PONDICHERRY UNIVERSITY THEORY EXAMINATION FEB - 2023

INDUS'TRIAL CASTING TECHNOLOGY

2 MARKS

ANSWER ALL THE QUESTIONS

1. Define pattern allowances.

Pattern allowance is a vital feature as it affects the dimensional characteristics of the casting. The selection of correct allowances greatly helps to reduce machining costs and avoid rejections. The allowances usually considered on patterns and core boxes are as follows:

1. Shrinkage or contraction allowance
2. Machining or finish allowance
3. Draft or taper allowance
4. Rapping or Shake allowance
5. Distortion or camber allowance
6. Mould wall Movement Allowance

2. Write the requirements of core sand.

The basic properties required in molding sand and core sand are adhesiveness, cohesiveness, collapsibility, flowability, dry strength, green strength, permeability, refractoriness

3. Give the basic difference between a furnace and an oven.

The difference is actually pretty simple. Any industrial heat-treating system that heats above 1000 degrees Fahrenheit is considered a furnace and anything below is an oven.

4. List the characteristics of a good casting material.

Being cast with desired quality, an alloy must have various characteristics including ease of feeding, fluidity (flowability), low hot tearing tendency, low porosity caused by gas dissolution, no macro segregation, no tendency to solder to the die, and no tendency to form sludge.

5. Classify Gates.

The gate is the passage that finally leads molten metal from the runner into the mould cavity. The location and size of the gates are so arranged that the mould can be filled in quickly with a minimum amount of cutting of the mould surfaces by the flowing metal. The gates should be so placed that cracks do not develop when the metal cools. The gate connections should be located where they can be readily removed without damaging the castings. In-gates should not be placed

too near the end of the runner. If necessary, a well may be provided at the runner end. According to their position in the mould cavity, gates may be broadly classified as
(1) Top gates
(2) Parting gates
(3) Bottom gates

6. Write the functions of gating and risering.
gating

Gating systems are channels through which molten metal flows into the die cavity. The primary purpose is to ensure a smooth and complete flow between the ladle and the cavity of the mold. It is important to have a well-designed gating system in order to achieve perfect castings.

risering.

Provide extra metal to compensate for the volumetric shrinkage
• Allow mould gases to escape
• Provide extra metal pressure on the solidifying mould to reproduce mould details more exact
• It also indicates to the foundry man whether mould cavity has been filled completely or not.

7. What products are made by high pressure die casting?

High pressure die casting can produce various aluminum and magnesium automotive structural components. It makes parts such as engine blocks, gearbox casings, oil sumps, engine mounts and structural parts like cross-car beams.

8. Mention the advantages of continuous casting.

- Reduced weight.
- Faster machining speeds for improved productivity.
- Longer tool life.
- Better surface finish.
- Compact, lead-free chips.
- Minimized deburring.
- No directionality of mechanical properties.
- Enhanced wear resistance.

9. Name any four casting defects.

Related to flow of molten metal
1. Misrun
2. Cold Shut
3. Cold shot
4. Shrinkage cavity

5. Microporosity
6. Hot tearing

Related to the use of sand Moulds

7. Sand blow
8. Pinholes
9. Sand wash
10. Scab
11. Penetration

10. How to prevent air pollution from foundries?

Scrubbers. Scrubbers are a type of system that is used to remove harmful materials from industrial exhaust gases before they are released into the environment. These pollutants are generally gaseous, and when scrubbers are used to specifically remove SOx it is referred to as flue gas desulfurization.

Wet scrubbers include low- and high-energy types. Dry collection includes bughouses, mechanical collectors, and electrostatic precipitators. In addition, to control emissions of organic compounds, incineration or afterburners may be required.

PART B

ANSWER ALL THE QUESTIONS

11. Explain the various types of pattern used in foundry with a neat sketch.

The types of the pattern and the description of each are given as under.

1. One piece or solid pattern
2. Two piece or split pattern
3. Cope and drag pattern
4. Three-piece or multi- piece pattern
5. Loose piece pattern
6. Match plate pattern
7. Follow board pattern
8. Gated pattern
9. Sweep pattern
10. Skeleton pattern
11. Segmental or part pattern

1. Single-piece or solid pattern

Solid pattern is made of single piece without joints, partings lines or loose pieces. It is the simplest form of the pattern. Typical single piece pattern is shown in Fig. 1.12.

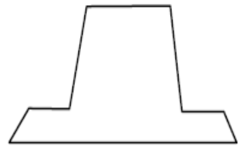


Fig. 1.12 Single piece pattern

2.Two-piece or split pattern

When solid pattern is difficult for withdrawal from the mould cavity, then solid pattern is splited in two parts. Split pattern is made in two pieces which are joined at the parting line by means of dowel pins. The splitting at the parting line is done to facilitate the withdrawal of the pattern. A typical example is shown in Fig. 1.13.

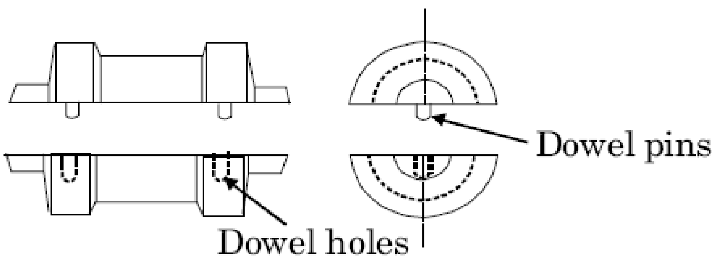


Fig. 1.13 Two piece pattern

3. Cope and drag pattern

In this case, cope and drag part of the mould are prepared separately. This is done when the complete mould is too heavy to be handled by one operator. The pattern is made up of two halves, which are mounted on different plates. A typical example of match plate pattern is shown in Fig. 1.14.

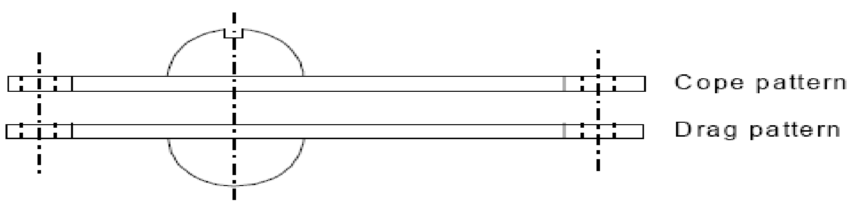


Fig. 1.14 Cope and drag pattern

4. Three-piece or multi-piece pattern

Some patterns are of complicated kind in shape and hence cannot be made in one or two pieces because of difficulty in withdrawing the pattern. Therefore these patterns are made in either three pieces or in multi-pieces. Multi moulding flasks are needed to make mould from these patterns.

5. Loose-piece Pattern

Loose piece pattern (Fig. 1.15) is used when pattern is difficult for withdrawal from the mould. Loose pieces are provided on the pattern and they are the part of pattern. The main pattern is removed first leaving the loose piece portion of the pattern in the mould. Finally the loose piece is withdrawal separately leaving the intricate mould.

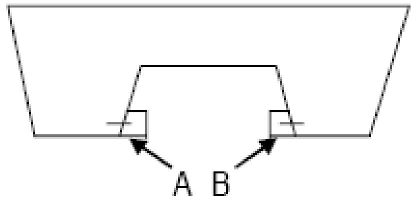


Fig. 1.15 Loose piece pattern

6. Match plate pattern

This pattern is made in two halves and is on mounted on the opposite sides of a wooden or metallic plate, known as match plate. The gates and runners are also attached to the plate. This pattern is used in machine moulding. A typical example of match plate pattern is shown in Fig. 1.16.

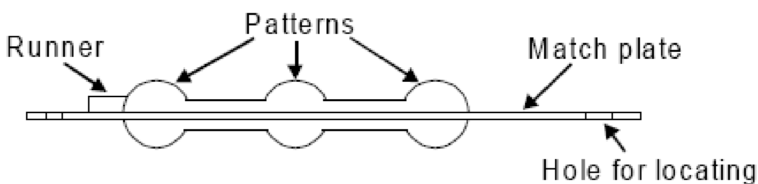


Fig. 1.16 Match plate pattern

7. Follow board pattern

When the use of solid or split patterns becomes difficult, a contour corresponding to the exact shape of one half of the pattern is made in a wooden board, which is called a follow board and it acts as a moulding board for the first moulding operation as shown in Fig. 1.17.

