Unit – I

Metal casting processes

Sand Casting : Sand Mould – Type of patterns - Pattern Materials – Pattern allowances –Molding sand Properties and testing – Cores –Types and applications – Molding machines– Types and applications; Melting furnaces : Blast and Cupola Furnaces; Principle of special casting processes : Shell - investment – Ceramic mould – Pressure die casting - Centrifugal Casting - CO2 process – Stir casting; Defects in Sand casting

Metal Casting Process

Manufacturing

Manufacturing in its broadest sense is the process of converting raw materials into useful products. It includes

i) Design of the product

ii) Selection of raw materials and

iii) The sequence of processes through which the product will be manufactured.

Casting

Casting is the process of producing metal parts by pouring molten metal into the mould cavity of the required shape and allowing the metal to solidify. The solidified metal piece is called as "casting".

Advantages

- ✓ Design flexibility
- ✓ Reduced costs
- ✓ Dimensional accuracy
- ✓ Versatility in production

Disadvantages

- ✓ Lot of molten metal is wasted in riser & gating
- ✓ Casting may require machining to remove rough surfaces

Sand Casting

Sand Casting is simply melting the metal and pouring it into a preformed cavity, called mold, allowing (the metal to solidify and then breaking up the mold to remove casting. In sand casting expandable molds are used. So for each casting operation you have to form a new mold.

- ✓ Most widely used casting process.
- ✓ Parts ranging in size from small to very large
- ✓ Production quantities from one to millions
- ✓ Sand mold is used.
- ✓ Patterns and Cores

  Solid, Split, Match-plate and Cope-and-drag Patterns

  Cores – achieve the internal surface of the part

Molds

- ✓ Sand with a mixture of water and bonding clay
- ✓ Typical mix: 90% sand, 3% water, and 7% clay
- ✓ To enhance strength and/or permeability and – Refractory for high temperature

Size and shape of sand

- ✓ Small grain size -> better surface finish
- ✓ Large grain size -> to allow escape of gases during pouring
- ✓ Irregular grain shapes -> strengthen molds due to interlocking but to reduce permeability

Types of sand

a) Green-sand molds - mixture of sand, clay, and water; “Green" means mold contains moisture at time of pouring.

b) Dry-sand mold - organic binders rather than clay and mold is baked to improve strength

c) Skin-dried mold - drying mold cavity surface of a green-sand

Mold to a depth of 10 to 25 mm, using torches or heating

Steps in Sand Casting

The cavity in the sand mold is formed by packing sand around a pattern, separating the mold into two halves

The mold must also contain gating and riser system For internal cavity, a core must be included in mold

A new sand mold must be made for each part

1. Pour molten metal into sand mold
2. Allow metal to solidify
3. Break up the mold to remove casting
4. Clean and inspect casting
5. Heat treatment of casting is sometimes required to improve metallurgical properties

2. Describe briefly about the various types of molding tools used with sketch.
(AU MAY – JUNE 2010)

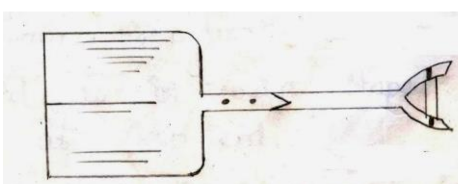
Molding tools:

The following tools are used in a hand molding process.

# Shovel	# sprue pin
# Riddle	# riser pin
# Rammer	# gate cutter
# Trowel	# draw spike
# Slick	# swal
# Strike-off-bar	# bellows
# Lifter	# mallet
# Vent wire	# molding boxes

1. Shovel

- It is a steel pan with long wooden handle.
- It is used to mix and temper the molding sand with clay, moisture and other additives before pouring into the mould.



- It is also used for carrying the molding sand from the sand pit or pill to the molding box.
- Now a day, a cast iron handle is also used.

2. Riddle:

- Steel wire mesh (screen) fitted into a circular or square frame is called riddle.

- It is used for removing foreign materials such as stones, nails, etc.
- It is also used to separate various sizes of sand grains.

3. Rammer:

- It is used to ram or pack the sand in the box.
- It is normally made of wood or metal.

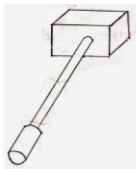
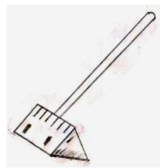



Fig: Rammer

- Rammer has two ends. Such that
- One end is in wedge shaped and is known as peen end.
- The other end is cylindrical in shaped is known as butt end.

4. Trowel:

- It has a metal pan with a short wooden handle.
- The pan may be in different shapes.

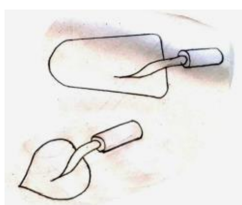


Fig: Trowel

- It is used to smoothen the surfaces of mould and repair the damaged portions of mould.

5. Slick:

- It is a spoon shaped doubled-ended trowel.

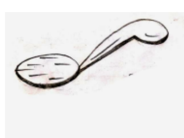


Fig: Double – ender or slick

- It is used for repairing and finishing small curved or straight surfaces and round corners of the mould.

6. Strike-off-bar:

- It is made of wood or metal
- It has a straight edge
- It is used to remove excess sand from the mould after ramming.

7. Lifter

- It is a bend and twisted blade as shown in figure.

Fig: Lifter

- It is used to lift dirt or loose and from the deep mould.
- It is also used for repairing and finished the cavity and gates.

8. Vent wire:

- It is a thin steel wire with handle.
- It is used to make small holes in the mould after ramming.

9. Sprue pin:

- It is a tapered cylindrical wooden piece.
- It is used to make a sprue hold in the cope.
- The sizes of sprue pin depend upon the size of the mould.
- The molten metal passes through this sprue hole to the cavity.

10. Riser pin.

- It is also a tapered wooden rod.

Fig: Riser pin

- Its size is smaller than the sprue pin. It is used to make a riser in the cope.

11. Gate cutter:

- It is a bend type of metal which is used to cut gates.

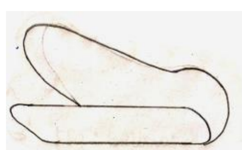


Fig: Gate cutter

- The gate is a passage between mould cavity and runner.

12. Draw spike:

- It is a pointed or threaded steel rod with a ring at one end as shown in fig.

Fig: Draw spike

- It is used to remove the pattern from the mould.

13. Swab:

- It is a small brush
- It is used to apply water on the sand around the pattern

Fig: Swab

- It may be used for sweep away the dust from the pattern or excessive sand from the mould joint or to give coating on the pattern.

14. Bellows:

- It is used to below off loose sand particles from the mould and pattern.

Fig: Bellows

15. Mallet:

- It is wooden hammer which is used to drive the draw spike into the pattern and then lifts from the mould.

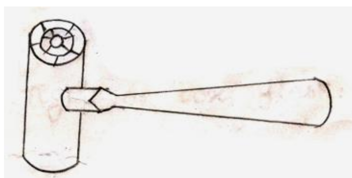


Fig: Mallet

16. Molding boxes:

- Molding box or flask is a frame or box of wood or metal which is used to hold molding sand.
- A molding box may be in two or three parts.
- The top part is cope
- The middle part is check
- The lower part is drag.

The main types of boxes are

- Snap flask
- Tight or box flask

(a) Snap flask

- It is generally made of wood.
- It has hinges on one corner opposite corners have latches to lock the flask in position.
- First the flask is locked to make mould. After making the mould, the latches are unlocked and flask is opened out.
- The flask is removed from the mould, number of moulds can be made with the help of one box in this way.

(b) Tight or box flask:

- It is a box shaped container without top or bottom.
- It is made of metal or wood.
- It is used for making small and medium size moulds.
- The top part (cope) and bottom part (drag) are held in position by dowel pins or bolt and nut.

3. Describe briefly the various pattern material used for making pattern.
Pattern materials: (AU MAY – JUNE 2010)

The following factors to be considered for selecting pattern materials

- ✓ Design of casting
- ✓ Number of casting to be produced
- ✓ Degree of accuracy and surface
- ✓ Finish required
- ✓ Shape, complexity and size of the castings
- ✓ Castings or molding method adopted patterns are made by different materials which have their own advantages, limitations and their filed of applications.

Commonly used pattern making materials are given below.

- ✓ Wood-teak wood, mahogany, white pine, etc.
- ✓ Metal-cast iron, brass, aluminum, white metal etc,
- ✓ Plaster
- ✓ Plastics
- ✓ Wax

Wood:

- ✓ Wood is a material commonly used for pattern making.
- ✓ Generally, teak wood, mahogany, white pine, rosé wood are used for making pattern.
- ✓ Laminated wooden sheets are also used for getting accuracy, surface finish and long life.
- ✓ These woods should not contain more than 10% moisture to avoid wrapping and distortion during subsequent drying.
- ✓ Metal spray coating up to 0.25mm thick may be given on wooden pattern.
- ✓ Zinc and aluminum are used for coating the metals and the wooden surface to avoid moisture absorption and good surface finish.

Advantages:

- ✓ It is light in weight, cheap and easily available.
- ✓ It is easy to work, easy to cut and easy to fabricate.
- ✓ It can be easily repaired
- ✓ It can be easily smoothened by varnishes and paints.

Limitations:

- ✓ It absorbs water from sand and changes its shapes.
- ✓ It has non uniform structure.
- ✓ It has high wear and tear by sand. Hence, it cannot be used for mass production.
- ✓ It cannot be used in machine molding.

Metal:

- ✓ Metal pattern is used when a larger number of castings are to be made.
- ✓ Metal pattern can be either cast from a masterpiece or may be machined by the usual method of machining.
- ✓ These patterns are usually used in machine molding.

Advantages:

- ✓ It has long life and accurate in size.
- ✓ It has smooth surface mass production is possible.

- ✓ It does not absorbs moisture and deform in size.
- ✓ It can be used for rough handling and its resistance to wear, tear abrasion and corrosion.

Disadvantages:

- ✓ It is costlier and heavier than wood.
- ✓ It cannot be easily repaired.
- ✓ Ferrous patterns can get rusted.
- ✓ It is difficult to make the required shape.

The materials commonly used for pattern making are,

- ✓ Cast-iron
- ✓ Brass
- ✓ Aluminium

Cast-iron

- ✓ Cast iron having fine grain can be used as a pattern material.
- ✓ It has high resistance to sand abrasion and smooth surface, but it is heavier and difficult to work.
- ✓ It cast is less and more durable than other metals.
- ✓ It is brittle and can be easily broken.
- ✓ It will get rusted by moisture unless it is protected.

Brass:

- ✓ It may be easily worked and built up by soldering or brazing.
- ✓ It is used only for small size pattern because of high cost.
- ✓ It is very strong and not affected by moisture.
- ✓ It takes very good surface finish and with sands wear and tear.
- ✓ It can make very high accuracy.

