UNIT I :Casting Processes

- Introduction to casting process
- Proc ess steps
- Pattern: types, materials and allowance
- Cores: Types of cores, core prints
- Principles and design of gating system
- Solidification of casting: Concept
- Solidification of pure metal and alloy
- Special casting processes
- Shell casting
- Investment casting
- Diecasting
- Centrifugal casting
- Casting defects and remedies.

Introduction

- Manufacturing is the backbone of any industrialized nation.
- Manufacturing and technical staff in industry must know the various manufacturing processes, materials being processed, tools and equipment's for manufacturing different components or products with optimal process plan using proper precautions and specified safety rules to avoid accidents
- Beside above, all kinds of the future engineers must know the basic requirements of workshop activities in term of man, machine, material, methods, money and other infrastructure facilities needed to be positioned properly for optimal shop layouts or plant layout and other support services effectively adjusted or located in the industry or plant within a well-planned manufacturing organization.

Importance of Manufacturing process

- Manufacturing is achieved through a proper planning and control system.
- It is classified as continuous production and intermittent production.
- Continuous production involves a continuous flow of material physically, leading to large quantities of finished good.
- Chemical processing, cigarette manufacturing and cement manufacturing are some of the industries employing continuous production.
- Also, sheets, wires, pipes, TV sets, motor cycles are examples of continuous production

- An intermitted production involves interrupted flow of material through the plant.
- Machine shops, welding shops, etc. are industries employing intermittent production.

- Manufacturing and tech

  Importance of manufacturing towards technology development nology are complementary to each other Growth in manufacturing enables increase availability of finish goods and its appliance in various sectors.
- Such appliance leads to technology development of the industries which is then transferred to development of manufacturing technology.
- Growth of manufacturing is also referred to as an index of technology growth of a country
- Manufacturing provides availability of finish goods for technology application.

  Importance of manufacturing towards social-economicdevelopment
- Manufacturing is backbone of any economy. Manufacturing industries provides employment to hundreds of people.
- Before the industrial revolution, manufacturing was carried out in rural area, where household-based manufacturing was the trend.
- Later government policy and entrepreneurs organized a number of manufacturing house hold in to a single enterprise producing goods at large scale
- It leads to development of industrialization and society.

- Manufacturing provides an opportunity for establishment of allied industries.
- It provides a boost to the services industry catering to the people employed.
- Manufacturing is considered as a wealth-producing sector of an economy.
- It provides important material supports for national infrastructure and for national defense.

Classification of Manufacturing Process

- For producing of products materials are needed. It is therefore important to know the characteristics of the available engineering materials.
- Raw materials used manufacturing of products, tools, machines and equipments in factories or industries are extracted from ores.
- The ores are suitably converted the metal into a molten form by reducing or refining processes in foundries.
- This molten metal is poured into moulds for providing commercial castings, called ingots.
- These forms of material supply are further subjected to various manufacturing processes for getting usable metal products of different shapes and sizes in various manufacturing shops.
- All these processes used in manufacturing concern for changing the ingots into usable products may be classified into six major groups as primary shaping processes, secondary machining processes, metal forming processes, joining

processes, surface finishing processes and processes effecting change in properties. These are discussed as under.

- 1.Primary Shaping Processes
- 2. Secondary or Machining Processes
- 3. Metal Forming Processes
- 4. Joining Processes
- 5. Surface Finishing Processes
- 6. Processes Effecting Change in Properties

1. **Primary Shaping Processes**

- Primary shaping processes are manufacturing of a product from an amorphous material.
- Some processes produces finish products or articles into its usual form whereas others do not, and require further working to finish component to the desired shape and size.
- Castings need re-melting of scrap and defective ingots in cupola or in some other melting furnace and then pouring of the molten metal into sand or metallic moulds to obtain the castings. Thus the intricate shapes can be manufactured.
- Typical examples of the products that are produced by casting process are machine beds, automobile engines, carburetors, flywheels etc. The parts produced through these processes may or may not require to under go further operations.

Some of the important primary shaping processes is:

(1) Casting, (2) Powder metallurgy, (3) Plastic technology, (4) Gas cutting, (5) Bending and (6) Forging.

2. Secondary or Machining Processes

- As large number of components require further processing after the primary processes. These components are subjected to one or more number of machining operations in machine shops, to obtain the desired shape and dimensional accuracy on flat and cylindrical jobs. Thus, the jobs undergoing these operations are the roughly finished products received through primary shaping processes.
- The process of removing the undesired or unwanted material from the work piece or job or component to produce a required shape using a cutting tool is known as machining. This can be done by a manual process or by using a machine called machine tool (traditional machines namely lathe, milling machine, drilling, shaper, planner, slotter)
- In many cases these operations are performed on rods, bars and flat surfaces in machine shops. These secondary processes are mainly required for achieving dimensional accuracy and a very high degree of surface finish. The secondary processes require the use of one or more machine tools, various single or multi-point cutting tools (cutters), job holding devices, marking and measuring instruments, testing devices and gauges etc. for getting desired dimensional control and required degree of surface finish on the workpiece.
- The example of parts produced by machining processes includes hand tools machine tools instruments, automobile parts, nuts, bolts and gears etc. Lot of material is wasted as scrap in the secondary or machining process.
- **Some of the common secondary or machining processes are**
- (1) Turning, (2) Threading, (3) Knurling, (4) Milling, (5) Drilling, (6) Boring, (7) Planning, (8) Shaping, (9) Slotting, (10) Sawing,

(11) Broaching, (12) Hobbing, (13) Grinding, (14) Gear cutting, (15) Thread cutting and (16) Unconventional machining processes namely machining with Numerical Control (NC) machines tools or Computer Numerical Control (CNC) machines tools using ECM, LBM, AJM, USM setups etc.

3. Metal Forming Processes Forming processes encompasses a wide variety of techniques, which make use of suitable force, pressure or stresses, like compression, tension and shear or their combination to cause a permanent deformation of the raw material to impart required shape. These processes are also known as mechanical working processes and are mainly classified into two major categories i.e., hot working processes and cold working processes.

In these processes, no material is removed; however it is deformed and displaced using suitable stresses like compression, tension, and shear or combined stresses to cause plastic deformation of the materials to produce required shapes. Such processes lead to production of directly usable articles which include kitchen utensils, rods, wires, rails, cold drink bottle caps, collapsible tubes etc. Some of the important metals forming processes are:

Some of the important metals forming processes are:

Hot working Processes (1) Forging,

(2) Rolling, (3) Hot spinning, (4) Extrusion, (5) Hot drawing and (6) Hot spinning.

Cold working processes (1) Cold forging,

(2) Cold rolling, (3) Cold heading, (4) Cold drawing, (5) Wire drawing, (6) Stretch forming, (7) Sheet metal working processes

such as piercing, punching, lancing, notching, coining, squeezing, deep drawing, bending etc.

4. Joining Processes

- These processes are used for assembling metal parts and in general fabrication work. Such requirements usually occur when several pieces are to be joined together to fabricate a desired structure of products.
- These processes are used developing steam or water-tight joints. Temporary, semi permanent or permanent type of fastening to make a good joint is generally created by these processes.
- Temporary joining of component scan be achieved by use of nuts, screws and bolts. Adhesives are also used to make temporary joints. Some of the important and common joining processes are: (1) Welding (plastic or fusion), (2) Brazing, (3) Soldering, (4) Riveting, (5) Screwing, (6) Press fitting, (7) Sintering, (8) Adhesive bonding, (9) Shrink fitting, (10) Explosive welding, (11) Diffusion welding, (12) Keys and cotters joints, (13) Coupling and (14) Nut and bolt joints.
- **5. Surface Finishing Processes**
- Surface finishing processes are utilized for imparting intended surface finish on the surface of a job.
- By imparting a surface finishing process, dimension of part is not changed functionally; either a very negligible amount of material is removed from the certain material is added to the surface of the job.
- These processes should not be misunderstood as metal removing processes in any case as they are primarily intended

to provide a good surface finish or a decorative or protective coating on to the metal surface.