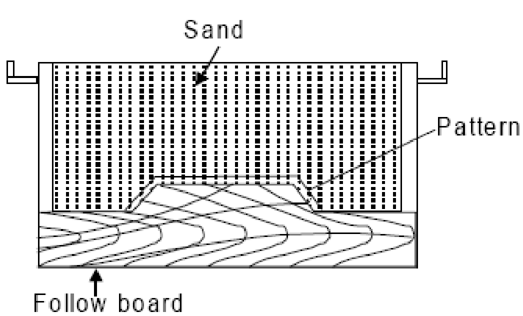


Fig. 1.17 Follow board pattern

8. Gated pattern

In the mass production of casings, multi cavity moulds are used. Such moulds are formed by joining a number of patterns and gates and providing a common runner for the molten metal, as shown in Fig. 1.18. These patterns are made of metals, and metallic pieces to form gates and runners are attached to the pattern.

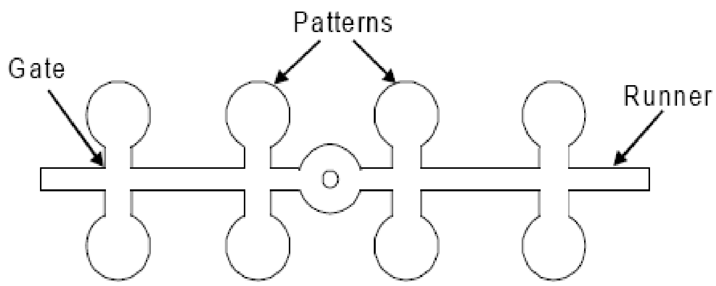


Fig. 1.18 Gated pattern

9.Sweep pattern

Sweep patterns are used for forming large circular moulds of symmetric kind by revolving a sweep attached to a spindle as shown in Fig. 1.19. Actually a sweep is a template of wood or metal and is attached to the spindle at one edge and the other edge has a contour depending upon the desired shape of the mould. The pivot end is attached to a stake of metal in the center of the mould.

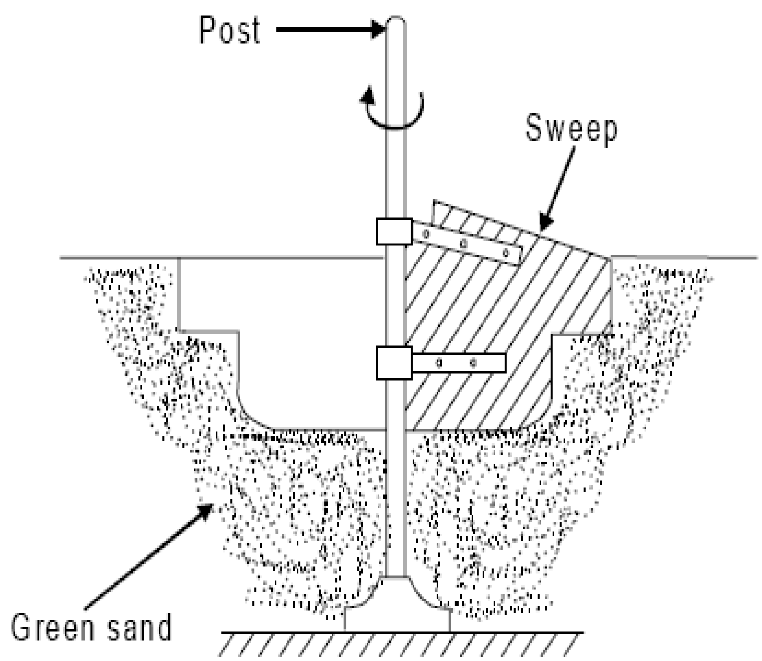


Fig. 1.19 Sweep pattern

10.Skeleton pattern

When only a small number of large and heavy castings are to be made, it is not economical to make a solid pattern. In such cases, however, a skeleton pattern may be used. This is a ribbed construction of wood which forms an outline of the pattern to be made.

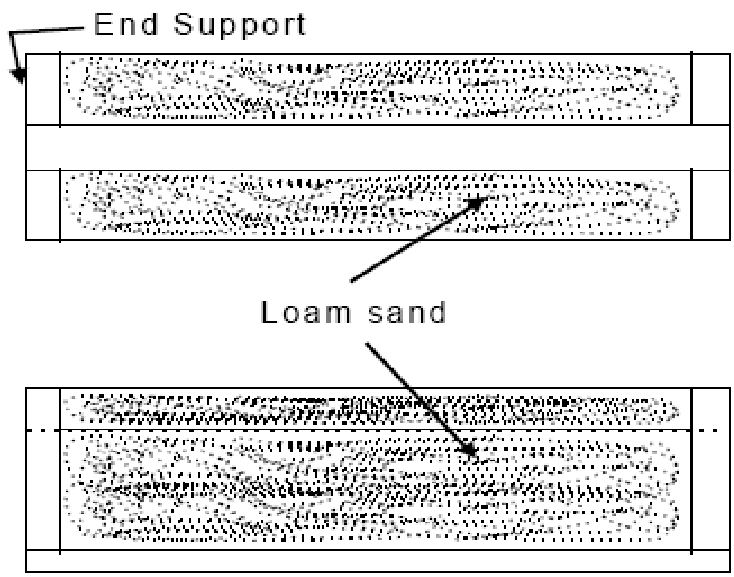
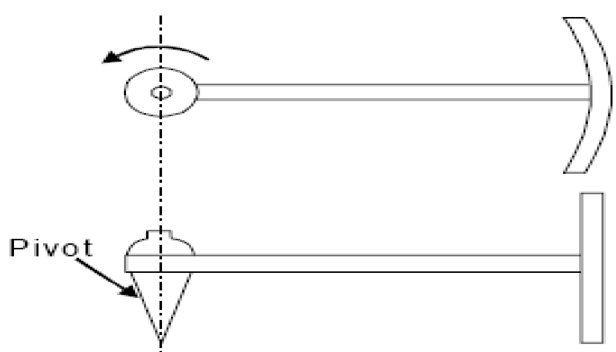


Fig. 1.20 Skeleton pattern

This frame work is filled with loam sand and rammed. The surplus sand is removed by strickle board. For round shapes, the pattern is made in two halves which are joined with glue or by means of screws etc. A typical skeleton pattern is shown in Fig. 1.20.

11.Segmental pattern

Patterns of this type are generally used for circular castings, for example wheel rim, gear blank etc. Such patterns are sections of a pattern so arranged as to form a complete mould by



being moved to form each section of the mould. The movement of segmental pattern is guided by the use of a central pivot. A segment pattern for a wheel rim is shown in Fig. 1.21.

Fig. 1.21 Segmental or part pattern

12. Explain the preparation moulding sand process.

principal ingredients of moulding sands

The principal ingredients of moulding sands are

- silica sand grains
- clay (bond)
- moisture

(1) Silica Sand Grains

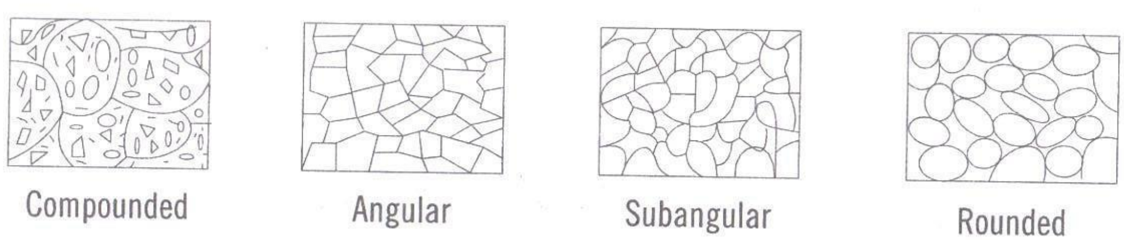
Silica sand grains are of paramount importance in moulding sand because they impart refractoriness, chemical resistivity, and permeability to the sand. They are specified according to their average size and shape. The finer the grains, the more intimate will be the contact and lower the permeability. However, fine grains tend to fortify the mould and lessen its tendency to get distorted. The shapes of the grains may vary from round to angular (Fig. 3.1). The grains are classified according to their shape.

(i) Rounded Grains These grains have the least contact with one another in a rammed structure, thereby making the sand highly permeable to gases. Sand having rounded grains, however, lacks strength and does not pack up to the optimum extent. The binder requirements are minimum.

(ii) Subangular Grains These grains have comparatively lower permeability and greater strength than the rounded ones.

(iii) Angular Grains These grains have defined edges, and the surfaces are nearly flat. They produce higher strength and lower permeability in the mould than sub- angular grains. The binder consumption is likely to be high.

(iv) Compounded Grains In some cases, the grains are cemented together such that they fail toseparate when screened. They may consist of rounded, subangular, or angular grains or a combination of the three. Such grains are called compounded grains and are least desirable due to their tendency to break down at high temperature.



In practice, sand grains contain mixed grain shapes, depending on origin. A subangular-to-rounded grainmixture would be the best combination.

(2) Clay

Clay imparts the necessary bonding strength to the moulding sand so that after ramming, the mould does not lose its shape. However, as the quantity of the clay is increased, the permeability of the mould is reduced.

