DEPARTMENT OF COLLEGIATE AND TECHNICAL EDUCATION

STUDY MATERIAL

ON

MANUFACTURING PROCESS

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For III Semester Diploma in Mechanical Engineering

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UNIT-1

SAND CASTING

Introduction to foundry

A foundry is a factory that produces metal castings. Metals are cast into shapes by melting them into a liquid, pouring the metal into a mold, and removing the mold material after the metal has solidified as it cools. The most common metals processed are aluminum and cast iron. However, other metals, such as bronze, brass, steel, magnesium, and zinc, are also used to produce castings in foundries. In this process, parts of desired shapes and sizes can be formed.

A large number of metal components in designs we use every day are made by casting. The reasons for this include:
(a) Casting can produce very complex geometry parts with internal cavities and hollow sections
(b) It can be used to make small (few hundred grams) to very large size parts (thousands of kilograms)
(c) It is economical, with very little wastage: the extra metal in each casting is re-melted and re-used
(d) Cast metal is isotropic – it has the same physical/mechanical properties along any direction

Common examples: door handles, locks, the outer casing or housing for motors, pumps, etc., wheels of many cars. Casting is also heavily used in the toy industry to make parts, e.g. toy cars, planes, and so on. Typical metal cast parts are shown in Fig.1

Fig.1: Typical metal cast parts

Safety Precautions to be taken in foundries

1. Dress properly when working with molten metal.
2. Wear a pair of clear goggles, leggings, and asbestos gloves.
3. Do not get the sand too wet. Water is enemy to the molten metal.
4. Never stand or look over the mold during the pouring or immediately after the pouring because the molten metal might spurt out of the mold.
5. Do not light the furnace until you have your teacher's permission.
6. If cold metal must be added to melted metal, be sure it is perfectly dry, and that tongs used fire also perfectly dry, or an EXPLOSION WILL RESULT
7. Housekeeping
    a. Everything on its place and a lace for everything.
    b. Never throw rubbish on the floor.
    c. Keep gangways and work area free of metal bars, components, etc.
    d. If oil or grease is spilled, wipe it up immediately or someone might slip and fall.
8. Moving About:
    a. Always carefully .... never run.
    b. Keep to gangways .... Never take short turns.
    c. Obey warning notices, signals, safety signs and alarms, etc.
    d. Never ride on a vehicle not made to carry passengers for example Truck. For Left
9. Truck First Aid
    a. Have first aid treatment for every injury however small.
    b. Know the first aid arrangements for your work place.

Casting components are made from the following different types

1. Sand casting
2. Die casting
3. Investment casting
4. Centrifugal casting
5. Shell moulding

1. Sand casting

Sand casting is temporary mould process uses natural or synthetic sand (lake sand) which is mostly refractory material called silica (SiO_2). Larger sized molds use green sand (mixture of sand, clay and some water). Sand can be re-used, and excess metal poured is cut-off and re-used also.

2. Die casting

Die casting is a very commonly used type of permanent mold casting process. Die casting is a manufacturing process that can produce geometrically complex metal parts through the use of reusable molds, called dies. The die casting process involves the use of a furnace, metal, die casting machine, and die. It is used for producing many components of home appliances (e.g rice cookers, stoves, fans, washing and drying machines, fridges), motors, toys and hand-tools.

3. Investment casting

Investment casting is an industrial process based on lost-wax casting, one of the oldest known metal-forming techniques.

4. Centrifugal casting

Centrifugal casting uses a permanent mold that is rotated about its axis at a speed between 300 to 3000 rpm as the molten metal is poured. Centrifugal forces cause the metal to be pushed out towards the mold walls, where it solidifies after cooling. Parts cast in this method have a fine grain microstructure, which is resistant to atmospheric corrosion; hence this method has been used to manufacture pipes.

5. Shell moulding

Shell mould casting is a metal casting process similar to sand casting, in that molten metal is poured into an expendable mould. However, in shell mould casting, the mould is a thin-walled shell created from applying a sand-resin mixture around a pattern. The pattern, a metal piece in the shape of the desired part, is reused to form multiple shell moulds. A reusable pattern allows for higher production rates, while the disposable moulds enable complex geometries to be cast. Shell mould casting requires the use of a metal pattern, oven, sand-resin mixture, dump box, and molten metal.

Sand Casting

Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. Over 60% of all metal castings are produced via sand casting process.

Typical sand moulds have the following Important parts:

1. Flask: A metal or wood frame, without fixed top or bottom, in which the mold is formed. It is referred to by various names such as following Depending upon the position of the flask in the molding structure:

2. Drag: “lower molding flask”,

3. Cope: “upper molding flask”,

4. Cheek: “intermediate molding flask used in three-piece molding”.

5. Pattern: It is the replica of the object to be made. The mold cavity is made with the help of pattern.

6. Parting line: is the dividing line between the two molding flasks that makes up the mold.

7. Molding sand: Sand, which binds strongly without losing its permeability to air or gases. It is a mixture of silica sand, clay, and moisture in appropriate proportions.

8. Facing sand: The small amount of carbonaceous material sprinkled on the inner surface of the mold cavity to give a better surface finish to the castings.

9. Core: A separate part of the mold, made of sand and generally baked, which is used to create openings and various shaped cavities in the castings.

10. Pouring basin: A small funnel shaped cavity at the top of the mold into which the molten metal is poured.

11. Sprue: The passage through which the molten metal, from the pouring basin, reaches the mold cavity. In many cases it controls the flow of metal into the mold.
12. Runner: The channel through which the molten metal is carried from sprue to the gate.
13. Gate: A channel through which the molten metal enters the mold cavity.
14. Chaplets: Chaplets are used to support the cores inside the mold cavity to take care of its own weight and overcome the metallostatic force.
15. Riser: A column of molten metal placed in the mold to feed the castings as it shrinks and solidifies. It is also known as "feed head".
16. Vent: Small opening in the mold to facilitate escape of air and gases.

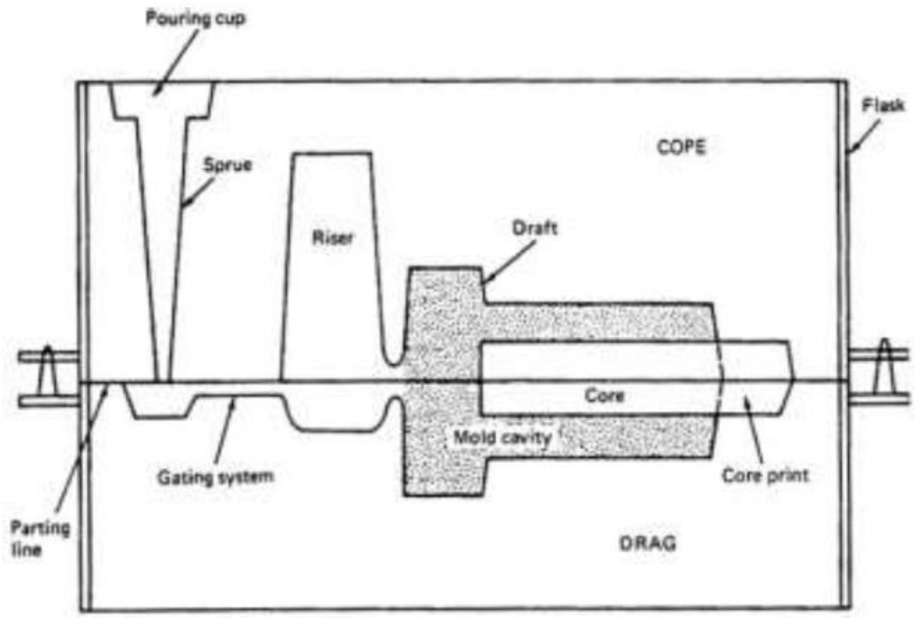


Fig 2: Schematic representation of a typical sand mould cross-section

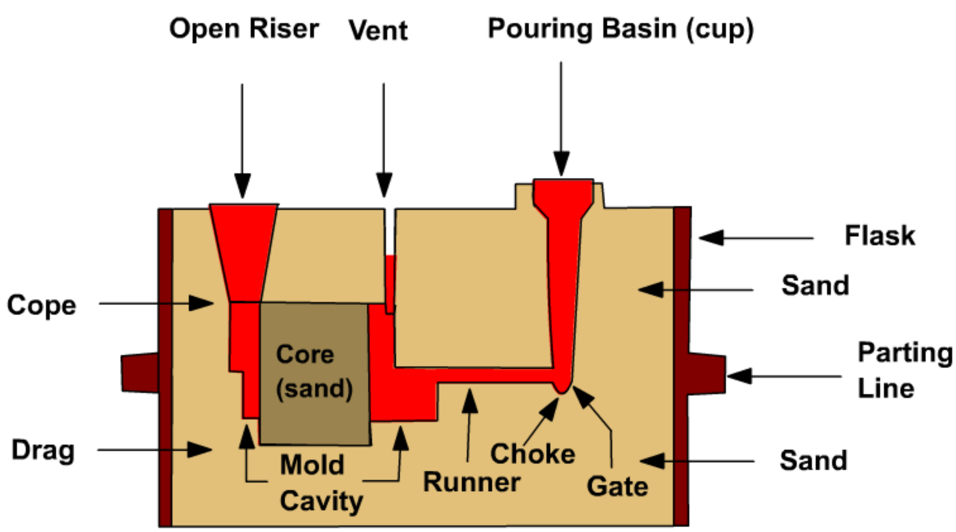


Fig 2: Schematic representation of a typical sand mould cross-section

Steps in Making Sand Castings:

Following are the different steps involved in sand casting process

1. Pattern Making
2. Sand Mixing
3. Mould Making
4. Core Making
5. Metal melting and Pouring
6. Fettling and Inspection

1. Pattern making:
Patterns are a model for the object to be cast. A pattern makes an impression on the mold, liquid metal is poured into the mold, and the metal solidifies in the shape of the original pattern. In addition to shaping the mold cavity, a pattern must provide accurate dimensions, have means of exiting the mold cavity without breaking it, compensate for solidification shrinkage and distortion, and include a feeding system of gates and risers to deliver liquid metal into the mold.

