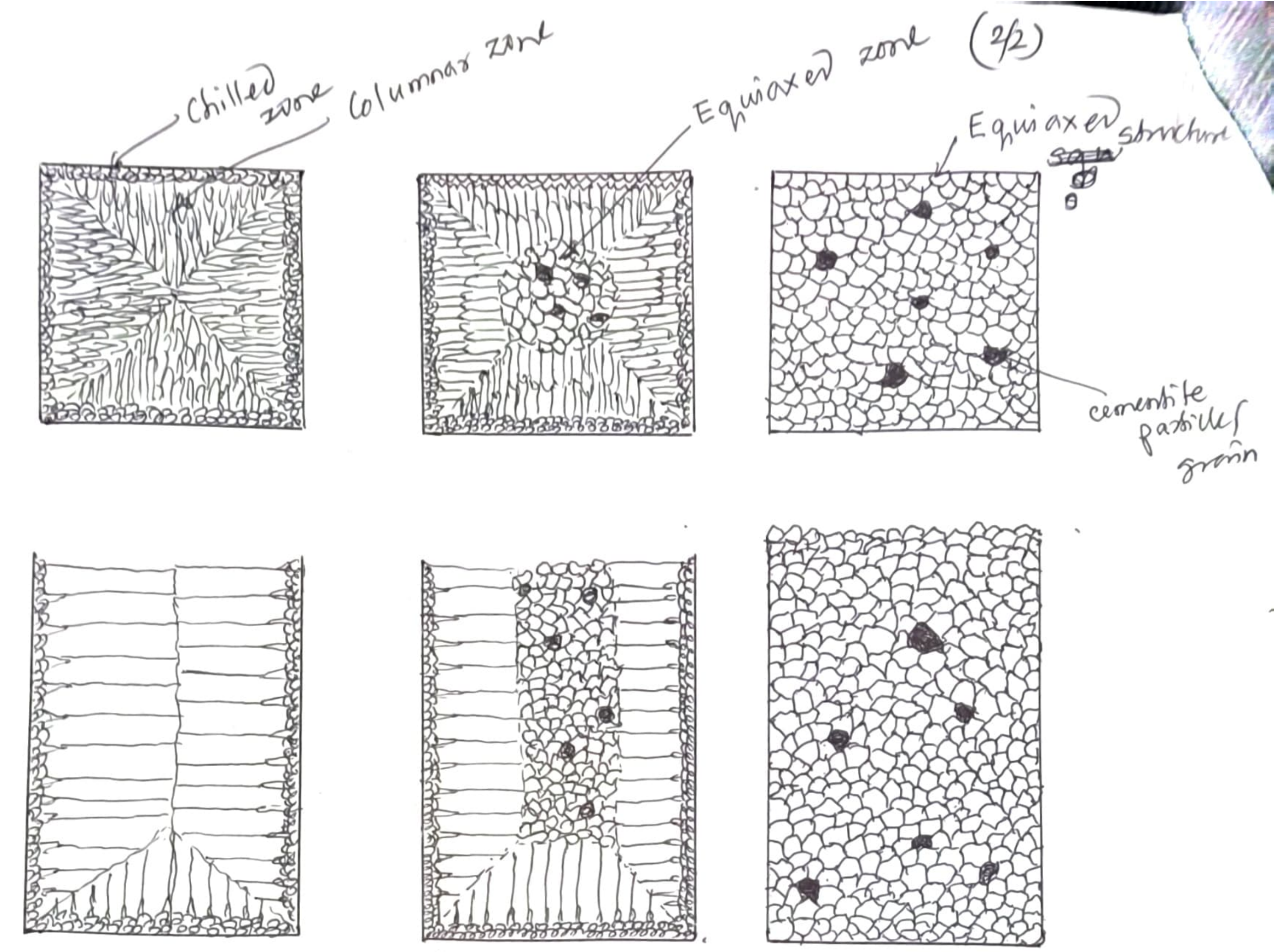
  ✓ size
  ✓ shape
  ✓ uniformity of chemical composition
  ✓ " " grains
  & ✓ diff. casting defects

throughout the casting.

The usual grain structure of

(i) Pure metal
(ii) Alloy and
(iii) Alloy with nucleating agent

in a square mould is shown in the following to know the differences in grain structure and



(a) Pure metal (b) Alloy (c) Alloy with nucleating agent.