Clay is defined by the American Foundrymen's Society (AFS), as those particles of sand (under 20 microns in diameter) that fail to settle at a rate of 25 mm per minute, when suspended in water. Clay consists of two ingredients: fine silt and true clay. Fine silt is a sort of foreign matter of mineral deposit andhas no bonding power.

True clay supplies the necessary bond. Under high magnification, true clay is found to be made upof extremely minute aggregates of crystalline particles, called clay minerals. These clay minerals are furthercomposed of flake-shaped particles, about 2 microns in diameter, which are seen to lie flat on one another.

(3) Moisture

Clay acquires its bonding action only in the presence of the requisite amount of moisture. When water is added to clay, it penetrates the mixture and forms a microfilm which coats the surface of each Hake. The molecules of water forming this film are not in the original fluid state but in a fixed and definite position.

As more water is added, the thickness of the film increases up to a certain limit after which the excess water remains in the fluid state. The thickness of this water film varies with the clay mineral. The bonding quality of clay depends on the maximum thickness of water film it can maintain.

When sand is rammed in a mould, the sand grains are forced together. The clay coating on each grain acts in such a way that it not only locks the grains in position but also makes them retain that position. If the water added is the exact quantity required to form the film, the bonding action is best. If the water is in excess, strength is reduced and the mould gets weakened. Thus, moisture content is one of the most important parameters affecting mould and core characteristics and consequently, the quality of the sand produced.

CONSTITUENTS OF MOULDING SAND

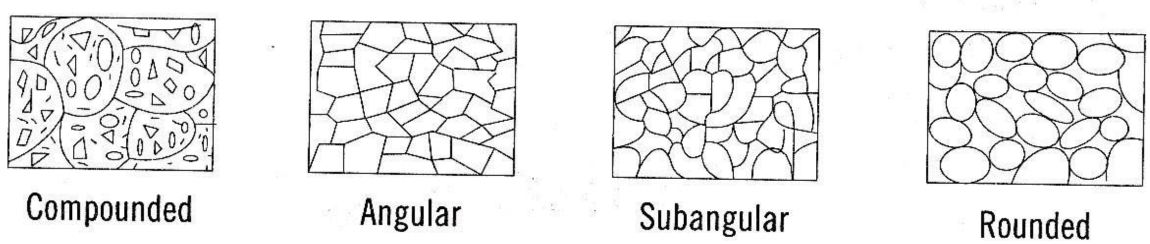
The main constituents of moulding sand involve silica sand, binder, moisture content and additives.

Silica sand

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

The chemical composition of silica sand gives an idea of the impurities like lime, magnesia, alkalis etc. present. The presence of excessive amounts of iron oxide, alkali oxides and lime can lower the fusion point to a considerable extent which is undesirable.

The silica sand can be specified according to the size (small, medium and large silica sand grain) and the shape (angular, subangular and rounded).



Types of Sand Grains

Binder

In general, the binders can be either inorganic or organic substance. The inorganic group includes clay sodium silicate and port land cement etc. In foundry shop, the clay acts as binder which may be Kaolonite, 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.

Organic binders are mostly used for core making. Among all the above binders, the bentonite variety of clay is the most common. However, this clay alone cannot develop bonds among sand grins without the presence of moisture in moulding sand and core sand.

Moisture

The amount of moisture content in the moulding sand varies generally between 2 to 8 percent. 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.

The effect of clay and water decreases permeability with increasing clay and moisture content. The green compressive strength first increases with the increase in clay content, but after a certain value, itstarts decreasing. For increasing the moulding sand characteristics some other additional materials besides basic constituents are added which are known as additives.

Additives

Additives are the materials generally added to the moulding and core sand mixture to develop some special property in the sand. Some common used additives for enhancing the properties of moulding and core sands are discussed as under.

Coal dust

Coal dust is added mainly for producing a reducing atmosphere during casting. 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 moulding sands for making moulds for production of grey iron and malleable cast iron castings.

Corn flour

It belongs to the starch family of carbohydrates and is used to increase the collapsibility of the moulding and core sand. It is completely volatilized by heat in the mould, thereby leaving space betweenthe sand grains. This allows free movement of sand grains, which finally gives rise to mould wall movement and decreases the mould expansion and hence defects in castings. Corn sand if added to moulding sand and core sand improves significantly strength of the mould and core.

Dextrin

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

Sea coal

Sea coal is the fine powdered bituminous coal which positions its place among the pores of thesilica sand grains in moulding sand and core sand. When heated, it 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 mould and core sand and hence makes the mould and core surface clean and smooth.

Pitch

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

Wood flour

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

Silica flour

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

STEPS INVOLVED IN MAKING A SAND MOULD

1. Initially a suitable size of moulding 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 moulding box must adjust mould 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. 1.27 (a).
3. The facing sand is then sprinkled carefully all around the pattern so that the pattern does not stick with moulding sand during withdrawn of the pattern.
4. The drag is then filled with loose prepared moulding sand and ramming of the moulding sand is done uniformly in the moulding box around the pattern. Fill the moulding 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 moulding sand at the same level of the moulding 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. 1.27 (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 mouldingsand. It will help to form suitable sized cavities for pouring molten metal etc. [Fig. 1.27 (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 mould cavity otherwise they may chill the casting and fill the cope with moulding 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 mould suitably if needed anddressing is applied
15. The gate is then cut connecting the lower base of sprue basin with runner and then the mouldcavity.
16. Apply mould coating with a swab and bake the mould in case of a dry sand mould.
17. Set the cores in the mould, if needed and close the mould by inverting cope over drag.
18. The cope is then clamped with drag and the mould is ready for pouring, [Fig. 1.27 (d)].

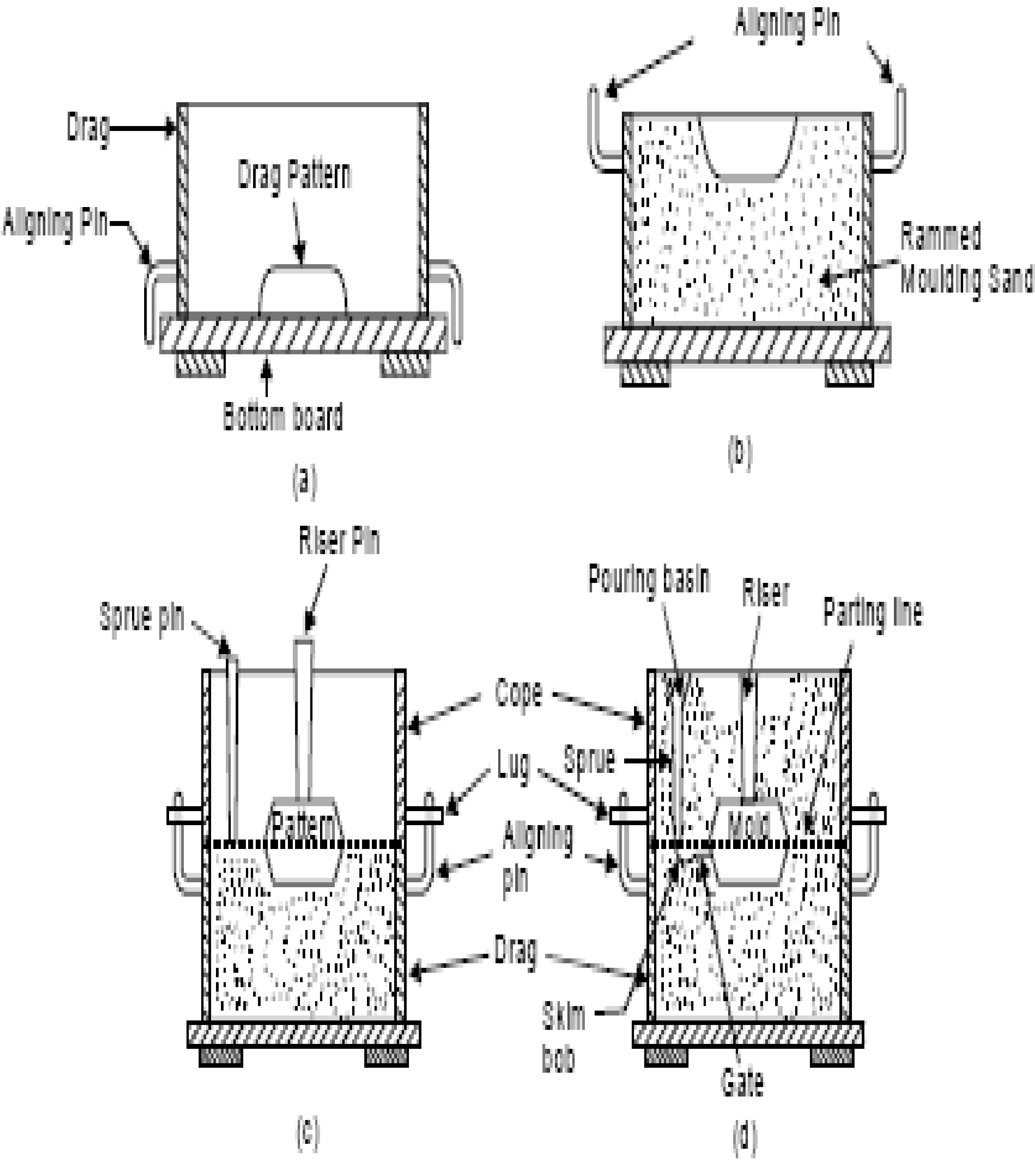


Fig. 1.27 Mould making

13. With a neat sketch, explain the working principle of Cupola furnace with different Zones

CUPOLA FURNACE

A cupola is a vertical cylindrical furnace equipped with a tapping spout near its base. Cupolas are used only for melting cast irons, and although other furnaces are also used, the largest tonnage of cast iron is melted in cupolas. General construction and operating features of the cupola are illustrated in Fig.
2.4. It consists of a large shell of steel plate lined with refractory.