2. Sand Mixing:
Sand mixing is a process of mixing of green sand, clay, water, binders in an appropriate proportion so that it forms a good strength mould

3. Mould Making:
Mould making consists of all operations necessary to prepare a mold for receiving molten metal. Molding usually involves placing a molding aggregate around a pattern held with a supporting frame, withdrawing the pattern to leave the mold cavity, setting the cores in the mold cavity and finishing and closing the mold.

4. Core making:
Cores are forms, usually made of sand, which are placed into a mold cavity to form the interior surfaces of castings. Thus the void space between the core and mold-cavity surface is what eventually becomes the casting.

5. Metal Melting and Pouring:
The preparation of molten metal for casting is referred to simply as melting. Melting is usually done in a furnace specifically designated area of the foundry, and the molten metal is transferred to the pouring area where the molds are filled.

6. Fettling and Inspection:
Fettling refers to all operations necessary to the removal of sand, scale, and excess metal from the casting. Burned-on sand and scale are removed to improve the surface appearance of the casting. Excess metal, in the form of fins, wires, parting line fins, and gates, is removed. Inspection of the casting for defects and general quality is performed.

Pattern

The pattern is a physical model of the casting used to make the mold. The mold is made by packing some readily formed aggregate material, such as molding sand, around the pattern. When the pattern is withdrawn, its imprint provides the mold cavity, which is ultimately filled with metal to become the casting. If the casting is to be hollow, as in the case of pipe fittings, additional patterns, referred to as cores, are used to form these cavities.

Need or Functions of Pattern

Following are the functions of pattern:
1. To produce the mould cavity of correct size and shape.
2. To produce seats for cores in the moulds.
3. To establish the parting surfaces and lines in the mould.
4. To establish distinct locating points in the moulds.
5. To minimize defects in castings.
6. To minimize the cost of castings.

Materials Used for Making Patterns

The common materials used for pattern making are:
1. Wood
2. Cast iron
3. Brass
4. Aluminum
5. White metal
6. Plastic
7. Plaster
8. Wax

1. Wood

Merits

a) It is easy to work and readily available.
b) Wood can be harvested and made into many forms by gluing, bending, and curving.
c) It is easily sanded to a smooth surface and may be preserved with shellac.

Demerits

a) It is readily affected by moisture.
b) Wood wears out instantly as a result of sand abrasion.
c) If it is not stored properly, it may warp badly.
d) Its strength is low and it may break on rough usage.

2. Cast Iron

Merits

a) It is strong.
b) It gives a good smooth mould surface with sharp edges.
c) cast iron is resistant to the abrasive action of the sand.

Demerits

a) Cast iron patterns are heavy and break easily.
b) The iron pattern causes too much rust and requires a dry storage area.

3. Brass

Merits

a) When metal patterns are small, brass is used.
b) It is strong, does not rust, and takes better finish than cast iron.
c) It is able to withstand the wear of the moulding sand.

Demerits

a) Brass patterns are heavier than cast iron.

4. Aluminum

Merits

a) It is soft and easy to work.
b) It is light in weight and resistant to corrosion.

Demerits

a) Since aluminum is soft, its patterns may be damaged by rough usage.

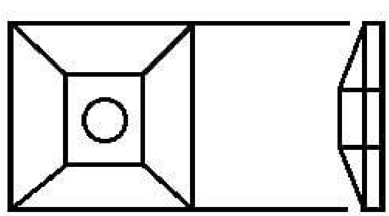
Types of Pattern

Following are the different types of pattern used in casting:

1. Single-piece or solid pattern
2. Split pattern
3. Match plate pattern
4. Cope and drag pattern
5. Gated pattern
6. Loose-piece pattern
7. Sweep pattern
8. Skeleton pattern
9. Segmented pattern
10. Shell pattern

1. Single-piece or Solid Pattern

This pattern made without joints, partings, or any loose pieces in its construction is called a single-piece or solid patter. These patterns are cheaper. The moulder has to cut his own runner to feed the gate and riser. The moulding operation takes more time. Hence these patterns are in limited production. Solid pattern is generally used for large castings of simple shape. The simplest type of pattern is the flat-back as shown in fig. It may have few or no irregularities and it may not have a core-point.



Single Piece or Solid Pattern

Fig.3 Single piece or solid pattern

When completed, the mould cavity will be entirely in the drag or entirely in the cope. A few examples of castings that are made by making solid patters are soil tamper, stuffing-box, and glad of the steam engine.

2. Split Pattern

For casting unusual shape split patterns are used to form a mould. These types of pattern are usually made in two parts. One part will produce the lower half of the mould and the other upper half. The two parts may or may not be of the same size and shape.

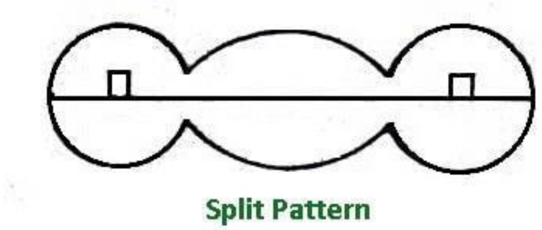


Fig.4 Split Pattern

These are held in their proper relative positions by means of dowel-pins.
The patterns are made in two or three pieces. Because many times the design of casting offers difficulty in mould making and withdrawal of patterns if a solid pattern is used.

3. Match Plate Pattern

These types of pattern are made in two pieces. One-piece mounted on one side of the plate and the other piece on the other side of the plate called the match plate pattern. The plate can only carry a pattern or a group of patterns on its two sides in the same way.

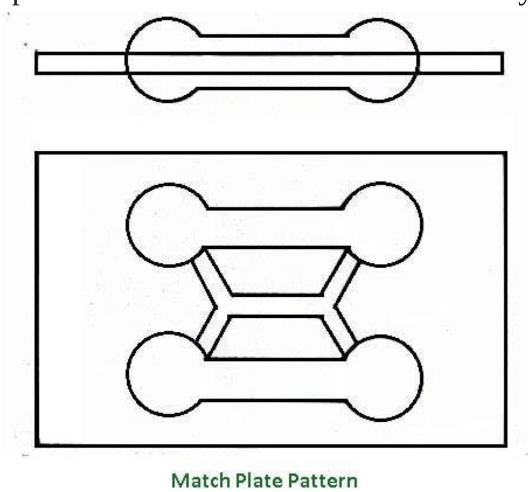


Fig.5 Match plate pattern

The plate is usually made of aluminum. The gate and runner are also connected to the plate with the pattern. These patterns are used where the rapid production of small and precise castings occurs on a large scale.

4. Cope or Drag Pattern

When quite large castings are to be made, the entire pattern becomes too heavy to be handled by anyone operator. Such types of pattern are made in two parts which are individually moulded into separate moulding boxes.
One group of operators prepare the cope half of the mould sand and another group prepares the drag half. After completion of the moulds, the two boxes are assembled to form the complete cavity.

5. Gated Pattern

Gated patterns are used in the mass production of small castings. For such castings, multi-cavity moulds are prepared i.e. a single sand mould carries a number of cavities as shown in the diagram. The patterns for these castings are interconnected by gate formers.

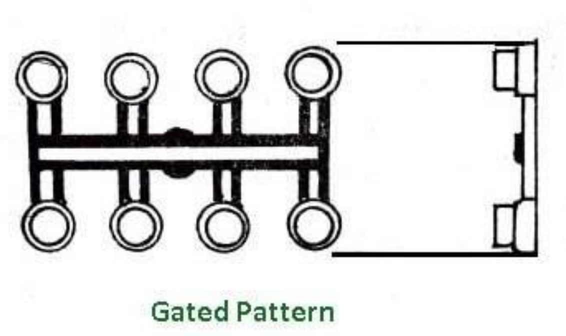


Fig.6 Gated Pattern

These gate formers provide suitable channels or gates in the sand for feeding the molten metal to these cavities. A single runner can be done to feed all cavities. This saves moulding time also there is uniform feeding of molten metal.

6. Loose Piece Pattern

In these types of pattern, some single piece patterns are made to have loose pieces in order to enable their easy withdrawal from the mould. These pieces make an integral part of the pattern while moulding

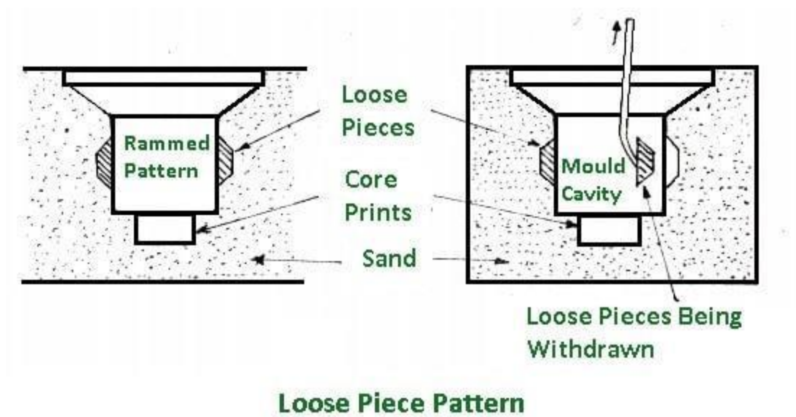


Fig.7 Loose piece pattern

After the mould is finished, the pattern is withdrawn, leaving the pieces in the sand. These pieces are later withdrawn separately through the cavity formed by the pattern as shown in the diagram.

7. Sweep Pattern

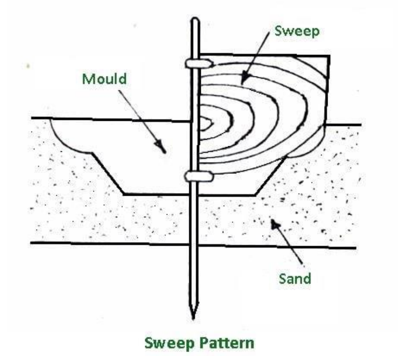


Fig8. Sweep Pattern

Sweep patterns are used for preparing moulds of large symmetrical castings, particularly of circular cross-section. Hence there is a large saving in time, labor, and material. The sweep pattern consists of a board that conforms to the shape of the desired casting.
This board is arranged to rotate about a central axis as shown in the diagram. The sand is rammed in place and the sweep board is moved around its axis rotation to give the moulding sand the desired shape.