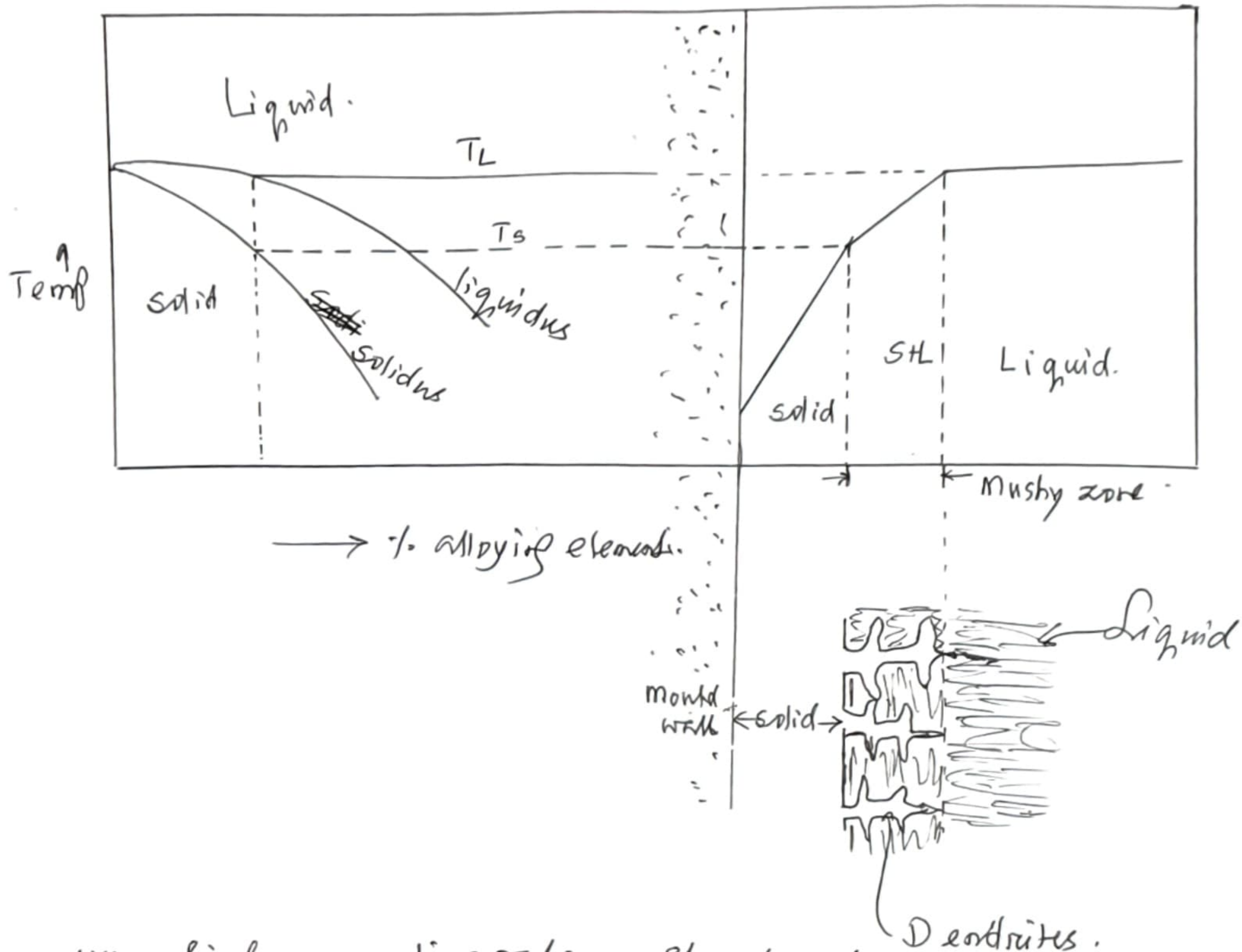
ultimately the property of casting

In case of pure metal due to rapid cooling near to mould wall, fine equiaxed grains are produced. The grains grow in a direction opposite to that of heat transfer through out the mould. These are columnar grains

In case of an alloy, solidification begins when the temperature drops below the liquidus, T_L and is complete when it reaches solidus, T_S. Within this temperature range, the alloy is in a mushy or pasty state with columnar dendrites (meaning tree)

Effect of cooling rate

Slow cooling rate → coarse dendrites
faster " " → finer "



For still higher cooling rate - structure becomes amorphous

The structure developed and the resulting grain size influence the property of casting.