The _charge, consisting of iron, coke, flux, and possible alloying elements, is loaded through a charging door located less than halfway up the height of the cupola. The iron is usually a mixture of pig iron and scrap (including risers, runners, and sprues left over from previous castings). Coke is the fuel used to heat the furnace.

Forced air is introduced through openings near the bottom of the shell for combustion of the coke. The flux is a basic compound such as limestone that reacts with coke ash and other impurities to form slag. The slag serves to cover the melt, protecting it from reaction with the environment inside the cupola and reducing heat loss.

As the mixture is heated and melting of the iron occurs, the furnace is periodically tapped to provide liquid metal for the pour.

Description of Cupola

- The cupola consists of a vertical cylindrical steel sheet and lined inside with acid refractory bricks. The lining is generally thicker in the lower portion of the cupola as the temperature are higher than in upper portion
- There is a charging door through which coke, pig iron, steel scrap and flux is charged
- The blast is blown through the tuyeres
- These tuyeres are arranged in one or more row around the periphery of cupola
- Hot gases which ascends from the bottom (combustion zone) preheats the iron in the preheatingzone
- Cupolas are provided with a drop bottom door through which debris, consisting of coke, slag etc.can be discharged at the end of the melt

A slag hole is provided to remove the slag from the melt Through the tap hole molten metal is poured into the ladle at the top conical cap called the spark arrest is provided to prevent the spark emerging to outside

Operation of Cupola

The cupola is charged with wood at the bottom. On the top of the wood a bed of coke is built. Alternating layers of metal and ferrous alloys, coke, and limestone are fed into the furnace from the top. The purpose of adding flux is to eliminate the impurities and to protect the metal from oxidation.

Air blast is opened for the complete combustion of coke. When sufficient metal has been melted that slag hole is first opened to remove the slag. Tap hole is then opened to collect the metal in the ladle.

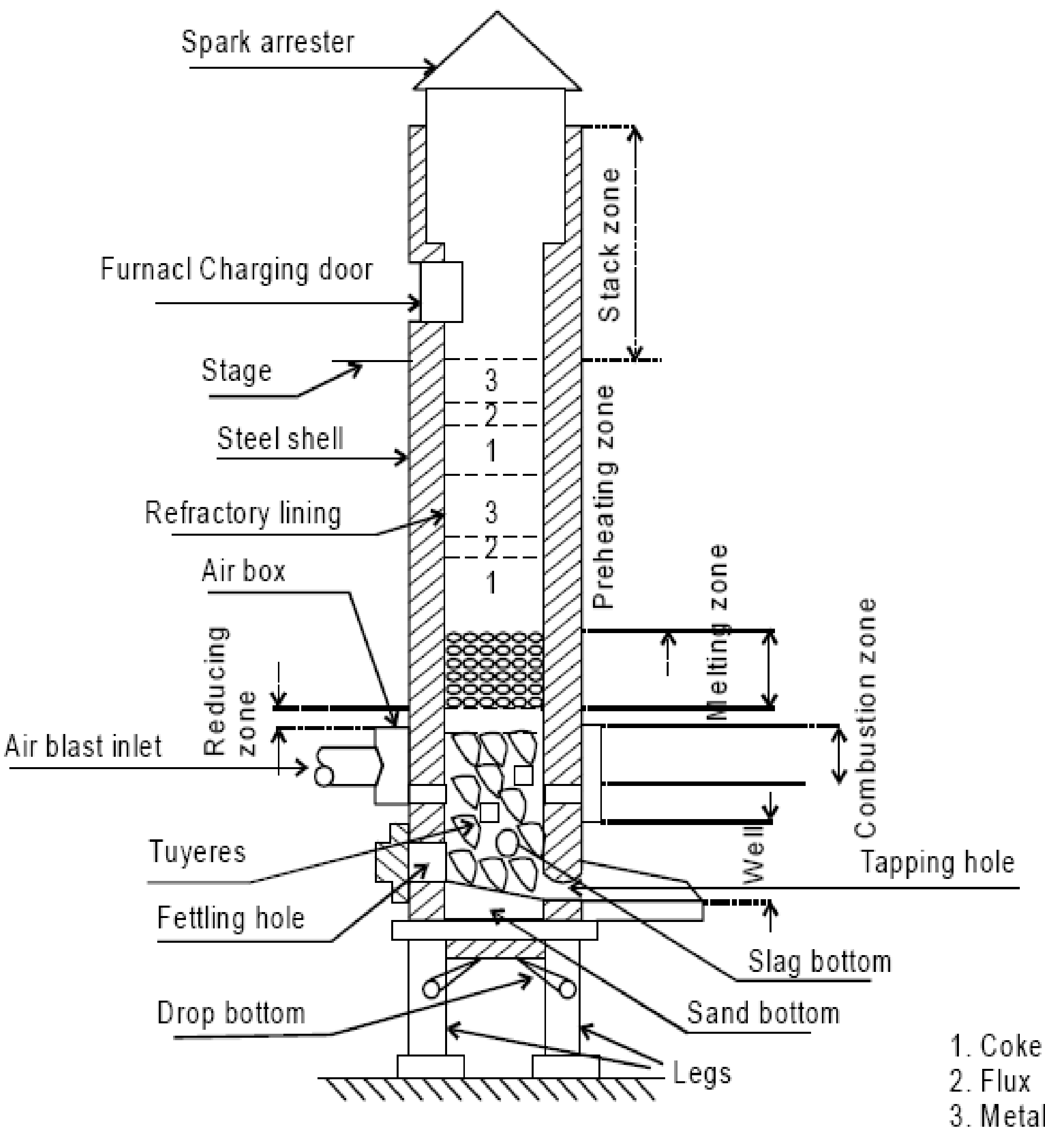


Fig. 2.4 Cupola Furnace

Working of Cupola Furnace

Initially the furnace prop is opened to drop the existing earlier charge residue. The furnace is then repaired using rich refractory lining. After setting the prop in position, the fire is ignited using firewood and then small amount of coke is used to pick fire. The little oxygen is then supplied for combustion. Lime, coke, and metal in balanced proportions are charged through the charging door upon the coke bed and at proper time on starting the blower.

Air is forced from wind box through tuyers into furnace. The forced air rise upward rough the stack furnaces for combustion of coke. Besides being fuel, the coke supports the charge until melting occurs. On increase of temperature, the lime stone melts and forms a flux which protects the metal against from excessive oxidation. Lime also fuses and agglomerates the coke ash.

The melting occurs and proceeds and molten metal is collected at the bottom. Molten metal may be tapped at intervals before each skimming, or the tap-hole may be left open with metal flowing constantly.

In most cupolas slag is drained from the slag hole at the back of furnace. When metal is melted completely the bottom bar is pulled sharply under the plates and bottom is dropped.

All remaining slag, un-burned coke or molten metal drops from the furnace. When the melt charge has cooled on closing furnace, it is patched and made ready for the next heat.

14. Explain with the help of neat sketches, the construction and working of a coal fired pit furnace and an oil fired tilting furnace.