8. Skeleton Pattern

When the size of the casting is very large and only a few numbers are to be made, it is uneconomical to make a solid pattern of that size. In such cases, a pattern consisting of a wooden frame and strips is made, called a skeleton pattern.

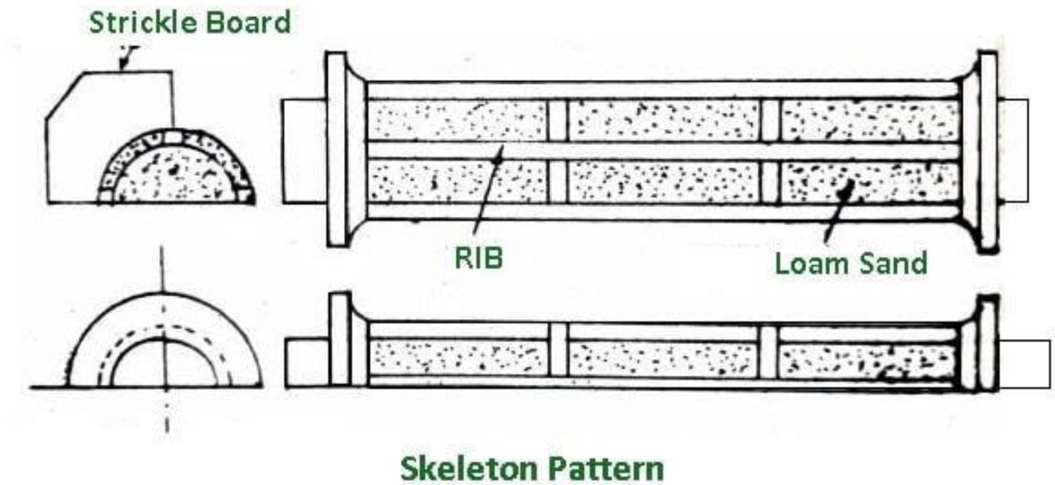


Fig.9 Skeleton Pattern

It is filled with loam sand and rammed. The excess sand is removed by means of a strickle. A half-skeleton pattern for a hollow pipe is shown in the diagram.
Since the pipe is symmetrical about the parting line, the same pattern will serve the purpose of moulding both the halves in two different flasks. These two flasks are joined later to form the complete cavity.

9. Segmented Pattern

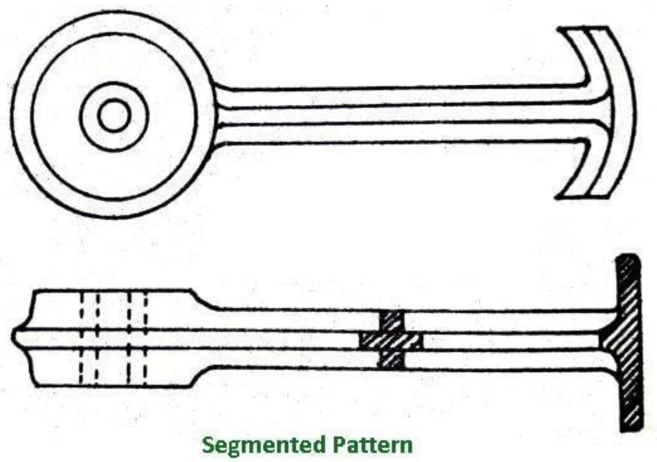


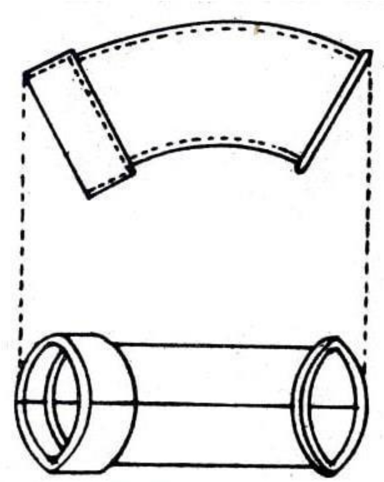
Fig.10 Segmented Pattern

These types of pattern are used to prepare moulds of large spherical castings. Hence the use of a solid pattern of the exact size is avoided. In principle, they work like a sweep pattern. But the difference is that a segmented pattern is a portion of the solid pattern itself and the mould is prepared in parts by it.

It is mounted on a central axis and after preparing the mould in one part, the section is moved to the next position. The operation is repeated until the complete mould is ready. A typical example is shown in the diagram.

10. Shell Pattern

These types of pattern are largely used for drainage fittings and pipework. A typical example is shown in the diagram. The shell pattern is usually made of metal. It is mounted on a plate and parted along the centerline.



Shell Pattern

Fig.11 Shell Pattern

The shell pattern is a hollow structure like a shell. The outside shape is used as a pattern to make the mould while the inside is used as a core-box for making core.

Types of Pattern Allowances

The common allowances provided on patterns are:
1. Shrinkage allowance
2. Draft allowance
3. Finish allowance
4. Distortion allowance
5. Rapping allowance

1. Shrinkage Allowance

All the metals used for castings contract and shrink in size after solidification and cooling. To compensate for this, a pattern is made larger than the finished casting by means of a shrinkage on contraction. In laying measurements for the pattern, the pattern-maker allows for this by using shrink or contraction rule. This rule is slightly longer than the ordinary rule of the same length. Different metals have different shrinkages. Therefore, there is a shrink rule for each type of metal used in casting.

2. Draft Allowance or Taper Allowance

When the pattern is drawn from a mould, there is a possibility of damaging the edges of the mould. This possibility is decreased if the vertical surfaces of a pattern are tapered slightly outward. This slight taper outside on the vertical surfaces of a pattern is known as the draft.
Draft is expressed in mm/meter on a side in degrees. Amount of draft needed depends upon:
1. The shape of the casting.
2. Depth of casting.
3. Mouling method
4. Mould material

3. Finish or Machining Allowance

Rough surfaces of castings, that have to be machined, are made to dimensions somewhat over those indicated on the finished working drawings. The extra amount of metal to be machined is called finish or machine allowance.
This allowance varies from 1.5 to 16 mm but 3 mm allowance is common for small and medium-size castings. The amount of finish allowance depends upon:
1. The kind of metal to be used
2. The size and shape of casting
3. Method of moulding

4. Distortion Allowance

Distortion is seen only in such castings which have an irregular shape and contraction is not uniform throughout. Such casting will distort or wrap during cooling due to setting up of thermal stresses in them. Such an effect is easily seen in some dome shaped or "U" shaped castings.
To eliminate this defect an opposite direction is provided in the pattern, so that the effect is neutralized and correct casting is obtained.

5. Rapping or Shake Allowance

When a pattern is to be withdrawn from the mould, it is first rapped or shaken. As a result of this, the size of the mould cavity increases a little and negative allowance is to be provided in the pattern to compensate for the same. This allowance may be considered negligible for small and medium sized castings.

Molding Sand and its Properties

Molding sand, also known as foundry sand, is a sand that when moistered and compressed or oiled or heated tends to pack well and hold its shape. It is used in the process of sand casting for preparing the mould cavity.

Types of Moulding Sand

According to the use, moulding sand may be classified as below:

1. Green Sand:

The green sand is the natural sand containing sufficient moisture in it. It is mixture of silica and 15 to 30% clay with about 8% water. Clay and water act as a bonding material to give strength. Molds made from this sand are known as green sand mould.
The green sand is used only for simple and rough casting products. It is used for both ferrous and non-ferrous metals.

2. Dry Sand:

When the moisture is removed from green sand, it is known as dry sand. The mould produced by dry sand has greater strength, rigidity and thermal stability. This sand is used for large and heavy castings.

3. Loam Sand:
Loam sand is a mixture of 50 percent sand and 50 percent clay. Water is added in sufficient amount. It is used for large and heavy moulds e.g., turbine parts, hoppers etc.

4. Facing Sand:
A sand used for facing of the mould is known as facing sand. It consists of silica sand and clay, without addition of used sand. It is used directly next to the surface of the pattern. Facing sand comes in direct contact with the hot molten metal; therefore, it must have high refractoriness and strength. It has very fine grains.

5. Parting Sand:
A pure silica sand employed on the faces of the pattern before moulding is known as parting sand. When the pattern is withdrawn from the mould, the moulding sand sticks to it.
To avoid sticking, parting sand is sprinkled on the pattern before it is embedded in the moulding sand. Parting sand is also sprinkled on the contact surface of cope, drag and cheek.

6. Backing or Floor Sand:
The backing sand is old and repeatedly used sand of black colour. It is used to back up the facing sand and to fill the whole volume of the box. This sand is accumulated on the floor after casting and hence also known as floor sand.

7. System Sand:
The sand employed in mechanical heavy castings and has high strength, permeability and refractoriness, is known as system sand. It is used for machine moulding to fill the whole flask. In machine moulding no facing sand is used. The system sand is cleaned and has special additives.

8. Core Sand:
A sand used for making cores is known as core sand. It is silica sand mixed with core oil (linseed oil, resin, mineral oil) and other binding materials (dextrine, corn flour, sodium silicate). It has remarkable compressive strength.

9. Molasses Sand:
A sand which carries molasses as a binder is known as molasses sand. It is used for core making and small castings of intricate shapes.

Properties of Moulding Sand
Following are the important properties of moulding sand:

1. Porosity:
Porosity also known as permeability is the most important property of the moulding sand. It is the ability of the moulding sand to allow gasses to pass through. Gasses and steam are generated during the pouring of molten metal into the sand cavity. This property depends not only on the shape and size of the particles of the sand but also on the amount of the clay, binding material, and moisture contents in the mixture.

2. Cohesiveness or strength:
Cohesiveness is the property of sand to hold its particles together. It may be defined as the strength of the moulding sand. This property plays a vital role in retaining intricate geometric shapes of the mould.

Insufficient strength may lead to a collapse in the mould particles during handling, turning over, or closing. Clay and bentonite improves the cohesiveness.

3. Adhesiveness:

Adhesiveness is the property of sand due to which the sand particles sticks to the sides of the moulding box. Adhesiveness of sand enables the proper lifting of cope along with the sand.