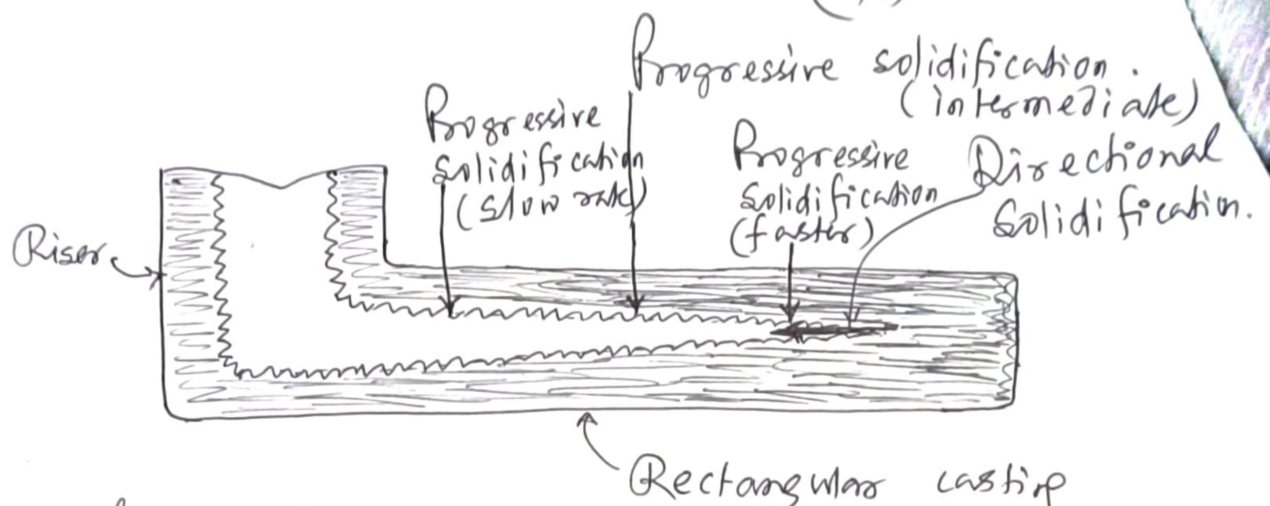
* As grain size decreases → the strength ↑ & ductility ↓
  → microporosity ↓
  → the tendency of casting to crack ↓
* Reverse is the case for bigger grain size.
* Lack of uniformity in grains size and grain distribution ⟶ anisotropic casting properties.

2. (c) Types of Solidification

Basically there are 2 types of solidifications take place in the casting.

(i) Directional Solidification

& (ii) Progressive Solidification



Casting has various sections.
All parts donot cool at same rate. Some part tend to solidify more quickly than other. These contraction causes voids and cavities in certain region of casting (if no riser is provided). The riser feeds liquid metal to compensate the shrinkage and voids are avoided. Hence the solidification direct towards the riser point which should be the last to solidify. This solidification is known as directional solidification.

Progressive solidification occurs at right angles to the direction of directional solidification. The rate of progressive solidification should be at fast rate in the extreme end and slow rate near to riser point and intermediate rate inbetween, otherwise void in the casting may occur. The directional and progressive solidification can be properly controlled by

(i) Design and positioning of riser
(ii) Use of padding (excess metal added to casting to favour directional solidification)
(iii) Use of exothermic materials in riser
(iv) Use of chills (metal inserts placed in the mould to allow solidification to start there).

© Special Casting Techniques

In the recent years, special casting techniques have been developed. A list of special casting techniques is stated in the following.

1. Shell mould casting
2. Precision Investment Casting
3. Permanent Mould casting
4. Die casting
5. Vacuum Die Casting
6. Low Pressure Die Casting
7. Centrifugal Casting
8. Continuous Casting
9. Slush Casting
10. Squeeze Casting
11. Vacuum Casting
12. Plaster mould Casting
13. Ceramic " "

© Advantages of special Casting over sand casting

1. Very smooth surfaces are obtained.
2. Very tight dimensional tolerance can be achieved.
3. Reduced cleaning and machining cost
4. Gives rapid production rates
5. Uniform grain structure
6. minimum finishing operation.
7. Complex shape can be produced with less labour
8. Less effort and skill is required for moulding
9. Expenses is less
10. Overall productivity can be improved.

© Special Casting Process - Die Casting

In die casting components are prepared by injecting molten metal at high pressure (·7 → 700 MPa) into a metallic die

In die casting, the die consists of 2 parts

one is the stationary half (= cover die)

and the other is moving half (= ejector die)

The moving half is moved out for the extraction of casting. The parts made from die casting are

* carburattor
* appliances components
* hand tools
* toys etc.