- Surface cleaning process also called as a surface finishing process.
- **Some of the commonly used surface finishing processes are**:
- (1) Honing, (2) Lapping, (3) Super finishing, (4) Belt grinding, (5) Polishing, (6) Tumbling, (7) Organic finishes, (8) Sanding, (9) deburring, (10) Electroplating, (11) Buffing, (12) Metal spraying, (13) Painting, (14) Inorganic coating, (15) Anodizing, (16) Sheradising, (17) Parkerizing, (18) Galvanizing, (19) Plastic coating, (20) Metallic coating, (21) Anodizing and (22) Sand blasting.
- **6. Processes Effecting Change in Properties**
- Processes effecting change in properties are generally employed to provide certain specific properties to the metal work pieces for making them suitable for particular operations or use.
- Some important material properties like hardening, softening and grain refinement are needed to jobs and hence are imparted by heat treatment. Heat treatments affect the physical properties and also make a marked change in the internal structure of the metal
- Similarly the metal forming processes effect on the physical properties of work pieces similarly shot peening process, imparts fatigue resistance to work pieces.
- **A few such commonly used processes are given as under:**
- (1) Annealing, (2) Normalising, (3) Hardening,
- (4) Case hardening, (5) Flame hardening, (6) Tempering, (7) Shot peeing, (8) Grain refining and (9) Age hardening. In addition, some allied manufacturing activities are also required to produce the finished product such as measurement and assembly.

Introductionto casting

- Casting or founding is the process of producing metal or alloy component parts.
- The parts of desired shapes are produced by pouring the molten metal or alloy into a prepared mould and then allowing the metal or alloy to cool and solidify.
- This solidified piece of metal or alloy is called as casting.

Steps Involved in Making a Casting Following are the steps to be followed while making a sand casting:

1. Pattern making: Make the pattern of wood, metal or plastic.
2. Sand mixing and preparation: Select particular sand, test it and prepare the necessary sand mixtures for mould and core making.
3. Core making: With the help of patterns prepare the mould and required cores.
4. Melting: Melt the metal or alloy to be cast.
5. Pouring: Pour the molten metal or alloy into the mould and remove the casting from the mould after solidification of metal.
6. Finishing: Clean and finish the casting.
7. Testing: Test and inspect the casting and remove the defects, if any.
8. Heat treatment: Relieve the casting stresses by using various heat treatments.
9. Re-testing: Again inspect the casting and deliver it.

Advantages of Metal Casting :

- Casting is one of the most versatile manufacturing processes.
- It provides the greatest freedom of design in terms of shape, size and quality of product.
- Casting provides uniform directional properties and better vibration damping capacity to the cast components.

- Complex and uneconomical shapes which are difficult to produce by other processes can be easily produced by casting process.
- A product obtained by casting is one piece; hence there is no need of metal joining processes.
- Very heavy and bulky parts which are difficult to get fabricated, may be cast.
- It also produces machinable parts.
- Casting process can be mechanized and generally used for mass production of components.

Applications of Metal Casting :

A few applications of casting or cast components are given below :

- Transportation vehicles (in automobile engine and tractors)
- Machine tool structures
- Turbine vanes and power generators
- Mill housing
- Pump filter and valve
- Railway crossings and aircraft jet engine blades Agricultural parts and sanitary fittings
- Construction, communication and atomic energy applications, etc.

Pattern Making

- A pattern is a mould forming tool in the hands of foundry men.
- A pattern is defined as a model or replica of the object to be cast.
- A pattern exactly resembles the casting to be made except for the various allowances.
- If one object has to be cast, then also pattern is required.

- It is a model or form around which sand is packed to give rise to a cavity called as mould cavity; in which molten metal is poured and the casting is produced.

The ways in which a pattern differ from a casting are as follows :

- A pattern is slightly larger than the casting because a pattern carries allowance to compensate. For metal shrinkage.
- Also, pattern carries allowances for machining so as to clean and finish the required surfaces.
- Pattern also has the necessary draft for its easy removal from the sand mass.
- It carries additional projections, called as core prints, to produce seats for the cores.
- A pattern may not have holes and slots which a casting will have. Such holes and slots make a pattern complicated, hence can be drilled in the casting after it has been made.
- The material from which casting and pattern is made, is also different.

Functions of a Pattern

The main functions of a pattern are as follows :

- To prepare a mould cavity of appropriate shape and size for the purpose of making a casting.
- To produce seats for the cores in the mould in which cores can be placed, for producing cavity in the casting. Such seats in the mould are called as core prints.
- To establish the parting line and parting surfaces in the mould.
- To minimize casting defects.
- To help for positioning of a core before the moulding sand is rammed.
- It should minimize the overall casting cost.

Types of Patterns

The type of pattern to be used for a particular casting will depend on following factors :

- Quantity of casting to be produced
- Size and shape of the casting
- Type of moulding method

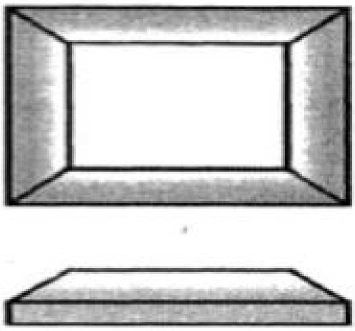
Design of casting.

The various types of patterns which are commonly used are as follows :

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

1. **Single piece or solid pattern**:

– It is the simplest of all the patterns and it is made in one-piece and does not carry loose pieces or joints.



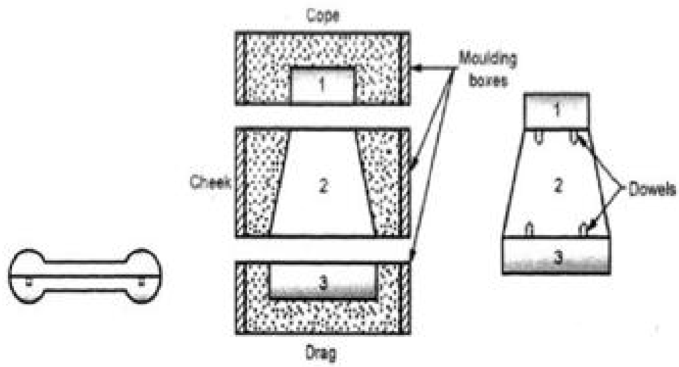
ɿ. 2.2: Single piece pattern

Single piece or solid pattern:

- It is generally used for making large sized simple casting.
- It is less expensive as compared to other types of pattern.
- Depending upon the quantity of the casting to be produced, it is usually made up of wood or metal.
- For making the mould, single piece pattern is used either in the cope or in the drag.
- Stuffing box of steam engine can be cast by using single piece pattern.

2. Two piece or split pattern :

- Patterns of complicated shape castings cannot be made in one-piece because of the difficulties associated with the moulding operations.
- Such patterns are made in two pieces, called as split pattern or two piece pattern.



(a) Split pattern *(b) Three piece pattern and its moulding arrangement*

Fig. 2.3: Two piece pattern

- Its upper and lower parts are accommodated in the cope and drag portions of the mould, respectively.
- For keeping the alignment between the two parts of the pattern, dowel pins are used. Patterns of more complicated casting are made in more than two pieces for their easy removal and they have three piece flasks for the moulding purpose.
- Casting of taps and water stop cocks are produced by using split patterns

. Loose piece pattern :

- Some patterns embedded in the moulding sand cannot be withdrawn, hence such patterns are made with one or more loose pieces for their easy removal from the moulding box.
- These patterns are known as loose piece patterns.

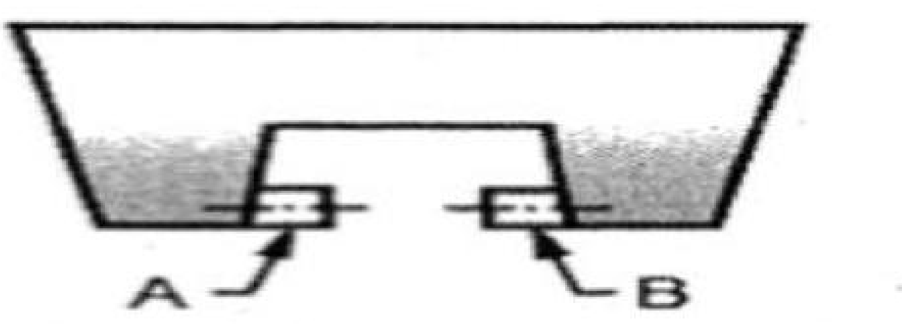


Fig. 2.4: Loose piece pattern

Loose pieces like A and B as shown in Fig. 2.4 remain attached with the main body by using dowel pins.

– These patterns consume more time for moulding operation and require more labour work.

4. Cope and Drag pattern :

- It is another form of split pattern.
- The pattern is split about a suitable surface or line.
- Each half of the pattern is fixed to a separate plate and besides the pattern it has provision for moulding runner and gates.
- Each half of the pattern is moulded separately in a separate moulding box and then assembled for pouring.