4. Plasticity:

Plasticity is the property of the moulding sand by virtue of which it flows to all corners around the mould when rammed, thus not providing any possibility of left out spaces, and acquires a predetermined shape under ramming pressure.

5. Flow-Ability:

Flow-ability is the ability of moulding sand to free flow and fill the recesses and the fine details in the pattern. It varies with moisture content.

6. Collapsibility:

Collapsibility is the property of sand due to which the sand mould collapse under minimum force after the solidification of the casting. The mould should disintegrate into small particles of moulding sand with minimum force after the casting is removed from it.

7. Refractoriness:

Refractoriness is the property of sand to withstand high temperature of molten metal without fusion or soften or mold must not melt, burn, or crack

Moulding sands with poor refractoriness may burn when the molten metal is poured into the mould. Usually, sand moulds should be able to withstand up to 1650°C.

8. Grain Size

The size of the individual particles of sand.

9. Grain Shape

This property evaluates the shape of the individual grains of sand based on how round they are. Generally, three grain categories are used in foundry sand:

a. **Rounded Grain sands** provide relatively poor bonding strength, but good flowability and surface finish.
b. **Angular Grains** have greater bonding strength because of interlocking, but poorer flowability and permeability than rounded grain sands.
c. **Sub-angular Grains** are the middle road. They possess better strength and lower permeability relative to rounded grains, but lower strength and better permeability than angular grains.

Ingredients of Molding Sand

The general sources of receiving molding sands are the sea shores, rivers, lakes, deserts and granular elements of rocks.

Molding sands can be classified mainly in to two types namely

1. **Natural molding sand or**

2. **Synthetic molding sand.**

Natural molding sands contains sufficient amount of binder material. Whereas synthetic molding sands are prepared artificially using basic sand molding constituents (silica sand in 85-91%, binder 6-11%, water or moisture content 2-8%) and other additives in proper proportion by weight with perfect mixing and mulling in suitable equipment's.

Constituents of Molding Sand

The main constituents of molding sand involve silica sand, binder, moisture content and additives.

1. Silica sand

Silica sand in form of granular quarts is the main constituent of molding sand having enough refractoriness which can impart strength, stability and permeability to molding and core sand. But along with silica small amounts of iron oxide, alumina, lime stone (CaCO3), magnesia, soda and potash are present as impurities.

2. Binder

Binders can be either inorganic or organic substance. Binders included in the inorganic group are clay sodium silicate and port land cement etc. In foundry shop, the clay acts as binder which may be Kaolinite, Ball Clay, Fire Clay, Limonite, Fuller's earth and Bentonite. Binders included in the organic group are dextrin, molasses, cereal binders, linseed oil and resins like phenol formaldehyde, urea formaldehyde etc

3. Moisture

The amount of moisture content in the molding sand varies from 2 to 8%. This amount is added to the mixture of clay and silica sand for developing bonds. This is the amount of water required to fill the pores between the particles of clay without separating them. This amount of water is held rigidly by the clay and is mainly responsible for developing the strength in the sand. For increasing the molding sand characteristics some other additional materials besides basic constituents are added which are known as additives.

4. Additives

Additives are the materials generally added to the molding and core sand mixture to develop some special property in the sand. Some commonly used additives for enhancing the properties of molding and core sands are coal dust, corn flour, dextrin, sea coal, pitch, wood flour, silica flour.

a. Coal dust

Coal dust is added mainly for producing a reducing atmosphere during casting process. This reducing atmosphere results in any oxygen in the poles becoming chemically bound so that it cannot oxidize the metal. It is usually added in the molding sands for making molds for production of grey iron and malleable cast iron castings.

b. Corn flour

Corn flour belongs to the starch family of carbohydrates and is used to increase the collapsibility of the molding and core sand. It is completely volatilized by heat in the sand mould, thereby leaving space between the sand grains. Corn sand if added to molding sand and core sand improves significantly strength of the mold and core.

c. Dextrin

Dextrin also belongs to starch family of carbohydrates that behaves also in a manner similar to that of the corn flour. Dextrin increases dry strength of the molds.

d. Sea coal

Sea coal is the fine powdered bituminous coal which positions its place among the pores of the silica sand grains in molding sand and core sand. When heated, sea coal changes to coke which fills the pores and is unaffected by water. Because to this, the sand grains become restricted and cannot move into a dense packing pattern. Thus, sea coal reduces the mould wall movement and the permeability in mold and core sand and hence makes the mold and core surface clean and smooth.

e. Pitch

Pitch is distilled form of soft coal. It can be added from 0.02 % to 2% in mold and core sand. Pitch enhances hot strengths, surface finish on mold surfaces and behaves exactly in a manner similar to that of sea coal.

f. Wood flour

Wood flour is a fibrous material mixed with a granular material like sand. Wood flour is relatively long thin fibers prevent the sand grains from making contact with one another. wood flour can be added in between 0.05 % to 2% in mold and core sand. Wood flour volatilizes when heated, thus allowing the sand grains room to expand. Wood flour will increase mould wall movement and decrease expansion defects. Wood flour also increases collapsibility of both mold and core.

g. Pulverized Silica or Silica flour

Silica flour is called as pulverized silica. Pulverized silica can be easily added up to 3% which increases the hot strength and finish on the surfaces of the molds and cores. It also reduces metal penetration in the walls of the molds and cores.

Preparation of mold

1. Initially a suitable size of molding box for creating suitable wall thickness is selected for a two-piece pattern. Sufficient care should also be taken in such that sense that the molding box must adjust mold cavity, riser and the gating system (sprue, runner and gates etc.).
2. Next, place the drag portion of the pattern with the parting surface down on the bottom (ram-up) board as shown in Fig. 12 (a).
3. The facing sand is then sprinkled carefully all around the pattern so that the pattern does not stick with molding sand during withdrawn of the pattern.
4. The drag is then filled with loose prepared molding sand and ramming of the molding sand is done uniformly in the molding box around the pattern. Fill the molding sand once again and then perform ramming. Repeat the process three four times,
5. The excess amount of sand is then removed using strike off bar to bring molding sand at the same level of the molding flask height to completes the drag.

6. The drag is then rolled over and the parting sand is sprinkled over on the top of the drag [Fig. 12 (b)].
7. Now the cope pattern is placed on the drag pattern and alignment is done using dowel pins.
8. Then cope (flask) is placed over the rammed drag and the parting sand is sprinkled all around the cope pattern.
9. Sprue and riser pins are placed in vertically position at suitable locations using support of molding sand. It will help to form suitable sized cavities for pouring molten metal etc. [Fig. 12 (c)].
10. The gaggers in the cope are set at suitable locations if necessary. They should not be located too close to the pattern or mold cavity otherwise they may chill the casting and fill the cope with molding sand and ram uniformly.
11. Strike off the excess sand from the top of the cope.
12. Remove sprue and riser pins and create vent holes in the cope with a vent wire. The basic purpose of vent creating vent holes in cope is to permit the escape of gases generated during pouring and solidification of the casting.
13. Sprinkle parting sand over the top of the cope surface and roll over the cope on the bottom board.
14. Rap and remove both the cope and drag patterns and repair the mold suitably if needed and dressing is applied
15. The gate is then cut connecting the lower base of sprue basin with runner and then the mold cavity.
16. Apply mold coating with a swab and bake the mold in case of a dry sand mold.
17. Set the cores in the mold, if needed and close the mold by inverting cope over drag.
18. The cope is then clamped with drag and the mold is ready for pouring, [Fig. 12 (d)].