CRUCIBLE FURNACE

- Crucible furnace is for the melting of non ferrous metals.
- Its capacity may range from 30 to 150 kg.
- The types of crucible furnace are:

1) Pit furnace

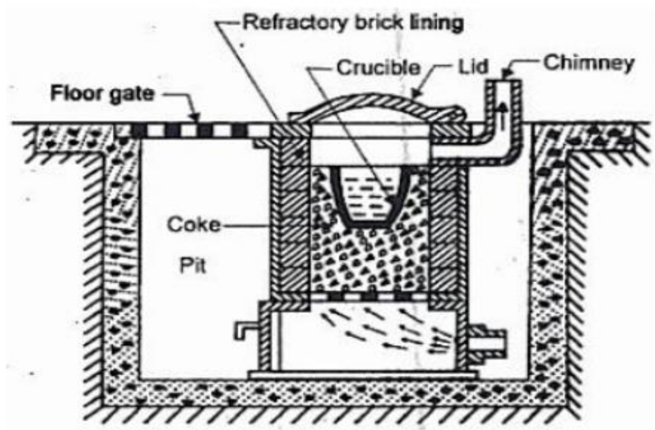
2) Coke fired stationery furnace

3) Oil fired tilting furnace

4) Pot furnace

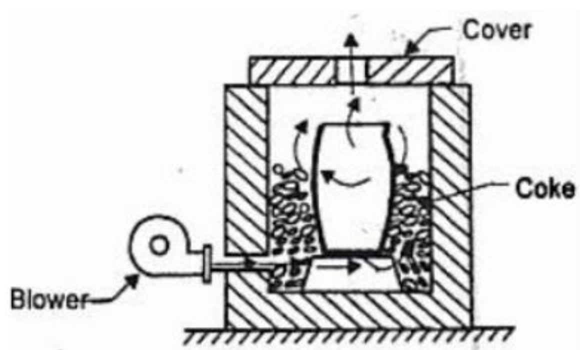
1) PIT FURNACE

- The crucible is placed in a pit below the floor level, it is fired with coke.
- The charge to be melted is placed in crucible; coke is packed around the crucible. Natural draft is provided by a tall chimney.
- Many crucibles can be placed in a single pit.
- After the metal is melted, the covers are removed, the crucibles are lift out with the help of tongs and taken to pouring placed.
- This furnace is used for melting non ferrous metals.



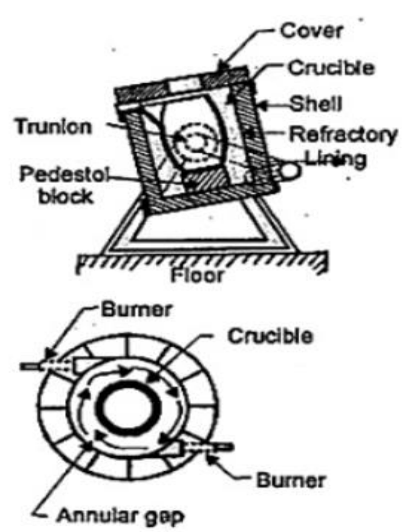
2) COKE FIRED STATIONERY FURNACE

- This furnace is used for melting non ferrous metals in small quantity.
- This furnace is placed above the floor level.
- The crucible is placed in the heating chamber.
- The heating chamber is lined with refractories.
- Coke is used as fuel. Forced draft is used.
- A blower is used for supply of air.



3) OIL FIRED TILTING FURNACE

- This furnace is used for melting non ferrous metals in small quantity and is fired by oil.
- This furnace is mounted on two pedestals above the floor level.
- For pouring the molten metal, the furnace is rotated by the geared hand wheel.
- Oil and air are admitted with pressure through a nozzle.
- The crucible is placed in the heating chamber and is heated by the flame.
- The furnace can be stopped whenever needed & temperature can be controlled easily.
- They give lesser pollution.



15. List the variations of gating position and explain with schematic sketch.

GATES

The gate is the passage that finally leads molten metal from the runner into the mould cavity. The location and size of the gates are so arranged that the mould can be filled in quickly with a minimum amount of cutting of the mould surfaces by the flowing metal. The gates should be so placed that cracks do not develop when the metal cools. The gate connections should be located where they can be readily removed without damaging the castings. In-gates should not be placed too near the end of the runner. If necessary, a well may be provided at the runner end.

According to their position in the mould cavity, gates may be broadly classified as

(1) Top gates

(2) Parting gates

(3) Bottom gates

(1) TOP GATES:

Molten metal is poured down the head or riser of the casting. Since the metal falls directly into the mould cavity, the mould should be hard and strong enough to resist erosion by the dropping metal. The advantage of top gating is that since all the metal enters the casting at the top, the hottest metal remains in this region. As such, proper temperature gradients are formed, and directional solidification towards theriser, located at the top of the casting, can be achieved. The gates themselves may be made to serve as risers (Fig. 3.6).

To prevent loose sand and drops from entering the mould cavity and to allow the metal to fall in a small stream, a large-sized pouring basin may be fixed on top of the sprue-cum-riser (Fig. 3.6A). A strainer core may also be fitted in the pouring basin for better results. In the case of light castings, wedge shaped gates called wedge gates may be provided (Fig. 3.6B).

Pencil gates, as shown in Fig. 3.6D, are used for massive iron castings where a minimum weightof head is desired and the slag is to be effectively checked from collecting in the mould cavity. In the finger gate (Fig. 3.6E), a modification of the wedge gate, the metal is allowed to reach the mould in a number of streams. The ring gate (Fig. 3.6F) also uses a core to break the stream of molten metal besides directing the metal into the desired position in the mould and, at the same time, retaining the slag.

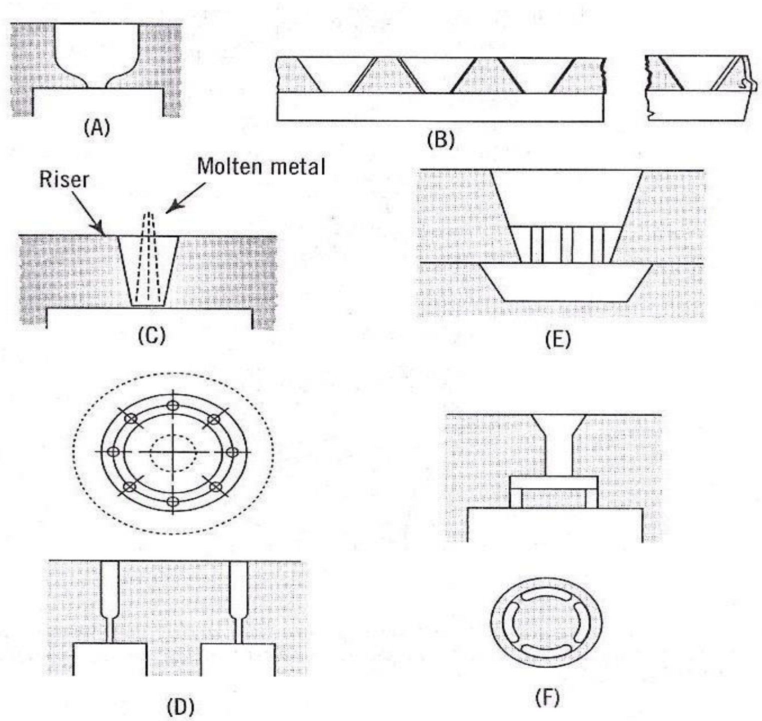


Fig. 3.6 Types of top gates (A) Top gate with pouring basin (B) Wedge gate

(B)Top run gate (D) Pencil gate (E) Finger gate (F) Ring gate

(2) PARTING GATES:

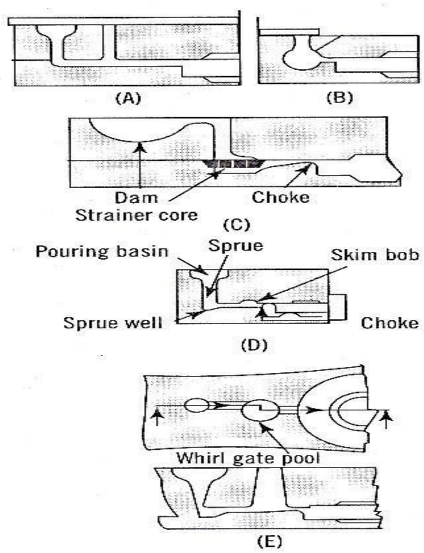
In the case of parting gates (Fig. 3.7), metal enters the mould cavity at the same level as the mould joint or parting line. Molten metal enters through the sprue and reaches the parting surface where the sprue is connected to the gate in a direction horizontal to the casting. The arrangement of providing a gate at the parting line allows the use of devices that can effectively trap any slag, dirt, or sand, which passes with the metal down the sprue. Fig. 3.7D shows the use of a skim-bob, which is a hollow or recess in the cope, to trap the slag and foreign matter in the metal.

This figure also indicates the use of a choke, which serves as a restriction to control the rate of flow of the metal. The choke may he placed in the gate either close to the casting, or away from it so asto prevent squirting of metal in the mould cavity and erosion of sand. Fig. 3.7A illustrates the use of a skimming gate, the purpose of which is similar to that of a skim-bob, viz., trapping the foreign matter which, here being lighter in weight than the metal, can rise up through the vertical passage. Fig. 3.7C depicts the use of a dam-type pouring basin, formed in the upper part of the cope, and a strainer core.

The purpose of both the dam and the strainer core is to separate the impurities and refine the metal. The metal, however, must be very fluid when a strainer core is used. If there is a tendency of shrinkage near the in-gate, a shrink-bob as shown in Fig. 3.7B may be required. At the bottom of the sprue, a dry sand core is sometimes fixed to prevent the sand from getting washed away.