Aluminium:

- ✓ Aluminium is the best material because it is light in weight, strong and easily machined.
- ✓ It can be made with high accuracy and good surface finish. It will not be affected by moisture and get rusted and also melt low temperature.
- ✓ It is a very soft and easily damage by rough surfaces.

4.Plastics:

- ✓ A plastics pattern has many advantages over other materials.
- ✓ Plastics pattern is cast from a wooden pattern called master pattern.
- ✓ It is light in weight but strong.
- ✓ It is not affected by moisture and more resistance to wear.
- ✓ It has very smooth glassy surface.
- ✓ It does not shrink much and has high dimensional accuracy and more economical than other metals.

The following plastics are widely used for pattern making with the composition based on epoxy, phenol formaldehyde and polyester resins.

- ✓ Poly acrylates
- ✓ Poly ethylene
- ✓ Poly vinyl chloride etc.

5. Wax:

- ✓ Wax pattern is primarily used in investment castings.
- ✓ The commonly used waxes are paraffin wax, shellac wax and microcrystalline wax .
- ✓ It has good surface finish and high dimensional accuracy.
- ✓ It will not absorb moisture and easy to work.
- ✓ Cost is very less, but it can be used for making small patterns only.

4. Explain the types of pattern in details. (AU NOV-DEC 2010)

Pattern:

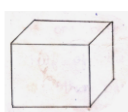
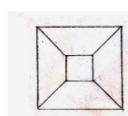
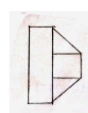
A pattern is one of the important tools used for making cavities in the mould into which molten metal is poured to produce a casting.

Types of patterns:

1. Solid or single piece pattern
2. Split pattern
3. Loose piece pattern
4. Match plate pattern
5. Sweep pattern
6. Skeleton pattern
7. Segmental pattern
8. Shall pattern

1. Solid or single piece pattern:

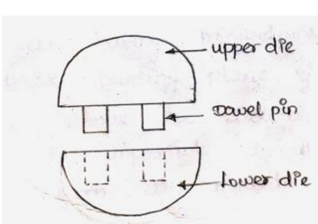
- ❖ These types of pattern are made of single solid piece without joints, partings or loose piece, it is called solid or one-piece pattern.

- ❖ It is made exactly into the designed casting to be produced with some allowances.
- ❖ It is used for making a few large size simple castings.
- ❖ Removal of pattern from the sand is easy.

2. Split pattern:

- ❖ One pattern which is having complex geometry cannot be removed from mould if they are made by single piece.
- ❖ Generally split pattern is made into to parts.
- ❖ One part is used to produce the lower half of the mould.
- ❖ Other part is used to produce the upper half of the mould.
- ❖ These two parts are assembled together in correct position by pins called dowel pins.
- ❖ The line separating the two parts is called parting line.



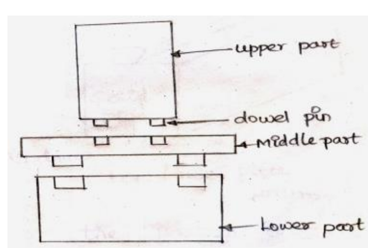


Fig: Split pattern Fig: Three piece pattern

- ❖ If the split pattern are made of three pieces. Then it is called three piece patterns.

3. Loose piece pattern:

- ❖ If a pattern is made from a single piece having projections or back parting plane is lie above or below, it is impossible to with draw it from the mould.
- ❖ In such cases, the pattern is built up into solid pattern and loose pieces.

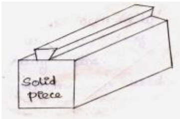


Fig: Loose piece pattern

- ❖ After making the mould, first the solid pattern is removed and then the loose pieces are removed without breaking mould. Is called loose piece pattern.
- ❖ Loose pieces are attached to the main body of the pattern by pins.

4. Match plate pattern:

- ❖ This pattern is made in two halves mounted on both sides of a plate called match plate which is made by aluminum or wood.
- ❖ The match plate is accurately placed between the cope and the drag flasks by means of locating pins.

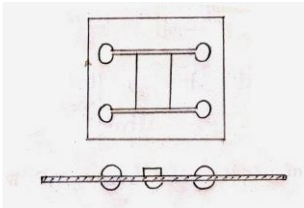


Fig: Match plate pattern

- ❖ Match plate patterns are used in machine molding.
- ❖ This type of pattern is used for small, accurate size and large number of castings.
- ❖ Piston rings of I.C engine are produced by this process.

5. Sweep pattern:

- ❖ Sweep patterns are mainly used to generate surfaces of revolution like cylinder, cone, sphere in large castings.

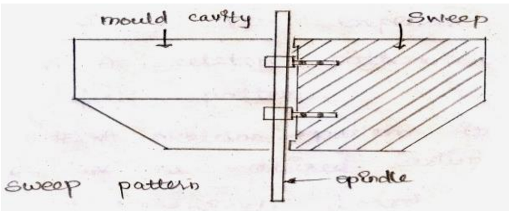


Fig: Sweep pattern

- ❖ A half of the board is fitted in the centre spindle.
- ❖ The sand is approximately rammed around the mould cavity.

- ❖ The sweep is rotated to form the mould cavity in the sand.
- ❖ Sweep patterns are used for making large and circular castings in loam molding.

6. Skeleton pattern:

- ❖ For larger casting of simple shape. If a solid pattern is made of wood.
- ❖ It is very expensive.
- ❖ A skeleton pattern is used instead of a full pattern.
- ❖ A skeleton pattern is a ribbed frame of a desired casting.

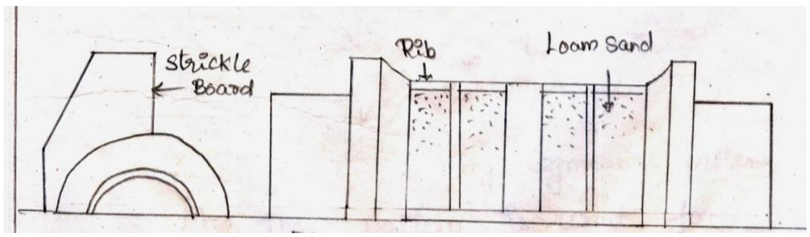


Fig: Skeleton pattern

- ❖ A strickle board is used to remove excess sand and to give correct shape.
- ❖ Moulds for water pipes, turbine castings, pipe bends are made by skeleton pattern.

7. Segmental pattern:

- ❖ A segmental pattern is a segment of whole pattern as shown in fig .

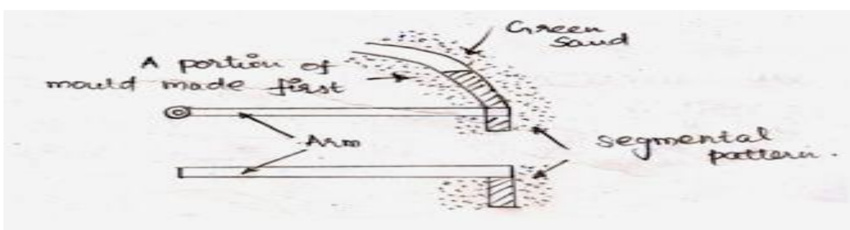
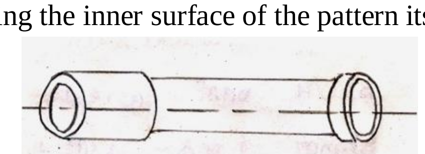


Fig: Segmental pattern

- ❖ This pattern is also called part pattern
- ❖ The pattern is used for forming circular moulds.
- ❖ This pattern is used for casting circular components such as rings, wheel rims, gear blanks, etc.

8. Shell pattern:

- ❖ Shell pattern is a hollow pattern its outer shape is used for making the mould.
- ❖ The core is prepared using the inner surface of the pattern itself. It is also known as block pattern.



- ❖ These patterns are usually made of metal.
- ❖ These patterns are mainly used for making drainage fittings and pipe work like short bends.

5. What are the types of molding process? And briefly explain.
Molding processes (AU NOV-DEC 2010)

Define the process of making a cavity similar to the product required in sand is called molding.

There are different types of moulds given below.

- Green sand mould
- Dry sand mould
- Loam mould

1. Green sand mould:

- Green sand mould contains 10 to 15% clay,4 to 6% of water and remaining percentage of silica sand.
- It is porous.
- It is that mould in which the molten metal is poured immediately after the mould is prepared.
- These moulds are preferred for making small and medium size castings.
- It is specially used for non-ferrous metals and alloy castings.

Advantages:

- The process is less expensive
- It can be used for all metals
- Mould distortion is less
- It does not restrict the free contraction of metal.
- It needs lesser time for making mould since drying is not required.

Limitations:

- Surface finish is less
- Strength of the mould is low
- Defects like blow holes may occur.

2. Dry sand mould:

- If the green sand mould is dried after making the mould, it is called dry sand mould.
- It is a mixture of silica sand, coal dust, and binders like clay, betonies and molasses etc.
- The step-by – step procedure of making dry sand mould is the same as that of green sand molding.

Advantages:

- It is stronger than green sand mould.
- It has better dimensional accuracy
- Permeability is more
- It can be stored for long time.

Limitations:

- It is a more time consuming process, since, it requires heating.
- Cost is high.
- It is subjected to hot tear.

3. Loam molding:

- Loam sand is a mixture of silica sand, water, graphite powder and more amount of clay.
- The mould made by using loam sand is called loam molding.
- This is made by using pit molding method.
- Initially, rough frame work is made by bricks. The loam sand is applied over the brick work.

- Loam molding is made also by skeleton pattern.

Applications:

- It is used for large cylinders large bells, wheels, kettles, gear wheels, pans and other large machine parts.

Advantages:

- Large castings can be made with less cost . since no pattern & mould boxed are required.
- It has good surface finish.
- Accurate casting can be produced.

Limitations:

- It is a time consuming process.
- Skilled labour are required.
-

6. Describe about the good properties needed for molding sand.

A good casting can be produced only with the use of good quality molding sand.

These properties are

1. Porosity or permeability
2. Plasticity or flow ability
3. Adhesiveness
4. Strength or cohesiveness
5. Refractoriness
6. Collapsibility

Porosity or permeability:

Permeability is a measure of molding sand by which the sand allows the steam and gases to pass through it.

Permeability of molding sand depends on the following factors.

1. Quality and quantity of clays and quarty.
2. Moisture content
3. Degree of compactness.

The following parameters which affect the permeability of molding sand.

1. If the clay content is less the permeability will be more and vice-versa.
2. If the grain size is layer, the permeability will be more and vice versa.
3. Soft ramming (ie, less density) improves the permeability.
4. Higher the silica content on sand lower will be the permeability.