Die casting are of 2 basic types

(a) Hot chamber Process

(b) Cold Chamber Process

(a) Hot Chamber Process

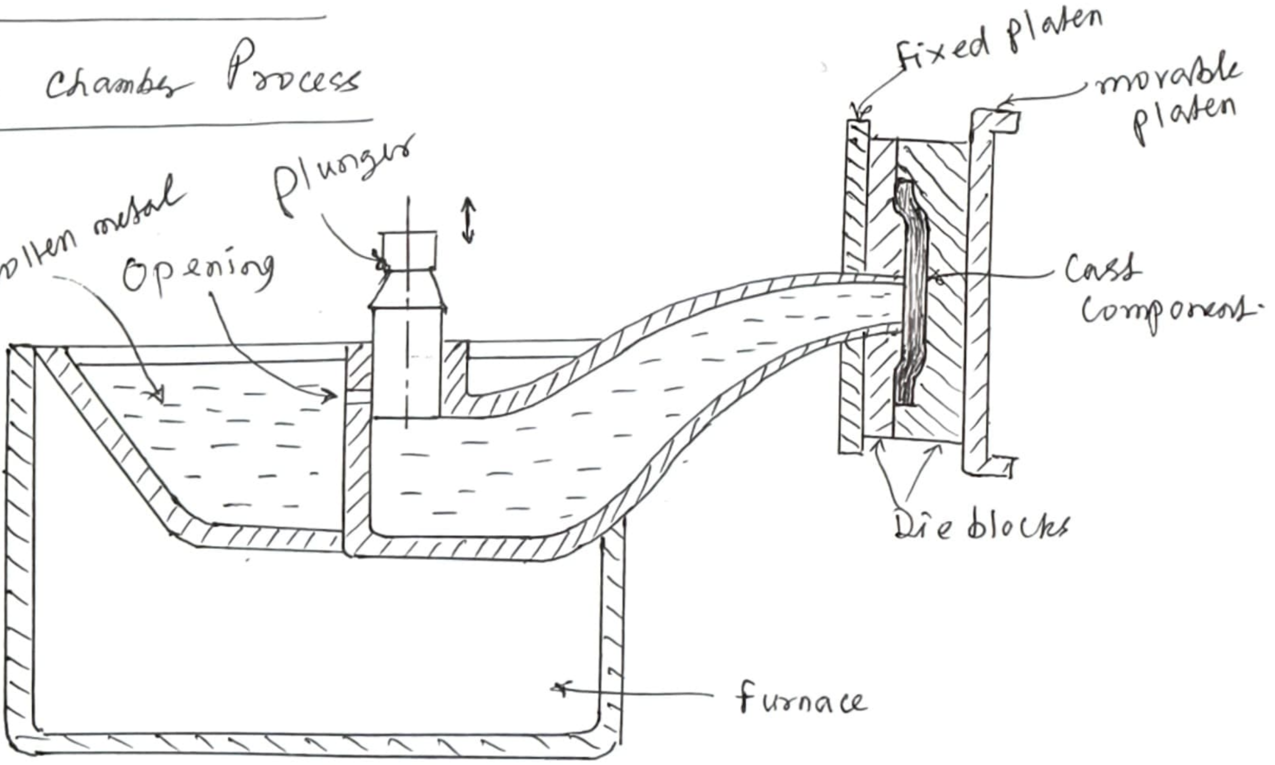


Fig- for Plunger type hot chamber die casting m/c

Process description:

→ It consists of a suitable furnace for ✓ melting and ✓ holding the material

→ When the plunger is raised → opening uncovered
⇒ molten metal fills the cylinder.

→ The two die halves are closed and held by 2 platens.

→ Then the molten metal is forced into the die cavity either by hydraulic pressure or air pressure applied to plunger.

→ As soon as the metal solidifies, the pressure on the metal is relieved and the plunger travels upward to its original position

- Then the dies open by moving movable platen
- The casting is removed by ejector pin

(Note: It may be noted that in another type, direct compressed air is applied to molten metal to force into die cavity)

(b) Cold Chamber Die Casting

Aluminium is not suitable for hot chamber die casting process. and goes for cold chamber die casting process. This process is explained as follows.

