UNIT - II

Introduction:- Melting Practice is an important aspect in casting operation. The quality of casting is depends on the correct casting temperature of molten metal. if the Temperature is low, the molten metal may not flow properly to fill the Mould cavity and if the Temperature of molten metal is high, the mechanical properties may suffer due to such Structure.

→ **Melting furnaces!-** The number of furnaces in the capacity range of few kilograms to upto 200tonnes are available for melting metals and alloys. The choice of furnace depends on following factors:

1) Temperature of casting and desired shape of metal.
2) Rate of melting and type of alloy being melted
3) Availability and cost of fuel
4) Capital and Running cost of the furnace.

→ **Types of furnaces:-** Based on type of Materials,

① For Gray Cast Iron: Cupola furnace, Air furnace [Reverberatory furnace], Rotary furnace and Electric arc furnace.

② For Steel! Electric furnaces, Open hearth furnace and Converter.

③ For Non-Ferrous Metals:

i) Reverberatory furnaces (Al, Cu) - Stationary and Tilting furnaces.
ii) Rotary furnaces - fuel fired & Electrically heated.
iii) Induction furnaces (Cu, Al) - low, high frequences.

4) Electric Arc furnaces (Cu)

5) Crucible furnaces (Al, Cu): Pit type, Tilting type, Electric resistance type (Cu)

6) Pot furnaces (Mg, Al) - Stationary and Tilting.

① **Cupola furnace:-** It is the standard melting unit of Iron foundry, and it is the cheapest method of converting scrap metal (or) Pig iron to usable cast iron. Cupola furnace is also employed for melting some copper alloys.

Construction of Cupola:-

a) It is a cylindrical shell which lined with fire bricks & clay supported on C.I legs.

b) The diameter of cupola varies from 0.9m to 2m, with a height of 4 to 5 times of diameter.

c) Air from the blower comes through the blast pipe and enters wind box which surround the cupola and supplies air uniformly to tuyers. and supply air necessary for combustion

d) Tap hole is placed at bottom of furnace to collect the molten metal.

e) Slag hole is placed at opposite and above the tap hole. It is 250 mm below tuyers. Slag is removed from slag hole.

f) Charging door is placed at top of furnace nearly at stack zone. which helps to charge the contents into the furnace. [metal, coke, limestone flux]

g) Sometimes collector, filter and precipitator are used to minimize pollution.

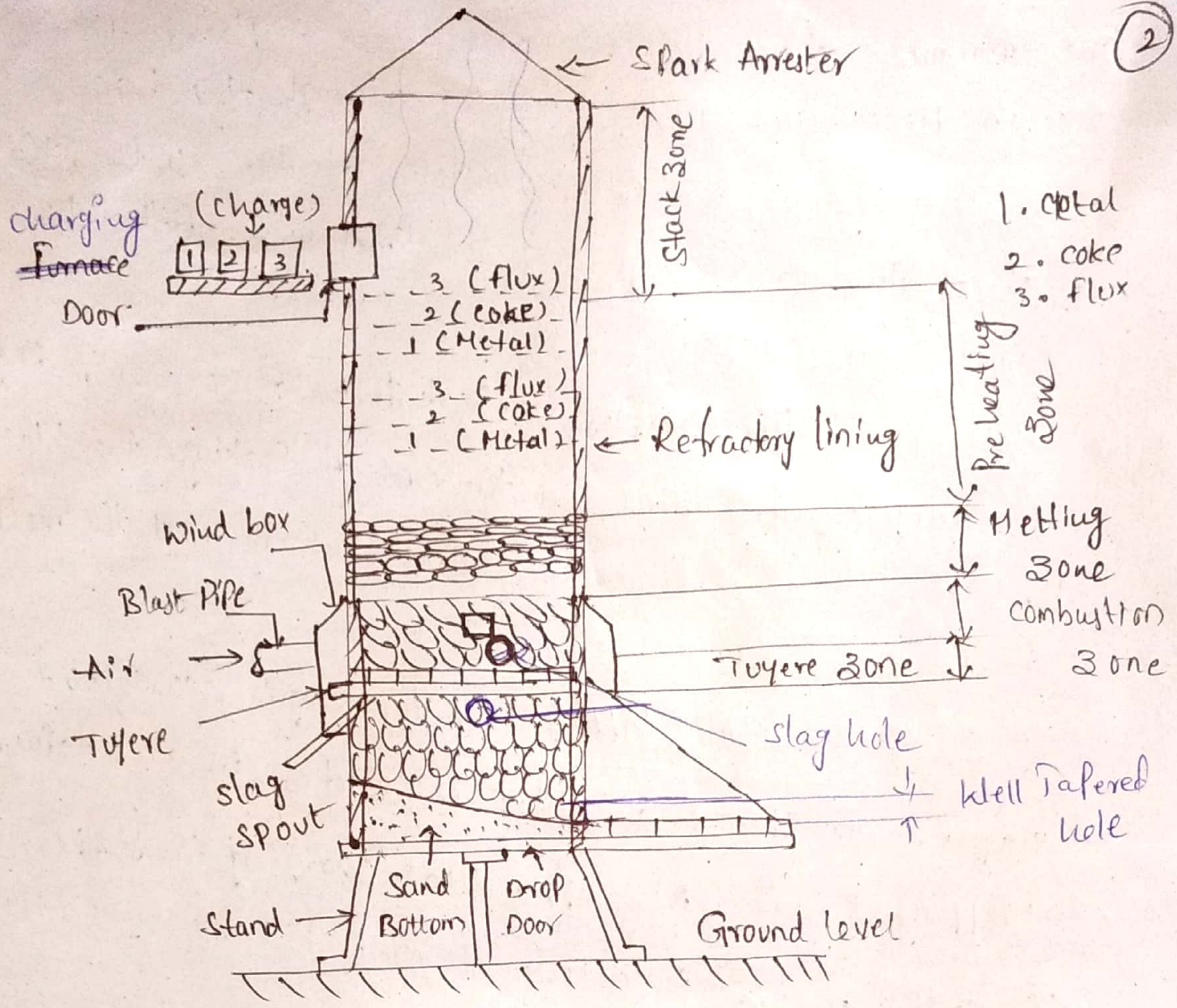


Fig: Cupola furnace

Working / operation:- The various steps in operating cupola are

(1) Preparation of cupola
(2) Lighteuing of cupola
(3) Charging of cupola
(4) Melting
(5) Slagging and metal-taping
(6) Dropping down.

① Preparation:- Bottom doors are opened and the charge [metal, coke, slag, flux] are dumped on furnace & removed. at that time this charge is sticks on sides of furnace wall and are chipped off. if any damage are placed we can correct the positions.

② Lightaning of cupola:- Cupola is fired 3-4 hours before molten metal needed. and wood are placed on sand bed and rammed above the bottom door. Coke is placed above the wooden pieces. and wood is ignited through tap hole.

③ ~~Melting~~ **Charging**:- After completion of the ignition, the charge is placed through charging door. Sometimes some additives like slag, dolomite are added.

④ **Melting**:- After charging, a soak period of 30-60 min is given to charge for preheating. at the end of soaking, the blast is turned on, so that coke becomes firmly hot to melt the metal charge.

⑤ **Slagging and Metal tapping**:- After slag is accumulated the slag hole is opened and slag is collected in a container.

⑥ **Dropping Down**:- As cupola heat charging is stopped, all the content of cupola is allowed to melt till one (or) 2 charge is left above coke bed.

→ **Advantages of cupola**:-

(1) It is widely used for melting practice to produce of grey cast Iron, nodular cast iron, malleable cast iron and alloy C.I.

(2) It can be used for melting some copper-base alloys.

(3) It can be used in duplexing & triplexing operations for making steel, ductile C.I etc...

→ **Crucible furnaces:-** These are Mainly used for Melting Non-Ferrous Metals such as Copper [Cu], Aluminium [Al] and their alloys. here the Metal is Placed in a crucible of refractory Metal and the heating is done in the crucible. mostly the crucible is made by clay (or) graphite. Crucible furnaces didnot have direct heat contact b/w flame and metal charge. So that Melt Quality and temperature Can also be controlled reasonably well. in these furnaces coal, oil (or) gas may be used as fuel.

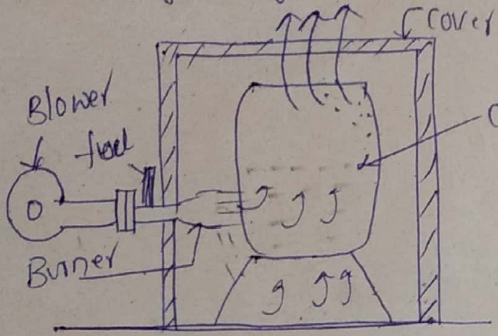


fig: Oil fired

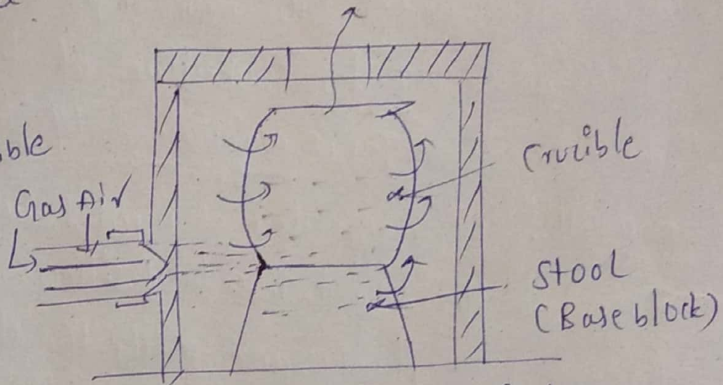


fig: Gas fired

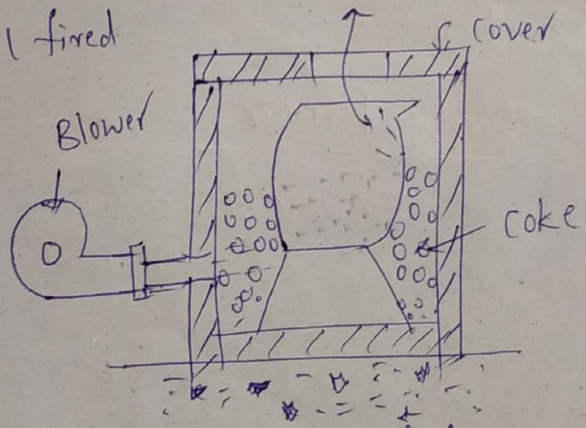
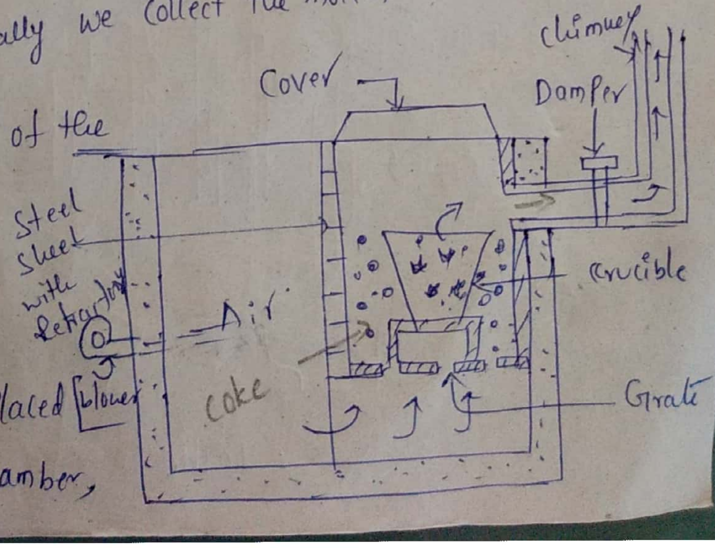


fig: coke fired

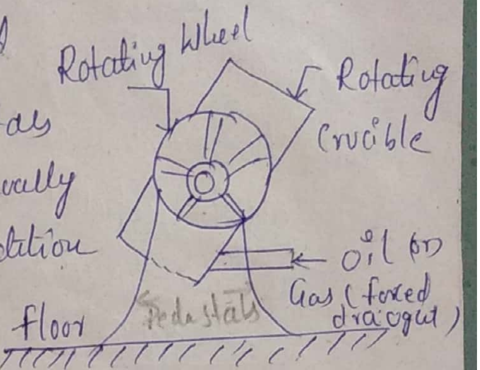
The above diagrams shows common Working Process i.e the charge is Placed on Crucible and this charge will be melts with help of different fuels like fuel, gas, coke. Finally we collect the molten metal from Crucible.