2. Plasticity or flow ability:

1. The property of molding san by which the molding sand flows around and over the pattern, and uniformly fills the flask.
2. It gives the shape of the pattern and retains the shape after removijg the pattern.
3. This property may be improved by adding clay and water to silica sand.

3. Adhesiveness:

1. The property of molding sand by which it sticks or adheres to another body.
2. The molding sand should cling or stick to the sides of the molding boxes.
3. It does not fall out when the flasks are lifted and turned over. This property depends on the type and amount of binder used in the sand mix.
4. Addition of clay and moisture increases the adhesiveness.

4. Strength or cohesiveness:

1. It is property of molding sand by which it sticks together.
2. A molding sand should have sufficient strength so that the mould does not collapse or get partially damaged during shifting, turning or pouring the molten metal.

Strength of the molding sand depends on

1. Grain size and shape
2. Moisture content
3. Density of sand after ramming strength is increased with increasing density, clay content and decreased size of sand grains.

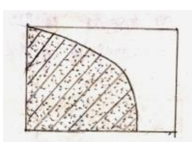
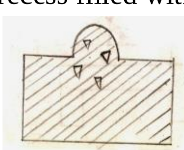
5. Refractoriness:

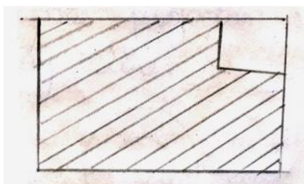
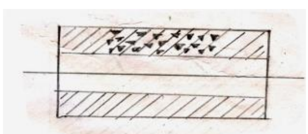
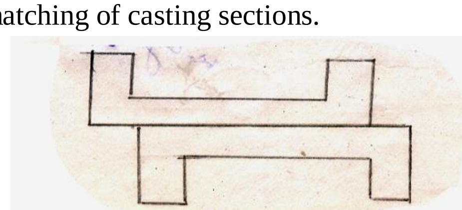
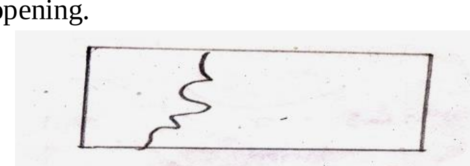
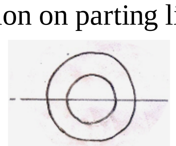
1. The property of molding sand to resist high temperature of molten metal.
2. This property mainly depends on the purity of the sand particles and size.
3. Rough and larger grain, and quarty content in molding sand increase the refractoriness.
4. Poor refractoriness will result in rough surface in casting.

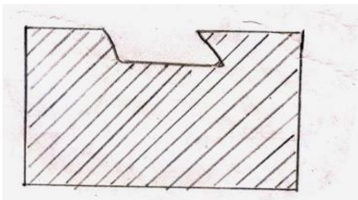
6. Collapsibility:

1. The property of the molding sand to decrease in volume to some extend under the compressive forces developed by the shrinkage of metal during freezing and subsequent cooling.
2. This property permits the molding sand to collapse easily after the casting solidifies.
3. If the mould or core does not collapse, it may restrict the free contraction of the solidifying material and causes crack on the casting.
4. This property depends on the amount of quarty and binders.

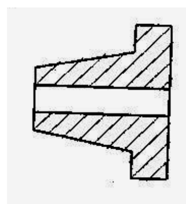
7. Enumerate the various casting defects and suggest suitable remits.(AU MAY-JUNE 2011, Nov/Dec-2012, 2013, May/June 2014) .

Defects	Remedies
1.Shrinkage: It is a depression on the casting surface formed if these gases could not come out; blow holes are formed on the interior of the casting. 	• Proper solidification • Pour at correct temperature • Modify gating runner and riser system • Control moisture content • Ram property • Provides sufficient vent holes • Control bitter content
3. Scab: It is the erosion or breaking down a portion of the mould and the recess filled with metal. 	• Provide uniform ramming. • Pour with correct velocity.

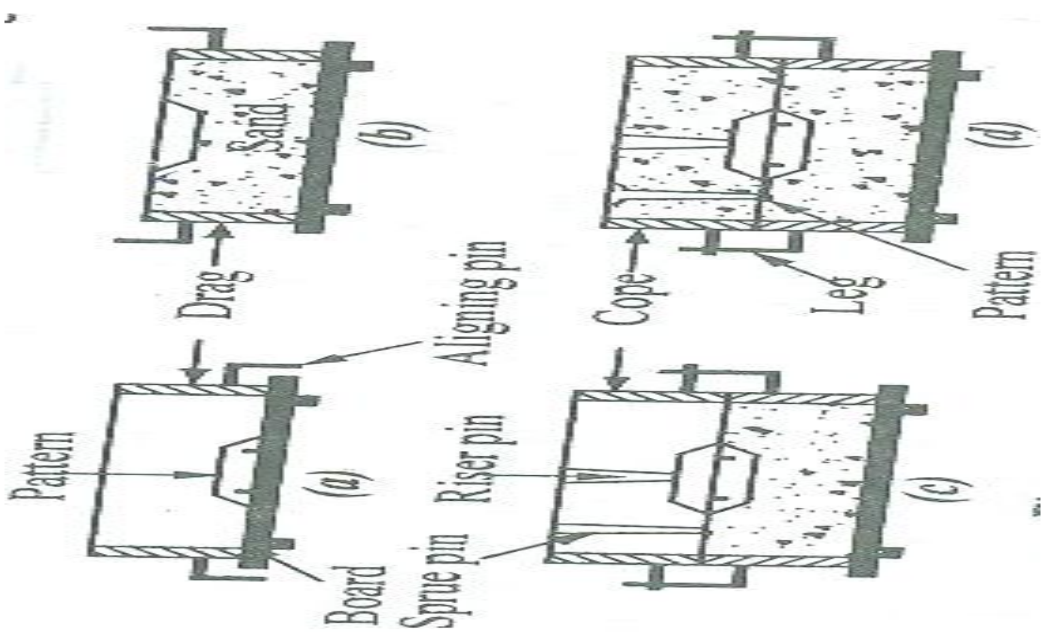
4. Swell: It is the enlargement of casting. 	• Ram property • Pour with correct velocity • Provide adequate support to the mould.
5. Hard spots: Some spots on the surface become hard. 	• Provide uniform coding • Pour – at correct temperature
6. Honey combing: Number of small cavities present on the casting surface. 	• Provide correct ramming • Provide correct gating system. • Pour at correct temperature.
7. Shift: Mismatching of casting sections. 	• Repair or replace the pins and dowel pins in the pattern. • Assembly the molding boxes properly. • Provide proper box locating of core.
8. Cold shut: It s the incomplete filling of the mould casting at one opening. 	• Pour at correct temperature • Provide correct gating system.
9. Fins: This projection on parting line. 	• Pour at correct temperature • Modify gating system.

10. Blister: The scar covered by the thin layer of a metal. 	• Pour at correct temperature. • Use sufficient molten metal.

8. a Figure shows the cross section of a control component (having a flange and an axial hole).



9. Describe briefly, with sketches, the steps involved in making a sand mould to cast this component. Sketch also the shape of the casting as soon as it removed from the mould.(AU MAY-JUNE 2012, 2014)



The procedure for making green sand mould (floor or bench molding method) is explained below:

1. Here , we are using single piece pattern. The single piece pattern is placed at center of the molding board as shown in figure (a)

2. The drag box is placed around the pattern. Dowel pins are connected on the drag box
3. 20 mm layer of facing sand is first placed around the pattern and then the drag box is filled up with green sand
4. Sufficient ramming is done by the peen end of the hand rammer.
5. Excess sand is removed by strike off bar.
6. Vent holes are made by vent wire which is used to escape the steam and gases produced during pouring.
7. The top surface is made smooth by trowel.
8. Then the drag is tilted upside down as shown in fig (b)
9. The parting sand is sprinkled over the surface of green sand to avoid sticking of sand on cope with the sand on drag.
10. Cope box is placed correctly in position on the drag using the dowel pins as shown in fig (c)
11. Raiser pin and sprue pin are placed in correct position.
12. The operation of filling, ramming and venting of the sand on cope are done similar to that of drag.
13. Sprue pin or raiser pin are removed
14. Cope and drag box are separated.
15. Then pattern piece are withdrawn slowly.
16. A gate is cut on the top surface of the drag. It should be exactly below the sprue on the cope.
17. Finally, the cope an drag are assembled. Weight is placed on the cope to prevent the cope from floating up when the molten metal is poured. Now, the mould is ready for pouring.

10. Explain the steps involved in "Lost wax process ",with suitable sketches. (May/ June 2012, Nov/Dec-2013)

The molten metal is poured in already made mould cavity by melting the mould pattern in the mould itself. When the wax pattern is heated, it will be melted and disposed of from the mould called "Lost wax process" . Before making the mould, first the wax pattern has to prepare from the master pattern.

Various steps involved in lost wax process:

1. The master pattern is prepared by casting process. It may be made of brass, aluminium alloy or steel metal shrinkage and wax allowances are provided on the master pattern.
2. A composite die is used for making master pattern. The die is made of low-melting alloy such as bismuth alloys, aluminium, CI etc. Master pattern die cavity is formed by machining process. Generally split type cavities are formed.

3. First, halves of die cavities are clamped together. Molten wax is injected under the pressure of about 4 bar to the die cavity. Die cavities are preheated to avoid immediate solidification of wax. If it is like this, partial filling of die cavity take place. Polystyrene, polythenes patterns are made at 35bar with higher temperature.
4. If the size of the wax pattern is large several small wax patterns are first prepared and assembled together with a gating system along with central spure. Assembling various small wax patterns are welded by using heated tools known as cluster.
5. The assembled wax patterns have to be smoothened/ super finished before putting into operation. This is done in two stages.

Stage 1:

First, slurry is made by mixing fine silica either with water or ethyl silicate. Then wax pattern are dipped in this prepared slurry to give primary coating of about 1mm thickness. It provides the improved surface quality to wax patterns. Then wax pattern is dried.