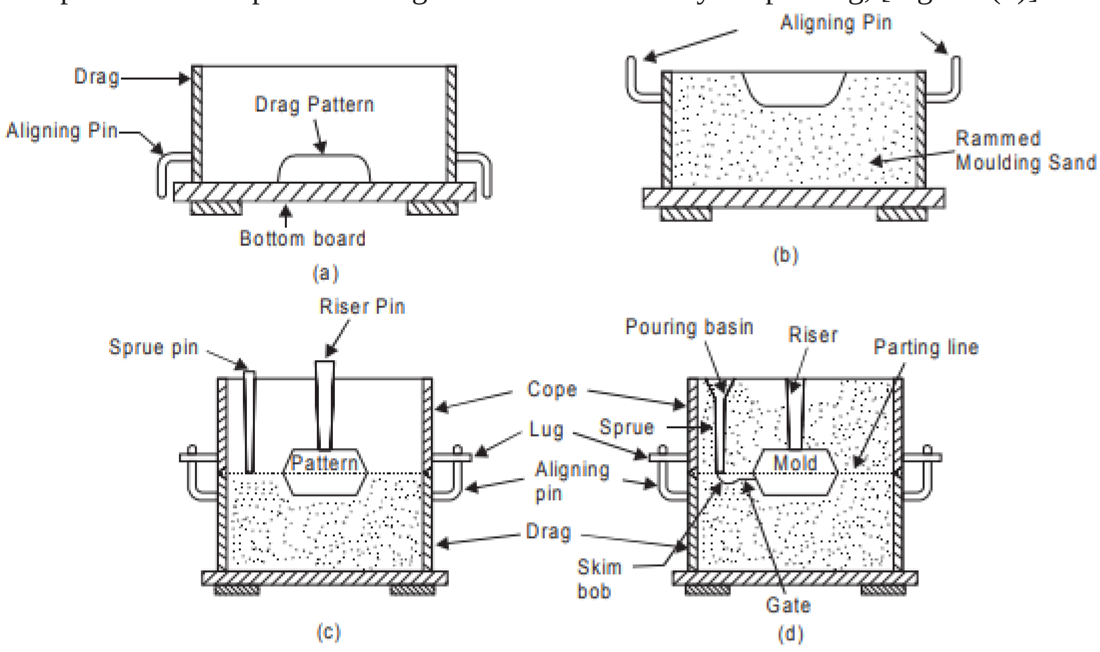


Fig.12 Mold making

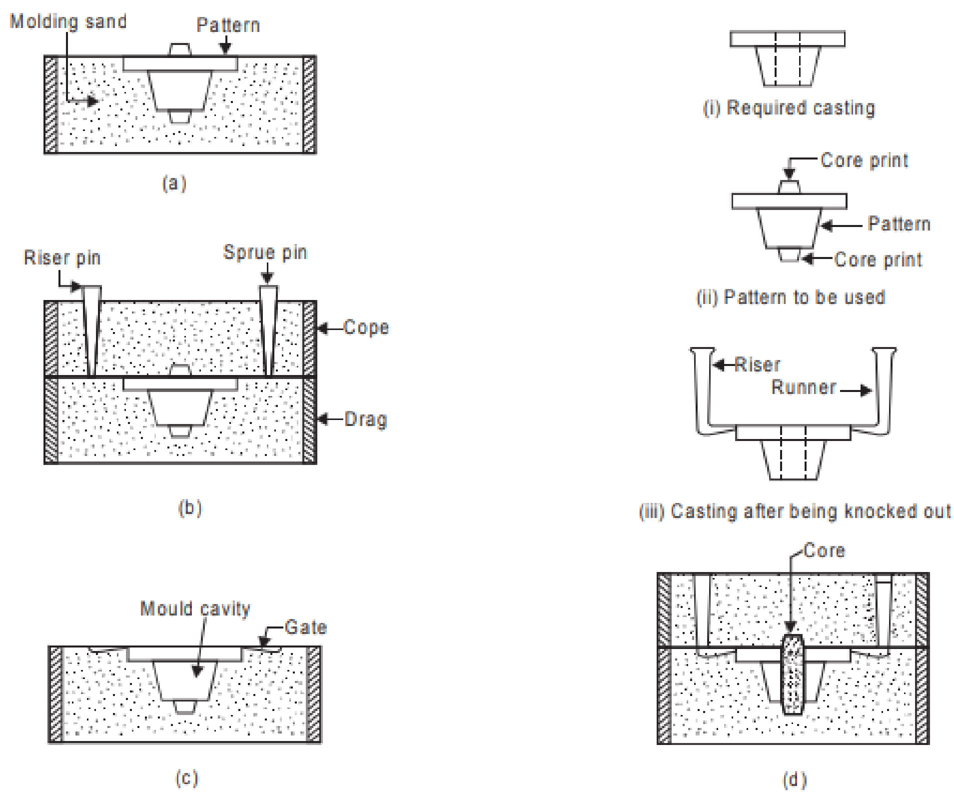


Fig.13 Example of making mold

Importance of Core and Core Prints-Gates-Runner-Riser

1. CORE

Cores are compact mass of core sand (special kind of molding sand) prepared separately that when placed in mold cavity at required location with proper alignment does not allow the molten metal to occupy space for solidification in that portion and hence help to produce hollowness in the casting.

The core must meet the following functions or objectives which are given as under.

1. Core produces hollowness in castings in form of internal cavities.
2. It must be sufficiently permeable to allow the easy escape of gases during pouring and solidification.
3. It may form a part of green sand mold.
4. It may be deployed to improve mold surface.
5. It may provide external undercut features in casting.
6. It may be inserted to achieve deep recesses in the casting.
7. It may be used to strengthen the mold.
8. It may be used to form gating system of large size mold.

2. CORE PRINT

A core print is a region added to the pattern, core, or mold to locate and support the core within the mold. Core print is an open space provided in the mould for locating, positioning and supporting the core. As we know the density of core (made of sand) is less than the density of metal being poured in the cavity. So there will be an upward buoyancy force on the core. To overcome this defect, the core prints are used.

3. GATING SYSTEM IN MOLD

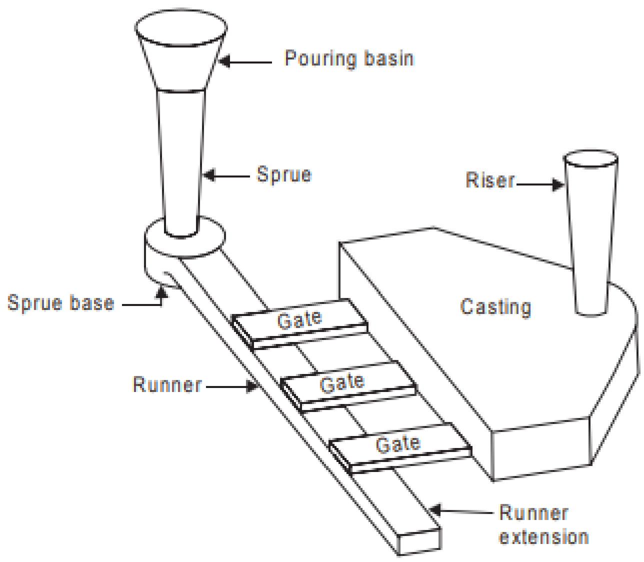


Fig.14 Gating System

Fig 14 shows the different elements of the gating system. Some of which are discussed as under.

1. Pouring basin

It is the conical hollow element or tapered hollow vertical portion of the gating system which helps to feed the molten metal initially through the path of gating system to mold cavity It helps in maintaining the required rate of liquid metal flow. It reduces turbulence and vertexing at the sprue entrance. It also helps in separating dross, slag and foreign element etc. from molten metal before it enters the sprue.

2. Sprue

It is a vertical passage made generally in the cope using tapered sprue pin. It is connected at bottom of pouring basin. It is tapered with its bigger end at to receive the molten metal the smaller end is connected to the runner. It helps to feed molten metal without turbulence to the runner which in turn reaches the mold cavity through gate. It sometimes possesses skim bob at its lower end. The main purpose of skim bob is to collect impurities from molten metal and it does not allow them to reach the mold cavity through runner and gate.

3. Gate

It is a small passage or channel being cut by gate cutter which connect runner with the mould cavity and through which molten metal flows to fill the mould cavity. It feeds the liquid metal to the casting at the rate consistent with the rate of solidification.

4. Choke

It is that part of the gating system which possesses smallest cross-section area. In choked system, gate serves as a choke, but in free gating system sprue serves as a choke.

5. Runner

It is a channel which connects the sprue to the gate for avoiding turbulence and gas entrapment.

6. Riser

It is a passage in molding sand made in the cope portion of the mold. Molten metal rises in it after filling the mould cavity completely. The molten metal in the riser compensates the shrinkage during solidification of the casting thus avoiding the shrinkage defect in the casting. It also permits the escape of air and mould gases.

7. Chaplets

Chaplets are metal distance pieces inserted in a mould either to prevent shifting of mould or locate core surfaces. The distances pieces in form of chaplets are made of parent metal of which the casting is. These are placed in mould cavity suitably which positions core and to give extra support to core and mould surfaces. Its main objective is to impart good alignment of mould and core surfaces and to achieve directional solidification. When the molten metal is poured in the mould cavity, the chaplet melts and fuses itself along with molten metal during solidification and thus forms a part of the cast material. Various types of chaplets are shown in Fig.15. The use of the chaplets is depicted in Fig.16.

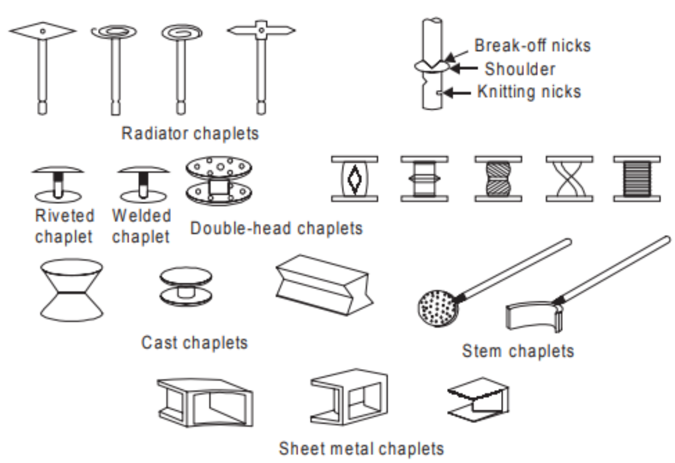


Fig.15 Types of chaplets

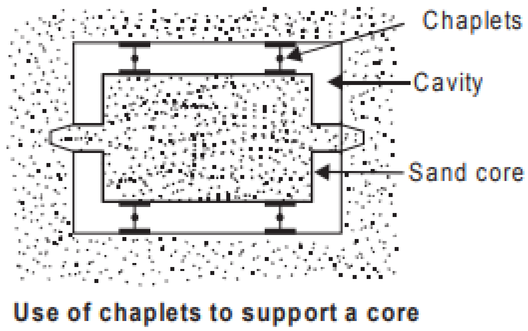


Fig.16 Use of chaplets to support a core

8. Chills

In some casting, it is required to produce a hard surface at a particular place in the casting. At that particular position, the special mould surface for fast extraction of heat is to be made. The fast heat extracting metallic materials known as chills will be incorporated separately along with sand mould surface during molding. After pouring of molten metal and during solidification, the molten metal solidifies quickly on the metallic mould surface in comparison to other mold sand surfaces. This imparts hardness to that particular surface because of this special hardening treatment through fast extracting heat from that particular portion. Thus, the main function of chill is to provide a hard surface at a localized place in the casting by way of special and fast solidification. Various types of chills used in some casting processes are shown in Fig. 17. The use of a chill in the mold is depicted in Fig. 18.

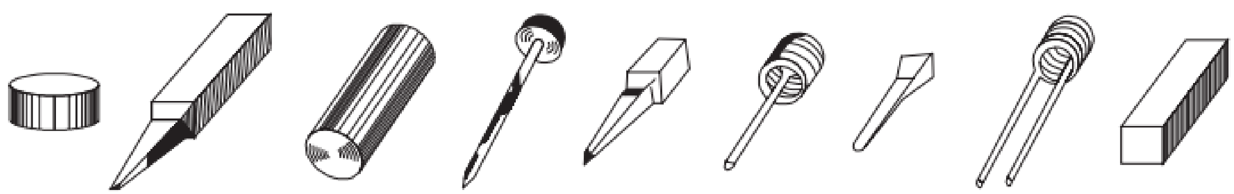


Fig.17 Types of Chills

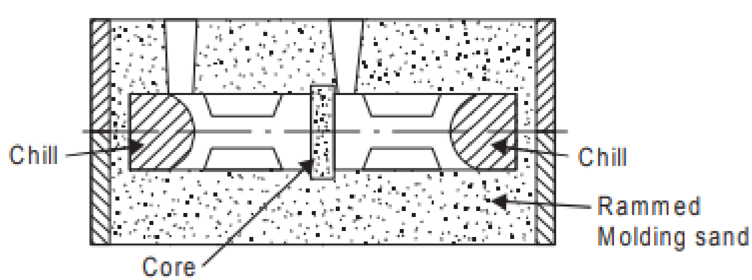


Fig.18 Use of chill

4. RUNNER

Runners are passages that distribute molten metal from the sprue to gates or risers around the cavity inside a mold or Runners are the connected channels that convey the molten metal to different parts of the mould. A well-designed running system can regulate the speed of the molten metal, avoid shrinkage and minimize turbulence.