These patterns are used for producing large casting

5. Gated pattern:

- To increase the strength and reduce the tendency to warp, gated patterns are generally made of metals.
- By using gated patterns number of casting can be made at a time, hence they are used in mass production system.
- The sections connecting various patterns serve as a runner and gates. Refer Fig. 2.5.

5. Gated pattern:

- This facilitates filling of the mould with molten metal in better manner and reduces the required time and labour work.
- These patterns are used for producing small castings.

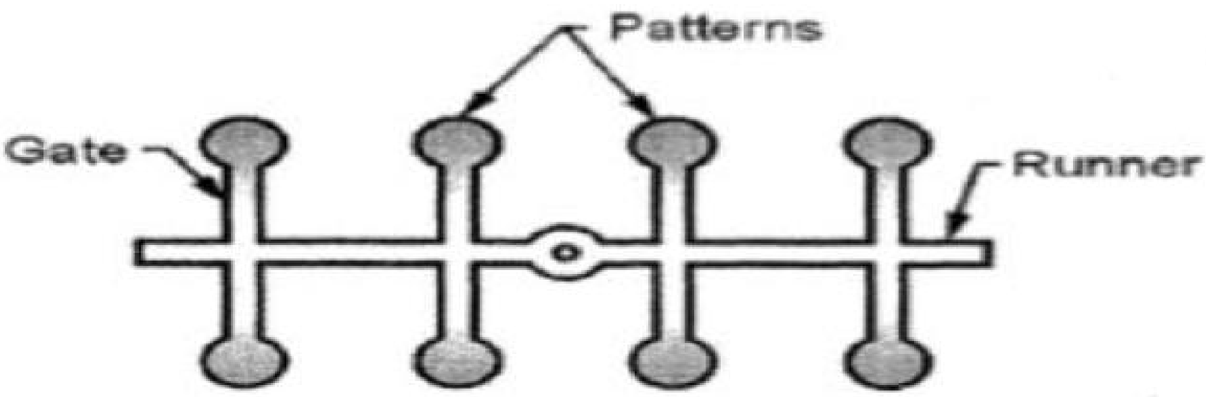


Fig. 2.5: Gated pattern

5. Gated pattern:

- This facilitates filling of the mould with molten metal in better manner and reduces the required time and labour work.
- These patterns are used for producing small castings.

6. Match plate pattern :

- These patterns are made in two pieces i.e. one piece mounted on one side and the other on the other side of the plate, called as match plate.
- The plate may carry one pattern or group of patterns mounted in the same way on its two sides. Refer Fig. 2.6.

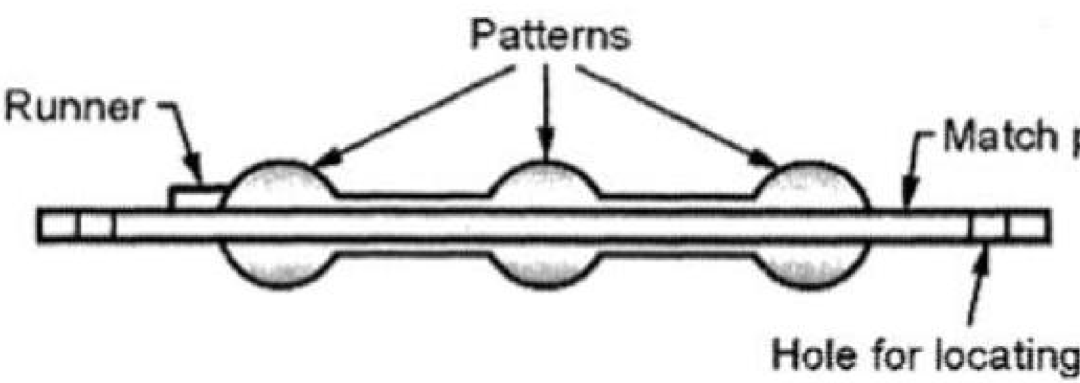


Fig. 2.6: Match plate pattern

- The plate can be of wood, aluminum, magnesium or steel.
- The match plate has runner and gates attached with it.
- Match plate patterns are generally used in machine moulding because they produce accurate casting at faster rates.

- Piston rings of I. C. engines are made by using these patterns.

7. Sweep pattern :

- Sweep pattern is just a form made on a wooden board which sweeps the casting shape into the sand all around the circumference.
- The equipment consists of a base, placed in the sand, vertical spindle and a wooden template called as sweep.
- The sweep is rotated about the spindle or post, to form the cavity as shown in Fig. 2.7.
- Once the mould is ready, sweep pattern and post can be removed

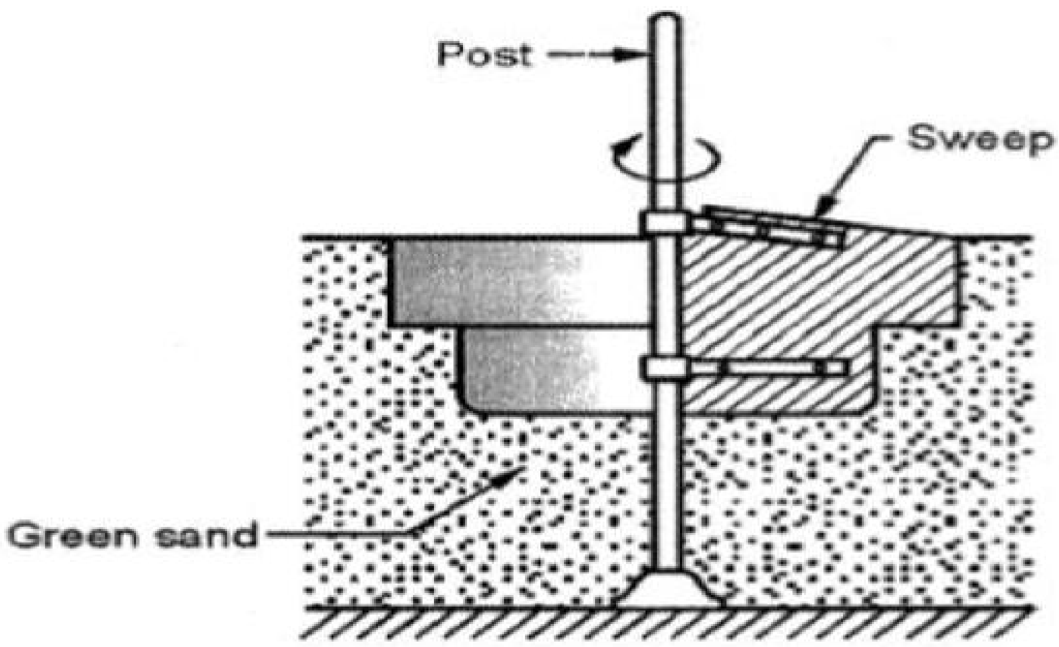


Fig. 2.7: Sweep pattern

- It saves lot of time and labour work as compared to making a full pattern. Sweep patterns are used for making large casting of circular sections and symmetrical shape; for example, large kettles of cast iron.

Skeleton pattern :

- – When the casting size is very large, but easy to shape and few are to be made, then it is not economical to make a large solid pattern of that size.
- – In such cases, a pattern consisting of a wooden frame and strips is made which is called as skeleton pattern.

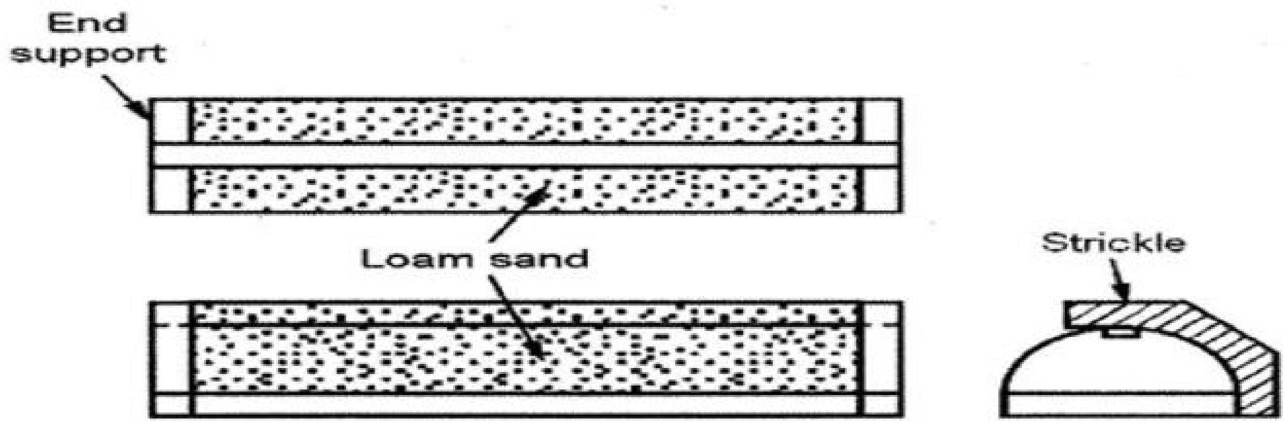


Fig. 2.8: Skeleton pattern

- It is filled with loam sand and rammed.
- A strickle is used for giving the desired shape to the sand and for removing the extra sand.
- Fig. 2.8 shows the skeleton pattern for a hollow pipe.
- Skeleton patterns are used for producing large casting like turbine casing, water pipes, L-bends, etc.