Stage 2:

In this stage, first ceramic slurry is prepared by using refractory material like silica and binder like gypsum. The gypsum is purely water-based sodium silicate. Wax, a solid type mould is placed over the assembled wax patterns. Then the ceramic slurry is poured over these assembled patterns

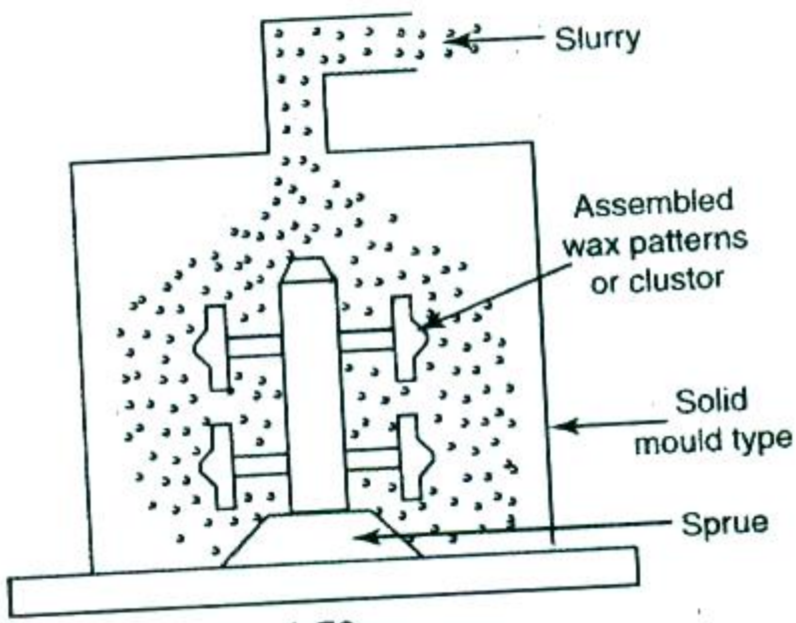


Fig 1.73

1. After applying coating, the mould is prepared using assembled wax pattern called cluster. Next, the mould made along with wax pattern dried in air for about 2 to 3hrs. then baking of patterns is done in an

oven for 2hours for melting the wax patterns. When the heating temperature reaches about 100 to 120^0C, the wax will start to melt. Finally, the melted wax will flow out through the sprue in molten form.

2. Again, the entire mould is transferred to heating furnace. First the mould is held at 150^0C for further drying. Next, the heating is continued about 800 to 900^0C to vaporize remaining wax inside the mould cavity. This preheated mould is used to fill mould cavity without partial filling due to solidification of molten metal, while pouring through the sprue. Then, it is allowed to solidify by cooling.
3. After solidification is over, the casting are removed from the mould by shaking out. At that time, the fragile material of mould will break. Then gates and sprue called runner are removed usually by machining.
4. Finally, the casting are cleaned and inspected to detect casting defects.

11. Write short notes on following: (May/ June 2012, Nov/Dec-2013)(Nov/Dec-2018)

(1) Ceramic mould

- In this method, first the ceramic slurry is prepared by mixing fine grained refractory powders of zircon ($ZrSio_4$) alumina (Al_2o_3), fused silica (SiO_2) and patented bending agents.
- Then this slurry is applied over the pattern surfaces to form thin coating around it. After applying coating on the pattern, it is baked in a less expensive fire clay. After this, the pattern is removed out from the mould and it is transferred to an oven for further heating mould about 1000^0C.
- Then the molten metal is poured in the mould cavity through the sprue to produce castings.
- In this case also, the preheated mould is used during pouring of molten metal. As a result, the partial filling of molding is completely eliminated due to solidification of molten metal.
- This type of mould casting method is mainly used for all materials using better ingredients in slurry.

(2) Centrifugal casting. (Nov/Dec-2013)(Nov/Dec-2018)

Centrifugal casting is primarily used for making hollow castings like pipe without using core. In this process, the metal mould is made to rotate. The rotating mould is mounted on a trolley as shown in fig. The trolley move over rails. The end of the mould is closed by end cores to prevent the flow of metal. The metal is poured into mould through a long spout. The mould rotate by electric motor or mechanical means as well as moves axially on the rails. Due to centrifugal force, the molten metal is thrown to walls of the mould. The outside of the mould is water-cooled. So, the molten metal solidifies immediately.

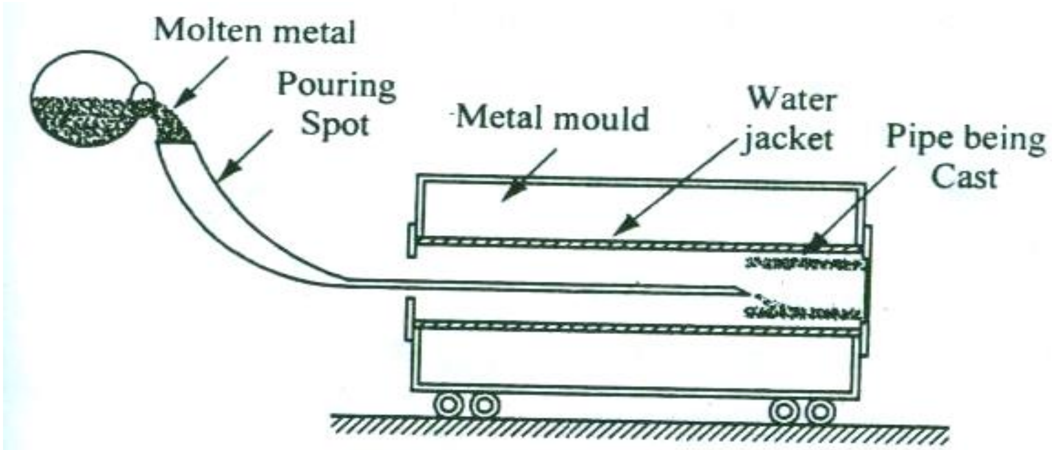


Fig 1.77 Centrifugal casting

Centrifugal casting method is used for producing cylindrical and symmetrical objects.

Applications

Components like water pipe, gears, bush bearings, fly wheel, piston rings, brake drums, Gun barrels etc.

Advantages

1. Core is not required to produce hollow components.
2. Rate of production is high.
3. Pattern, runner, riser are not required.
4. Thin castings can be made.
5. Castings have uniform physical properties.

Limitations

1. It is suitable only for cylindrical and symmetrical shaped castings.
2. Cost of equipment is high.

12. Describe the various pattern allowances which can be quantitatively specified. [AU-NOV/DEC-2012;May/JUNE-2013](Nov/Dec-2018)

- Patterns are not made into the exact size of the castings to be produced.
- patterns are made slightly larger than the required castings.
- This extra size given on the pattern is called pattern allowances.
- Pattern allowances are given for the purpose of compensating the metal shrinkage to provide extra metal which is to be removed in machining, to avoid metal distortion, for easy withdrawal of pattern from mould and for rapping.
- If allowances are not given on the pattern, the casting will become smaller than the required size.

The various types of allowances are

- ❖ Shrinkage allowance
- ❖ Machining or finish allowance

- Draft or taper allowance
- Distortion or camber allowance
- Rapping or shake allowance

SHRINKAGE ALLOWANCE

The metal shrinks on solidification and contracts further on cooling to room temperature. To compensate this, the pattern is made larger than the required casting.

This extra size provided on the pattern for metal shrinkage is called shrinkage allowance. If it is not given, the casting will become smaller.

Materials	Shrinkage allowance (mm/min)
C.I	10.4
Aluminium	17
Brass	15.3
Steel	20.8
Zinc,lead	25

MACHINING OR FINISH ALLOWANCE

All the castings are to be machined to get the required surface finish on the metal. During machining, some of the metal is removed from the casting. For this purpose, the pattern is made larger than the required casting.

This extra size given to the pattern for machining purpose is called machining or finishing allowance. The amount of finish allowance depends on the material of the casting, size of casting, volume of production, method of molding, configuration of the casting, method of machining and degree of finishing etc.

Machining allowance is always larger for hand molding when compared to machine molding. The machining allowance for various materials is shown below.

Materials	Machining allowance	
	0-300mm	0-600mm
Cast Iron	2.5mm	4.0mm
Aluminium	1.6mm	3.2mm
Bronze	1.6mm	3.2mm
Brass	1.6mm	3.2mm
Cast steel	3mm	4.5mm

DRAFT OR TAPER ALLOWANCE

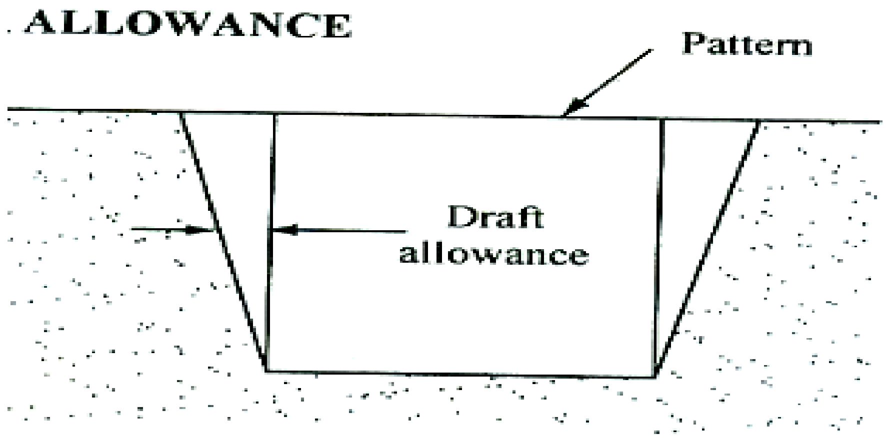


Fig 1.10 Draft allowance

If the vertical faces of pattern are perpendicular to parting line, the edges of mould may damaged when the pattern is removed from the sand. Hence, the vertical faces are made into taper for as removal of pattern. This slight taper provided on the vertical sides of pattern is called draft allowance.

The amount of taper depends upon the following factors

a. Height and size of pattern

b. molding method

c. Mould materials

The common draft provided on the pattern is 1˚ to 3˚

Otherwise, For taper on external surface,10 to 25 mm/m is provided.

For taper on internal surface,40 to 65 mm/m is provided

DISTORTION OR CAMBER ALLOWANCE

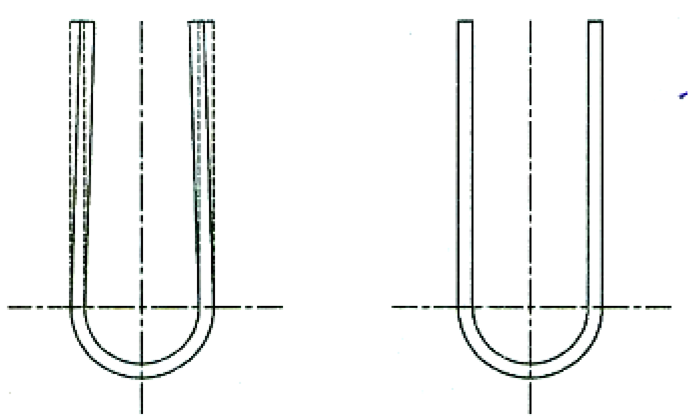


Fig 1.11 Distortion allowance

The casting may distort or wrap during cooling if it is an irregular shape, flat long casting furnace and U or V shape. All surfaces do not shrink uniformly. The arms having unequal thickness are also the reason for distortion.

Due to distortion, the casting will not get the required shape. It may bend. To avoid this, the shape of the pattern is slightly bent into the opposite direction.

So, the casting neutralizes the initial distortion given on the pattern and gets the correct shape after cooling. For example, a casting of U shape may distort and legs become divergent, instead of being parallel.