In the case of large castings, molten metal flows through a common runner, which is laid around the mould cavity, and the metal is uniformly distributed to the casting through a number of branch gates.

To trap the slag, etc., another effective method is to use a skimming gate with a whirlpool (Fig. 3.7E).Theslag, due to whirlpool action, comes to the centre from where it rises up in the skimming gate.



<u>Fig. 3.7 Types of parting gates</u> (A) Skimming gate (B) Parting gate with shrink-bob (C) Parting gate withdam type pouring basin (D) Parting gate with skim-bob (E) Whirlpool gate

(3) BOTTOM GATES:

In the case of bottom gates, usually favoured for large-sized casting, especially those of steel, molten metal flows down the bottom of the mould cavity in the drag and enters at the base of the casting. These are used to keep the turbulence of metal at a minimum while pouring and to prevent mould erosion. Metal is allowed to rise gently in the mould and around the cores.

The disadvantages of bottom gating are the following:

(i) The metal continues to lose its heat as it rises in the mould cavity, and, by the time it reaches the riser, it becomes much cooler. As such, directional solidification is difficult to achieve.

(ii) It is difficult to place the riser near the gate entrance where the metal is hottest.

Two types of bottom gates are shown in Fig. 3.8. The horn type (Fig. 3.8A) enables the mould to be made in two boxes only, thus eliminating the necessity of a 'cheek'. The pattern for this gate is rammed in the drag and later extracted by turning it out of the sand.

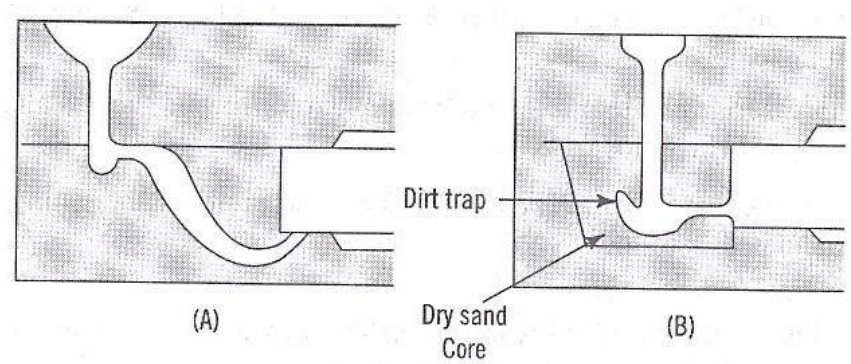


Fig. 3.8 Types of bottom gates (A) Horn gate (B) Bottom gate with dry sand core

Fig. 3.8B shows a bottom gate using a dry sand core. The sprue is curved at the bottom end to form a dirt-trap for slag, dirt, etc. This type of gate also enables the mould to be made in two boxes. Bottom gating can be provided with ease in case of three-part moulds by keeping the in-gates on the parting face of drag und middle part. A draw-in type of runner gate can also be used for simplicity in moulding.

The runner-gate pattern is tapered and can be pulled into the mould cavity after the main pattern for the casting has been withdrawn. The gate is generally placed tangentially on the casting so as to impart a spinning action to the incoming metal. The spinning and whirling action tends to move the slag and scum to the centre from where it can ascend into the riser.

16. Briefly explain the practical measures that can be used to control directional solidification in order to obtain sound casting.

DIRECTIONAL SOLIDIFICATION

Directional solidification is the solidification of molten metal from the sprue to the mould cavity andthen to the riser to produce a casting which is free from voids and internal cavities.

As the molten metal cools in the mould and solidifies, it contracts in volume. The contraction of themetal takes place in three stages:

(i) Liquid contraction;

(ii) Solidification contraction; and

(iii) Solid contraction.

Liquid contraction occurs when the molten metal cools from the temperature at which it is poured to the temperature at which solidification commences. Solidification contraction takes place during the time the metal changes from the liquid state to the solid, e.g., when the metal loses its latent heat. Solid contraction spans the period when the solidified metal cools from freezing temperature to room temperature.

Only the first two of these shrinkages are considered for risering purposes, since the third is accounted for by the patternmaker's contraction allowance. Of the first two types, liquid shrinkage is generally negligible but solidification contraction is substantial and should therefore be considered.

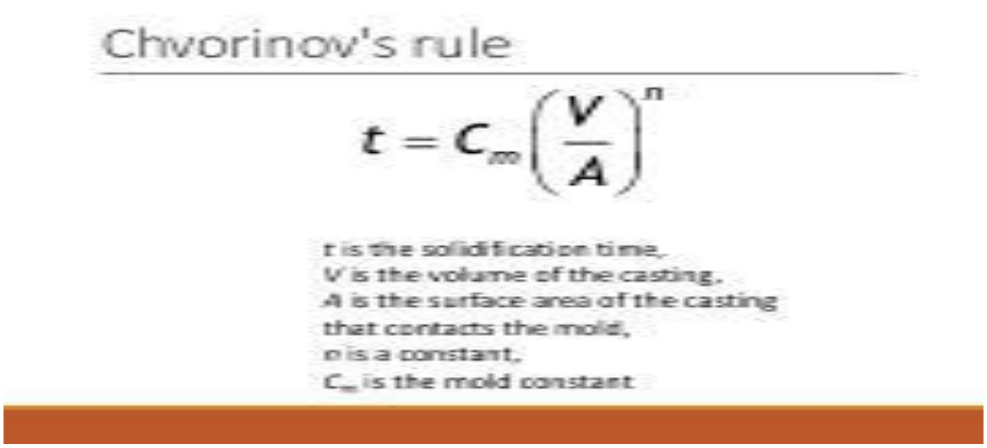
Since all the parts of the casting do not cool at the same rate, owing to varying sections and differing rates of heat loss to adjoining mould walls, some parts tend to solidify more quickly than others. This contraction phenomenon causes voids and cavities in certain regions of the casting. These voids must be filled up with liquid metal from the portion of the casting that is still liquid and the solidification should continue progressively from the thinnest part, which solidifies, first, towards therisers, which should be the last to solidify. If the solidification takes place in this manner, the casting willbe sound with neither voids nor internal shrinkage. This process is known as directional solidification, and ensuring its progress should be a constant endeavor for the production of sound castings.

In actual practice, however, it may not always be easy to fully achieve directional solidification owing to the shape and design of the casting, the type of casting process used, and such other factors. In general, directional solidification can be controlled by

- ✓ Proper design and positioning of the gating system and risers
- ✓ Inserting insulating sleeves for risers
- ✓ The use of padding to increase the thickness of certain sections of the casting
- ✓ Adding exothermic material in the risers or in the facing sand around certain portions of thecastings
- ✓ Employing chills in the Moulds
- ✓ Providing blind risers

METHODS TO ACHIEVE DIRECTIONAL SOLIDIFICATION

Desired directional solidification is achieved using Chvorinov's Rule to design the casting itself, itsorientation in the mold, and the riser system that feeds it



Where TST = total solidification time;V = volume of the casting;
A = surface area of casting;

n = exponent usually taken to have a value = 2; and

Cm is mold constant

Locate sections of the casting with lower V/A ratios away from riser, so freezing occurs first in these regions, and the liquid metal supply for the rest of the casting remains open.

Chills - internal or external heat sinks that cause rapid freezing in certain regions of the casting.

Cm depends on mold material, thermal properties of casting metal, and pouring temperature relative to melting point.

Value of Cm for a given casting operation can be based on experimental data from previous operations carried out using same mold material, metal, and pouring temperature, even though the shape of the part may be quite different.

17. Explain the pressure die casting process with a neat sketch. Also write its advantages and disadvantages.

High Pressure Die Casting

Unlike permanent mould or gravity die casting, molten metal is forced into metallic mould or die under pressure in pressure die casting. The pressure is generally created by compressed air or hydraulically means. The pressure varies from 70 to 5000 kg/cm2 and is maintained while the casting solidifies. The application of high pressure is associated with the high velocity with which the liquid metal is injected into the die to provide a unique capacity for the production of intricate components at a relatively low cost. This process is called simply die casting in USA. The die casting machine should be properly designed to hold and operate a die under pressure smoothly.

There are two general types of molten metal ejectionmechanisms adopted in die casting set ups which are:

(i) Hot chamber type

(a) Gooseneck or air injection management

(b) Submerged plunger management

(ii) Cold chamber type

Die casting is widely used for mass production and is most suitable for non-ferrous metals and al1oys of low fusion temperature. The casting process is economic and rapid. The surface achieved in casting is sosmooth that it does not require any finishing operation. The material is dense and homogeneous and has no possibility of sand inclusions or other cast impurities. Uniform thickness on castings can also be maintained.