9. Segmental pattern :

- The working principle of segmental pattern is similar to sweep pattern.
- The main difference between them is that, a sweep is given a continuous revolving motion to generate the required shape, whereas a segmental pattern is a portion of the solid pattern itself and the mould is prepared in parts by it.
- It is mounted on a central pivot and it completes one portion of the mould and then moves to the next portion. Refer Fig. 2.9.

- These patterns are used for producing large circular casting like big gears, wheel rims, etc.

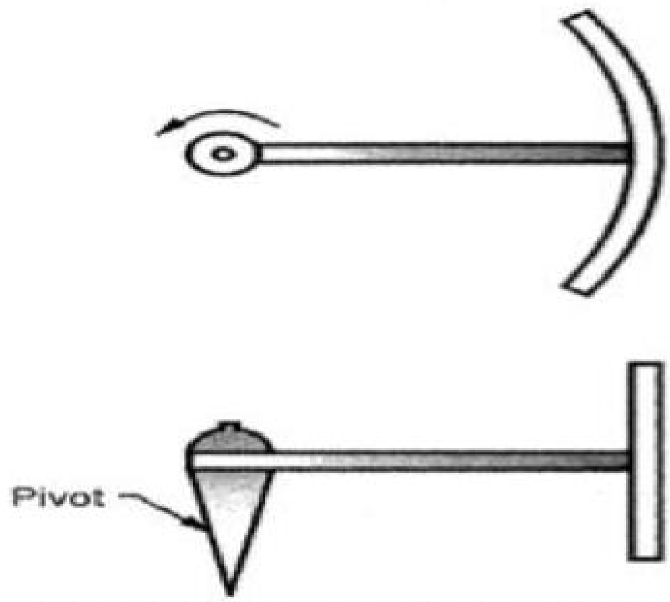


Fig. 2.9: Segmental pattern

10. Follow board pattern :

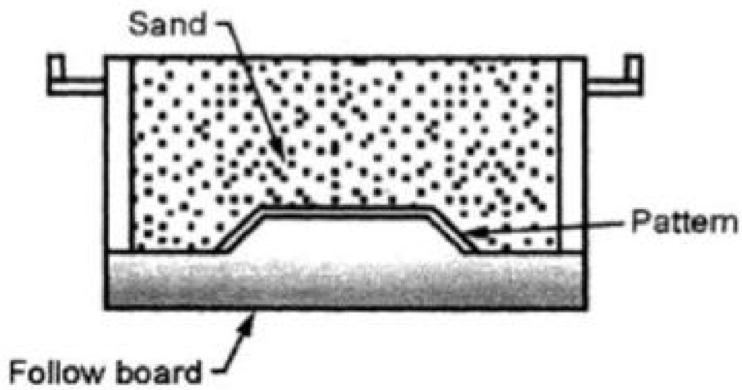


Fig. 2.10: Follow board pattern

Follow board pattern :

- A follow board is a wooden board and is used for supporting a pattern which is very thin and fragile.
- With the help of follow board support under the weak pattern, the drag is rammed and then the follow board is removed. Refer Fig. 2.1 0.
- A follow board also forms the natural parting line of the mould or the casting.
- Follow board patterns are used for casting master patterns for many applications

11. Lagged-up pattern

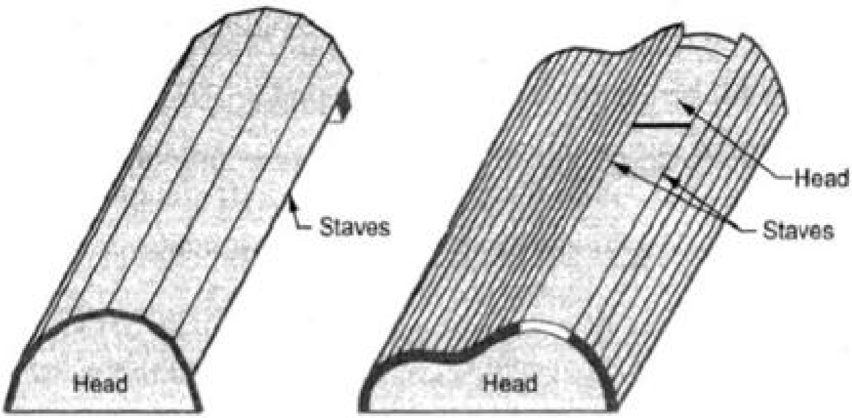


Fig. 2.11: Lagged-up pattern

- Cylindrical work pieces such as cylinders, pipes or columns are built up with lag (stave) construction.
- Lags (staves) are longitudinal strips of wood which are bevelled on each side to make the joint tight from outside and glued or screwed to the end pieces of wood called as heads. Refer Fig. 2.11.
- Such construction gives the maximum amount of strength to the pattern.

Selection of materials for pattern

The following factors should be considered while selecting proper material for pattern :

- The number of casting to be made; metal patterns are preferred for large quantity of production.
- Degree of accuracy in dimensions and the quality of surface finish required on the casting.
- Method of moulding to be used i.e. hand or machine.
- Type of casting method to be used i.e. sand casting, investment casting, etc.

- Shape, size and complexity of the casting.
- Casting design parameters.

Type of moulding material to be used.

Materials for Making Patterns

The common materials of which the patterns are made are as follows :

1)Wood

2)Metal

3)Plastic

4)Plaster

5)Wax

1.Wood:

- It is the most common material for making patterns for sand casting because of following advantages :**Advantages:**
- It is cheap and easily available in large quantities.
- It can be easily shaped and machined to different configurations and forms.
- Good surface finish can be easily obtained.

- Due to lightness in weight its manipulation is easy and it can also be repaired easily.

Limitations:

- Wooden patterns are weak as compared to metal patterns.
- They cannot withstand rough handling.
- They possess poor wear resistance and hence they are abraded easily by sand action.
- They absorb moisture, hence get warped and change the shape and size.

Applications:

- Wooden patterns are mostly used where number of casting to be made is small and the size of pattern is large.

The common woods used in pattern making are :

a. White pine

b. Mahogany

c. Maple

d. Cherry

e. Teak

f. Shisham

2. Metals: Metal patterns are cast from wooden patterns.

Advantages:

- They do not absorb moisture.
- They are stronger and accurate, hence more life as compared to wooden patterns.

- They have greater resistance to abrasion and wear.
- They can withstand rough handling.

Limitations:

- As compared to wooden patterns they are more expensive.
- They are heavier than wooden patterns.
- Ferrous material patterns get rusted.

They cannot be repaired easily.

2. Metals: Metal patterns are cast from wooden patterns.

Applications:

− Metal patterns are used where large numbers of castings have to be produced from the same patter.

The various metals and alloys employed for making patterns are :

a.Aluminium and its alloys

b. Steel

c. Brass

d. Cast iron

e. White metal

3. Plastic:

Plastic is now a days considered as a pattern material due to their following advantages :

Advantages:

- Light weight and high strength.
- Resistance to wear and corrosion.
- Provides good surface finish.

- They are easy to make and less costly also.

Limitations:

- Plastic patterns are fragile; hence light sections may need metal reinforcements.
- They may not work well when subjected to conditions of severe shock.

4. Plaster:

Plaster of Paris or gypsum cement is used as a patterns material because of following advantages :

Advantages:

- Complicated shapes can be cast without any difficulty.
- It can be easily worked with the help of wood working tools.
- It has high compressive strength.
- Unlike metals it expands while solidifying.

Applications:

- Plaster is used for making small and intricate patterns and core boxes.

5. Wax:

Advantages:

- They provide good surface finish.
- After being moulded, the wax pattern is not taken out; rather the mould is inverted and heated and the molten wax comes out or gets evaporated, hence there is no chance of the mould cavity getting damaged while removing the pattern.
- Also, they provide high accuracy to the castings. **Applications:**

Wax patterns are exclusively used in investment casting process.