(a) **Pit furnace:-** It is one of the Stationary crucible furnace, constructed "below the ground level." The crucible which is filled with the metal is Placed on the inside of heating chamber,



The Surrounding of Crucible is filled with coke and top is covered with lid, the rate of melting is depends on the supplied air through blower. after complition of melting process, the crucible is taken out of the furnace with help of tongs with long handles.

(b) **Tilting furnace:-** This furnace is placed above floor level and is mounted on 2 pedastals placed on ground. The crucible is rotated manually (or) hydraulic devices. The main important condition is the air supply for "combustion of fuel like coke-oil (or) gas is maintained by forced draught." when the fuel is injected into combustion chamber through a nozzle, placed in horizontal position. The flame of burning gases heats the crucible uniformly and melts the charge placed in it. after that the furnace is tilted for pouring.

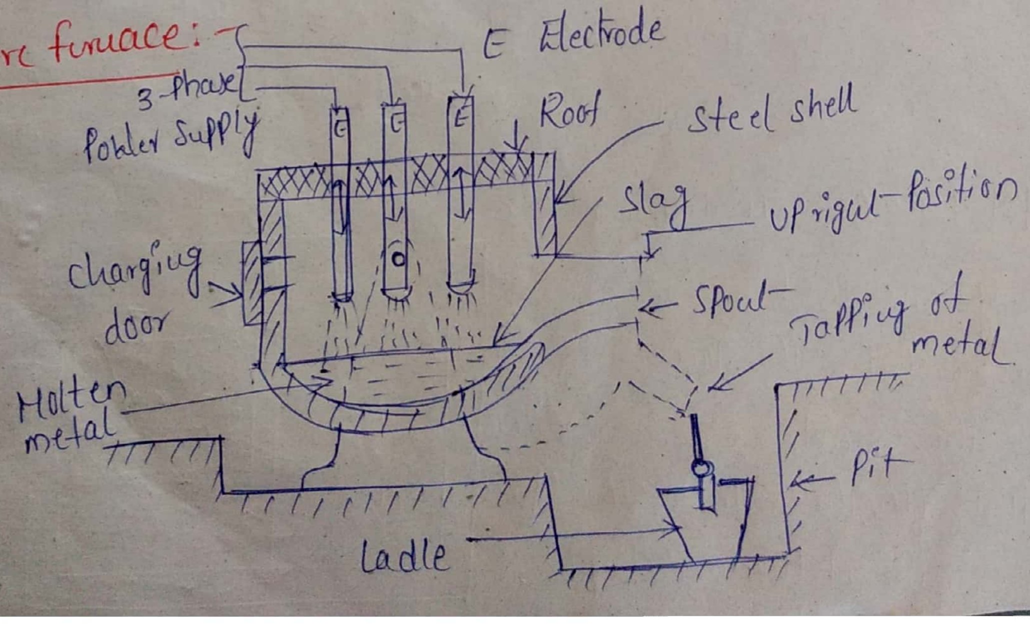


Electric furnace

Electric furnace is the best equipment for melting metals in the foundry industries. These are 2 main types of Electric furnace

1. Arc furnace
   (a) Direct arc furnace (b) Indirect Arc furnace.
2. Induction furnace.

1. Arc furnace:-



① The interior of furnace [i.e refractory linings] is preheated before placing the metal charge either steel scrap (or) Iron scrap.

② The charge will be placed on the furnace through charging door.

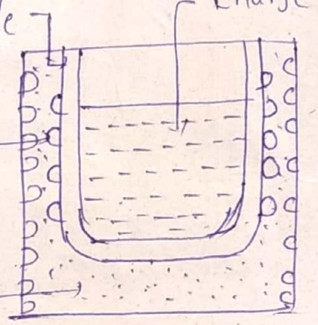
③ The electrodes are directly placed into the furnace which are connected to 3-phase power supply.

④ When start the operation, the current flows through electrodes so that heat will be generated inside the surface. finally the charge will be melt.

⑤ The molten metal is collected with help of ladle.

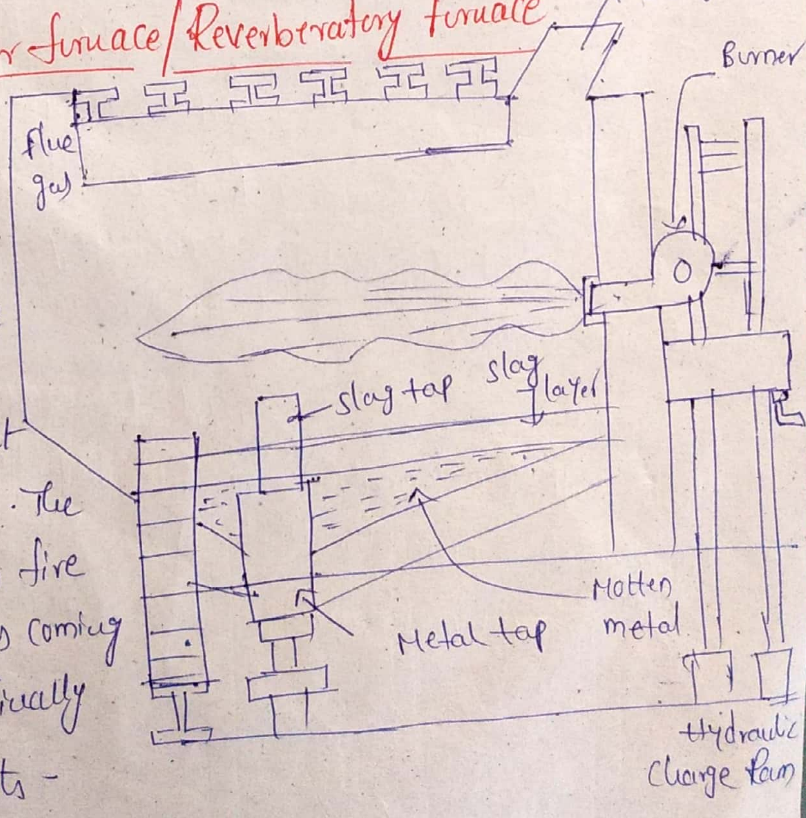
② Induction furnace :-

The crucible in induction furnace is surrounded by water cooled primary coil through which a high frequency electric current is passed. The current in this coil develops an intense heat in metal charge placed in crucible. The heat produced is sufficient to melt the charge. The advantage of this furnace is it doesnot require electrodes.



Air furnace / Reverberatory furnace

This is one of the special type of furnace. Here the fuel burners fire within a refractory hood "above the metal bath". This is widely applicable for melt metal in large accounts. The charge is placed below on fire and the firing coutlet is coming from Burner so that finally the metal will be melts -



Solidification of Casting

The cooling process of Molten Metal is called as Solidification. The structure and mechanical properties of casting are depends on rate of cooling i.e. Solidification. Generally solidification can be divided into 2 categories:

1. Solidification of Pure metal
2. Solidification of Alloy.

① Solidification of Pure metal:-

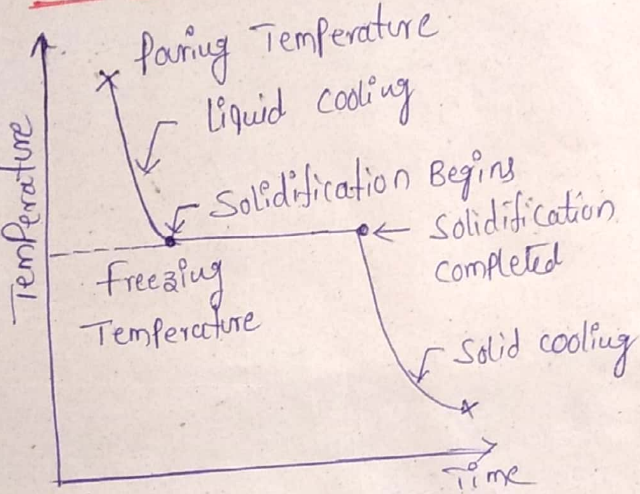


fig: Cooling curve

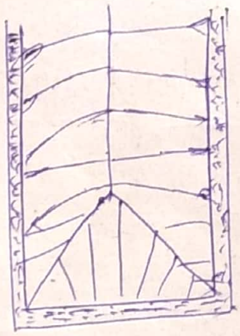


fig: Grain Structure of Pure metal

The above diagrams indicates the Phases changes from liquid state to solid state. Above the freezing Point metal completely liquid and below it is completely solid. The liquid metal cools quickly to freezing point, and then the temperature remains constant until the metal is completely solidified. further cooling of solid metal is continued upto room Temperature.

Solidification will not occur suddenly, it starts with the formation of solid particles [nucleus] within the liquid metal. once the stable nucleus is formed, the growth of grains begins by acquiring atoms from liquid.

→ Solidification of an alloy:-

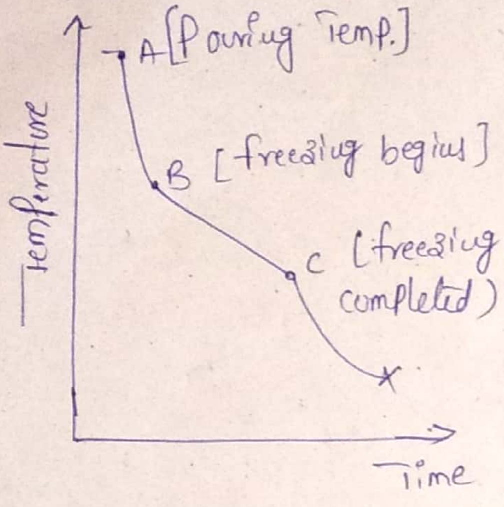


fig: cooling curve

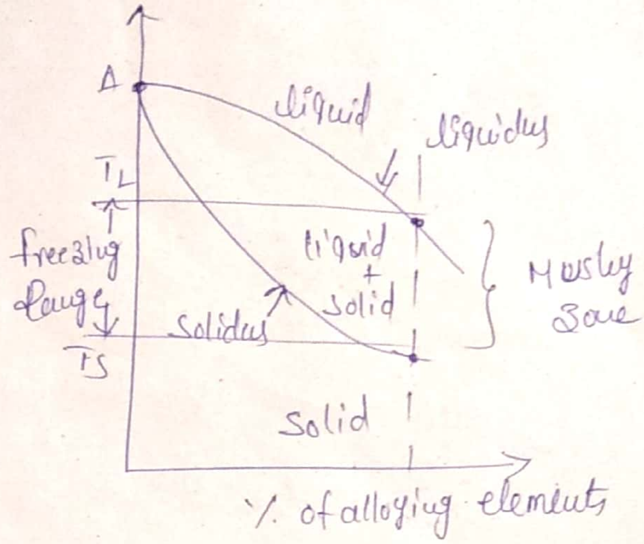


fig: Phase diagram

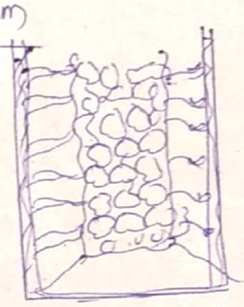


fig: Grain structure of alloy

The exact range of solidification is depends on the alloy system and composition. In above diagram the freezing begins at liquidus [Point B] and is completed at solidus [Point C]. In between the liquidus & solidus the solid & liquid are exist together. The width of region where liquid & solid co-exist is called as "Mushy zone". It will be calculated by.