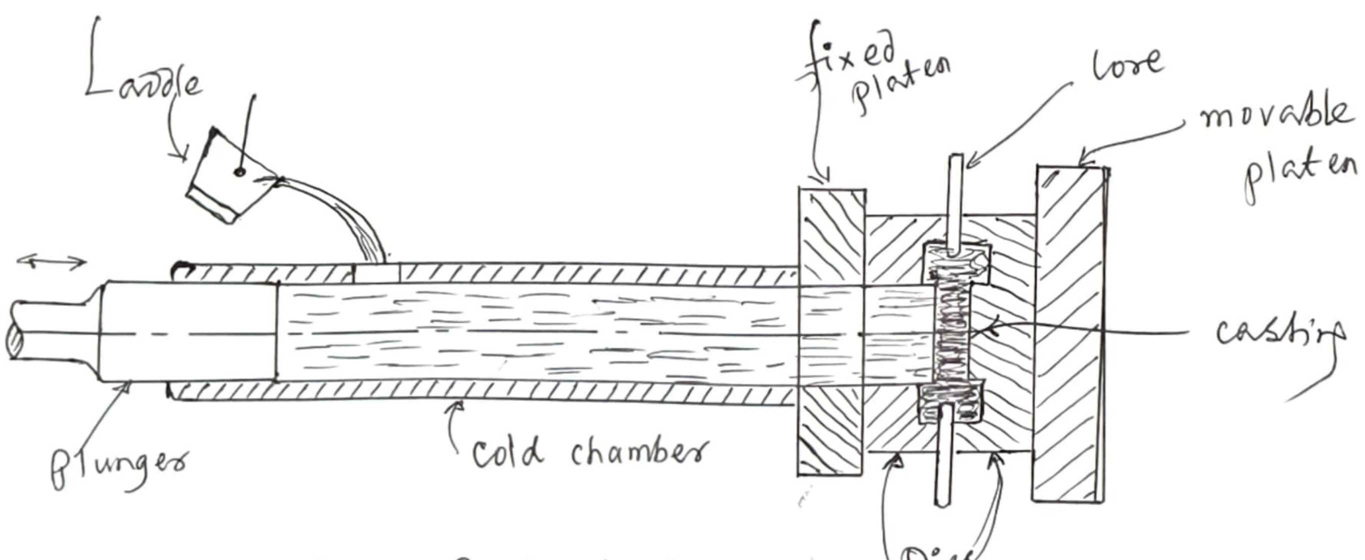


fig → Cold chamber die casting m/c.

→ It consists of a horizontal steel cylinder into which molten metal is quickly introduced by a laddle

→ After filling is done, the plunger is allowed to move through cold chamber forcing the metal into the die.

→ After a sufficient time period, (for solidification) the die automatically opens.

As the die opens, some portion of hot metal at the end solidifies. It is pushed out (called buiscuit)

→ Operation of cold chamber die casting is slower as compared to Hot chamber die in operation.

Advantages of Die Casting Process

1. Complex casting can be produced due to the use of movable core.
2. Very small thickness can be easily filled due to injection of high pressure liquid metal
3. Very high production rate (i.e. 200 nos/hr)
4. The process can be automated
5. Because of metallic die → good surface finish is achieved.
6. Close dimensional tolerances of the oder of ±0.08 mm.
7. The die life is long. (i.e. 300000 pieces for Zn alloy & 150000 " " Al alloy.)
8. Better mechanical properties than sand castin products.
9. Very economical for large scale production.

Disadvantages

1. The maximum size of die cast product is limited to 4 kg normally but rarely goes upto 15 kg.
2. Not suitable for all materials because of limitation of die materials. Normally, Zn, Al, Mg & Cu alloy are die cast.
3. The air in the cavity gets trapped inside the casting
4. The dies & m/c are very expensive.
5. Die life is less due to high temp. molten metal.

(c) Centrifugal casting

In centrifugal casting process, the mould is rotated about the central axis while metal being poured into it.

ADV: Because of centrifugal reaction force, a continuous pressure will act on the metal during solidification as a result of which lighter materials like slag + oxides + other inclusion float at the centre and can be separated out.

Centrifugal Casting
- (a) True Centrifugal Casting
- (b) Semi Centrifugal Casting
- (c) Centrifuging

(a) True Centrifugal casting (TCC)

→ Used to produce hollow pipes, tubes (Ex gun barrel, C.I. pipe).

→ Axis of rotation
- Horizontal (long pipe)
- Vertical (short pipe)
- or in any angle.

→ Mould is made of steel / iron / graphite, and maybe coated with refractory lining

→ Delavaud process is popular – for making socketed C.I pipe.

→ It consists of a metal mould / die surrounded by cooling water

→ The machine is mounted on a wheel ⇒ It can travel as shown below. The metal is poured as shown