The principal base metals most commonly employed in the casting are zinc, aluminum, and copper, magnesium, lead and tin. Depending upon the melting point temperature of alloys and their suitability for the die casting, they are classified as high melting point (above 540°C) and low melting point (below 500°C) alloys. Under low category involves zinc, tin and lead base alloys. Under high temperature category aluminum and copper base alloys are involved.

Types of Die-Casting Machines

The machines for feeding metal into dies under pressure are

(1) hot-chamber machine;

(2) cold-chamber machine; and

(3) Air-blown or goose-neck machine.

1) *Hot-Chamber Machine* This machine (Fig. 4.2) has a suitable furnace for melting and holding the metal. Submerged below the surface of the molten metal, a plunger operates within a cylinder. When the plunger is raised, it uncovers an opening or port in the cylinder wall through which the metal spills into the cylinder.

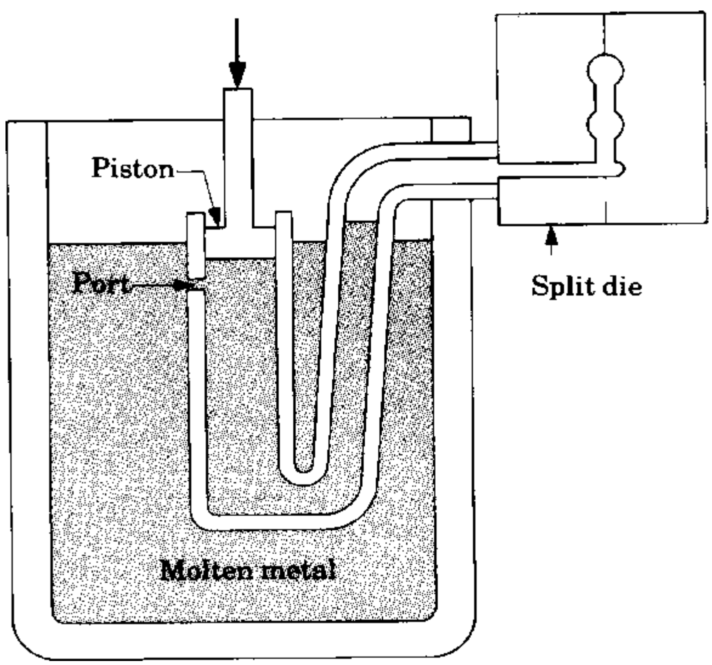


Fig. 4.2 Plunger type hot-chamber die-casting Machine

After the cylinder is filled, the plunger is forced downwards, pneumatically or hydraulically closing the opening and then forcing the confined metal up through a channel and nozzle into the die. After a predetermined time, the plunger is again raised, allowing the surplus molten metal in the channel and nozzle to drop back into the cylinder. The die is then opened and the solidified die casting ejected. Metal- injection speeds and pressures are controllable to suit different metals and casting.

Generally, these machines work at pressures below 150 kg/cm2 as higher pressures have not proved advantageous. In order to attain uniformity and maximum speed of operation, it is necessary to use a predetermined and automatically controlled cycle for various operations. The operator is however required to manually remove the casting from the die, and inspect and sometimes lubricate it.

(2) *Cold-Chamber Machine* The cold chamber is a horizontal steel cylinder into which molten metal is quickly introduced (Fig. 4.3). This metal is normally ladled by hand from a nearby holding furnace. After the chamber with slightly more metal than is needed to fill the die, the operator pushes a button which starts an automatic-cycle. First, the plunger rapidly advances, forcing the metal into the die; after allowing sufficient feeding time for solidification, the die is automatically opened; as the die opens, the plunger pushes out the so-called biscuit of excess metal from the cold chamber; finally, the die casting isremoved. The cold-chamber machine is ideal for metals such as aluminium alloys which cannot be cast in hot- chamber machines due to the high reactivity of molten aluminium with steel. High melting temperature alloys of the non-ferrous type are also best die cast in cold-chamber machines. The pick-up of iron by aluminium in the cold chamber is negligible as the actual contact between the molten metal and the chamber and its plunger is only momentary. Pressures in cold-chamber machines range from 300 kg/cm2 to 1600 kg/cm2.

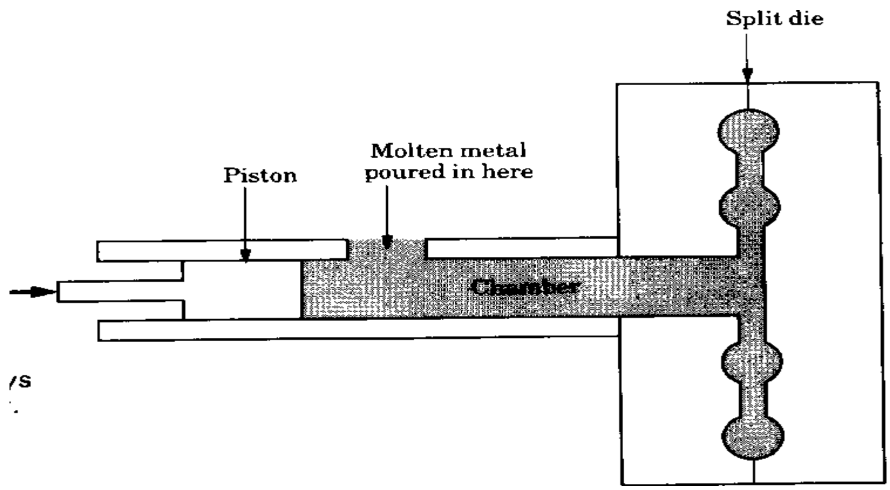


Fig. 4.3 Cold-chamber die casting machine

ADVANTAGES OF DIE CASTING OVER SAND CASTING

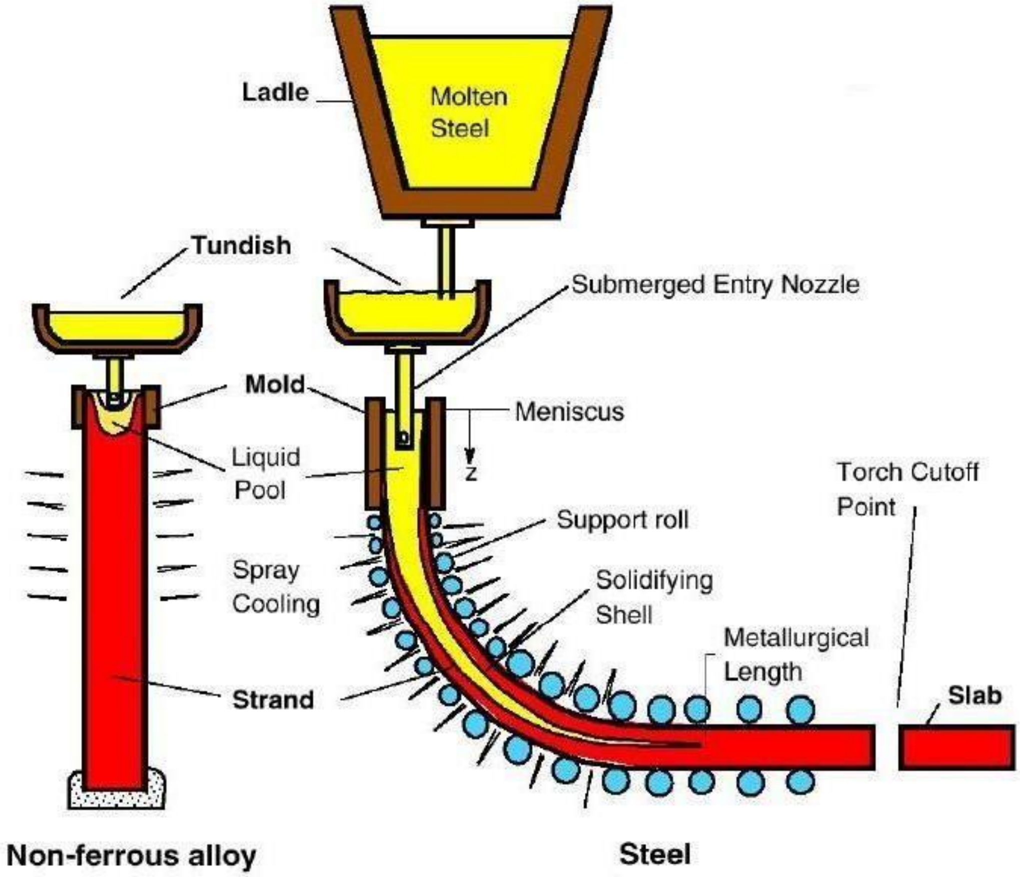
1) Die casting requires less floor space in comparison to sand casting.
2) It helps in providing precision dimensional control with a subsequent reduction in machining cost.
3) It provides greater improved surface finish.
4) Thin section of complex shape can be produced in die casting.
5) More true shape can be produced with close tolerance in die casting.
6) Castings produced by die casting are usually less defective.
7) It produces more sound casting than sand casting.
8) It is very quick process.
9) Its rate of production is high as much as 800 casting / hour.