Freezing Range = $T_L - T_S$

$< 50^\circ C$ for short freezing range.

$> 110^\circ C$ for long freezing range.

T_L = Liquidus temp.

T_S = Solidus Temp.

The freezing range will determined with help of T_L and T_S values. T_L, T_S from Phase diagram by drawing a vertical line through the composition of alloy.

(a) Short freezing Range:- In the alloy of short freezing range the crystals grow like "dendrites with sharp interface" b/w liquid & solid. The alloy finally freezes with a large shrinkage cavity. So that it requires a large risers.

Long freezing range:- In this case it doesnot have sharp interface b/w liquid and solid. The microstructure and shrinkage cavity is greatly reduced. They have poor fluidity and grains exhibit variations of composition.

Risers

① A riser is a vertical passage placed in the cope to permit the molten metal to rise above the highest point of casting.

② The main function of riser to act as reservoir of molten metal to feed the casting during solidification, and also vent for gases.

③ With help of riser we can checkout the complete filling of cavity.

→ **Types of Risers:-** ① Open Riser → Top riser, → Side riser

② Blind Riser

① **Open riser:-** This is simplest type of riser which are applicable for Non-ferrous metals like Cu, Al etc... This type of risers are openly "exposed to atmosphere".

→ Top risers are generally placed on top of casting

→ Side riser are placed on side (on) parting line of casting.

(2)

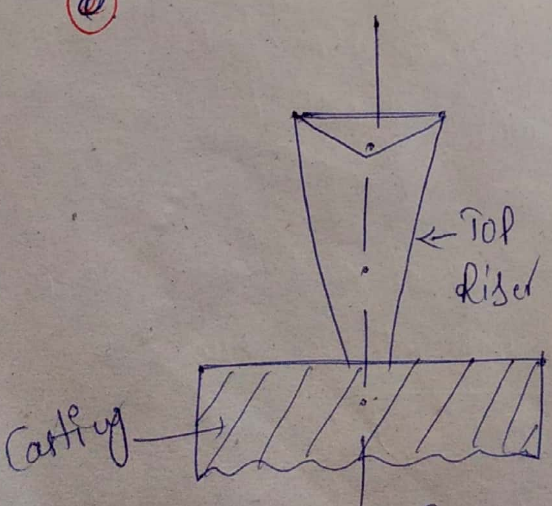


fig: Top Riser

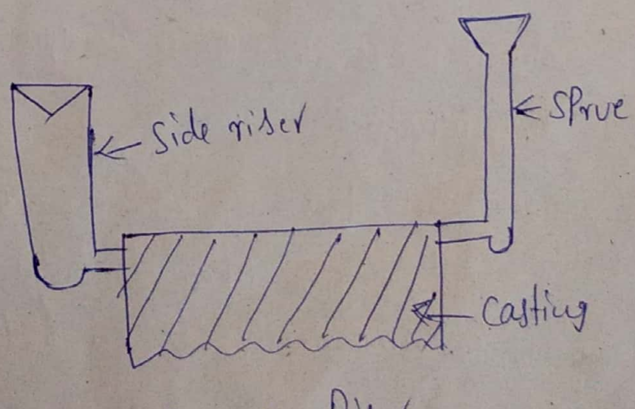
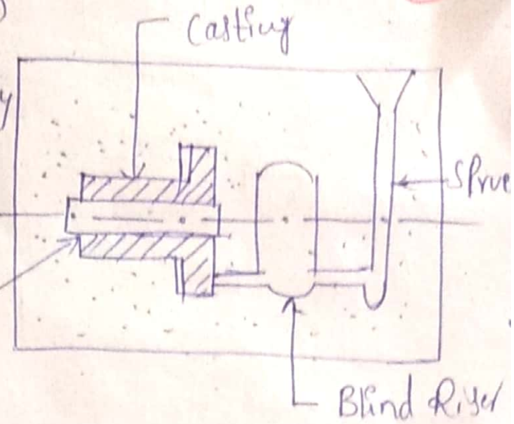


fig: Open Riser

(2) Blind Riser:- In the diagram we can observe the position of riser which is completely enclosed in the moulding sand. at that time the rate of heat loss is done slowly. They can be located more conveniently/core than open risers.



→ Design Consideration of riser:-

(1) Shape and Size of Casting:- Based on the shape and size of casting, we can design the specification of riser, most of the cases the size of riser is proportional to the size of casting. sometimes 2(or) more risers are used for projections of casting.

(2) Material of the casting: Most of cases the materials exhibit shrinkage when the molten metal is contact with the material of riser. So that we can prefer "the volume of riser should be atleast equal to 3 times the shrinkage volume of casting".

(3) Shape of Riser:-

$$\left[\frac{\text{Surface Area}}{\text{volume}}\right]_{Riser} < \left[\frac{\text{Surface Area}}{\text{volume}}\right]_{casting}$$

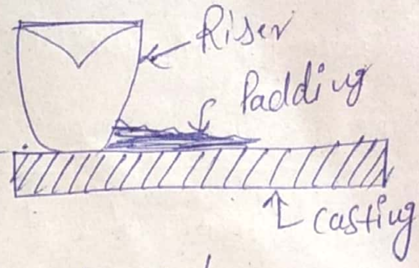
$$\left[\frac{A_s}{V}\right]_R < \left[\frac{A_s}{V}\right]_C$$

(4) Location of Riser:- Riser should be located at thick section of casting. mostly we can prefer middle portion of casting.

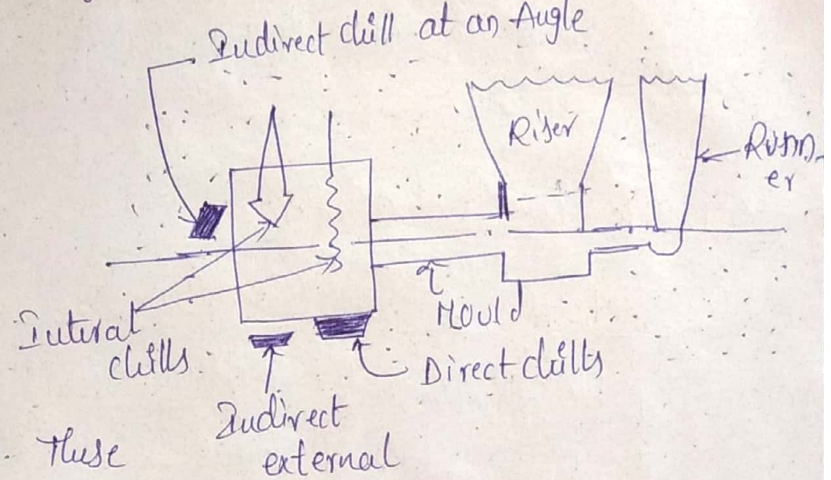
(5) Need of chills and Padding:- 1, chills and padding are helps to riser for the purpose of solidification.
2, The efficiency of riser will be increases by minimize the heat loss through riser and adding exothermic material.

→ Uses of Padding and chills:-

(i) **Use of Padding:-** It is one of the extra material which is added to the casting for the purpose of solidification. after completion of casting operation padding is removed by Machining operation.



(ii) **Use of chills:-**



These are Metallic pieces which are kept in mould "to avoid craks" due to uneven contraction of parts. These are helps to fast up the cooling process.

→ Generally 2 types chills i.e Internal and external chills are used. They are shown in above fig. Internal chills are placed in inside of mould and external chills are plased on outside of cavity.

Casting Defects

The major defects in sand casting are

Casting defects

① **Gas Defects**
- (a) Blow holes & open blows
- (b) Air Inclusions
- (c) Pin hole porosity
- (d) Shrinkage cavities

Moulding Material defects
- (a) Cuts and washers
- (b) Metal penetration
- (c) fusion
- (d) Run-out
- (e) Rat Tails
- (f) Swell
- (g) Drop

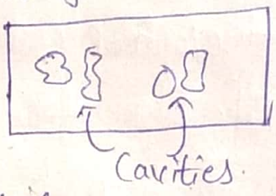
Pouring Metal defects
- (a) Misruns and cold shuts
- (b) slag Inclusions

Metallurgical defects
- (a) Hot Tears
- (b) Hot spots

 Scanned by CamScanner

① **Gas defects:-** This type of defects are raises due to "lower venting and lower permeability of mould."

→ Blow holes & open blows are looking like spherical, elongated cavities which are present on inside of casting. →



→ When we pour the molten metal from furnace to ladle, after that pour into cavity, the atmospheric gases absorbed by molten metal. So that defects are raises.

→ During solidification of casting shrinkage cavities are formed.

② **Moulding Material Defects:-** This defect are raises due to characteristics of moulding materials and improper ramming process.

→ cuts & washes are appears as spots and areas of excess metal. which are caused by erosion of moulding.

→ When the molten metal enters in b/w sand grains, the rough casting surface presents. i.e. Metal Penetration.

③ **Pouring Metal defects:-**

→ When the molten metal is unable to fill the mould cavity in specified time automatically misrun (or) cold shuts formed.

→ In melting process the slag will be formed, and this slag is removed by slag hole before pouring the molten metal into cavity. If we don't remove slag, the defect are raises in casting.

④ **Metallurgical defects:-**

→ Hot spots are raises due to chilling process

→ Hot Tears are cracks formed by contraction stresses in casting just after solidification.

Special casting Processes

Generally 80% of castings are made by sand casting due to cheap cost and easily operated. but somuch of defects are raises like blow holes, hot tears, mis-run etc.. These Problems are avoided with help of Special casting Processes.

→ Advantages of Special casting Process over conventional casting Process.

1. Greater dimensional accuracy with higher metallurgical quality.
2. high Production rates with lower cost
3. Better Surface finish occurs.
4. Low labour and finishing cost

→ Types of Special casting Processes:-

1. Shell Moulding
2. Investment Casting [lost-wax casting]
3. CO_2-Process
4. Permanent Mould Casting
5. Centrifugal casting
6. Die casting
7. Continous casting
8. Squeeze casting
9. Slush casting
10. vacuum casting.

1. Investment Casting:- [Lost-wax Casting] (or) [Precision casting]

In Investment casting wax patterns are used. which are coated with refractory [ceramic] materials to form a mould. The wax is then melted out and mould cavity is filled with molten metal. after that cast metal is cooled and slurry broken to get castings. This type of casting is very high precision (or) accurate.

→ Steps Involved in Investment casting:-

① **Pattern Creation:-** firstly, the wax Pattern Material is injected under Pressure of about 2.5 MPa into a metallic die, after that the wax will be allow for Solidification so that Pattern will be Produced. Then the clusters [group] of wax Patterns are attached to the gating System (or) Sprue (or) Riser, which is looking like tree

② **Mould Creation:-**

→ The Pattern tree is dipped into the ceramic slurry, this Process was repeated until the Pattern consists of thickness is 6-15mm reaches.