Pattern Allowances

- A pattern is always made larger than the final casting, because it carries certain allowances due to metallurgical and mechanical reasons.
- The following allowances are provided on the pattern :

a. Shrinkage or contraction allowance
b. Machining allowance
c. Draft or taper allowance
d. Distortion allowance
e. Raping or shake allowance

a. **Shrinkage or contraction allowance:** – Almost all the metals used in the casting work shrink or contract during cooling from pouring temperature to room temperature.

– This contraction takes place in three forms i.e.

Liquid contraction

Solidifying contraction

Solid contraction

- To compensate liquid and solidifying contraction, gates and risers are provided in the mould, whereas for solid contraction adequate allowances are provided on the pattern.
- The different metals shrink at different rates because shrinkage is the metal property, hence corresponding allowances are also different.

The shrinkage of metal depends on the following factors :

– The metal to be cast

– Pouring temperature of the molten metal

– Dimensions of the casting

– Method of moulding

Shrinkage allowance for different cast metals is given in the following Table 2.1 :

Table 2.1: Shrinkage allowance for different metals

Metal	Grey cast iron	Steel	Aluminium	Bronze	Brass	Magnesium
Allowance mm/meter	6.95 to 10.4	20.8	16.5	10.5 to 21	15.4	16.5

Machining allowance:

The amount of machining allowance depends upon following factors :

o Metal of casting

o Machining method used

o Casting method used

o Shape and size of the casting

o Amount of finish required on the machined portion

– Ferrous metal needs more allowance than the non-ferrous metals. and similarly, large castings need more allowance than small castings.

– Machining allowance varies from 1.5 mm to 16 mm, but 3 mm allowance is more common for small and medium castings.

- Machining allowance or finish allowance is the amount of dimension on a casting which is made oversized to provide stock for machining.
- A casting may require machining all over or on certain specified portions.
- Such portions or surfaces on the pattern are given adequate allowance in addition to the shrinkage allowance.

The amount of machining allowance depends upon following factors :

o Metal of casting

o Machining method used

o Casting method used

Draft allowance:

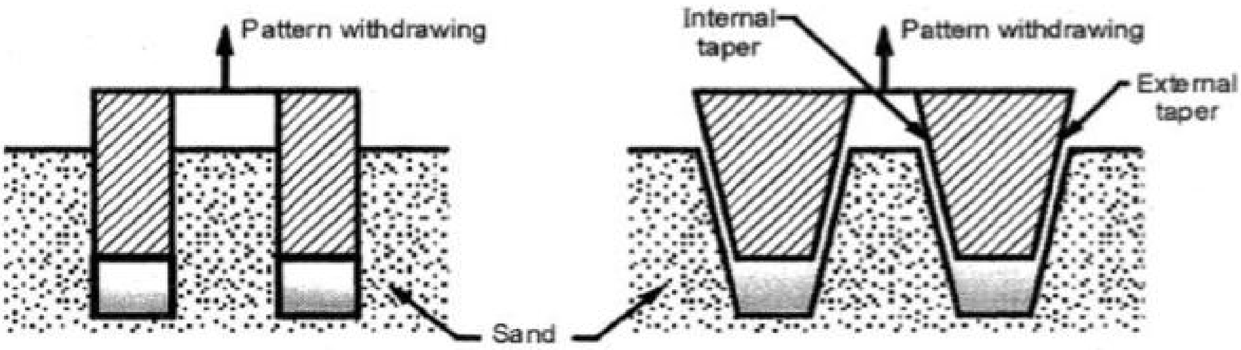
- Draft allowance or taper allowance is given to all vertical faces of a pattern for their easy removal from sand without damaging the mould.
- This slight taper inward or outward on the vertical faces is known as draft.
- It can be expressed either in degrees or in mm/meter.
- Generally, it is more on internal surfaces as compared to external surfaces

The amount of draft allowance depends on following factors :

o Shape and size (height) of the pattern

o Method of moulding

o Material of moulding.



(a) Pattern without allowance (b) Pattern with allowance

Fig.2. 1: Taper or draft allowance

The amount of draft allowance depends on following factors

- This allowance varies from 10 mm to 25 mm per meter. on external surfaces and 40 mm to 65 mm per meter on internal surfaces.
- Fig. 2.1 shows two patterns i.e. one without taper allowance and other with taper allowance
- It can be seen that, it is easy to withdraw the pattern having taper allowance out of the mould without damaging the mould cavity.

Distortion allowance (Camber allowance):

- The tendency of distortion is not common in all the castings.
- The casting will distort or warp if :

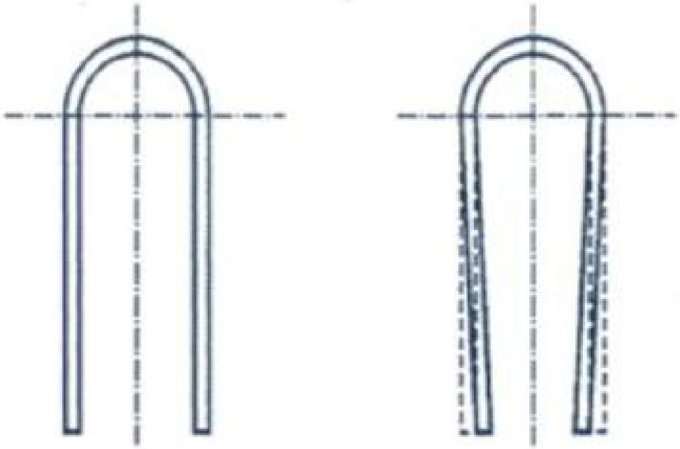
o It is of irregular shape.

o It is of or V-shape.

o The arms having unequal thickness.

o One portion of the casting cools at a faster rate than the other To eliminate this defect, an opposite distortion is provided on the pattern, so that the effect is balanced and correct shape of the casting is produced.

− The amount of distortion allowance varies from 2 mm to 20 mm as per the size, shape and casting material.



Refer Fig. 2.1 (c).. *Fig. 2.1 (c): Distortion or camber allowance*

Rapping or Shake allowance:

- When a pattern is to be taken out from the mould, it is first rapped or shaken by striking it with a wooden piece from side to side.
- This is done so that the pattern surface becomes free from adjoining sand of the mould.
- Due to this, there is little increase in the size of the mould cavity.
- For this purpose, a negative allowance is provided on the pattern i.e. the dimensions are kept smaller.
- It is normally provided only to the large castings and negligible for small and medium sized castings.

Core

- Core is a sand shape or form which makes the contour of a casting for which no provision has been made in the pattern for moulding.
- Core may be made up of sand, plaster, metal or ceramics.
- Core is an obstruction which when positioned in the mould, does not permit the molten poured metal to fill the space occupied by the core hence produce hollow casting.

- Cores are used as inserts in moulds to form design features which are difficult to be produced by simple moulding.

Functions of core :

- Core provides a means of forming the main internal cavity for hollow casting.
- Core provides external undercut feature.
- Cores can be inserted to obtain deep recesses in the casting.
- Cores can be used to increase the strength of the mould.
- It can be used as a part of gating assembly.
- It can form a part of green sand mould and can also be used to improve the mould surface

Essential characteristics of core:

A dry sand core must possess following properties :

- It should have sufficient strength to support itself without breaking.
- It should have high permeability and high refractoriness.
- It should have smooth surface to ensure a smooth casting.
- It should have high collapsibility, to assist the free contraction of the solidifying metal.
- It should have those ingredients which does not generate mould gases.

Core Applications

- Core and its form increase the versatility of moulding processes and operations.

- **In addition to recess forming and holes in the casting, cores are used as follows :**
- o Cores are used for mould making.
- o Cores can be used as strainer, gates and pouring cups.
- o Cores are used for increasing production from match plate pattern.
- o Cores can be used as core mould in centrifugal casting process.
- o Also it can be used as slab core for increasing castings output from one mould.

Types of Cores

Various types of cores of different designs and sizes are used in different ways in foundry work.

A general way of classifying them is, according to their shapes and positions in the prepared moulds.

Their main types are as follows:

1. Horizontal core

2. Vertical core

3.Hanging core

4. Balanced core

5. Ram up core

6. Kiss core

7. Drop core

1. **Horizontal core**

- A horizontal core is positioned horizontally in the mould. Refer Fig. 2.16.
- According to the shape of the cavity required in the casting, a horizontal core may have any shape.
- Uniformly sectioned horizontal cores are mostly placed at parting line.