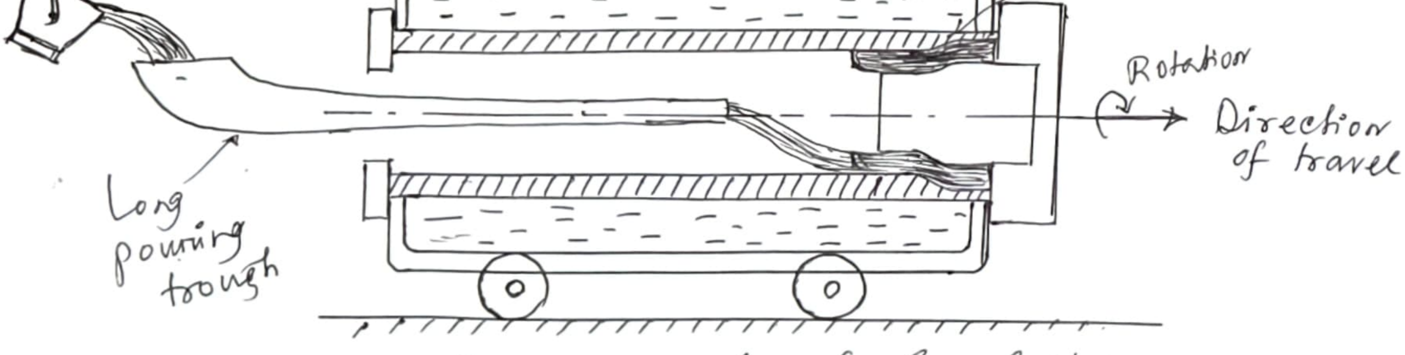


Fig. For True Centrifugal Casting

→ mould is rotated and travel simultaneously.

→ The rotation should be such that centrifugal force = 75 times the force due to gravity.

Advantages

1. The mechanical properties of centrifugally cast jobs are better as compared to other processes because, the inclusions such as slag and oxides get segregated towards the centre and can be easily removed by machining.
2. Proper directional solidification can be obtained
3. No core is required for making concentric hole.
4. No need of gates and runners.

Limitations

1. Only concentric holes are suitable
2. The equipment is expensive.

(b) Semi Centrifugal Casting

→ Used to produce casting with symmetrical about central axis. Ex.- wheels, gear blanks, grooved pulley etc.

→ Casting shape is more critical as compared to TCC.

→ Central hole may or may not be present. If present, core is used.

→ A central sprue is provided.

→ Spinning speed is less as compared to TCC.

→ The mould may be
* green sand mould
or, * dry sand mould
or, * metal mould.

The schematic drawing for Semi-Centrifugal casting is presented in the following.

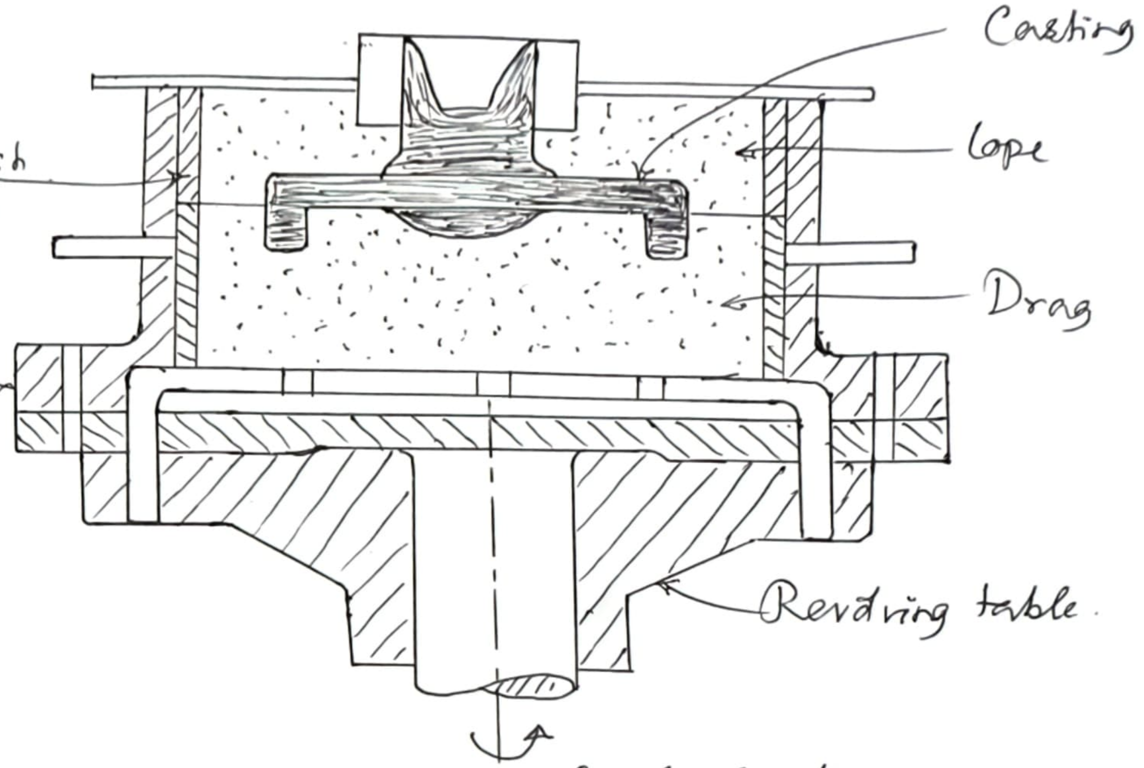


Fig. for Semi Centrifugal Casting.

(c) Centrifuging

→ Used for small casting of any shape.