5. ROLE OF RISER IN SAND CASTING

Metals and their alloys shrink as they cool or solidify and hence may create a partial vacuum within the casting which leads to casting defect known as shrinkage or void. The primary function of riser as attached with the mould is to feed molten metal to accommodate shrinkage occurring during solidification of the casting. Riser also permits the escape of evolved air and mold gases as the mold cavity is being filled with the molten metal. It also indicates to the foundry man whether mold cavity has been filled completely or not.

DEFECTS IN CASTING

A casting defect is an undesired irregularity in a metal casting process. Some defects can be tolerated while others can be repaired, otherwise they must be eliminated.

A properly designed casting, a properly prepared mould and correctly malted metal should result in a defect free casting. However, if proper control is not exercised in the foundry-sometimes it is too expensive - a variety of defects may result in a casting.

These defects may be the result of:

(a) improper pattern design,
(b) improper mould and core construction,
(c) improper melting practice,
(d) improper pouring practice and
(e) Because of molding and core making materials.
(f) Improper gating system
(g) Improper metal composition
(h) Inadequate melting temp and rate of pouring

It creates a deficiency or imperfection.

The following are the different types of casting defects.

1. Gas porosity

Gas porosity occurs when the metal traps gas (most often nitrogen, oxygen or hydrogen) during casting.

When the casting cools and solidifies, bubbles form because the solid form of the metal cannot hold as much gas as the liquid form. These bubbles appear on a casting as rounded, circular cavities or holes.

There are three types of casting defects related to gas porosity:

a.Blow holes:

Blow holes, gas holes or gas cavities are well rounded cavities having a clean and smooth surface. They appear either on the casting surface or in the body of a casting.

These defects occur when an excessive evolved gas is not able to flow through the mould. So, it collects into a bubble at the high points of a mould cavity ad prevents the liquid metal from filling that space.

Probable Causes

- Excessive moisture content in molding sand.
- Rust and moisture on chills
- Cores not sufficiently baked.
- Excessive use of organic binders.
- Molds not adequately vented.
- Molds not adequately vented.
- Molds rammed very hard.

Suggested Remedies

- Control of moisture content.
- Use of rust free chills, chaplet and clean inserts.
- Bake cores properly.
- Ram the mold less hard.
- Provide adequate venting in mold and cores.

b. Pin holes:

Pin holes are small gas holes either at the surface or just below the surface. When these are present, they occur in large numbers and are fairly uniformly dispersed over the surface.

This defect occurs due to gas dissolved in the alloy and the alloy not properly degassed.

c. Open holes

These blowholes appear on the surface of the cast and are easier to detect than subsurface blowholes.

Causes and prevention of gas porosity

- Poor venting of mold and cores
- Insufficient drying of mold and cores

Potential solutions include:

- Increase gas permeability of sand: coarser sands have a higher permeability
- Increase permeability of mold and cores. Allow air and gas to escape from the mold cavity
- Dry out molds and cores before use and store dry
- Increase rate of solidification by reducing metal temperature during casting

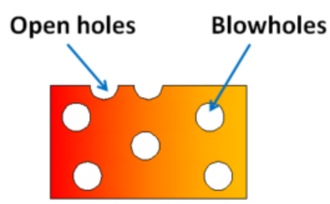


Fig.19 open holes and blowholes

3. Penetration:

It is a strong crust of fused sand on the surface of a casting which results from insufficient refractoriness of molding materials, a large content of impurities, inadequate mould packing and poor quality of mould washes.

When the molten metal is poured into the mould cavity, at those places when the sand packing is inadequate, some metal will flow between the sand particles for a distance into the mould wall and get solidified. When the casting is removed, this lump of metal remains attached to the casting.

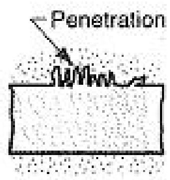


Fig.20 Penetration defect

4. Shrinkage:

A shrinkage cavity is a depression or an internal void in a casting that results from the volume contraction that occurs during solidification.

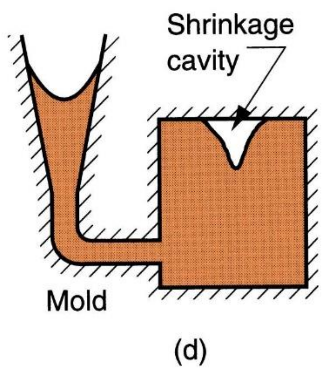


Fig.21 Shrinkage defect

5. Swell:

A swell is a slight, smooth bulge usually found on vertical faces of castings, resulting from liquid metal pressure. It may be due to low strength of mould because of too high a water content or when the mould is not rammed sufficiently. Using a strong, properly rammed mold prevents swells.

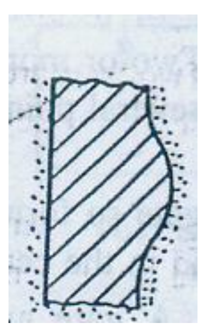


Fig22. Swell defect

6. Shift:

Mold shift refers to a defect caused by a sidewise displacement of the mold cope relative to the drag, the result of which is a step in the cast product at the parting line.

Core shift is similar to mold shift, but it is the core that is displaced, and (he dis-placement is usually vertical. Core shift and mold shift are caused by buoyancy of the molten metal

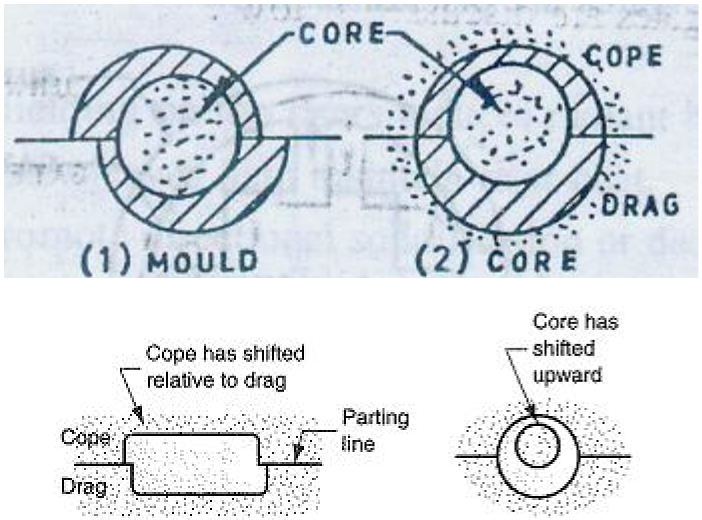


Fig23. Shift defect

7. Misrun or cold sheet or short run:

This defect is incomplete cavity filling. The reasons can be: - inadequate metal supply, too- low mould or melt temperature, improperly designed gates, or length to thickness ratio of the casting is too large. When molten metal is flowing from one side in a thin section, it may loose sufficient heat resulting in loss of its fluidity, such that the leading edge of the stream may freeze before it reaches the end of the cavity.

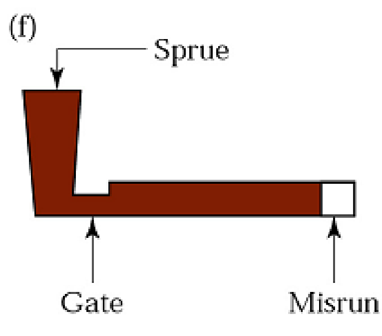


Fig24. Misrun defect

8. Cuts and washes

Cuts and washes are areas of excess metal. These appear when the molten metal erodes the molding sand.

Cuts and washes can be caused by molten metal flowing at a high velocity, causing too much metal to flow through the gate.

You can prevent cuts and washes easiest by:
Designing the gating system properly
Improving mold and core strength
Adding more binders to the facing and core sand

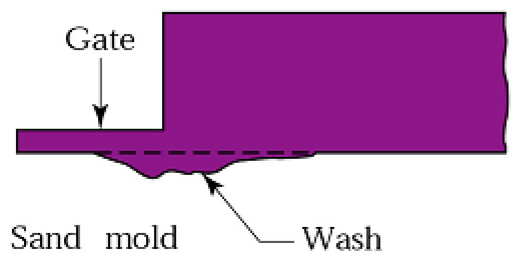


Fig.25 cuts and washes defect

9. Hot/hard spots

Hot spots are spots that are harder than the surrounding area. This is because they cooled more quickly than the surrounding material.

Causes and prevention of hot spots

Hot spots are a direct result of improper cooling practices. There are two potential solutions if hot spots are your problem:

- Start by correcting cooling practice
- Also consider changing the metal’s chemical composition

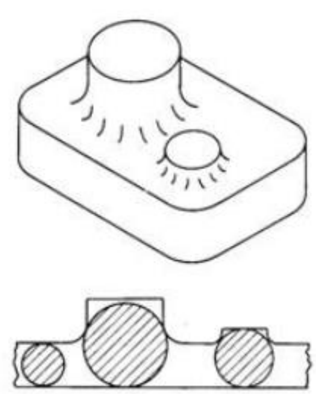


Fig.26 hard spot defect

10. Cold shots

Splattering during pouring of a liquid can cause solid globules to form. As these globules freeze, they become entrapped in the casting. Cold shots are typically ball, drop or pearl shaped and loosely attached to the metal.