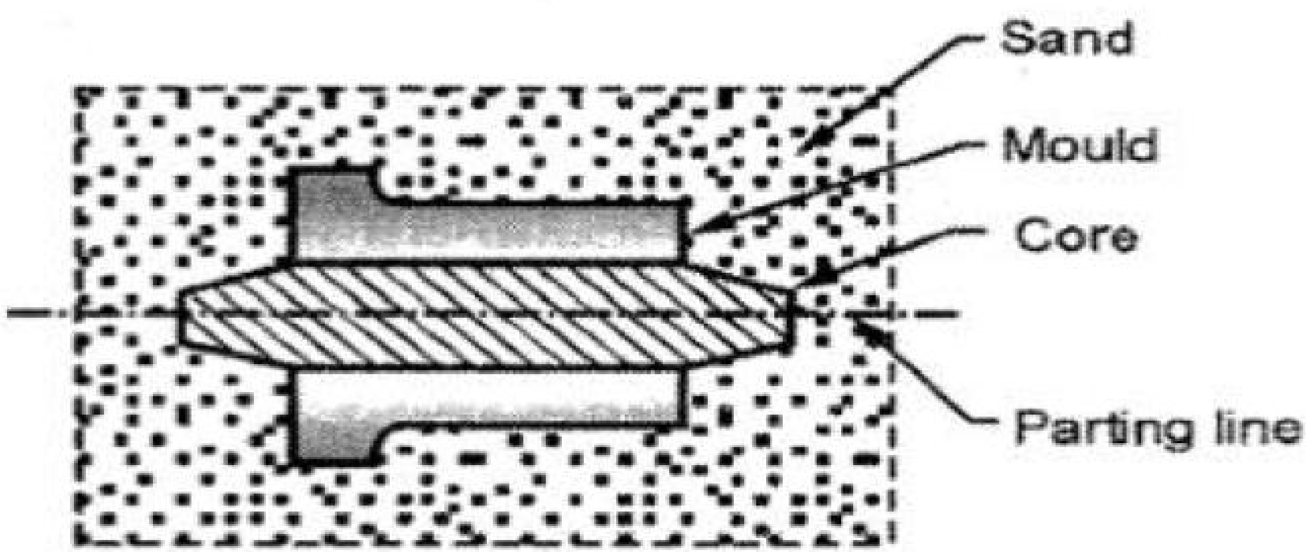


Fig. 2.16: Horizontal core

2. Vertical core

- Itis similar to horizontal core, except that it is fitted in the mould with its axis vertical. Refer Fig. 2.17.
- The top end of the core is provided with more amount of taper, to have a smooth fitting of the cope on the core.
- A major portion of the vertical core generally remains in the drag.

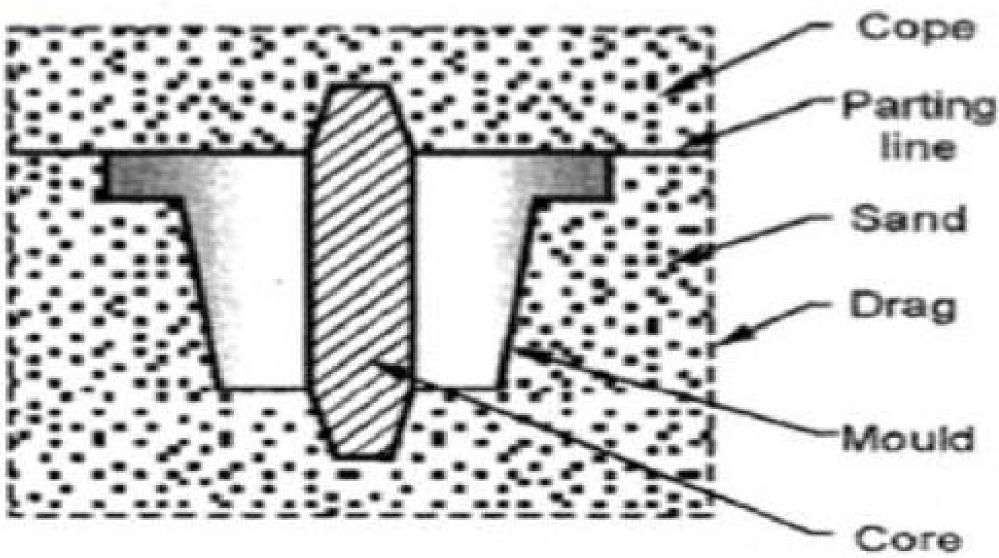


Fig. 2.17: Vertical core

3.Hanging core :

- Hanging core is also called as cover core as shown in Fig. 2.18.
- It is supported from above and it hangs vertically in the mould cavity.
- It has no support from the bottom.
- They are provided with a hole through which molten metal reaches the mould cavity.

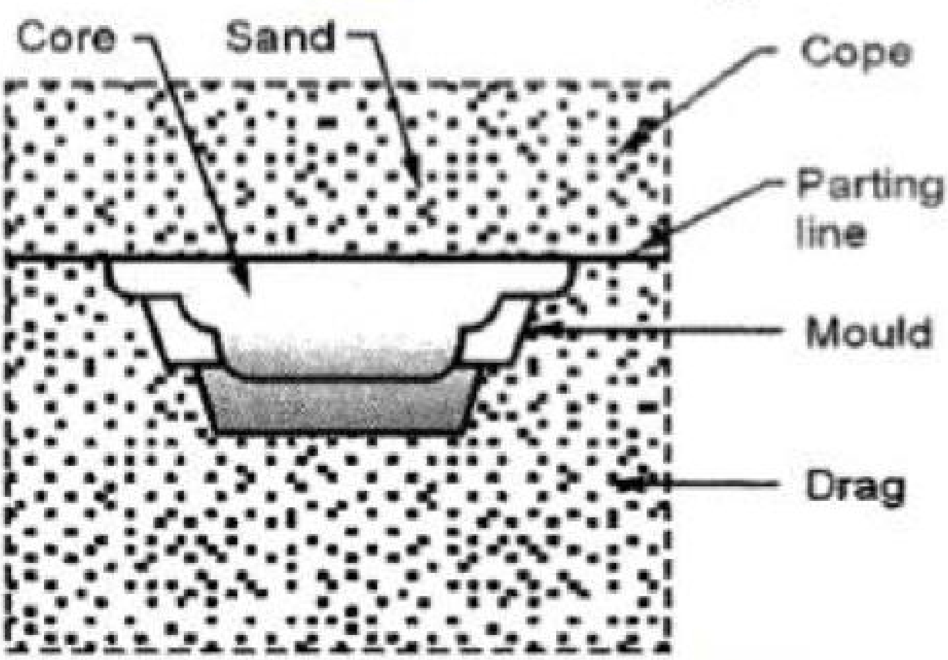


Fig. 2.18: Hanging or cover core

4. Balanced core :

- Balanced core is supported and balanced from its one end only.
- It requires long core seat, so that the core does not fall into the mould cavity. Refer Fig. 2.19.
- It may be supported on chaplets.

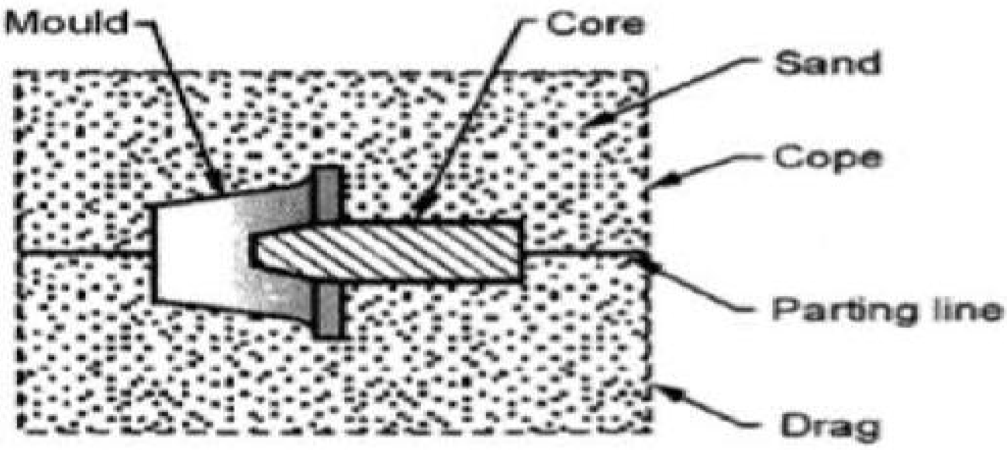


Fig. 2.19: Balanced core

5. Ram up core :

- Ram up core is placed in the sand along with pattern before ramming the mould. Refer Fig. 2.20.
- It is used to make internal or external details of a casting.