To avoid this, the legs are made convergent instead of being parallel. So, the legs are become parallel after cooling.

RAPPING OR SHAKE ALLOWANCE

To remove the pattern out of mould cavity, it is slightly rapped or shaked to detach it from the mould cavity. This is called rapping. So the mould cavity may become larger.

To avoid this, the pattern is made slightly smaller than the required casting.

This allowance given in the pattern is called Rapping or shakes allowance. As the allowance is subtracted from pattern dimensions, this is known as negative allowance.

13.What are the desirable properties of molding sand for sand casting? Explain briefly each one[AU-NOV/DEC-2012]

A good casting can be produced only with the use of good quality molding sand.
These properties are

7. Porosity or permeability
8. Plasticity or flow ability
9. Adhesiveness
10. Strength or cohesiveness
11. Refractoriness
12. Collapsibility

1. Porosity or permeability:

Permeability is a measure of molding sand by which the sand allows the steam and gases to pass through it. When molten metal is poured into the mould, steam and gases are formed due to moisture, binder and additives present in the sand.

If the gases are not removed, casting defects such as blowholes will occur. Even though we provide vent holes and riser, all of these gases will not escape through it.

To escape these gases, the molding sand should have good gas permeability

Permeability of molding sand depends on the following factors.

1. Quality and quantity of clays and quartz.
2. Moisture content
3. Degree of compactness.

The following parameters which affect the permeability of molding sand.

1. If the clay content is less the permeability will be more and vice-versa.
2. If the grain size is larger, the permeability will be more and vice versa.
3. Soft ramming (ie, less density) improves the permeability.
4. Higher the silica content on sand, lower will be the permeability.

2. Plasticity or flow ability:

1. The property of molding san by which the molding sand flows around and over the pattern, and uniformly fills the flask.
2. It gives the shape of the pattern and retains the shape after removing the pattern.
3. This property may be improved by adding clay and water to silica sand.

3. Adhesiveness:

1. The property of molding sand by which it sticks or adheres to another body.
2. The molding sand should cling or stick to the sides of the molding boxes.
3. It does not fall out when the flasks are lifted and turned over. This property depends on the type and amount of binder used in the sand mix.
4. Addition of clay and moisture increases the adhesiveness.

4. Strength or cohesiveness:

1. It is property of molding sand by which it sticks together.
2. A molding sand should have sufficient strength so that the mould does not collapse or get partially damaged during shifting, turning or pouring the molten metal.

Strength of the molding sand depends on

1. Grain size and shape
2. Moisture content
3. Density of sand after ramming strength is increased with increasing density, clay content and decreased size of sand grains.

5. Refractoriness:

1. The property of molding sand to resist high temperature of molten metal.
2. This property mainly depends on the purity of the sand particles and size.
3. Rough and larger grain, and quartz content in molding sand increase the refractoriness.
4. Poor refractoriness will result in rough surface in casting.

6. Collapsibility:

1. The property of the molding sand to decrease in volume to some extend under the compressive forces developed by the shrinkage of metal during freezing and subsequent cooling.
2. This property permits the molding sand to collapse easily after the casting solidifies.

13.Explain the stages of preparing shell mould, with suitable sketches. List the unique advantages of making castings in shell moulds. [AU-NOV/DEC-2012, 2013)]

The shell mould casting is a semi-precise method for producing small castings in large numbers. The process involves the use of match plate pattern similar to cope and drag patterns which are used in green sand mould casting.

Initially the patterns are machined from copper alloys, aluminium or CI depending upon the lift of the pattern. They are made with usual allowances and polished surfaces. Then it is attached to the metal match plate.

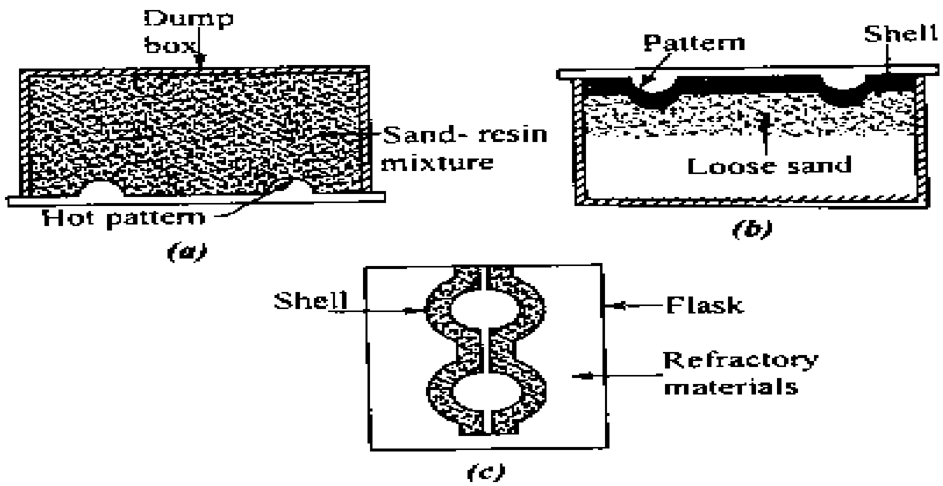


Fig 1.69 Shell moulding

The mould contains 5 to 10% of phenolic resin mixed with fine dry silica. These are mixed with either dry oil or in the presence of alcohol. It should be noted that there is no water used.

The pattern is heated to about 230-600˚C.Then the sand-resin mixture is either dumped or blown over its surface. Sometimes, to prevent the sticking of sand with pattern, a release agent silicone is sprayed over the hot pattern. The heated pattern melts and hardens the resin. This results in bonding the sand grains closely together and forms a shell around the pattern. After a specified time of 20-30 sec, the pattern and sand are inverted as shown in fig.1.69 (b).The thickness of the shell can be accurately controlled by the time of contact of the mixture with the heated pattern. In about 20-30 sec, we can get a normal shell thickness of 6mm.The extra sand which is not adhered to the shell is removed off. The thickness of the shell is depending on the required strength and rigidity to hold the weight of the liquid metal to be poured into the mould.

Then the mould is heated in an oven at 300˚C for 15-60 sec. This curing makes the shell rigid when it can be stripped off by means of ejector pins mounted on the pattern. Thus, the formed shell constitutes one half of the mould. Two such halves, placed one over the other, make the complete mould as shown in fig.1.69(c)

While pouring the molten metal, the two halves are clamped down together by clamps or springs. After cooling and solidification, the shells are broken or shaken away from the castings.

Applications;

1. Used for making brake drums and bushings.

2. Cams, cam shaft, piston and piston rings can be made.

3. Used for making small pulleys, motor housing, fen blade

4. Air compressor, crankcases and cylinders, conveyors, rollers can be made.

Advantages:

1. A high accuracy castings with tolerances of 0.002 to 0.005 mm/min is possible.

2. Good surface finish can be obtained.

3. Complex parts can be made by this method.

4. Less sand is used compared to other methods

5. Moulds can be stored for long time.

Limitations:

1. Only small size of the castings can be made.

2. Serious dust and fume problem during sand and resin mixing will occur.

3. Cost is more.

4. Carbon pickup may occur in the case of steels.

14. Describe the process of Investment casting. What process controls are needed in this case? (May/ June 2013)

The castings obtained by this method have very smooth surfaces and possesses high dimensional accuracy. Hence, it is called as precision investment casting.

Here, the term " Investment " means the layer of refractory material with which the pattern is covered to make the mould.

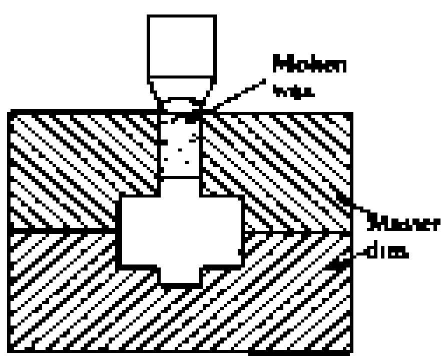


Fig 1.78 Investment casting

Like sand casting method, we can´t use the mould again and again. The method involves the use of expendable (heat disposable) pattern surrounded with a shell of refractory material to form the casting mould. Casting are formed by pouring the molten metal in the mould cavities created by melting out pattern. Since the pattern made of wax is melted out and gets destroyed, that is, why the name is called as " Last-wax method".

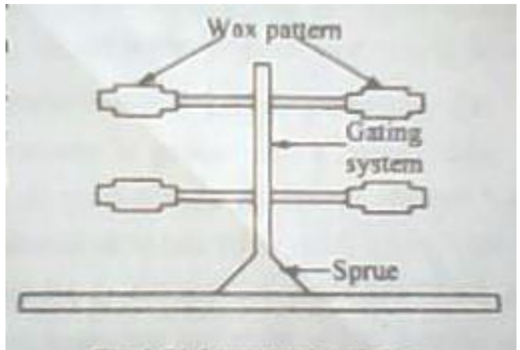


Fig 1.71 Investment casting

Initially, the master pattern which is equal to the part to be cast is made by metal that can be easily machined, such as, brass, aluminium alloy or a fusible alloy (tin, lead and bismuth).

The dimension of the pattern is slightly larger than the actual size of the part to be made to compensate the adjustments in the die, in the wax, in the investment material. Determination of pattern dimension is very difficult job. This makes the pattern very costly.

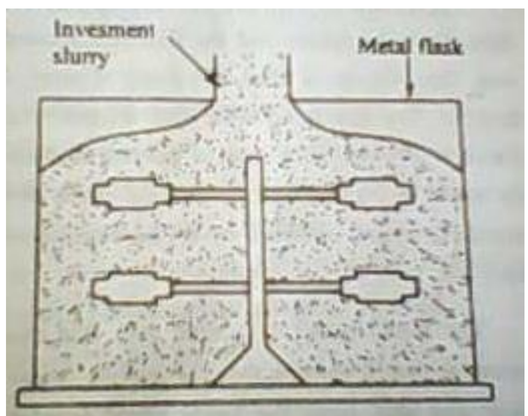


Fig 1.72 Investment casting

This pattern is used to make a die out of a soft material e.g. aluminium. Therefore, wax or plastic is injected under pressure into the die to form an expendable pattern. The molten wax is slightly above its melting point and injection pressure is above 4 bars. If it is a plastic material like polystyrene, polythenes etc. the injection pressure is of the order of 35 bars with higher temperature.

This expendable pattern is rinsed in alcohol to remove grease and dirt. After drying, a thin coating of primary investment slurry is made around the wax pattern by dipping these in the slurry. Investment slurry consists of silica flour, water and some bonding agent. Then, the pattern is taken out of the slurry and rotated to produce a uniform coating, to fill inside corners and to drain out the excessive slurry. This slurry coating being in direct contact with the surfaces of the wax patterns will determine the surface quality of the casting. Sometimes, a number of expendable patterns are assembled as a ´tree´ for economy as shown in fig.