→ The Pattern is then Placed into the Moulding flask/oven

→ The heat will be allowed on the Pattern, so that the wax is completely drained [removed]. so it is called as "Lost-wax"

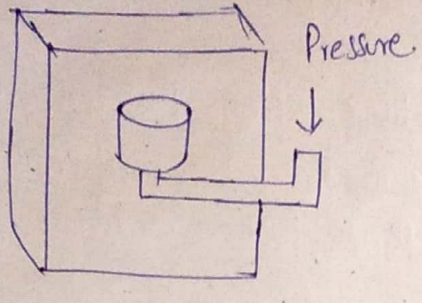
→ After the moulds are then Preheated to a Temperature of 100 to 1000°c for complexity Sections of Patterns.

③ **Pouring:-** The molten metal is Poured into the mould under Pressure, gravity, by evaluating the mould first.

④ **Cooling:-** After complition of Pouring Process, the molten metal will be allow for Solidification.

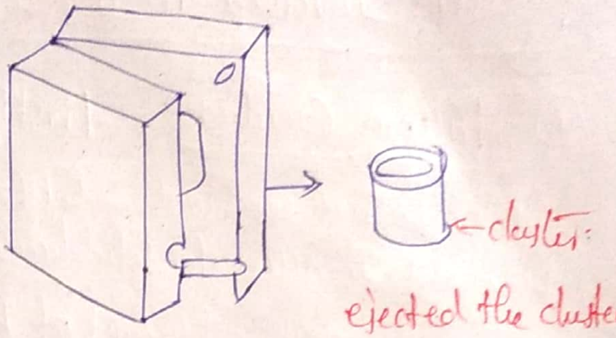
⑤ **Casting Removal:-** After complition of Cooling Process the final object is collected by breaking of casting and shaking of casting.

→ Sometimes the removal of casting is difficult, at that time we use water Jets. Finally the clusters are collected by sawing (or) cold breaking. used by liquid Nitrogen.



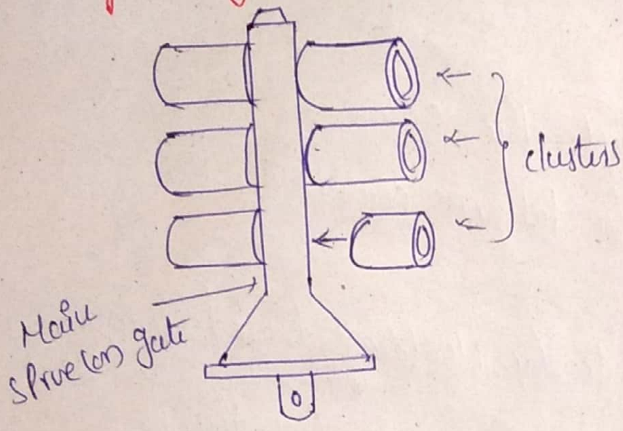
Step 1

The Parts of Pattern are Prepared by applying Pressure



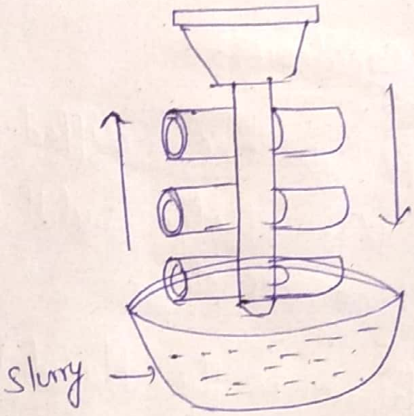
ejected the clusters

Step 2



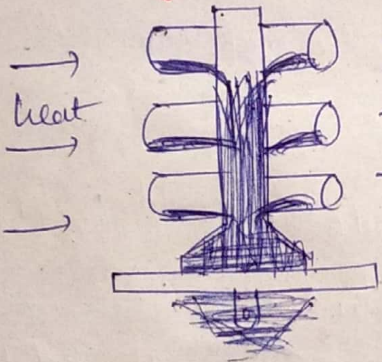
Step 3

Attaching Process of cluster to main Sprue (or) Gate



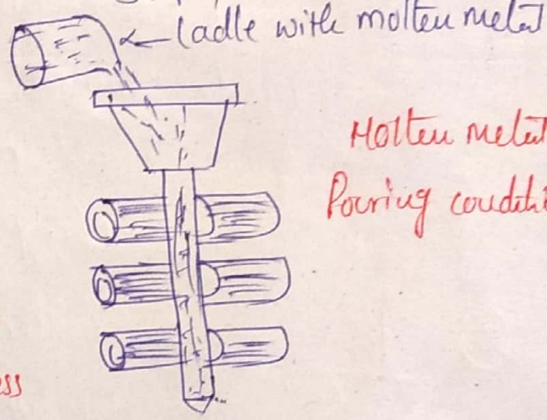
Dipping Process of Pattern into Ceramic Slurry

Step 4



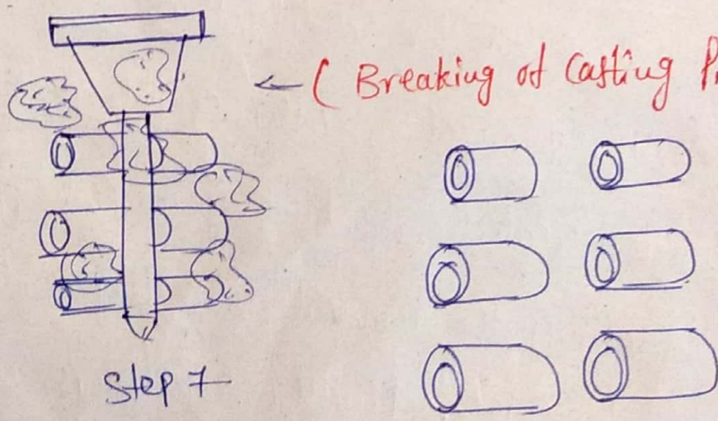
heat Applying heat Process/ treatment to Pattern and also Removal of Wax Process

Step 5



Molten metal Pouring condition

Step 6



(Breaking of Casting Process)

Step 7

– Finally collect the objects.

→ Applications of Investment Casting:-

1. Complex shapes like Sewing M/c, locks, rifles x barrels, burners, Surgical instruments, Nozzles, Engines, x Movie cameras, cutting M/c, Picture Projections, Jewellery etc.. are Produced.
2. very fine thin Sections Produced, because Preheating is done.
3. Machining Process is ~~Negligible~~ Neglect in this casting.
4. No Parting line, dimensions across it would not vary.

→ Advantages of Investment Casting:-

1. Intricate shapes and complex shapes are Produced
2. The lost-wax can be reused.
3. Additional Machining is not required
4. Good surface finish occured.
5. close dimensional control ±0.075mm

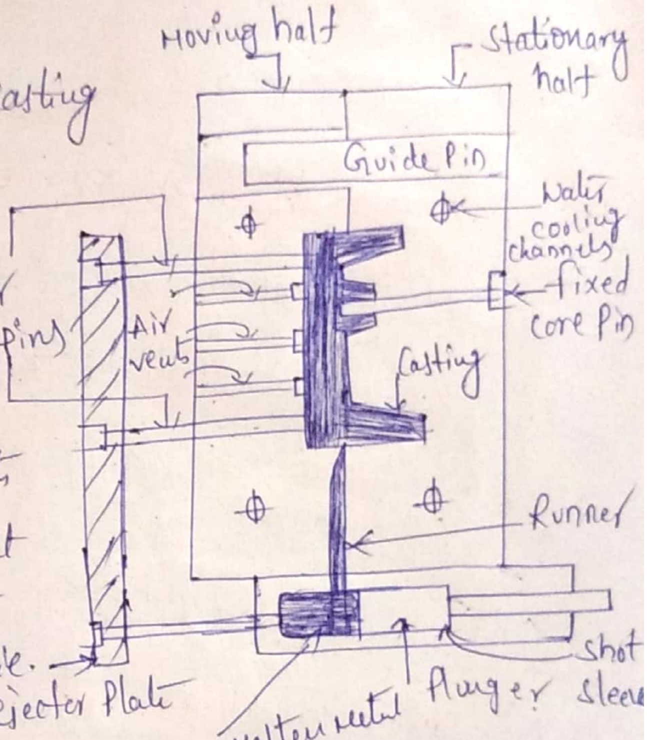
→ Disadvantages | Limitations:-

1. This Process is limited by size and mass of casting.
2. Larger Manual labour are Required
3. Cores cannot be used
4. Thickness is usually restricted to 15mm
5. It is time-consuming [slow] Process.

Die casting / Pressure die casting

Die casting Involves the Production of objects by "Injecting the Molten Metal at high Pressure into a Metallic die" here the Metal is forced into in under Pressure, so we can called as Pressure die casting. The Projected Sections, Narrow sections are easily Produced with help of die casting Process.

The cross-sectional view of die-casting was shown in fig. it consists of 2-halfs, one is stationary (or) cover die and another one is Moving half (or) ejector die. The casting Process was starts when 2 Parts of the die are apart, the lubricant will sprayed on the die, so that the casting will not stick to the die. after that the 2-halfs are coupled with help of Pin, and the molten metal will be injected into the die under Pressure, after that it will be allow for solidification, finally the die is opended and casting is ejected.