It cannot be placed in the mould after the mould has been rammed.

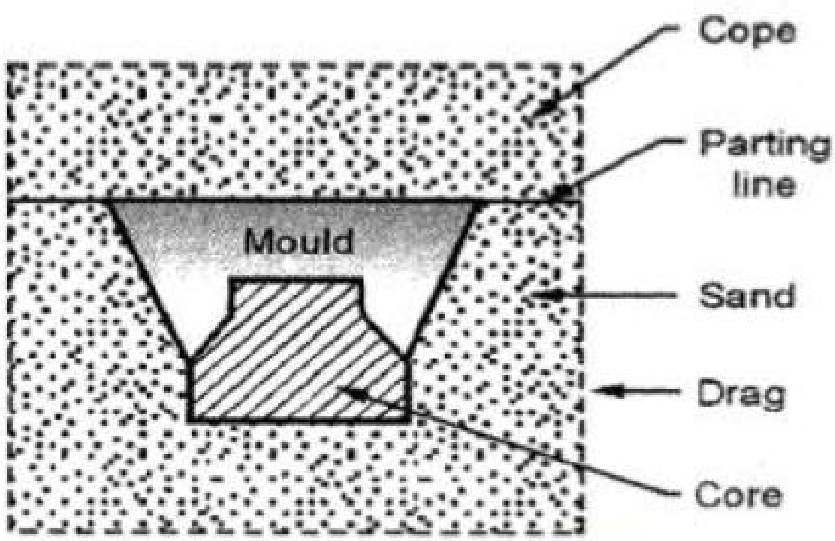


Fig. 2.20: Ram-up core

6.Kiss core:

- It does not require core seats for getting support.
- It is held in position between drag and cope due to the pressure exerted by core on the drag
- To obtain a number of holes in a casting, a number of kiss cores can be simultaneously positioned. Refer Fig. 2.21.

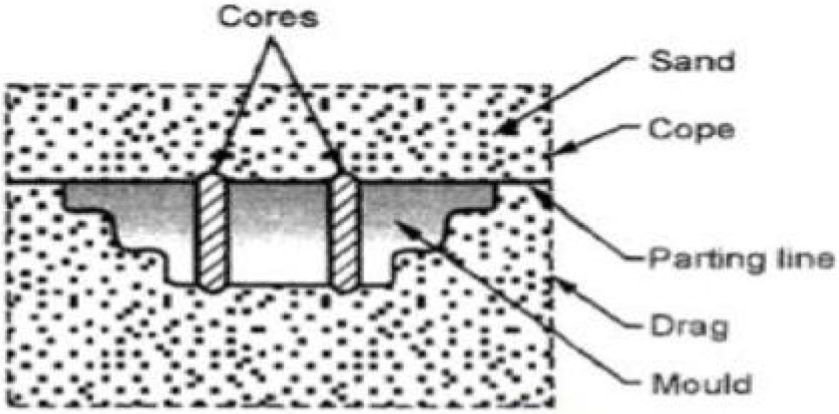


Fig. 2.21: Kiss core

7.Drop core:

- Drop core is also called as stop off core.
- It is used to make a cavity which cannot be made with other types of cores. Refer Fig. 2.22.
- It is used when a hole recess or cavity required in a casting is not in line with parting surface

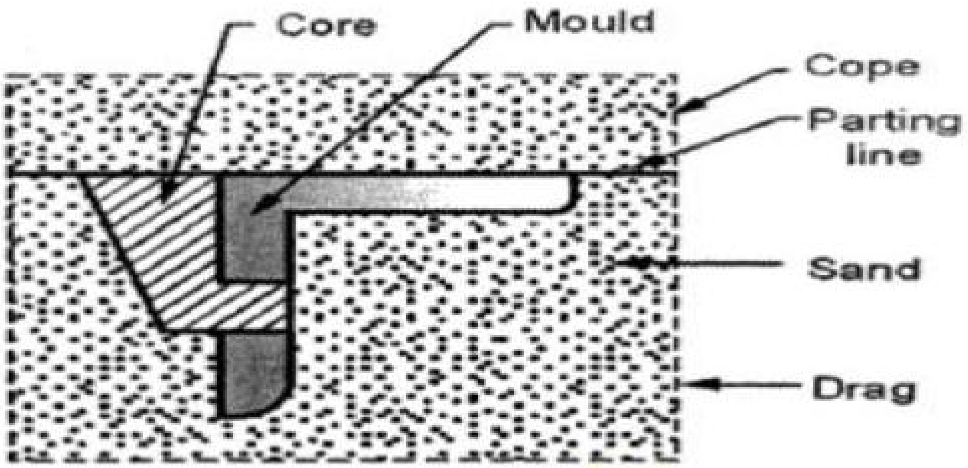


Fig. 2.22: Drop core

Core Boxes

- Basically, core box is a pattern for making cores.
- They are employed for ramming cores in them.
- Core boxes provide the required shape to the core sand.

The commonly used types of core boxes are as follows:

1.Half core box

2.Dump core box

3.Split core box

4. Strickle core box

5. Gang core box:

6. Loose piece core box

7. Left and right hand core boxes

.Half core box :

- Half core box is shown in Fig. 2.23 which can make cylindrical cores.
- At one time, half portion of the core is made in the core box.
- After producing number of half core portions, they are cemented together to make full cylindrical cores.

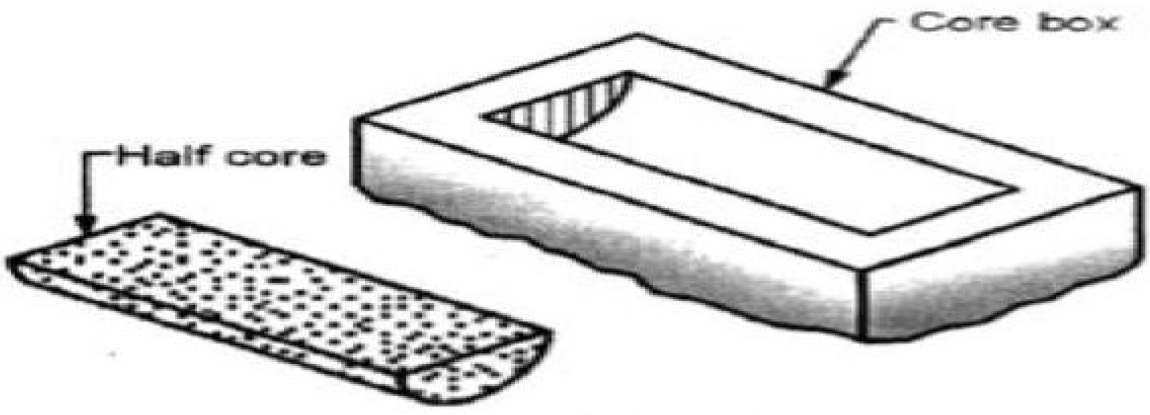


Fig. 2.23: Half core box

2.Dump core box :

- It is also called as slab core box
- It is similar to half core box in its construction but, it makes full core at a time, hence used to produce rectangular, square or trapezoidal cores. Refer Fig. 2.24.

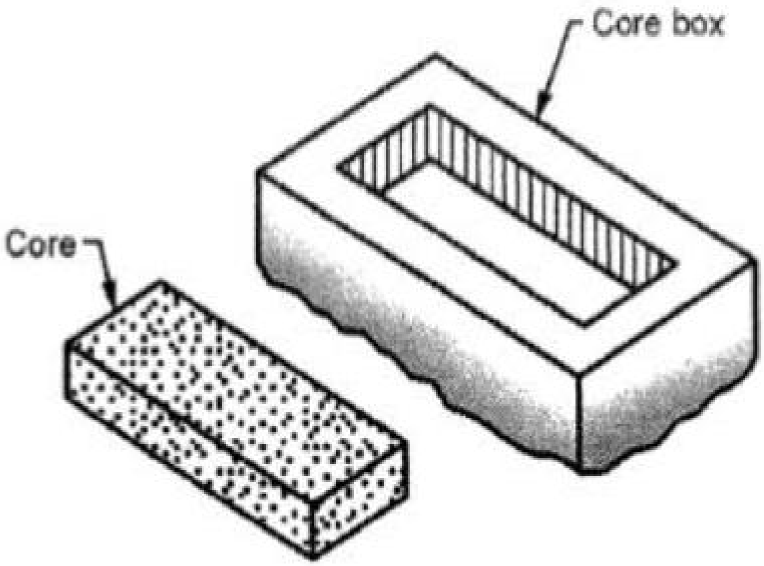


Fig. 2.24: Dump core box

3.Split core box :

- This type of core box moulds the entire core, but to remove the core after moulding, the box is separated in two or more parts. Refer Fig. 2.25.
- Two portions of the split core box can be aligned temporarily with the help of dowels.
- For making the core, two portions of the split core box are joined and then sand is rammed.