Finally, fine-grain silica sand is sprinkled over the wet slurry surface. Thus the produced coating on the expendable pattern after drying is called pre-coat.

The pattern with the pre coat is then placed in a metal container type flask. Both the pattern and flask are secured to the base by molten wax. Then, the can is filled with slurry of heavy, self-hardening refractory material. This material sets in after a lapse of 24 hrs when the flask is placed in an oven. Thus, most of the wax or plastic melts and flows out of the mould by leaving a cavity with the shape of the intended casting.

16. Briefly explain the Principle, operation, advantages, disadvantages and application of CO_2 molding. (May/ June 2013)(Nov/Dec-2018)

Principle:

Co2 Casting is a kind of sand casting process. In this process the sand molding mixture is hardened by blowing gas over over the mold. This process is favoured by hobby metal casters because a lot of cost cutting can be done. In addition, one can be sure of getting dimensionally accurate castings with fine surface finish. But, this process is not economical than green sand casting process.

Operation:

The Mold for **Co2 Casting** is made of a mixture of sand and liquid silicate binder which is hardened by passing Co2 gas over the mold. The equipment of the molding process include Co2 cylinder, regulator, hoses and hand held applicator gun or nozzle. Carbon di oxide molding deliver great accuracy in production.

Any existing pattern can be used for the molding purpose which can be placed in the mold before the mold is hardened. This method helps in producing strong mold and cores that can be used for high end applications. If the process is carefully executed then casting can be as precise as produced by the shell casting method.

Carbon di oxide casting is favored both by the commercial foundry men and hobbyist for a number of reasons. In commercial operations, foundry men can assure customers of affordable castings which require less machining.

The molding process which can be fully automated is generally used for casting process that require speed, high production runs and flexibility. In home foundries this is one of the simplest process that improves the casting quality .

Applications:

Co2 casting process is ideal where speed and flexibility is the prime requirement. molds and cores of a varied sizes and shapes can be molded by this process.

Advantages:

This process has many advantages in comparison to other forms of castings some of them are as follows:

- Compared to other casting methods cores and molds are strong
- Reduces fuel cost since gas is used instead of to other costly heating generating elements
- Reduces large requirement for number of mold boxes and core dryers

- Provides great dimensional tolerance and accuracy in production
- Moisture is completely eliminated from the molding sand
- This process can be fully automated.

17. Describe with a neat sketch of cold chamber die casting machine. Give its Advantages and Limitations. (May/ June 2013)

In cold chamber die casting, the metal melting unit is not an integral part of the machine. The metal is melted in a separate furnace and brought to the machine for pouring. The process is shown in fig

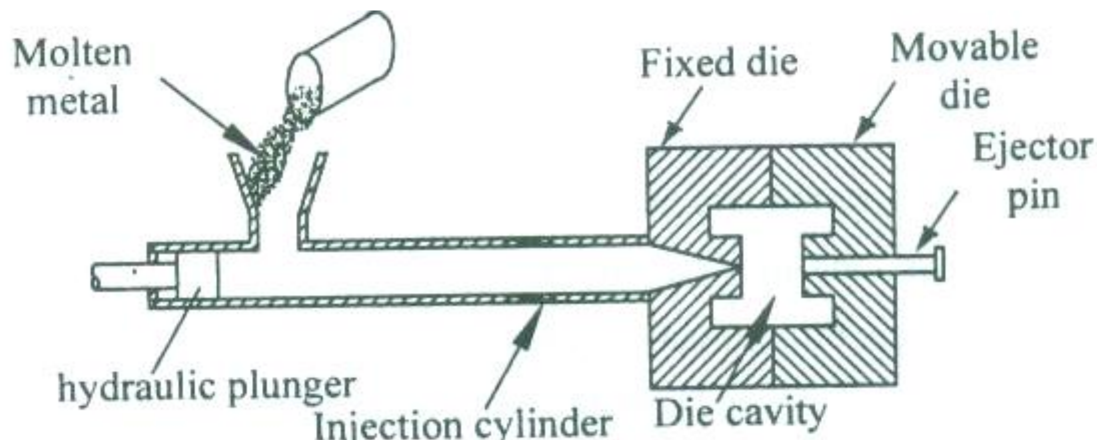


Fig 1.75 Cold chamber die casting

The machine has a cold chamber of cylindrical shape with a hydraulic plunger. A measured quantity of molten metal is poured into the injection cylinder. Then the plunger move to the right and force the molten metal into the die cavity. As the die is water-cooled, immediate solidification of molten metal take place. Then the dies are separated. The finished casting is removed by ejector pin.

Application

1. Household equipments like washing machine parts, vacuum cleaner body, fan case, store parts etc.
2. Automobile parts like fuel pump, carburetor body, horn, wiper and crank case**.**
3. Component for telephone, television sets, speakers, microphones, record players etc.
4. Toys like pistols, electric trains, model aircrafts etc

Advantages

1. Castings with very good surface finish can be made.
2. Rate of production is high
3. Castings with varying thickness wall can be made.
4. There is no possibility of sand inclusions.
5. Casting defects are less
6. It can be stored and used for long time.
7. The process depends on the metal to be cast.

Limitations

1. Only small part can be made
2. Only non-ferrous metals can be cast.
3. Equipment cost is high
4. It is more suitable for mass production only.

18. Explain with neat blast furnace.

BLAST FURNACE

A blast furnace shown in figure ---is a type of furnace for smelting metal ore, usually iron ore. The combustion material and ore are supplied from the top while air flow is supplied from the bottom of the chamber , so that the chemical reaction takes place, not only at the surface throughout the ore. This type of furnace is typically used for smelting iron to produce pig iron, the raw material for wrought and cast iron.

Blast furnace is named so because very high temperature developed inside it by means of forcing a blast of heated air. Its height is about 30 metres and interior diameter is of 8 metres.

PROCESS

In this furnace the unwanted silicon and other impurities are lighter than the molten iron (pig iron) which is its main product. The furnace is built in the form of a tall, chimney – like structure lined with refractory bricks. Coke, limestone and iron ore (iron oxide) are poured in at the top.

Air is blown in through tuyers near the base. This “blast” allows combustion of the fuel. This reduces the oxide in the metal, which being heavier sinks into the bottom of the furnace. The nature of reaction takes place inside the furnace is:

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

More precisely, the compressed air blown into the furnace reacts with the carbon in the fuel to produce carbon monoxide, which then mixes with the iron oxide, reacting chemically to produce iron and carbon dioxide, which leaks out of the furnace at the top. The temperature in the furnace is typically about 1500^oC, which is also enough to decompose limestone (calcium carbonate) into calcium oxide and additional carbon dioxide:

$$CaCO_3 \rightarrow CaO + CO_2$$

The calcium oxide reacts with various acidic impurities in the iron (notably silica), forming a slag containing calcium silicate, $CaSiO_3$ which floats on the iron.

The pig iron produced by the blast furnace is not very useful due to its high carbon content (around 4 -5 %) which makes it very brittle. It is used to make cast iron goods, often being remelted in a foundry cupola. The blast furnace remains an important part of modern production. Modern furnaces include cowper stoves to pre-heat the blast air to high temperatures in order to avoid cooling (and the having re-heat) the mix they use fairly complex systems to extract the heat from the hot carbon dioxide when it escapes from the top of the furnace, further improving efficiency. The largest blast furnaces produce around 60,000 tonnes of the iron per week.

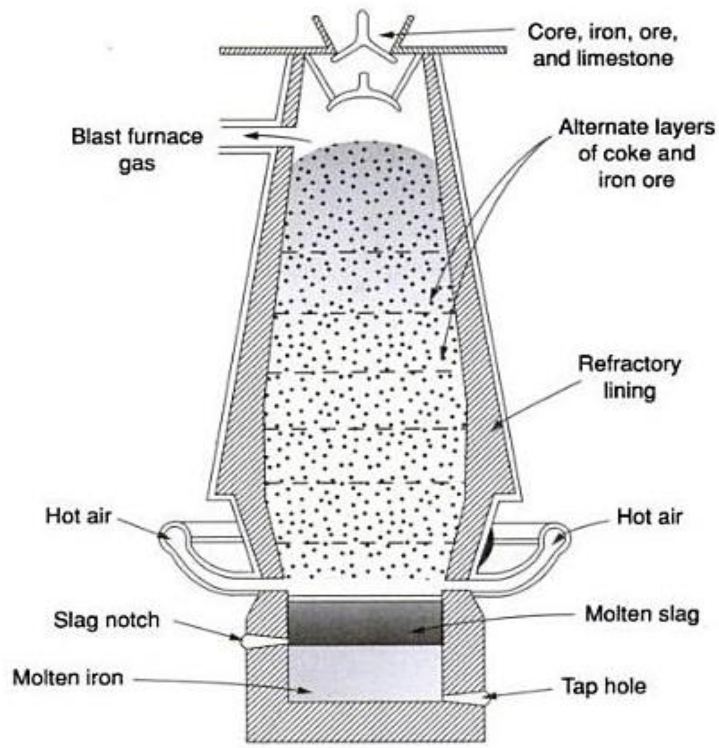


Fig-Blast Furnace

19. Explain with neat sketch with Stir casting with advantages.(Apl/May-2019)

STIR CASTING

Stir casting is a liquid state method of composite materials fabrication in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring. Among the variety of manufacturing processes available for discontinuous metal matrix composites, stir casting is generally accepted, and currently practised commercially.

Process

- In general stir casting of MMCs(Metal Matrix Composites) involves producing a melt of the selected matrix material, followed by the introduction of a reinforcing material into the melt, obtaining a suitable dispersion through stirring.
- The next step is the solidification of the melt containing suspended particles to obtain the desired distribution of the dispersed phase in the cast matrix. The schematic diagram of this process is as shown in Figure.
- In composites produced by this method, particle distribution changes significantly depending on process parameters during both the melt and solidification stages of the process.

The addition of particles to the melt drastically changes the viscosity of the melt, and this has implications for casting processes. It is important that solidification occurs before appreciable settling is allowed to take place.