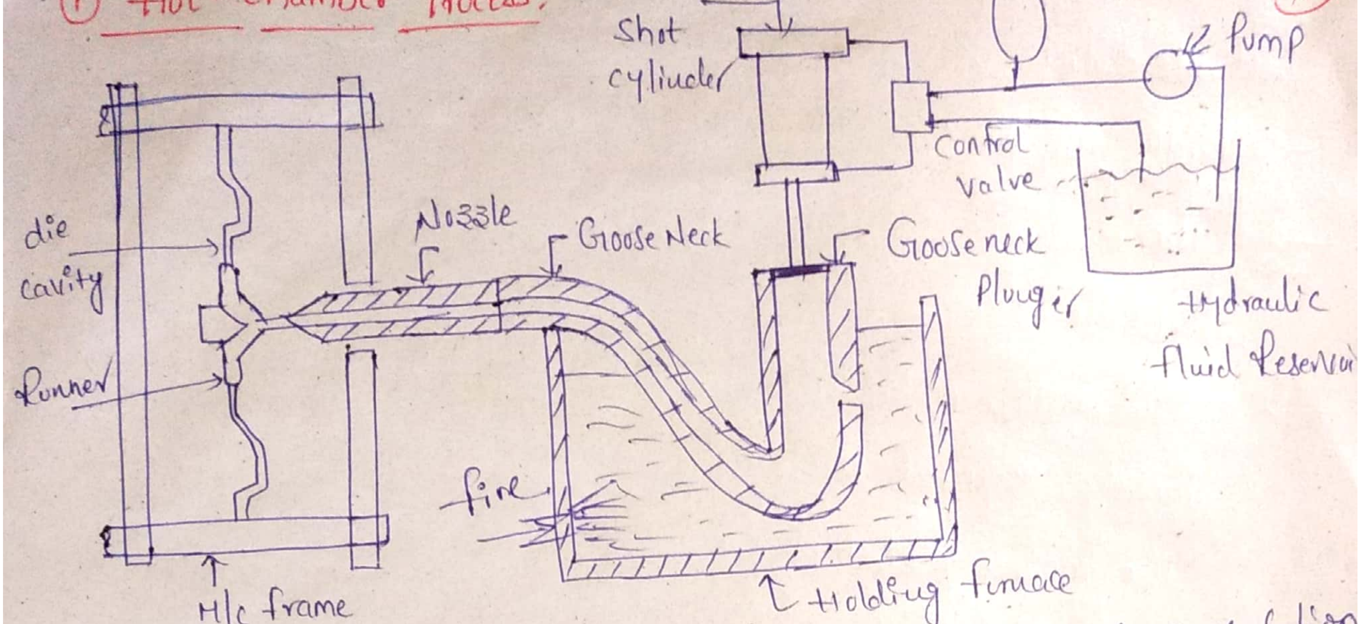
→ The die casting M/c are 2-types

1. Hot chamber die casting
2. Cold chamber die casting.

→ In hot chamber die casting, the holding furnace for molten metal is Required

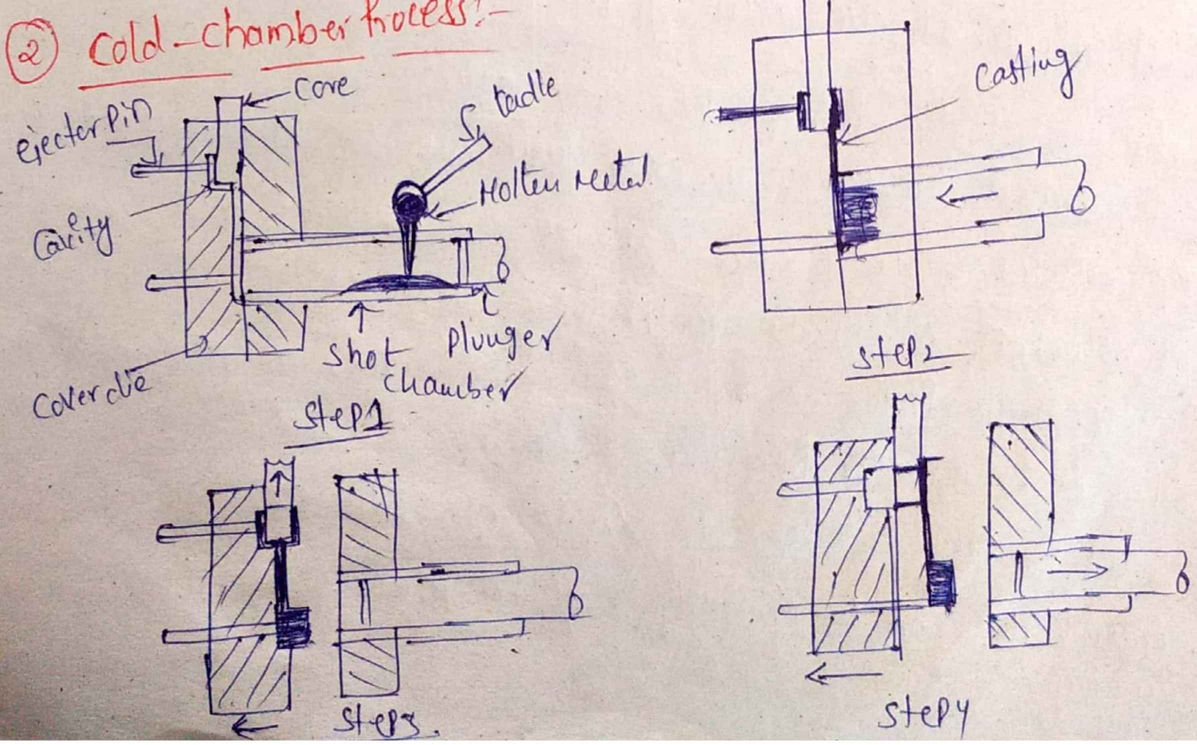
→ In cold chamber die casting, the ~~molten~~ metal is melted in a Separate furnace and the liquid metal is poured into the die-casting M/c.

① Hot-Chamber Process:-



In the above diagram, we can observed that the cross-section of die casting was connected to the holding furnace. The gooseneck is used for pumping the molten metal into the die cavity through Nozzle. The gooseneck is submerged [dipped] into the furnace which is made up of grey alloy (or) ductile Iron, steel etc... the Plunger is operated with help of hydraulic system. When Plunger runs automatically 'Pressure' will be develops into the cavity, at that time, the metal will be injected into the cavity, after allow for solidification Process, finally we can collect our required object.

② Cold-chamber Process:-



It is Similar to the hot-chamber die-casting Process. but We didn't use any holding furnace in this Process.

→ firstly the lubricant was sprayed throughout the mould cavity

→ The molten metal was Poured in chamber with help of Ladle.

→ This molten metal will be moved forward with help of forward movement of Plunger.

→ The molten metal is uniformly Spredout throughout the mould cavity.

→ If we need any hollow section in casting we are used core.

→ After ~~complical~~ completion of Pouring Process, it will be allow for solidification, finally the casting will be collected by ejecting the moving half with help of Ejector Pins.

→ If Any breaks, craks are Produced on object, it will be allow for Secondary operation.

→ Application of die-casting Process:-

The complicated Products like carburettors, crank cases, handle-bar scooter Parts, motor cycles, zip-fasteners, lamps etc. Produced

→ Advantages:- 1, complex castings are Produced and very Small thickness of objects are Produced very easily.

2, very high Production rates can be acheived, Typically 200 Pieces Per hour since the Process is completely automated.

3, It is very economical for large-scale Production.

4, Inserts can be readily cast in Place.

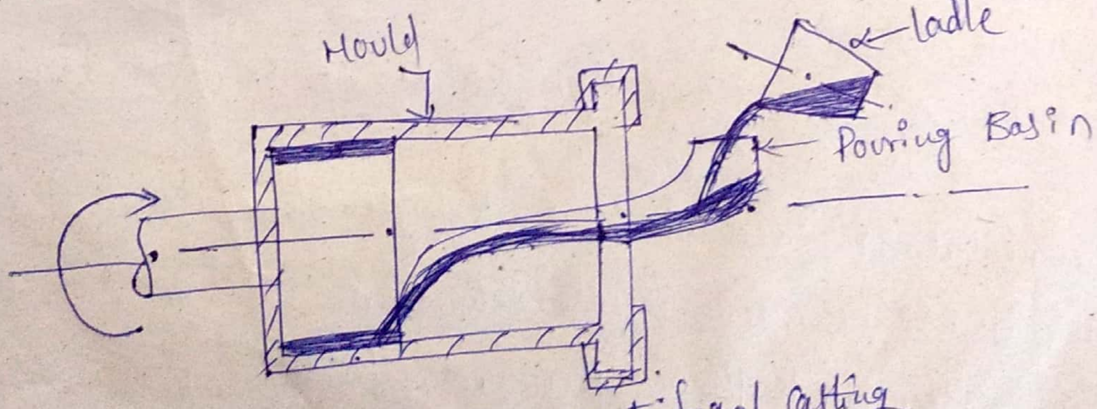
Centrifugal casting

Centrifugal casting is the method which helps to Produce objects in a rotating Mould [May be horizontal (or) Vertical]. In this centrifugal casting, The molten metal is Poured into the Pouring basin with help of ladle, after that the molten metal is entered into the rotating Mould, which is rotated at a speed of 1500 r.p.m [300 – 3000 R.P.M] at that time, the liquid metal is uniformly spread into the walls of the Mould tube along the entire length. after this Process it will be allow for Solidification. finally We can collect the our Required hollow section object from the Mould. This method is more applicable for "Production of the hollow Pipes, hollow tubes, wheels, gears etc."

According to form of the Mould, the centrifugal casting classified as 3 types

1. True centrifugal casting
2. Semi-centrifugal casting
3. centrifuging [centrifuge casting]

① True centrifugal casting:-



-fig: True centrifugal casting

This is one of the best casting Process to produce "hollow casting objects" without using of any core, core prints etc...

→ Firstly we should maintain the mould which is rotated by using of Motor and Revolving drums (or) wheels.

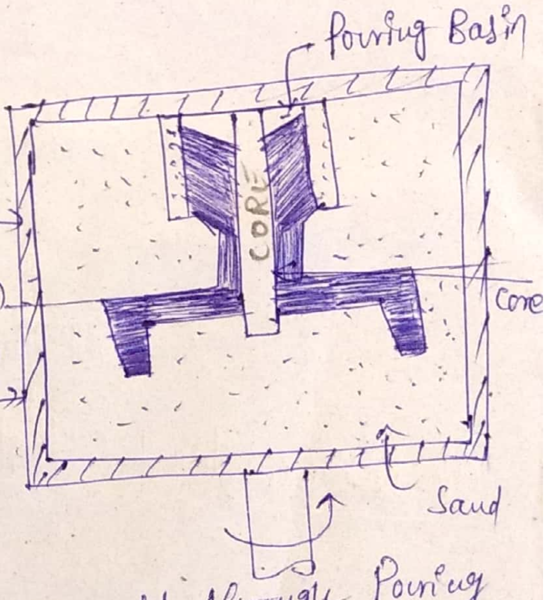
→ When the mould is Rotated at constant speed [1500 r.p.m], the molten metal is poured into the pouring basin

→ This molten metal will be try to settle on the walls of the mould, this process is repeated until we get our required thickness.

→ After it will be allow for solidification, and finally we collect the our required object from the mould.

→ If any machining operation is required we can done the M/c processes on object.

② Semi-centrifugal Castings:-



This casting is used for production of objects which are more complicated than the True centrifugal casting, but are axi-symmetric in nature like wheel with spokes, fly wheels, pulleys and gears. here core is used for hollow sections.

→ The mould is rotated at central axis about 300 r.p.m

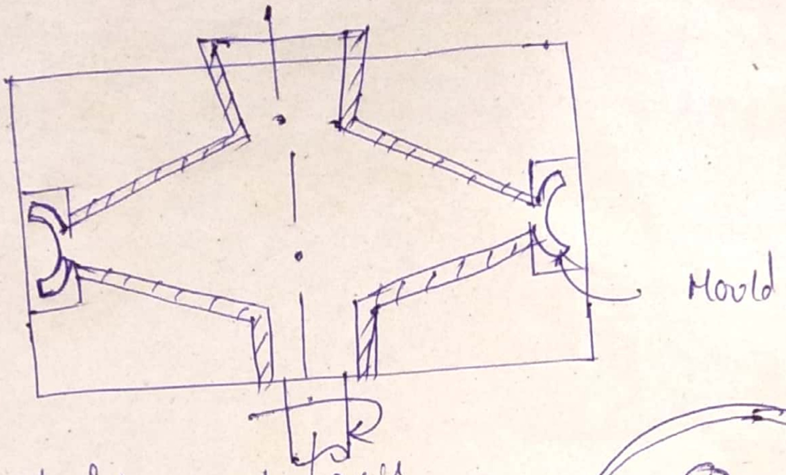
→ the molten metal is poured into the mould through pouring basin.

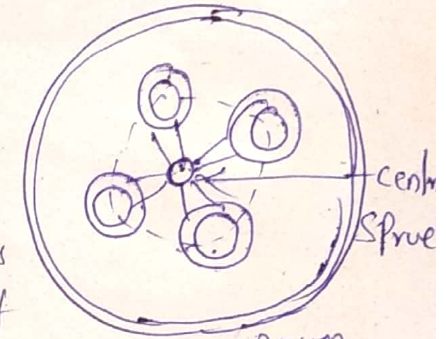
→ The metal is forced out by centrifugal force.

→ After it will be allow for solidification

→ finally we collect the object from mould.

3. Centrifuging:-





If casting shapes are not axis symmetrical, the centrifuging method is used. In this method we can produce small jobs of any shape. In this process the jobs are joined together by means of radial runners with central sprue on a revolving Drum. After complition of arrangement the molten metal is poured on central sprue, so that this metal will be uniformly spread on each and every section, after that it will be allow for solidification, finally we collect our required job.

→ Advantages of Centrifugal casting:-

1, The mechanical properties of centrifugally cast objects are better compared to other process.

2, Slag, oxides are get segragated towards the centre so that these are easily removed by machining process.

3, In true casting process, No need to use cores for hollow sections.

4, No need to use gates, runners, which increases the casting yield, reaching almost 100%.