Causes and prevention of cold shots

To prevent splattering and cold shots, consider

- **Modifying pouring procedures** to minimize turbulence
- **Adjusting gating system designs** to reduce gate speed

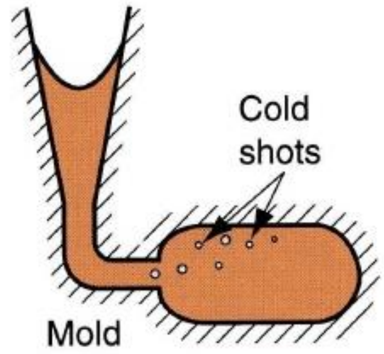


Fig.27 Cold shot defect

11. Warping

Warping is an unwanted casting deformity that can occur over time, which results in a change in the dimensions of the final product. It can happen during or after solidification.

Causes and prevention of warping

Warping is typically a result of different rates of solidifications of different sections, which causes stress in adjoining walls. Large and flat sections are more prone to warping.

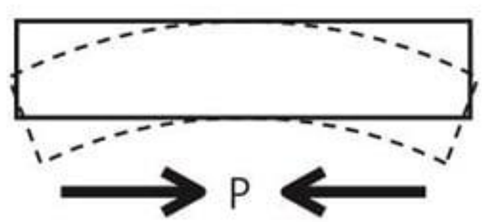


Fig.28 Warping defect

INSPECTION OF CASTING

Every step in the process of metal casting, from patternmaking to heat treating, is done carefully to avoid problems with the soundness, surface finish, mechanical properties, and final dimensions of the finished casting. Yet even castings made with diligence should undergo inspection for quality control.

Casting inspection methods are in place to ensure any hidden defects are identified during the manufacturing process. Some common casting defects include surface defects, inclusion defects, and cooling defects.

Some of the prominent nondestructive methods are described below:

1. Visual Inspection:

It consists of inspecting the surface of the casting with naked eye or sometimes with a magnifying glass or microscope. It can only indicate surface defects such as blow holes, fusion, swells, external cracks, and mismatch. Almost all castings are subjected to certain degree of visual inspection.

2. Dimensional Inspection:

Dimensional inspection is carried out to make sure that the castings produced have the required overall dimensions including allowances for machining. It may sometimes be necessary to break a part of the casting to take measurements of inside dimensions.

3. Sound Test:

This is a rough test to indicate a flaw or discontinuity in a casting. The casting is suspended from a suitable support free of all obstructions and tapped at various places on its surface with a small hammer. Any change in the tone produced indicates the existence of a flaw. The method cannot indicate the exact location and extent of the discontinuity.

4. Impact Test:

In this test the casting is subjected to a blow from a hammer of known weight striking or falling on the casting. Defective castings fail under the impact of the blow but the method is very crude and unreliable.

5. Pressure Test:

This test is carried out on castings required to be leak proof. All openings of the castings are closed and a gas or fluid under pressure is introduced in it. Castings having porosity leak under this pressure. The leakage may be detected by submerging the casting in a water tank or using a soap film if the pressure is applied by compressed air. If a liquid is used for applying pressure the leakage can be found by visual inspection.

6. Radiography:

Radiography uses X-rays or gamma rays penetrating through the castings and giving a shadow picture on a photographic film placed behind the work piece as shown in Fig.29. The ability of these waves to penetrate through metal depends also on the density of the metal and as such they can penetrate more easily in places where there is less metal that those where more metal is present leading to a shadow picture formation on the film. Any defects in the casting can easily be identified from this picture

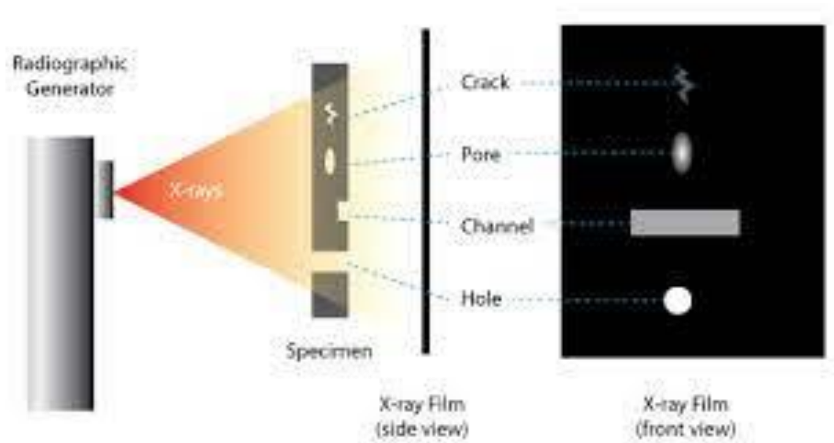


Fig.29 Radiographic test for sand casting specimen

7. Magnetic Particle Testing:

This test is used for detecting cracks in metals like cast iron and steel which can be magnetized. For carrying out the test the casting is magnetized and then fine particles of iron or steel are spread on its surface. Presence of a crack or void in the casting results in interruption of the magnetic field and leakage of magnetic flux at the place of the crack. The particles of iron or steel spread on the casting surface are held by this leaking flux giving a visual indication of the nature and extent of crack. Very small cracks or voids at or near

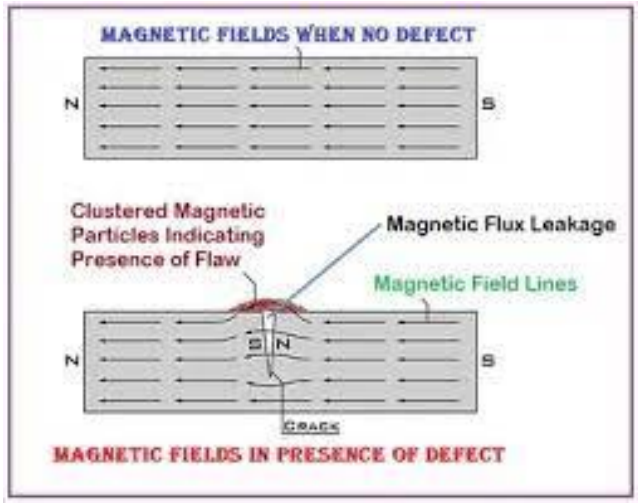


Fig.30 Magnetic particle test for sand casting specimen

8. Penetrant Testing:

This method also is used for detecting very small surface cracks and has the advantage over the magnetic particle method that it can be used for any material. The parts to be tested are either dipped into or covered with a penetrant testing liquid which has very good wetting and penetrating ability. The liquid is drawn into the cracks or voids by capillary action.

After the penetrant has been applied to the surface to be tested extra penetrant is wiped off the surface is dried and a developer applied to it. This developer helps in drawing out the penetrant so that it becomes visible on the surface as shown in Fig.31. The penetrant liquids often contain materials which fluoresce under ultraviolet light or a die to indicate their presence.

Fig.31 penetrant testing for sand casting specimen

9. Ultrasonic Testing:

Ultrasonic testing is used to detect defects like cracks, voids or porosity within the interior of the casting. The method uses reflection and transmission of high frequency sound waves. Ultrasonic sound waves much higher than the audible range are produced and made to pass through the casting as shown in Fig.32.

The time interval between the transmitted ray and reflected ray is recorded by a cathode ray oscilloscope. Any crack or void in the casting results in reflection or some of the sound from the crack which appears as a pip between the two pips representing the thickness of the casting. The depth of the crack from the surface of the casting can be easily calculated from the distance between these pips.

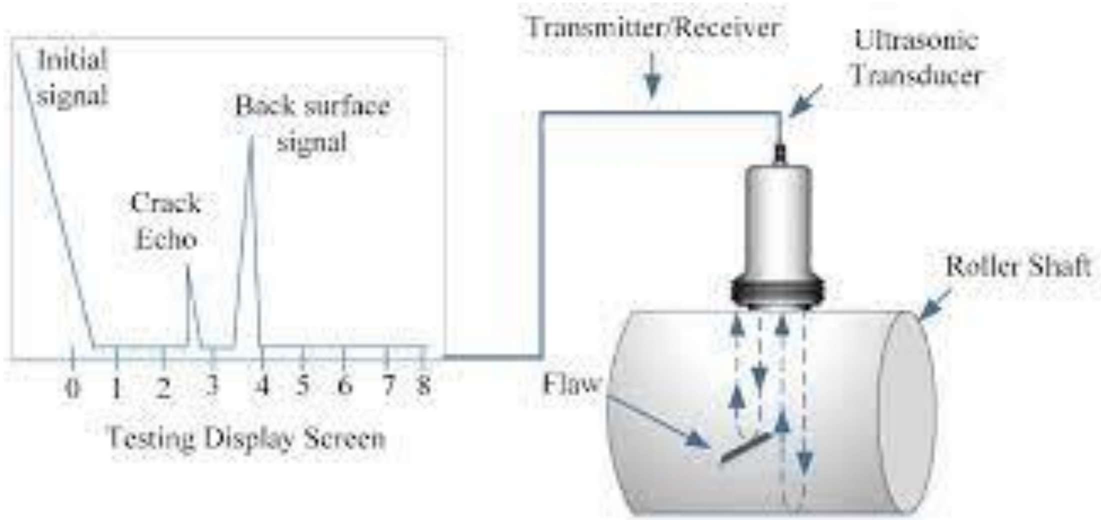


Fig.32 Ultrasound testing for sand casting specimen

Determination of Production Cost of a given material considering Raw material, Process cost, Overheads and other expenses

The prediction of casting cost generally depends on the cost drivers relating with the casting process. The prediction of casting cost generally depends on the cost drivers relating with the casting process. The casting cost drivers include the cost of materials consumed, labour cost, energy cost, overhead expenses and other direct expenses. After the identification of cost drivers, the cost was allocated to each driver. The cost estimation function for casting is defined by the following expression:

$$T_{cast}=M_c+L_c+C_e+OH_c+OD_c$$

where T_{cast} is total cost of casting,
M_c is material cost,
L_c is the labour cost,
C_e is the energy cost,
OH_c is overhead cost and
OD_c is other direct cost associated with the casting process.

1. **Material cost**

(a) Cost of material required for casting is calculated as follows:

(i) From the component drawing, calculate the volume of material required for casting. This volume multiplied by density of material gives the net weight of the casting.

(ii) Add the weight of process scrap i.e. weight of runners, gates and risers and other material consumed as a part of process in getting the casting.

(iii) Add the allowance for metal loss in oxidation in furnace, in cutting the gates and runners and over runs etc.

(iv) Multiply the total weight by cost per unit weight of the material used.