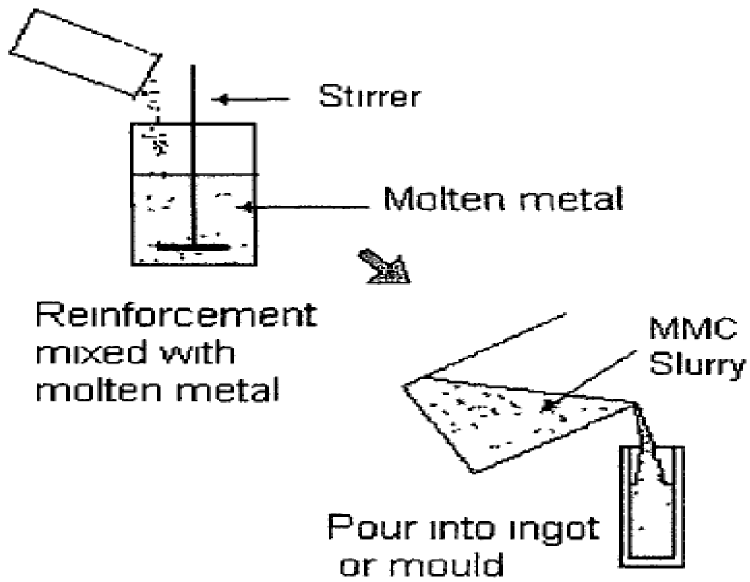


Fig-Stir Casting

Advantage:

- Its advantages lie in its simplicity, flexibility and applicability to large scale production and, because in principle it allows a conventional metal processing route to be used, and its low cost.

- This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production allows very large sized components to be fabricated, and is able to sustain high productivity rates.

- The cost of preparing composites materials using a casting method is about one-third to one-half that of a competitive method, and for high volume production, there shall be a possibility for further reduction of cost to the extent of one-tenth

20. MELTING FURNACES

Various types of melting furnace are used in foundry shop. The type of furnace used depends upon the type of metal and the quantity of metal to be melted.

The melting furnace used in foundries is

1. Cupola furnace-For cast iron

2. Open hearth furnace –For steel

3. Crucible furnace-For non-ferrous metal

a. Pit type furnace

b. Coke fired stationary furnace

c. Oil fired tilting furnace

4. Pot furnace

5. Electric furnace

a. Direct arc furnace

b. Indirect arc furnace

c. Induction furnace.

21. Explain the constructional features of Cupola Furnace with Neat sketch?(Nov/Dec-2018)

This type of furnace is used for melting cast iron.

Construction:

It is a vertical, cylindrical shell made of 10mm thick steel plate. It is lined with refractory bricks inside. Two bottom doors close the bottom of the cupola. A sand bed is laid over the bottom doors sloping towards the tap hole. Molten metal stays over this bed. The legs are set at the bottom of the furnace using concrete. There is a tap hole for taking molten metal. A plug made of clay closes the tap hole. The slag hole is provided in the shell above the tap hole. The slag hole is provided in the shell above the tap hole. The slag floating over the molten metal is removed through this slag hole.

The opening called tuyeres are provided one meter above the bottom. Fuel is supplied through these tuyeres for making complete combustion of fuel. There is a wind box and blower for the supply of air into the furnace. For charging metal and fuel into the furnace a separate charging door is made.

Preparation:

The slag and waste from previous melting are cleaned. Broken bricks are repaired or replaced if necessary. Then bottom doors are closed. A sand bed with sloping towards tap hole is prepared upto a height of 200 mm.

A tap hole is formed and lined with clay. Then a slag hole is prepared. Finally, the cupola is dried thoroughly.

Firing:

Oil waste and wooden pieces are placed at the bottom and the fire is started. Now sufficient amount of air is supplied. When the wood starts burning. The coke is charged at several portions.Now, the coke burns.

The blast is turned off. Again coke is added up to the level of bed charge. Then the coke is allowed to burn for half an hour. Finally, the charging is done through the changing door.

Charging and Melting:

Pig iron and iron scrap are charged into the furnace through the charging door. Then coke is charged alternatively. Limestone is added to the charge to remove impurities and also to

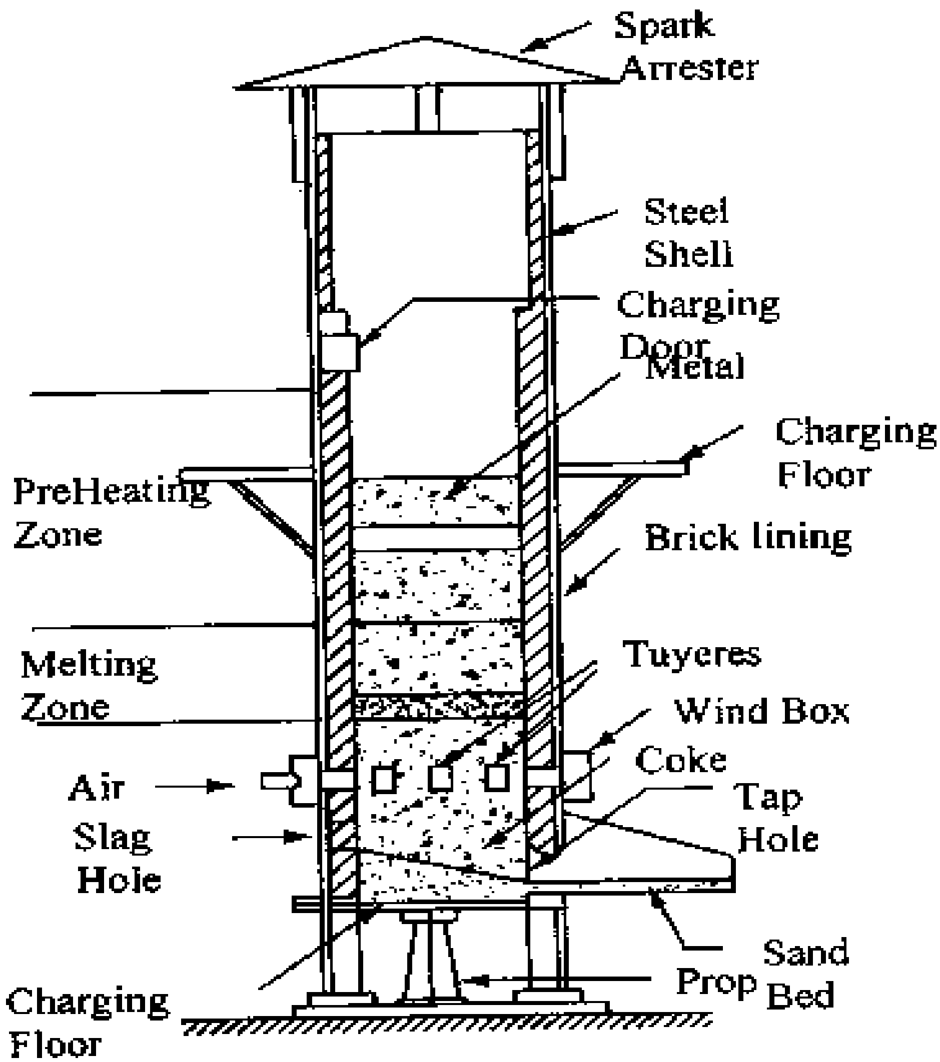


Fig 1.62 Cupola furnace

ensure thorough mixing of molten metal. The ratio of pig iron to limestone and pig iron to coke are 25:1 and 10:1 respectively. The cupola is fully charged. Then the iron is soaked for one hour. After that the blast is turned on. Molten metal will begin to collect at the sand bed. After melting enough quantity of molten metal, clay plug is removed and collected in ladles.

Then the molten metal can be directly poured into moulds. The floating slag on the top layer of the molten metal is tapped out through the slag hole. Again the furnace should be charged to the full level for repeating the same procedure.

At the end of the cupola is shut off by stopping the air blast. Then the remaining molten metal is removed, the bottom doors are opened, the wastes are dropped down and they are quenched by water.

Application: Cupola is used to melt cast iron.

Advantages:

1.Initial cost is comparatively lower than other type of furnaces.

2.It is simple in design.

3.It requires less floor area

CRUCIBLE FURNACE:

The metal is melted in the crucible. It is made up of silicon carbide, graphite or other refractory materials. Generally it is used for melting non ferrous metals and low melting point alloys. The fuel used may be oil, gas or coke. The capacities range from 30 to 150kg.

PIT FURNACE

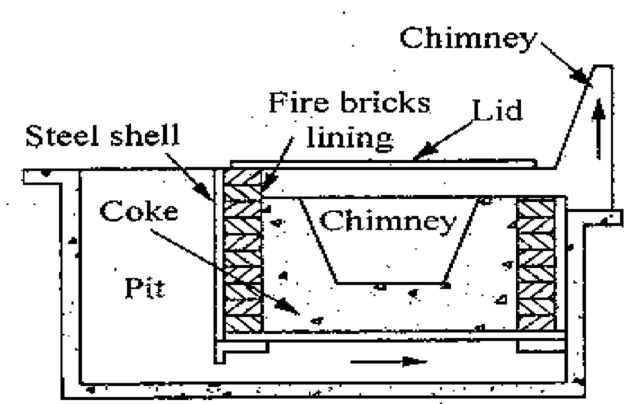


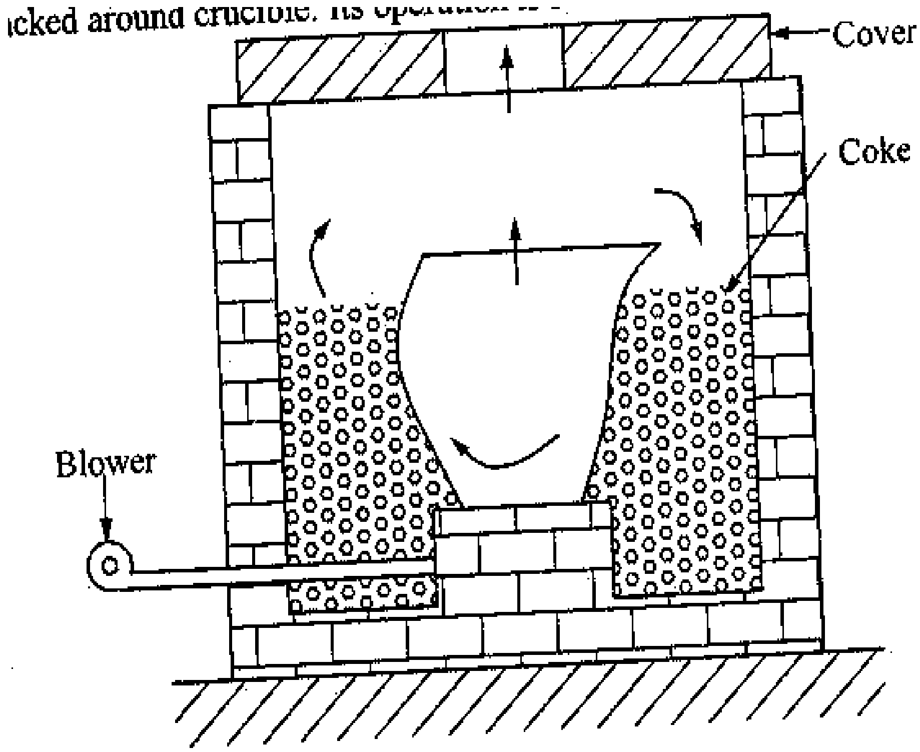
Fig 1.63 Pit furnace

The crucible is placed in a pit below the ground level. It is usually fired with coke. The furnace is made of steel shell with a grate and pit at its bottom. The steel shell above the grate is fired with firebricks. A chimney provides natural draught. The metal is placed in the crucible. The metal charge is pig iron, foundry returns and broken castings. The coke is placed around and above the crucible. The fuel is ignited and allow to burn. After reaching maximum combustion, the coke above the crucible is shifted to sides. Then its top is covered with a lid. A blower may be used to provide necessary air. After melting the metal, the lid is removed. The crucible is lifted using tongs. Then it is taken to the place of pouring.