Limitations:- 1, equipment is very expensive. So that.

it is suitable for large quantity production

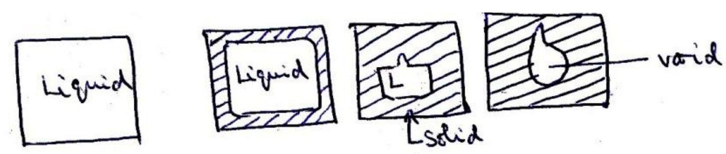
2, In true casting centrifugal only concentric holes are produced.

3; In semi-centrifugal casting axis-symmetric objects are produced.

UNIT-2

SOLIDIFICATION OF CASTING , RISERS AND METHODS OG MELTING

The function of a riser is to feed the casting during solidification to avoid shrinkage cavities. The requirement of casting depends on type of metal powered and complexity of the casting. Different metals may have different volumetric shrinkages. Grey cast-iron sometimes may have negative shrinkage.



As time progresses, the metal starts loosing heat through all sides and as a result starts fruzing from all sides equally trapping the liquid metal inside. By further solidification and subsequent volumetric shrinkage and the metal contraction due to change in temperature. Causes formation of a void. On completion of solidification finally results in the shrinkage cavity.

Liquid shrinkage occurred ends up as a void. Such isolated spots which remain hot till the end are called 'hot spots'.

The turn directional solidification normally used in the casting terminology. Since cooling is achieved by the removal of heat from all surfaces which are exposed to the atmosphere or sand, cooling normally starts from the point which is the thinnest or is exposed over a larger surface area.

CAINES METHOD:-

The cooling characteristics of accosting can be represented by the surface are a to volume ratio

$$t_S = K \left(\frac{V}{SA}\right)^2$$

Where, t_S = solidification time, s

V = volume of the costing

SA = surface area

K = mould constant

MODULUS METHOD:

The modulus is the inverse of the cooling characteristics (surface area/volume). In steel castings it is preferable to choose a riser with a height to diameter ratio of 1.

$$\text{Volume} = \frac{\pi D3}{4}$$

Where D is the diameter of the riser

NOVAL RESEARCH LAB METHOD:

This defines as a shape factor to replace the freezing ratio. The shape factor is

$$\frac{\text{Length} + \text{width}}{\text{thickness}}$$

FEEDING DISTANCES:

The riser would be able to feed, whatever may be the length of the casting. If the costing is long, the entire costing may not be sound because the riser could not be able to feed the entire length of the costing. The total costing could be classified as bars, plates or spherical or cubical sections. In cubical sections the feeding would not be a problem.

FETTLING:

The complete process of cleaning is called fettling which involves the removal of the cores, gates and risers, cleaning of the costing surface and chipping of the unnecessary projections on surfaces.

The gates and runners can be removed by hammering, chipping, hack sawing, abrasive cut off or by flame or arc cutting.

DEFECTS IN CASTING:

a. Gas defects b. Shrinkage cavities c. Moulding material defects

d. Powering metal defects e. Metallurgical defects.

(a)Gas defects:-

(i) Blow holes and open blows:-

These are spherical, flattened or elongated cavities present inside the costing or on the surface. On the surface they are called open blows and inside they are called blow holes. These are caused by the moisture left in the mould and in the core. Due to the heat in molten metal, the moisture is converted into steam, part of it is untrapped in the casting ends up as blow hole or open blow. This defect is also caused due to the lower permeability or lower venting of mould.

(ii) Air inclusions:

the atmospheric and other gases absorbed by the molten metal in the furnace, in the laddle and during the flow in the mould when not allowed to escape would be trapped inside costing and weaken it.

(iii) Pin hole porosity:

This is caused hydrogen in the molten metal. The formation of hydrogen is due to dissociation of water inside mould cavity. As the molten metal gets solidified it looses the temperature. Which decreases the solubility of gases and there by expelling the dissolved gases. The hydrogen while having the molten metal would cause very small diameter. And long pin holes showing the path of escape. These pin holes causes the leakage of fluids under high pressure. The reason for this is high powering temperature. Which increases the gas pickup.

shrinkage cavities:

These are caused by liquid shrinkage occurring during solidification.

Moulding material defects:

Cuts and washes – metal penetration – fusion – run out – rattails and buckles, swell and drop. The above defects occur due to the lack of required properties to moulding materials and improper ramming.

Cuts and washes appear as rough spots and area of excess metal. These are caused by the erosion of moulding sand due to lack of enough strength. Or high velocity of molten metal. Cuts may be avoided by the proper choice of moulding sand and washes can be avoided by tittering the gate design.

Pouring metal defects:

Miss runs, cold shuts and sand inclusions.

Metallurgical defects:

Hot tears – hot spots

PRODUCT DESIGN FOR SAND CASTING:

a. **Design of economical moulding:-**
   1. Parting lime
   2. Bosses and undercuts
   3. Coring
   4. Simplified moulding

b. **design for eliminating defects:-**

   1.shrinkage defects

   2. distortion

   3. hot tears

   4. Escape of gases

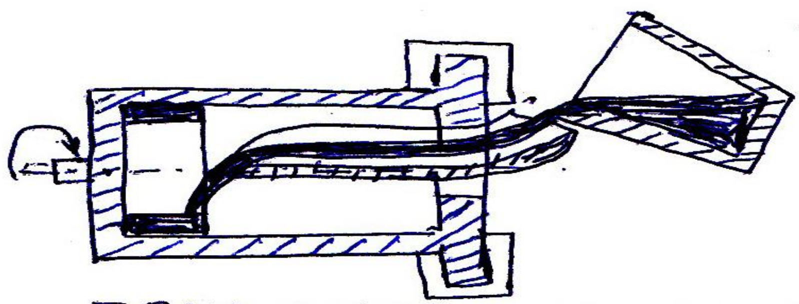
c. Designing features to avoid handling of castings:-

SPECIAL CASTING PROCESS

a. Centrifugal casting   b. Die castings   c.Investment casting

a. Centrifugal casting:

This is a process of producing hallow cylindrical costing without core. The molten metal is fed into the revolving mould. The axis of rotation is usually horizontal but can be vertical for short pieces. Moulds are made of steel or graphite may be cooled with a refractory material to increase mould life. The metal is forced against the mould surface by the centrifugal force until its solidifies. After solidification mould rotation is stopped and the casting is pulled out. This is used to make cylindrical parts such as pipes, gun barrels and street lamp post.



TRUE CENTRFUGAL CASTING

Advantages:-

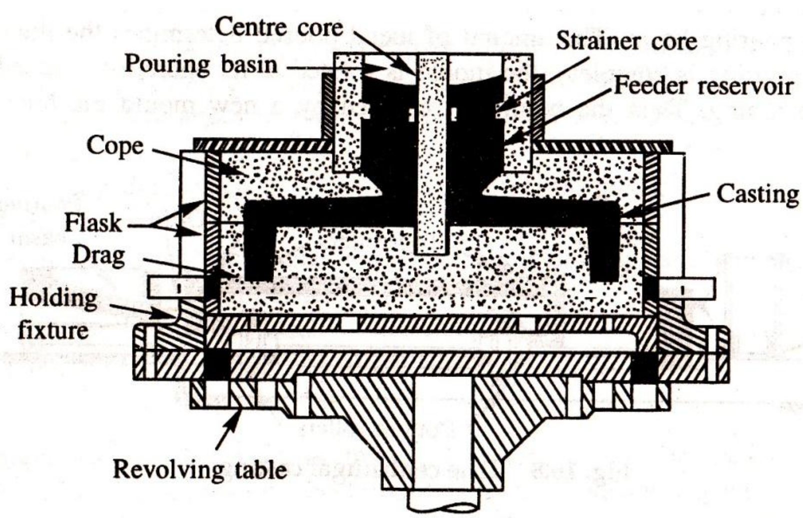
1. The mechanical properties of centrifugally east jokes are better compare to other processes since in elusion such as slag and oxides gets segregated towards the centre and can be easily removed by machining pressure acting on metal throughout the solidification, causes the porosity to be eliminated giving rise to dense metal.
2. Up to certain thickness of objects, proper directional solidification can be obtained starting from the mould surface to the centre.
3. No cores are required for making concentric holes in case of true centrifugal casting.
4. There is no need for gates and runners there by cost will be reduced.

Limitations:-

1. Only certain shapes which axi symmetric and having concentric holes are suitable for true centrifugal casting.
2. The equipment is expensive and thus is suitable only for large quantity production.

Semi centrifugal casting:-

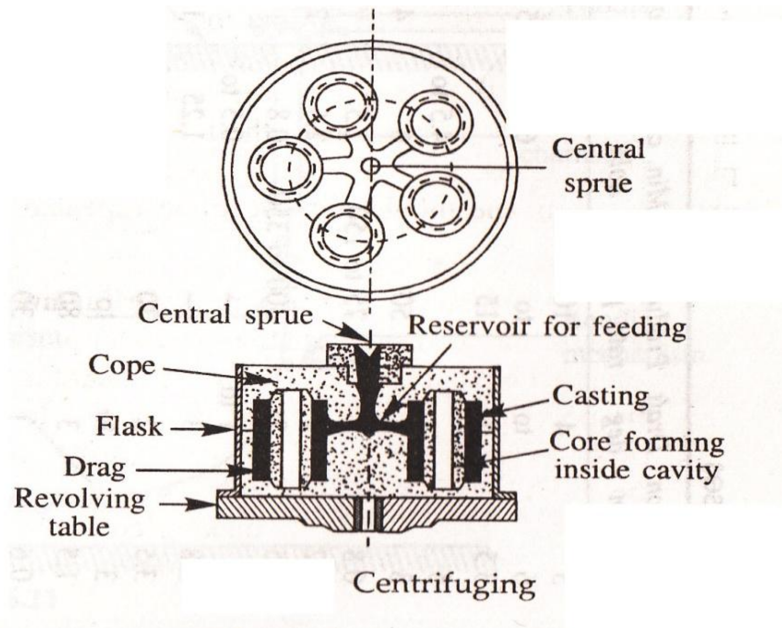
This is used for more complicated jobs which are not possible to cost by true centrifugal casting, that are axi symmetric in nature. No need of central hole which is to be obtained with the help of core. The mould made of sand or metal is rotated about a vertical axis and the molten metal enters the mould through a central powering basin. For larger production rates, the moulds can be stacked one over the other, all feeding from the same central pouring basin. The rotating speeds are not high as in true centrifugal costing.



Semi-centrifugal casting

CENTRIFUSING:

This metal is used to get higher metal pressure during solidification, when casting shapes are not axi symmetrical. Used for small jobs of any shape. A number of such small jobs are joined together by means of radial runners with a central sphere on a revolving table. The jobs are uniformly placed on the table around the periphery so that here masses are properly balanced. This process is similar to semi centrifugal casting.



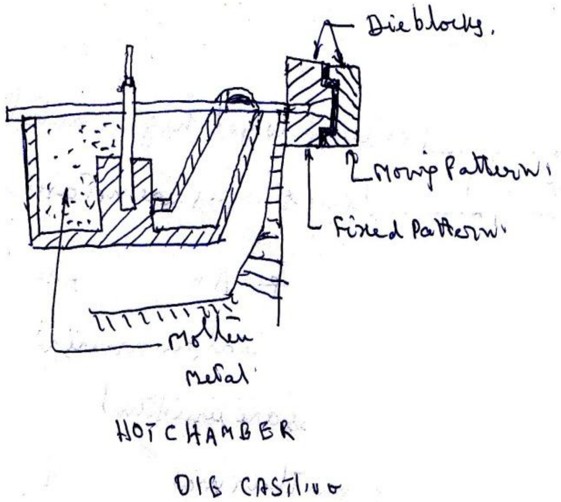
DIES:-

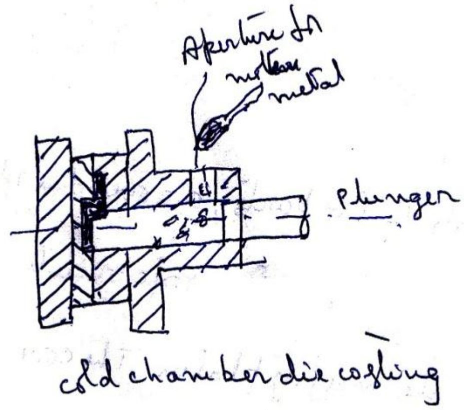
The die casting die consists of two parts, a cover die which is fixed to the stationary platen of the die casting machine while the other, called the eject die, is fixed to the moving platen. The cover die consists of the sphere also called biscuit, runner and gates, and also in contact with the nozzle of the goose nick in the case of hot chamber and with the shot chamber in case of cold chamber process.