→ According mould cavity of any shape as shown aside is placed at a certain distance from the central axis.

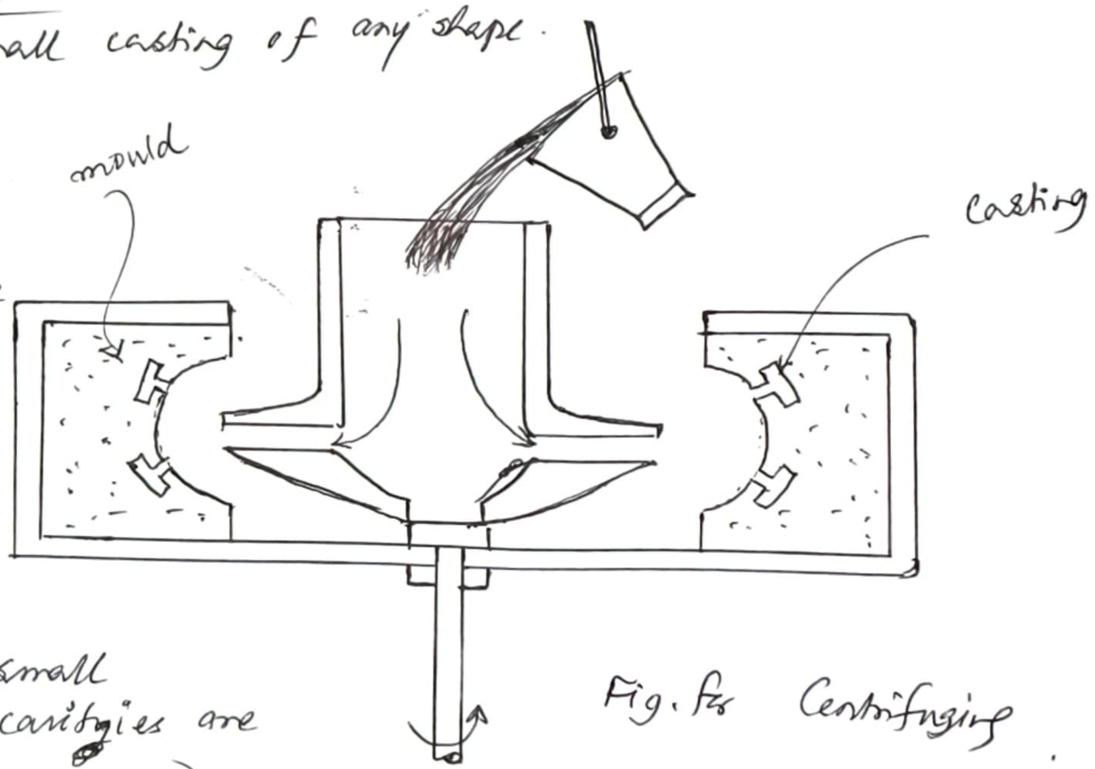


Fig. for Centrifuging

→ A no. of small mould cavities are arranged around a central sprue. ~~and connected to moulds by radial gate~~

(2/12)

→ Mould cavities are connected to central sprue by radial gate as shown in the figure.

→ The jobs are uniformly placed on the table around the periphery so that masses are properly balanced.

→ This process is similar to semi-centrifugal casting

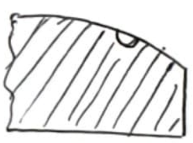
(c) Casting Defects

The major defects found in sand casting are due to

* Improper design of casting and pattern
* Inappropriate moulding sand, design of mould and core.
* metal composition /metallurgical defects.
* Improper degasification
* Gating and risering defects.

Figs. for different defects: and description →.

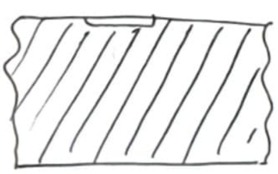
(1)



(i) Blow

→ Large well round cavity on convex casting surface.
→ Generally appear in the cope part.
→ Due to entrapment of gas.
→ Eliminated by proper venting.

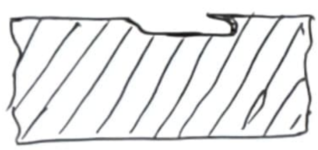
(2)



(ii) scar

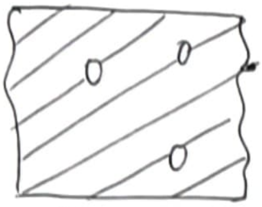
→ Shallow blow in flat casting surface.
→ Eliminated by proper venting

(3)



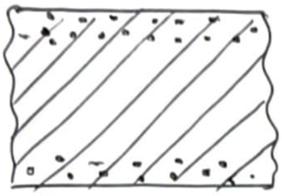
Blister

→ It is a scar covered by thin layer of metal
→ Eliminated by proper venting.