APPLICATIONS:

It is used for melting cast iron and non ferrous metals and alloys in small quantity

COKE FIRED STATIONARY FURNACE



The furnace is erected above the ground level. The furnace is made of steel shell lined with fire bricks. A blower is used to create draught coke is packed around crucible. Its operation is similar to coke fired pit furnace.

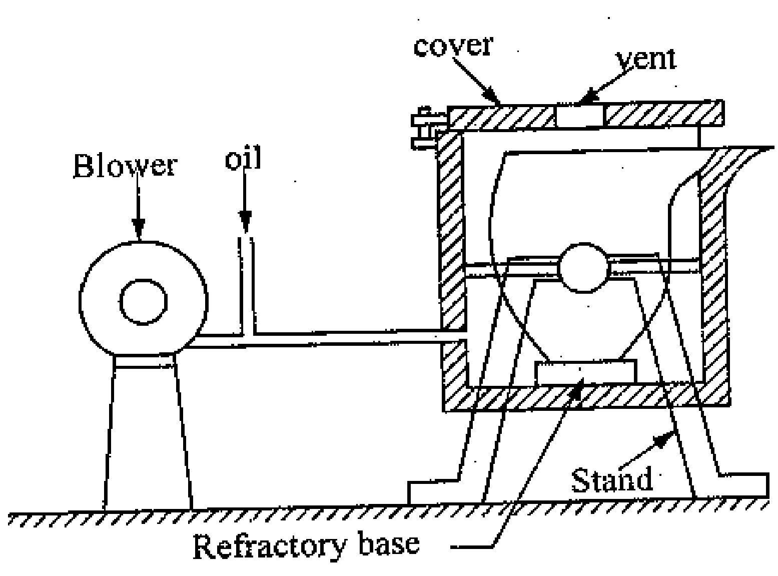


Fig 1.65 Oil fired furnace

OIL FIRED TILTING FURNACE:

The tilting furnace may be coke, oil or gas fired, Mostly oil and gas fired are used because it has more advantages. Thye furnace consists of steel shell. Firebrick lining is provided inside the shell. Crucible is placed centrally in such a way to form a hollow chamber. The crucible is placed on a refractory base and fixed well. A burner is mounted tangentially at the bottom of the furnace. The furnace is mounted on two pedestals. It can be tilted by a geared stand wheel. While firing, oil and air are directed through the nozzle.

The flame circulates in the hollow chamber. It heats the metal charge lying in the crucible.

Advantages:

1. It is easy to start and stop the operation.

2. It is easier the control temperature.

3. It occupies less floor area.

4. It requires less labour.

5. It provides a fast melting rate.

6. It has less contamination of work place.

ELECTRIC FURNACES

Electric furnaces are used for melting steel, alloy steel, brasses etc. It is used for producing high quality castings. Because of the following reasons,

1. Oxidation losses are eliminated.

2. Furnace atmosphere can be more closely controlled

3. Alloying elements can be added without loss

4. Composition of the melt and its temperature can be accurately controlled.

The following are the different types of electric furnaces

1. Direct arc furnace

2. Indirect furnace

3. Induction furnace

DIRECT ARC FURNACE

It consists of a heavy steel shell. The shell is lined with refractory brick. It has a bowl shape bottom with a detachable roof./The roof is lined with silica brick. Three graphites or carbon electrode pairs into the shell through the roof. The electrode can be raised up or down. The furnace has two spouts in which one is for molten metal and another one is for slag. The furnace is mounted in turn ions with the help of bearings. So it can be tilted backward or forward for charging, running of the slag and pouring the molten metal into the ladle.

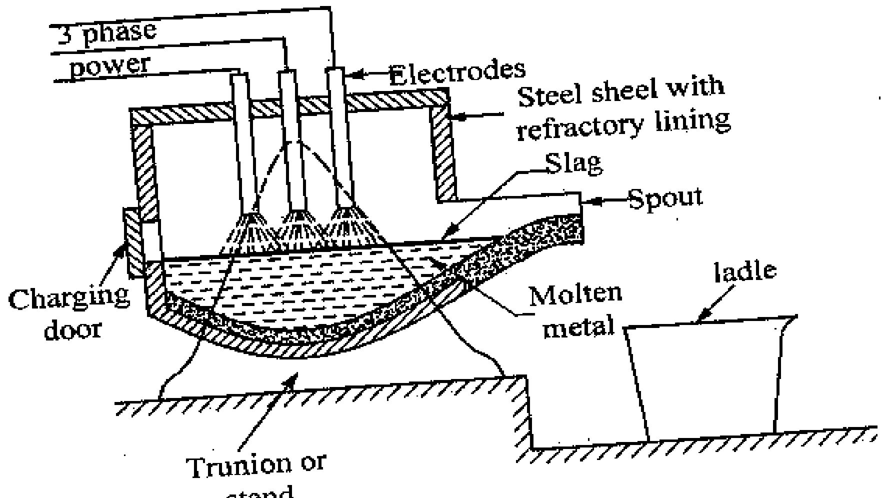


Fig 1.66 Direct arc furnace

Working:

At first the furnace is preheated. Then the ferrous is charged with steel scraps by opening the roof or through the charging door, the electrodes are lowered down and a gap between the electrodes and metal charge surface is maintained. Then the electric supply is given to produce electric arc. The heat produced by the arc melts the metal. The electrodes may be consumed and becomes shorter. The arc gap between the electrodes and charge are maintained by automatic control. The slag formed on the top of the molten metal reduces the oxidation, refine the metal, and protects the roof and sidewalls from heat radiation.

Applications:

It is used to melt high quality carbon steels and alloy steels.

Advantages:

1. Thermal efficiency is high

2. Very pure metal can be obtained.

3. It can make steel directly from pig iron and steel scrap.

Disadvantage:

Heating cost is higher.

INDIRECT ELECTRIC ARC FURNACE

It consists of a steel shell with refractory lining. Two graphite electrodes are mounted at opposite ends. An opening is provided at the center of shell for charging metal. A pouring spout is built up with the charging door. The furnace is mounted on the rollers. The rollers are driven to rock the furnace by a rocking drive unit.

Working:

At first the pig iron is charged. The scrap is charged over the pig iron. With electric power on two electrodes are brought nearer to produce arc. The heat generated by arc melts the metal. Some metal is melted as soon as possible. The furnace is set to rock to and fro.

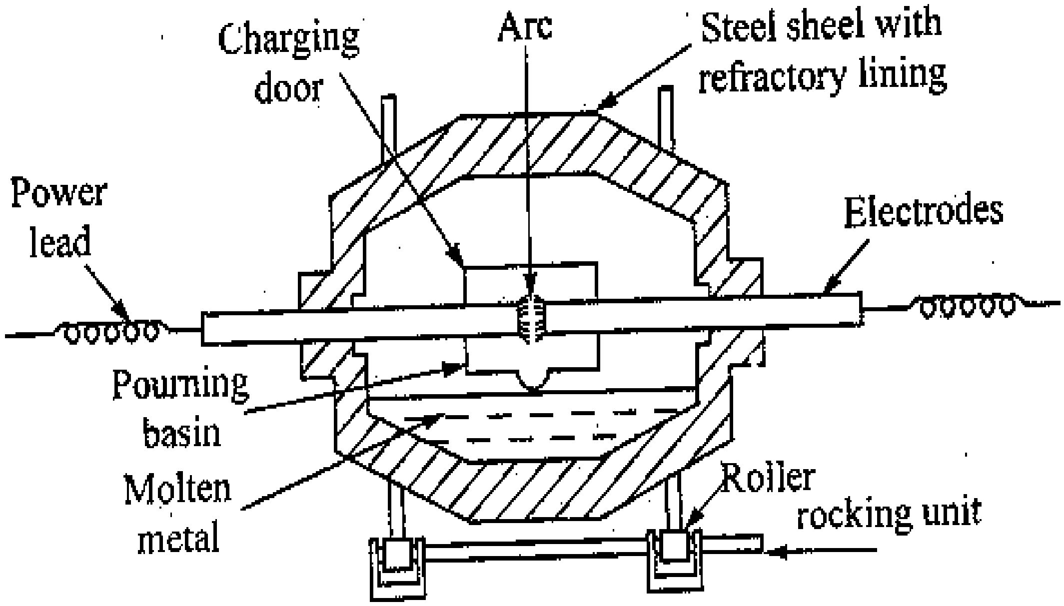


Fig 1.67 Indirect arc furnace

The metal melts because of

1. The heat radiation from the arc

2. The hot refractory walls of the furnace

3. Conduction from the hot linings when the furnace is tilted to pour molten metal in the ladle.

Applications:

To metal cast iron, steel, copper and its alloys

Advantages:

1. Uniform composition of metal can be obtained.

2. Operation and control are simple.

3. Low cost scrap can be used.

20. Explain the hot chamber die casting with figure. (May/June 2014)(Apl/May2019) (Nov/Dec-2018)

In hot chamber die casting, the melting furnace is an integral part of the mould. There is a gooseneck vessel which is submerged in molten metal. There is a plunger at the top of the gooseneck vessel. When the plunger is in the upward position, the molten metal flows into the vessel through a port provided on the sidewall. When the plunger comes down, the molten metal is forced into the dies. Since, the die is cooled by water, immediately and sufficient cooling is provided for solidification.

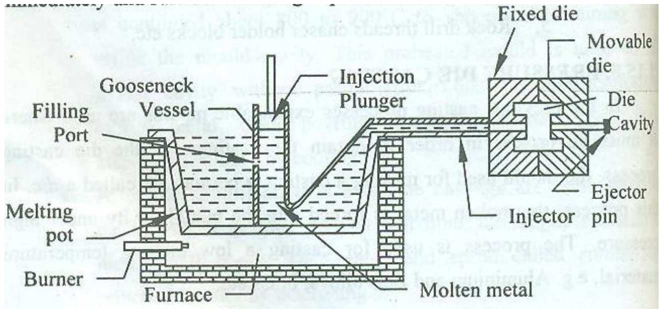


Fig 1.74 Hot chamber die casting

Then the movable die is moved some distance and finished casting is removed by ejectors. The plunger and movable die are operated by hydraulic systems. The operating pressure of hydraulic plunger is 15 MN/m^2.

Hot chamber die-casting is suitable for casting of metals such as Zinc, tin and lead.