DIE COSTING:-

Die casting involves the preparation of components by injecting molten metal at high pressure into metallic die. Die casting is closely related to permanent mould casting. The dies are reversible. It is also called pressure casting. Due to high pressure the die casting are used for narrow sections, complex shapes and fine surface finish can easily be produced.

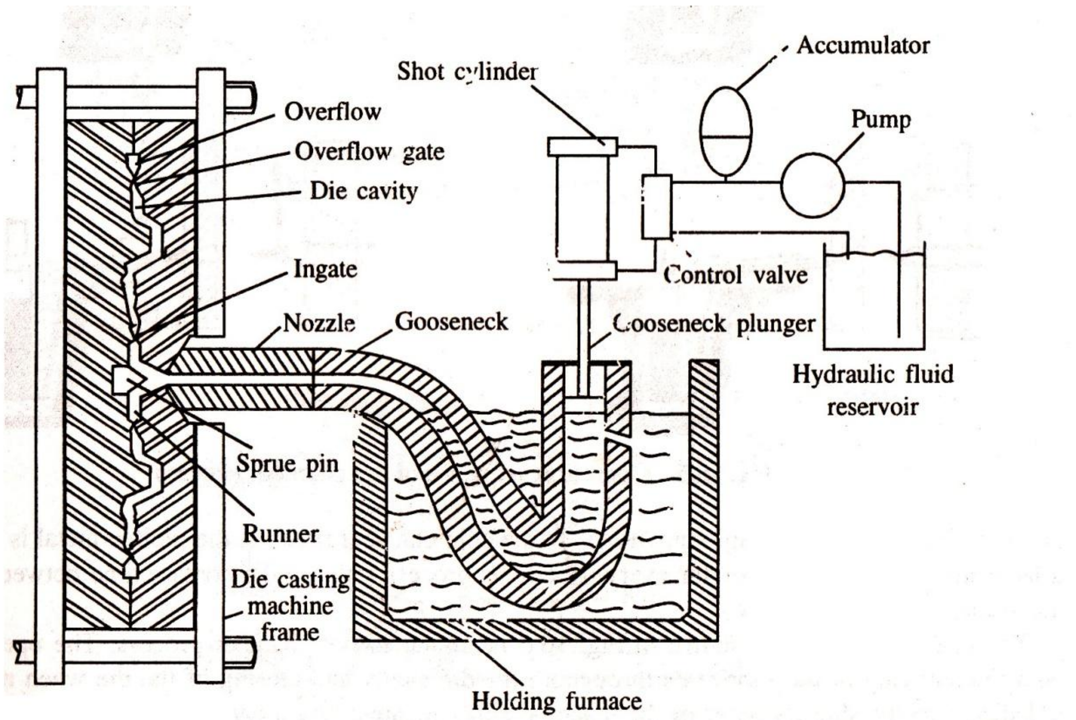
Die casting machines are of two types 1. Hot chamber die casting and 2.cold chamber die casting. In hot chamber process holding furnace for the liquid metal is integral with the die casting machine when as in cold chamber machine the metal is melted in a separate furnace and then powered into the die casting machine with a laddel for each casting cycle which is also called shot.





HOT CHAMBER PROCESS:

Hot chamber die costing m/c is provided with goose neck for pumping the liquid metal in to the liquid metal in to die cavity. The goose neck is sub merged in the holding furnace containing the molten metal. Goose neck is made of ductile iron (gray), cost steel. a plunger made of alloy C.I and is hydraulically operated move up in the goose neck to un cover the entry port for the entry of liquid metal in to the goose neck. Required pressure will be developed by the plunger. The nozzle at the end of the goose neck is kept in loose contact with the spure located in the cover die.



Schematic of a hot chamber die casting machine

The cycle starts with the closing of the die, when the plunger is in the highest position in the goose neck. Thus facilitating the filling of the goose neck by the liquid metal. The plunger then starts moving down to force the metal in to the goose neck to be injected in to the die cavity. The metal is held at the same pressure till it is solidified. The die is opened cores are removed. The plunger moves back original position returning the un used liquid metal to the goose neck.

Cold chamber process:

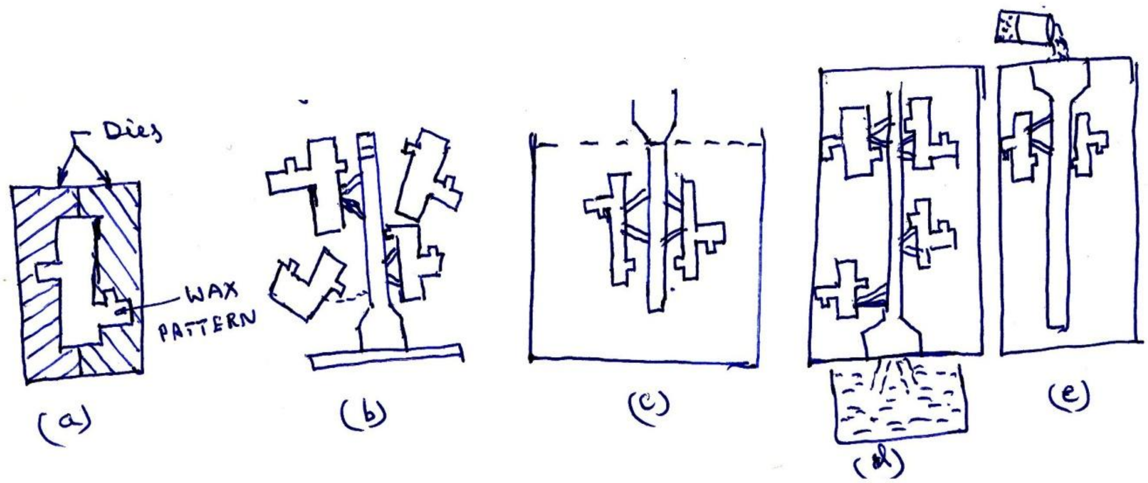
Hot chamber process is used for low melting temp alloys such as Zink, lead and tin.

Metals having high melting point such as aluminum, brass use cold chamber process.

The molten metal is powered with ladle in to the shot chamber

INVESTMENT CASTING:

This process is often termed as last wax process and precision casting process. The process broadly consists of preparing and expands able pattern of wax plastic or frozen mercury by powering the same in to a metal mould or die. The pattern is used for making the mould of investment material which consists of refractory material and a liquid binder.the investment mould is used for costing.



(a) **DIE MASKING**:

To make a suitable metal die in which the molten metal powered to produce a pattern.

(b) MAKING WAX PATTERN:

The die halves are closed and properly clamped molten wax is then forced in to the die, under pressure by means of a wax injection m/c. the injection pressure is between 8 to 150kg/cm^2 solidification 1 to 2 minutes. The die is then opened and the pattern removed. A lubricant is then sprayed on to the die surface and then the same closed for the next wax pattern.

(c) ASSEMBLING THE WAX PATTERNS:

Assemble a number of small wax patterns to a common wax gating system so that they can be placed together in one mould.

(d) **INVESTMENT PREPARATION:**

The expandable wax pattern is now dipped in to a flask which contains slurry of finally ground refractory grains and suitable liquid binder. After dipping the assembly is coated by sprinkling it with silica Saud and allows it to dry. This process is referred to as "investment" of the pattern.

REMOVEL OF THE WAX PATTERN:

The finished mould is then backed in an oven in an inverted position for about 2 hours to melt out the wax at a temp of 100^0c to 120^0 c. the wax melts and collects in the bottom plate in to a tray. The cavity of high dimensional accuracy for costing process. The collected wax may be reused.

POWRING AND COSTING:

The prepared mould is preheated to 538 to1038^0c depending on the material to be poured. The investment moulds may be poured under simple gravitational force or force of applied pressure or by centrifugal force.

ADVANTAGES:

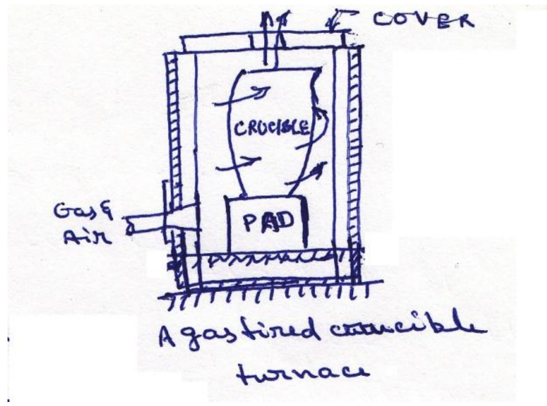
1. High dimensional accuracy with very closed tolerances.
2. Thin sections, to the extent of 0.75mm can be cost.
3. This process can be adopted for all types of metals and alloys that can be melted and poured.
4. Complex shaped parts can be casted.
5. Suitable for mass production of small sized castings.
6. Sound and defect free castings can be produced.

DISADVANTAGES:

1. Unsuitable for castings more than 5kgs.
2. The raw materials, special tooling, equipment and technology is costly.
3. Precise control is required at all states of production.

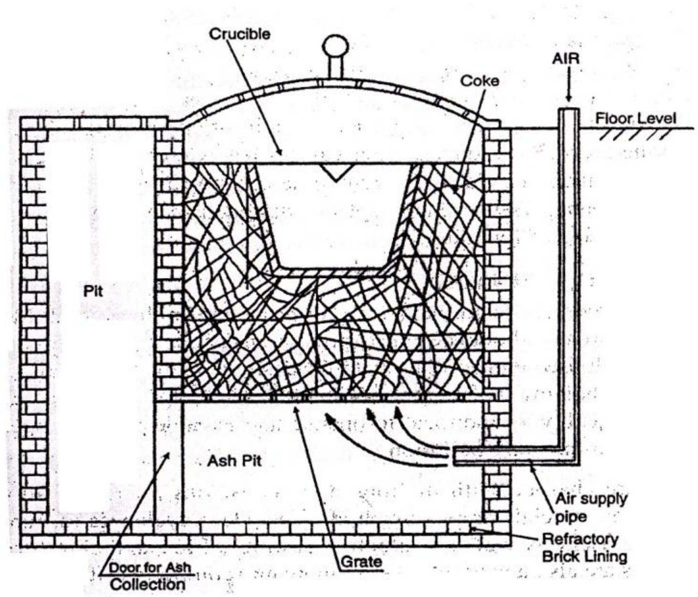
METHOD OF MELTING:

CRUCIBLE MELTING: -



These furnaces are simple and used in most of the small foundries. In these furnaces the entire melting of metals is to be melted inside a melting pot called crucible made of clay and graphite. Size of crucible varies from no: 1 to no: 400. Each no representation a definite quantity of metal. These furnaces are classified into two groups

1) Coke fired furnaces 2) Oil and gas fired furnaces. 3) Oil fired tilting furnace