(v) Subtract the value of scarp return from the amount obtained in step (iv), to get the direct material cost.

(b) In addition to the direct material, various other materials are used in the process of manufacture of a casting. Some of the materials are:

(i) Materials required in melting the metal, i.e., coal, limestone and other fluxes etc. The cost of these materials is calculated by tabulating the value of material used on per ton basis and then apportioned on each item.

(ii) Material used in core shop for making the cores, i.e., oils, binders and refractories etc. The cost of core materials is calculated depending upon the core size and method of making the core. Similarly, the cost of moulding sand ingredients is also calculated. The expenditure made on these materials is generally expressed as per kg of casting weight and is covered under overhead costs.

The material cost M_c for a sand casting process can be estimated by using the following expression:

$$M_c = W_{cast} \times C_w$$

$$W_{cast} = V_{casted\ comp} \times \rho$$

where M_c is material cost in Rs,
W_{cast} is casting weight (kg),
C_w represents the material rate in Rs /kg,
$V_{casted\ comp}$ is casting volume in mm^3 and
ρ is material density (kg·mm-3).

2. Labour cost

Labour is involved at various stages in a foundry shop. Broadly it is divided into two categories:

(i) The cost of labour involved in making the cores, baking of cores and moulds is based on the time taken for making various moulds and cores.

(ii) The cost of labour involved in firing the furnace, melting and pouring of the metal. Cleaning of castings, fettling, painting of castings etc., is generally calculated on the basis of per kg of cast weight.

The labour cost can be calculated by the following expression:

$$L_c = \sum_{i=1}^{n} T_i \times N_i \times Cl$$

where L_c represents the labour cost in Rs,
n is the number of activities,
T_i is the time to complete the activity i in seconds,
N_i is number of labours involved in completing the activity i, and
Cl is labour unit charges in Rs /hour.

3. Energy cost

In the sand casting process, energy is consumed to melt the material. Energy consumption depends upon the melt time, furnace power and furnace efficiency. The energy cost is calculated through the following expression:

$$E_c = E_r \times [(V_f \times I_f / \eta_f \times 3600)] \times T_m$$

where E_c denotes the energy consumption cost in Rs,
E_r represents the unit energy price in Rs per kilowatt-hour,
V_f is the furnace voltage in volts,
I_f is the furnace current in kA,
η_f is furnace efficiency,
T_m is the time to melt the material in seconds.

4. Overhead expenses

Overhead expenses include the administrative overhead expenses and shop overhead expenses. The administrative overhead expenses include the administration cost and depreciation cost like salary and wages of supervisory staff, pattern shop staff and inspection staff, administrative expenses, water and electricity charges etc. The overheads are generally expressed as percentage of labour charges. These costs are assigned on the basis of the casting weight and casting hours as given below.

The overheads consist of the.

$$C_{overheads} = C_{administrative\text{-}overheads} + C_{shop\text{-}overheads}$$

where, $C_{overheads}$ is the overhead cost in Rs,
$C_{administrative\text{-}overheads}$ represents the administrative overhead costs,
$C_{shop\text{-}overheads}$ denotes the shop overhead costs,

5. Other direct expenses

The other direct expenses, OD_c, include the cost of pattern making, core boxes, cost of using machines, cost of irrecoverable losses during melting, pouring and fettling, research and development cost, and other items which were directly identified for a particular product. The cost of patterns, core boxes etc., is distributed on per item basis.

PROBLEMS

1. Calculate the total cost of CI (Cast Iron) cap shown in Fig. 33, from the following data:
Cost of molten iron at cupola spout = Rs. 30 per kg
Process scrap = 17 percent of net wt. of casting
Process scrap return value = Rs. 5 per kg
Administrative overhead charges = Rs. 2 per kg of metal poured.
Density of material used = 7.2 gms/cc

The other expenses details are

Process	**Time per Piece**	**Labour chares per hr**	**Shop overheads per hr**
Moulding and pouring	10min	Rs. 30	Rs. 30
Casting removal gate cutting etc.	4 min	Rs. 10	Rs. 30
Fettling and inspection	6 min	Rs. 10	Rs. 30

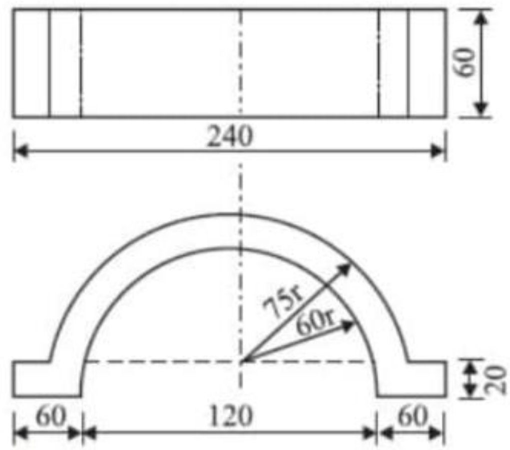


Fig. 33 All dimensions are in mm

Solution:

Volume of the component = $(2\ x\ (l\ x\ w\ x\ h) + \frac{\pi}{2}(R^2 - r^2)h$

= $(2\ x\ (60\ x\ 20\ x\ 60) + \frac{\pi}{2}(75^2 - 60^2)60$

= 335058.75 mm^3

= 335 cc / 335 cm^3

Net weight of the casting is $W_{cast} = V_{casted\ comp} \times \rho$

W_{cast}=335 X 7.2

= 2412 grm

W_{cast}=2.4 Kgs

Process Scrap = 17 percent of net wt. of casting

= 0.17 X 2.4

= 0.4 Kgs

Metal required per piece = 2.4 +0.4 = 2.8Kgs

Material cost per piece =2.8 x 30 =Rs. 84

Process return = 0.4 x 5 = Rs. 2

Net material cost per piece = 84 – 2 = Rs. 82

Calculate lobour cost and overhead

Process	**Time per Piece**	**Labour chares per piece (Rs.)**	**Shop overheads per per piece (Rs.)**
Moulding and pouring	10min	$\frac{10}{60}x30 = 5$	$\frac{30x10}{60} = 5$
Casting removal gate cutting etc.	4 min	$\frac{4}{60}x10 = 0.67$	$\frac{30x4}{60} = 2$
Fettling and inspection	6 min	$\frac{6}{60}x10 = 1$	$\frac{30x6}{60} = 3$
Total		Rs. 6.67	Rs. 10

Labour charges = Rs. 6.67 per piece

Shop overheads = Rs. 10 per piece
Administrative overheads =2x2.8 = Rs.5.6
Total cost per piece = 82 + 6.67 +10 + 5.6
= Rs. 104.27

2. A cast iron component is to be manufactured as per Fig. 34. Estimate the selling price per piece from the following data:
Density of material = 7.2 gms/cc
Cost of molten metal at cupola spout = Rs. 20 per kg
Process scrap = 20 percent of net weight
Scrap return value = Rs. 6 per kg
Administrative overheads = Rs. 30 per hour
Sales overheads = 20 percent of factory cost
Profit = 20 percent of factory cost
The other expenses details are

Operations	**Time (min)**	**Labour cost per hr (Rs.)**	**Shop overheads per hr (Rs.)**
Moulding and pouring	15	20	60
Slot blasting	5	10	40
Fettling	6	10	40

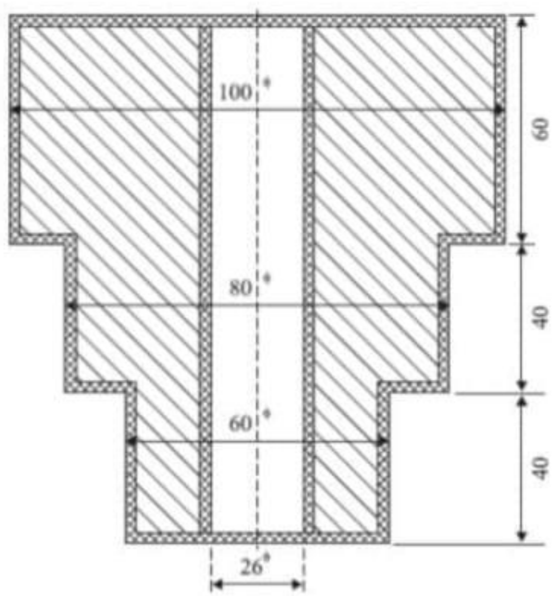


Fig. 34 All dimensions are in mm

(i) Material cost:
Net volume of cast component $= \frac{\pi}{4}(10^2 x 6 + 8^2 x\ 4 + 6^2 x\ 4 + 2.6^2 x\ 14)$
= 711 cc
Net weight of cast component = 711 x 7.2 = 5117 grms
= 5.117Kg
Process scrap = 20 percent of 5.117 Kg
= 0.2 x 5.117

= 1.02 Kg

Total metal required per component = 5.12 + 1.02 = 6.14Kg

Cost of metal poured = 6.11 x 20 =Rs. 112.8

Process return value = 1.02 x 6 = Rs. 6.12

Material cost per component = 122.8 - 6.1 = Rs. 116.7

(ii) Labour cost and factory overheads

Operations	**Time (min)**	**Labour cost per piece (Rs.)**	**Shop overheads per piece (Rs.)**
Moulding and pouring	15	$\frac{15}{60}x20 = 5$	$\frac{15}{60}x60 = 15$
Slot blasting	5	$\frac{5}{60}x10 = 0.83$	$\frac{5}{60}x40 = 3.33$
Fettling	6	$\frac{6}{60}x10 = 1$	$\frac{6}{60}x40 = 4$
Total	**26 min**	**Rs. 6.83**	**Rs. 22.33**

Labour cost = Rs.6.83

Shop overheads = Rs. 22.33

(iii) Factory cost per component = 116.7 + 6.83 + 22.33 = Rs. 145.86

(iv) Administrative overheads = $\frac{26}{60}x30 = Rs. 13$

(v) Sales overheads = 0.2 x 145.86 = Rs. 29.17

(vi) Profit = 0.2 x 145.86 = Rs. 29.17

(vii) Selling price per component = Factory cost + Administrative overheads + sales overheads + profit

= 145.86 +13 + 29/17 + 29.17

= Rs. 217.2