(4) 

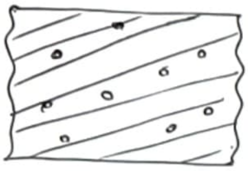
Gas holes

→ Entraped gas holes
→ Nearly spherical shape.
→ Eliminated by proper degasification and venting.

(5) 

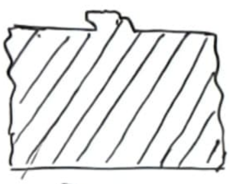
Pin holes

→ Tinny blow holes just below the surface.
→ It occurs due to hydrogen gas escape.
→ Eliminated by degasification.

(6) 

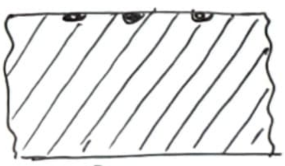
Porosity

→ Very small holes – uniformly distributed.
→ Occurs due to escape of hydrogen.
→ Eliminated by proper degasification

(7) 

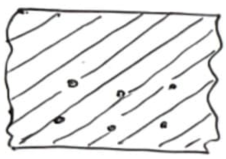
Drop

→ Irregular projection due to dropping of sand
→ Eliminated by adequate sand strength.
→ " " proper ramming.

(8) 

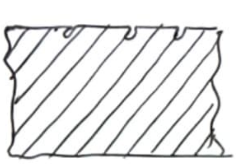
Dross

→ Lighter impurities appear on the top surface of casting
→ Taken care at pouring time using strainer and skim bob.

(9) 

Inclusion (non metallic)

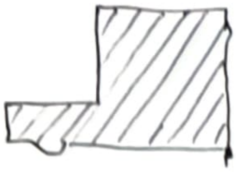
→ Due to presence of non-metallic particles in the metal matrix
→ Eliminated by maintaining smooth metal flow so that the molten metal can't take mould material through errosion

(10) 

Dirt

→ Angular grooves/holes on the top surface of casting due to embedment of sand particles.
→ Eliminated by putting most critical part of casting in the drag.

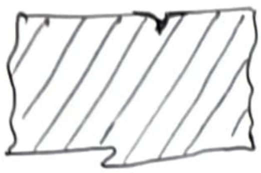
(11)



Wash

→ Low projection near gate
→ Due to erosion of sand
→ Eliminated by reducing velocity of molten metal

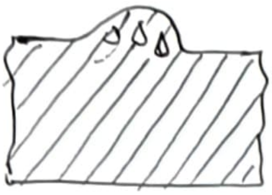
(12)



Buckle

→ Long, fairly shallow V shaped depression
→ Occur in case of high m.p. metal casting (due to expansion of thin layer of sand)
→ Eliminated by addition of volatile additives

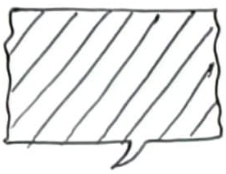
(13)



Scab

→ Rough thin layer of metal protruding above the casting surface
→ Avoided by ↑ of sand strength.

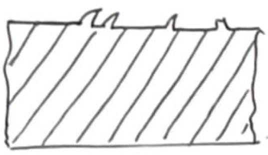
(14)



Rat tail

→ Long angular tail like ~~structure~~ projection
→ Due to evaporation of thin layer of sand
→ Eliminated by adding volatile additives

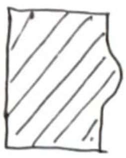
(15)



Penetration

→ Rough projection of metal.
→ Occurs if the mould surface is too soft and porous.
→ Eliminated by proper sand mix and ramming.

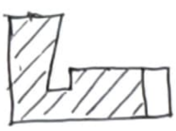
(16)



Swell

→ Projection on vertical surface of casting
→ Due to influence of metallostatic force on mould wall
→ Eliminated by proper sand strength and ramming.

(17)



misrun

→ Due to insufficient superheat of molten metal
→ The molten metal freezes before reaching the farthest point.

(18)

Cold shut

→ When 2 metal streams donot fuse with each other.

→ It occurs due to
- thin casting section
- improper gating
- slow pouring
- intermittent pouring
- poor fluidity of molten metal

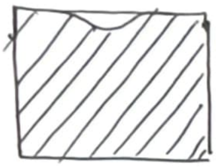
(19)

Hot tear

→ A crack is developed due to high residual stress.

→ It occurs due to poor casting design.

(20)



Shrinkage Cavity

→ Due to shrinkage during solidification

→ Due to improper riser design.

→ It can be eliminated by proper riser design.

(21)

(a) Mould shift (b) Core shift

Shift

→ Due to misallignment of 2 halves of mould.