18. With a neat sketch explain continuous casting process and mention its merits and demerits.

CONTINOUS CASTING

In this process the molten metal is continuously poured in to a mould cavity around which a facility for quick cooling the molten metal to the point of solidification. The solidified metal is then continuously extracted from the mould at predetermined rate. This process is classified into two categories namely Asarco and Reciprocating. In reciprocating process, molten metal is poured into a holding furnace. At the bottom of this furnace, there is a valve by which the quantity of flow can be changed. The molten metal is poured into the mould at a uniform speed.

The water cooled mould is reciprocated up and down. The solidified portion of the casting is withdrawn by the rolls at a constant speed. The movement of the rolls and the reciprocating motion of the rolls are fully mechanized and properly controlled by means of cams and follower arrangements.



Continuous Casting

Advantages of Continuous Casting

(i) The process is cheaper than rolling

(ii) 100% casting yield.

(iii) The process can be easily mechanized and thus unit labor cost is less.

(iv) Casting surfaces are better.

(v) Grain size and structure of the casting can be easily controlled.

Applications of Continuous Casting

(i) It is used for casting materials such as brass, bronzes, zinc, copper, aluminium and its alloys,magnesium, carbon and alloys etc.

(ii) Production of blooms, billets, slabs, sheets, copper bar etc.

It can produce any shape of uniform cross-section such as round, rectangular, square, hexagonal,and fluted or gear toothed etc.

19. Describe the various heat treatment processes used for the treatment of castings.

HEAT TREATMENT OF CASTINGS

Heat treatment involves the improvement of the properties of materials by bringing about certain permanent structural changes. Modern demands for high-quality castings have made heat treatment an indispensable step between the casting process and the finished product for engineering applications.

Fundamentals

The engineering properties of an element or a commercial material as an alloy of several elements depends solely on its structure, viz., atomic structure, crystal structure, microstructure, and macrostructure.

The atomic structure refers to the distribution of electrons, protons, neutrons, and other fundamental particles in the atom. The various elements have different atomic structures and hence different properties and behaviour. The crystal structure refers to the arrangement of atoms in the material. Most of the engineering metals and alloys have simple crystal structures, like face-centred cubic (fee), hexagonal close packed (hcp) and body-centred cubic (bcc). It has now been established that mechanical yielding or deformation of materials takes place mainly by the movement of line imperfections, called dislocations, along definite slip systems (the combination of crystallographic planes and directions).

The microstructure (generally observed through a microscope by magnifying the specimen surface 100 times or more) is made up of microconstituents (phases) present in the material, the kind of phases present in a material being governed by the type of interaction among atoms of its constituent elements. The dependence of the engineering properties of a material on its microstructure entails the consideration of (i) the number of phases and the size and shape of grains present in each phase; (ii) the intrinsic properties of phases; (iii) the relative amount of each phase; and (iv) the distribution of the phases.

The macrostructure of a material, observed with the naked eye or smaller magnification of about five times, refers to the presence of inhomogeneity, segregation, dendritic growth, and inclusions. Unless these defects are eliminated the material remains weak and has poor plastic properties.

The numerous heat-treatment processes in commercial use today fall under two categories: (i) anneal-quench-temper treatment for castings of plain carbon steels, alloy steels, and cast irons, and (ii) solutionise quench-age treatment for non-ferrous alloys. Both these processes may produce a material with substantially improved mechanical properties in comparison with the as-cast alloy.

Different types of Heat Treatment

- Annealing
- Normalizing and Hardening
- Hardenability

Annealing

Annealing is a heat treatment process that changes the physical and sometimes also the chemical properties of a material to increase ductility and reduce the hardness to make it more workable. The annealing process requires the material above its recrystallization temperature for a set amount of time before cooling. The cooling rate depends upon the types of metals being annealed. For example, ferrous metals such as steel are usually left to cool down to room temperature in still air while copper, silver and brass can either be slowly cooled in air or quickly quenched in water. The heating process cause atoms to migrate in the crystal lattice and the number of dislocations reduces, which leads to the change in ductility and hardness. The heat-treated material recrystallizes as it cools. The crystal grain size and phase composition depend on the heating and cooling rates and these, in turn, determine the material properties. Hot or cold working of the pieces of metal following annealing alters the material structure once more, so further heat treatments may be required to attain the desired properties. However, with knowledge of material composition and phase diagram, heat treating can soften metals and prepare them for further working such as forming, shaping and stamping, as well as preventing brittle failure.

Normalizing

Normalizing is a heat treatment process similar to annealing in which the Steel is heated to about 50 degree Celsius above the upper critical temperature followed by air cooling. This results in a softer state which will be lesser soft than that produced by annealing. This heat treatment process is usually carried for low and medium carbon steel as well as alloy steel to make the grain structure more uniform and relieve the internal stresses.

Normalizing carried for accomplishing one or more of the following:

- To refine the grain size.
- Reduce or remove internal stresses.
- Improve the machinability of low carbon steel.
- Increase the strength of medium carbon steel.
- And also to improve the mechanical properties of the medium Carbon Steel.

This heating and slow cooling alters the microstructure of the metal which in turn reduces its hardness and increases its ductility.

Hardening

Hardening is metallurgical metalworking process used to increase the hardness of a metal. The hardness of a metal is directly proportional to the uniaxial yield stress at the location of the imposed strain. A harder metal will have a higher resistance to plastic deformation than a less hard metal. Process of Hardening

- Hall-Petch method

- Strain Hardening
- Solid Solution Hardening
- Precipitation Hardening
- Martensitic Hardening

Hall-Petch Method The Hall–Petch method, or grain boundary strengthening, is to obtain small grains. Smaller grains increases the likelihood of dislocations running into grain boundaries after shorter distances, which are very strong dislocation barriers. Strain Hardening In work hardening (also referred to as strain hardening) the material is strained past its yield point, e.g. by cold working. Ductile metal becomes harder and stronger as it's physically deformed.

The plastic straining generates new dislocations. Solid Solution Hardening In it, a soluble alloying element is added to the material desired to be strengthened, and together they form a “solid solution”. Precipitation Hardening Precipitation hardening (also called age hardening) is a process where a second phase that begins in solid solution with the matrix metal is precipitated out of solution with the metal as it is quenched, leaving particles of that phase distributed throughout to cause resistance to slip dislocations. Martensitic Hardening Martensitic transformation, more commonly known as quenching and tempering, is a hardening mechanism specific for steel. The steel must be heated to a temperature where the iron phase changes from ferrite into austenite, i.e. changes crystal structure from BCC (body-centered cubic) to FCC (face-centered cubic).

20. List the various sources of pollutants in cast iron foundries and explain in detail.

POLLUTANTS IN A FOUNDRY

Foundries are among the industrial plants causing environmental pollution, producing substantial quantities of air pollutants. The numerous processes available for moulding, melting and casting are accompanied by evolution of heat, noise, dust and gases. Dust, fines, fly ash, oxides, etc., which form particulate matter are generated in large quantities when preparing mould and core sands and moulds, melting metals, pouring moulds, knocking out poured moulds and loading and unloading raw materials. Gaseous matter like gases, vapours, fumes and smoke are produced during melting and pouring operations. The major pollutants emitted from various work areas in a foundry are given in Table 9.1. The basic means of controlling the emission of pollutants are changing the production process, sup plying adequate make-up air, proper aeration and ventilation of the shop, reduction of pollutants at source by taking appropriate control measures, dispersion and dilution of pollutants in the air space and good housekeeping.

Major pollutants emitted in a foundry

Work area	Pollutan t	Emission concentration g/m3
Pattern shop	Sawdust, wood chips	Heavy
Sand preparation	Dust and fumes,	100-175
	powder materials	75-150
Moulding and core-making	Sand	50-100
	fumes	100-175
	Binder dust	75-150
	Vapours	Light
Mould drying and ladle heating	CO, so2	Light
Cupola	so2	Light
	CO	Heavy
	Unburnt hydrocarbons.	Heavy

	smoke	
	Metallic oxides	Moderate
	Coke dust	100-175
	Limestone dust, fly ash	Moderate
Electric arc furnance	Dust, CO, S02 oxides,	Moderate
	Nitrogen cyanide, fluoride, etc.	Light
Electric induction furance	Dust, oxides, smoke	Light
Pouring and mould cooling	CO	Light
	Binder fumes	Moderate
	Oil vapours	Heavy
Knock-out	Sand, fines and dust	200-350
	Smoke, steam, vapours	Heavy
Fettling	Dust, metal dust, sand fumes	>100
	Abrasive powder	10-50
Heat treatment	CO, SO,, oil vapours	Light