Pit Furnance

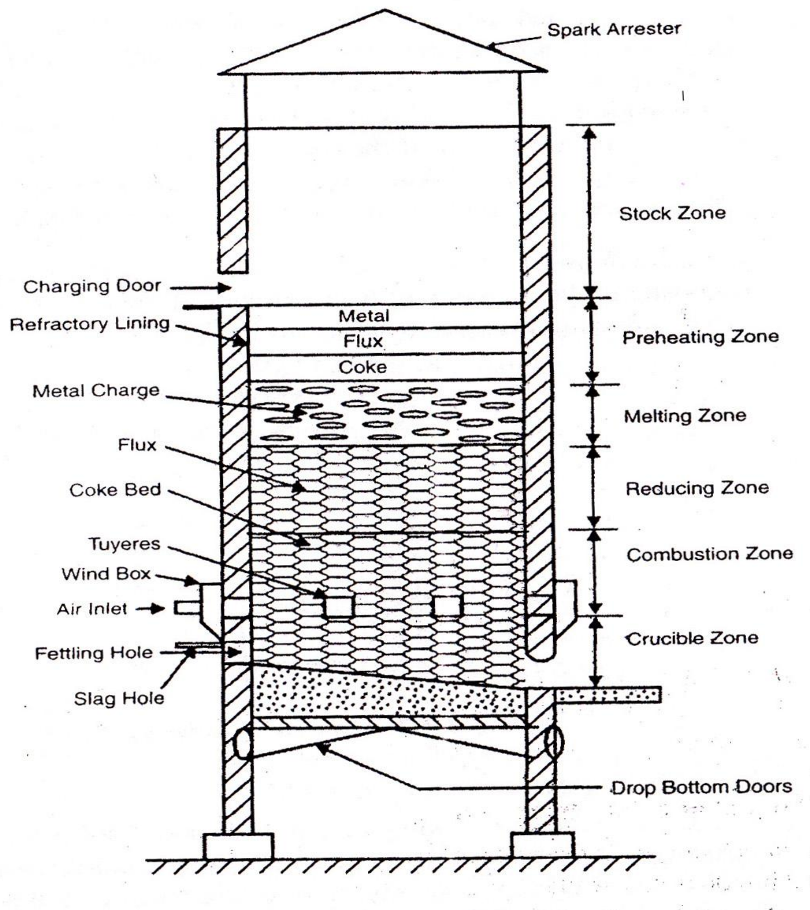


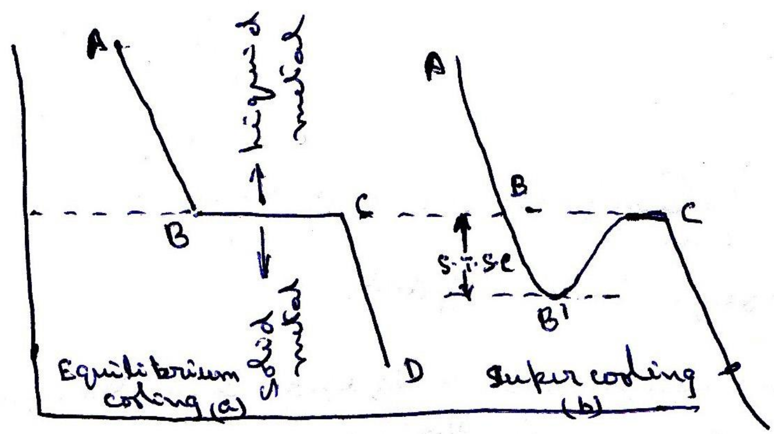
Fig. 3.3 Cupola

CONCEPTS OF SOLIDIFICATION OF CASTINGS:

1. A metal is molten condition processes high energy.
2. As the metal cools, it loses energy to form crystals.
3. Heat loss is more rapid near mould wolls than any other place, the submicroscopic metal crystals it is called nucleus form here.
4. Melt experiences difficulties in starting to crystallize of no nucleus the form of impurities are present.
5. However under such conditions melt under cools and thus nuclei or seed crystal form.
6. Nuclei formed as above tend to grow at the second stage of solidification.
7. The crystal growth proceeds with release of energy at crystal melt interfaces.
8. The crystal growth occurs in a dendritic manner.
9. Dendritic growth takes place by the evolution of small army on the original branches of individual dendrites.
10. As solidification proceeds, more and more arms grow on an existing dendrite and more dendrites form until the whole melt is crystallized.

SOLIDIFICATION OF PURE METALS:

a. Pure metals generally possess
   1. Excellent thermal, electrical conductivity9good conductors of heat electricity)
   2. Higher dielctricity and melting point lower yield point tensile strength
   3. Better corrosion resistance compared to alloys
b. Because of their higher melting point, pure metals exhibit certain difficulties in casting. i.e., during pouring, occurrence of severe metal mould reactions greater tendency towards cracking. This mode of solidification produce defective castings
c. Pure metals melt and solidify at a single temperature which is called melting point or freezing point.
d. Above freezing point the metal is in a liquid state and below freezing point it is in solid state.



e. If a pure metal cools rapidly or even otherwise when it is very pure and does not contain at all any impurity as nucleus to start crystallization it may cool as(B).
f. When pure metals are all owed to solidify in a mold, the portion of molten metal next to mould wolls begins to solidify.
g. This metal solidifies in the form of a solid skin and then the liquid metal tends to freeze on to it.
h. The boundary between the solid metal and melt is a well defined smooth surface.
i. As the successive layers of metal built up in the form of solid skin, the mould falls because of solidification shrinkage.

This causes the necessity of risers in order to have casting free form shrinkage defects.

SPECIAL CASTING METHODS

1. Die casting 2. Centrifugal casting 3. Investment casting

Two types of die casting machines are

1. Hot chamber die casting machine
2. Cold chamber die casting machine

ADVANTAGES OF DIECASTING

1. Large quantities of identical parts can be produced rapidly and economically
2. The parts produced are having smooth surface and close dimensional tolerances.
3. Thin and complex shapes can be produced accurately and easily
4. They require less floor area
5. Sound casting are produced with less defects
6. Rapid cooling rate produces, high strength and quality in many alloys.

DISADVANTAGES:

1. Cost of equipment and die is high
2. Only some nonferrous alloys can be economically die cost
3. Die castings may contain some porosity due to the entrapped air
4. Not economical for small runs
5. Heavy castings can not be cast

-> Centrifugal castings are classified into three types

1. True centrifugal casting
2. Semi centrifugal casting
3. Centrifuging

ADVANTAGES:

1. Casting produced are sound
2. Separate gates and rises are totally eliminated
3. Percentage of rejects are very low
4. Thin suctions and intricate can be easily cost
5. Castings are free from porosity defects
6. Castings have dense metal with very good mechanical properties.

DISADVANTAGES:

1. All shapes cannot be cast
2. Initial investment is high
3. Maintenance is quick expensive.

INVESTMENT CASTING:

ADVANTAGES:-

1. High dimensional accuracy with very closed tolerances.
2. Thin sections, to the extent of 0.75mm can be cost.
3. This process can be adopted for all types of metals and alloys that can be melted and poured.
4. Complex shaped parts can be casted.
5. Suitable for mass production of small sized castings.
6. Sound and defect free castings can be produced.

DISADVANTAGES:-

1. Unsuitable for castings more than 5kgs.
2. The raw materials, special tooling, equipment and technology is costly.
3. Precise control is required at all states of production.

DEFECTS IN CASTING AND CAUSES , REMEDIES:-

1. **SHIFTS:** this is an external defects due to mismatching of top and bottom parts of the casting and miss alignments of flashes. Make alignment of flashes and matching should be done.

2. **WARPAGE:** This will happen during or after solidification. Stresses developed at different at different rates of solidification.

3. **SWELL:** enlargement of mould cavity by metal pressure. Sand should be rammed perfectly.

4. **FIN:** a thin projection of metal not a part of the casting. They may occur at the parting line.

   Incorrect assemble of will cause tins and improper weight on top.

5. **DROPS:** it occurs when the upper surface of the mould cracks and sand pieces of sand fall into the molten metal.

6. **FIN HOLES:** small holes of dia less than 2mm appear on the top surface of the casting. These are caused due to absorption of hydrogen or carbon monoxide when the moisture content of sound is more.

7. **SHRINKAGE CAVITY:** this is due to high temperature of pouring metal.

8. **SAABS:** these are rough, irregular projections on the surface of a casting due to too fine sand having low permeability as uneven mould ramming.

9. Metal penetration and rough surface due to high permeability and large grain size.

10. **COLD SHUT AS MIS RUNS:** it is discontinuity of casting due to imperfect fusion of two streams of metal in the mould cavity, this defect is due to two much thin sections, damaged patterns and intermitting powering etc.
11. **HOT TEARS:** these are internal dragged discontinuities on the costly surface due to poor design, abrupt change in sections, no proper fillets and corner radii are provided properly.

12. **POWERED SHORT:** when the metal is not completely filled at one pouring. When the metal is not completely filled at one powering.

DEFECTS CASTING:-

1. **SHIFTS:**
   Causes: core misplacement, miss matching of top and bottom parts of the casting miss alignment of flasks.
   Remedies: to provide large areas for uniform solidification add sufficient rib like shapes, to provide equal cooling rates.
   Sand should be rammed properly.

2. **WARPAGE:**
   Causes: stresses developed at different suctions of a casting, due to different rates of solidification.
   Remedies: same as above

3. **SWELL**:
   Causes: enlargement of mould cavity by metal pressure. Improper ramming of the mould.
   Remedies: same as above

4. **FIN:**
   Causes: a thin projection of metal not intended as a part of the casting occurs at parting of the mould. Cores in correctly assembled insufficient weighing of moulds improper damping of flashes.
   Remedies: same as above

5. **BLOWHOLES:**
   Causes: due to untrapped bubbles of gapes with smooth walls due to excessive moisture in sand per mobility of sand is low sand grains are too fine ram is may be hard venting is sufficient.
   Remedies: same as above

6. **DIRT:**
   Causes: crushing of the mould due to improper handling, sand wash presence of slag particles in the molten metal.
   Remedies: may be prevented from entering the mould cavity by proper fluxing and the use of direct traps.

7. **DROPS:**
   Causes: due to crakes on the upper part of the mould cracks. Sand falls into the molten metal.

   Remedies: same as above

8. **PINHOLES:**
   Causes: small dia holes of less than 2mm dia visible on the surface of the casting due to absorption of hydro general.
   Carbon monoxide when the moisture content is high. When steel is powered how set laddles sufficiently degasified.
   Remedies: same as above

9. **SHRINKAGE CAVITY:**
Causes: depression in the casting due to uncontrolled and hap hazard solidification of metal. Due to excess pouring temperature.

10. **SCOBS:**
Causes: rough, irregular projecting on the surface of casting emborded sand.
Using too fine sand- low permeability uneven mould ramming.
Remedies: by missing additions such as wood flow- sea coal- den trim.

11. **METAL PENETRATION AND ROUGH SURFACE:**
Causes: sand has high permeability - large grain size – soft ramming of sand
Remedies: same as above

12. **COLD SHUT AND MISRUN:**
Causes: discontinuity is formed due to imperfect fusion of two streams of metal in the mould cavity – cracks.
Remedies: too thin sections and whole thickness improper gating system – damaged patterns – slow and inter content pouring of molten metal – the above conditions should be improved.

13. **HOT TEARS:**
Causes: internal or external ragged discontinuities – cracks on the surface due to poor design of casting – abrupt sectional changes takes place – no proper fillets – corner radii – poor collapsibility of mould and core – ramming two hard – incorrect powering temperatures – improper placements of gates and risers.
Remedies: same as above

14. **POWERED SHORT:**
Causes: when the mould casting is not completely filled up at one powering.
Remedies: same as above.

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