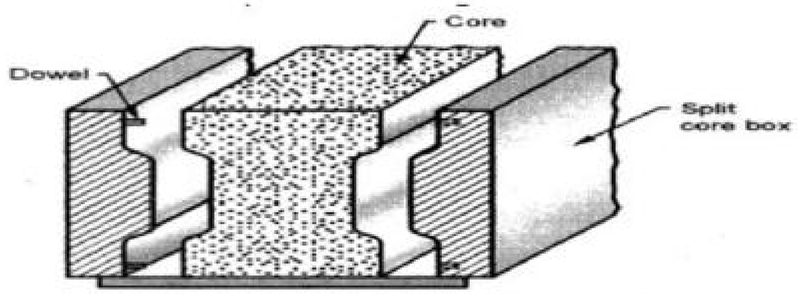


Fig. 2.25: Split core box and rammed core

4.Strickle core box :

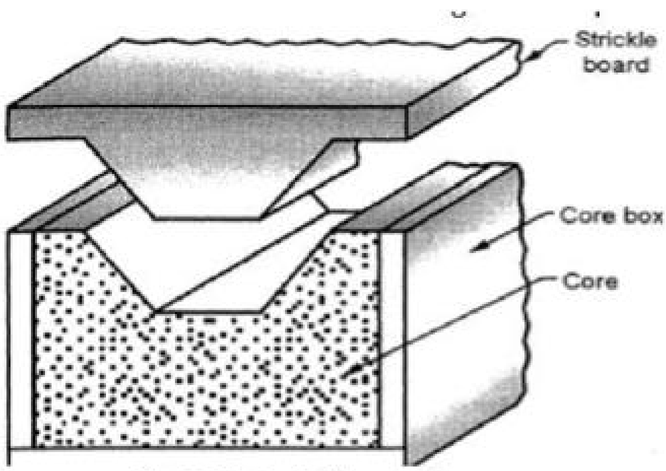


Fig. 2.26: Strickle core boxes

- Sand is rammed in the dump core box.
- The top surface of the core in the core box is given a required shape by using trickle board cut and finished to the desired shape.
- A strickle board strikes off excess sand not confirming to its shape.
- A strickle board is made up of wood and in any shape, as per the requirement. Refer Fig. 2.26.
- This me7thod of producing cores is less costly as compared to others.

5. Gang core box:

- Gang core box contains a number of cavities, so that more than one core can be rammed at a time. Refer Fig. 2.27.

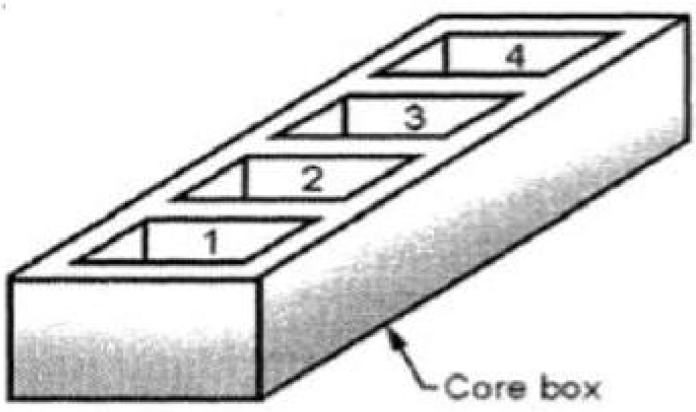


Fig. 2.27: Gang core box

6. Loose piece core box :

- It is similar to half core box.
- But loose piece core box can produce two halves of a core, which may be neither identical in size nor in shape.
- It is achieved by inserting loose wooden pieces in the core whenever required. Refer Fig. 2.28.

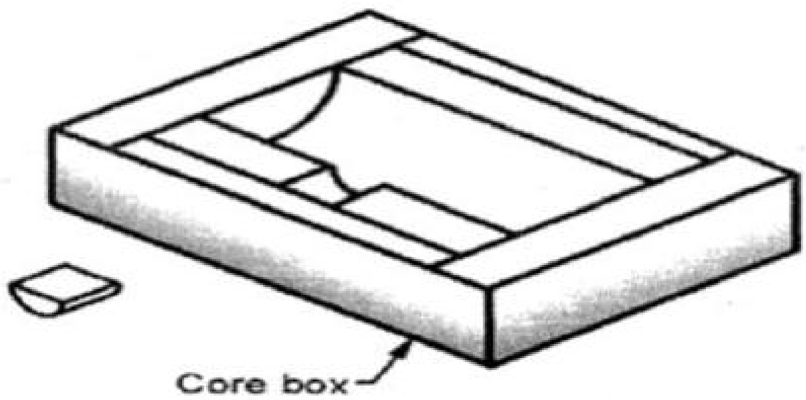


Fig. 2.28: Loose piece core box

7. Left and right hand core boxes :

- These core boxes are used to make cores for producing pipe bends.
- Half of the pipe bend core is made in each core box.
- Two halves of pipe bends are then rammed, baked and joint together to form a full core. Refer Fig. 2.29.

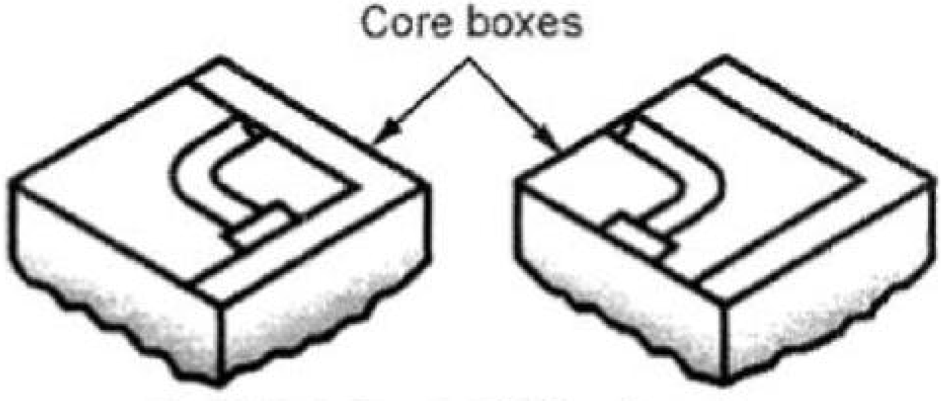


Fig. 2.29: Left and right hand core boxes

Core Prints

- Core prints are basically extra projections provided on the pattern.
- They form core seats in the mould when pattern is embedded in the sand for mould making.
- Core seats are provided to support all the types of cores.
- Though the core prints are the part of pattern, they do not appear on the cast part.
- Fig. 2.30 shows a core positioned in the core seat made by the core print provided on the pattern.

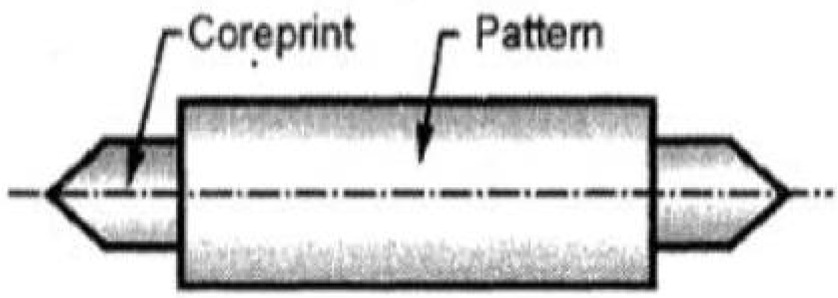


Fig. 2.30: Core print

Core prints are of the following types:

- Horizontal core print
- Vertical core print
- Cover core print
- Wing core print
- Balance core print

Gating System

- Gating is the term applied to the method of forming channels in the sand through which the molten metal travels from the sprue hole to the mould and out of the mould to the riser.

- Gating system refers to all channels by means of which molten metal is delivered to the mould cavity.
- Since the way in which liquid metal enters the mould has a decided influence on the quality and soundness of a casting.
- The different passages for molten metal are carefully designed and produced.

The various components of gating system which is composed of

a. Pouring cups and basins

b. Sprue

c. Runner

d. Gates

e. Riser

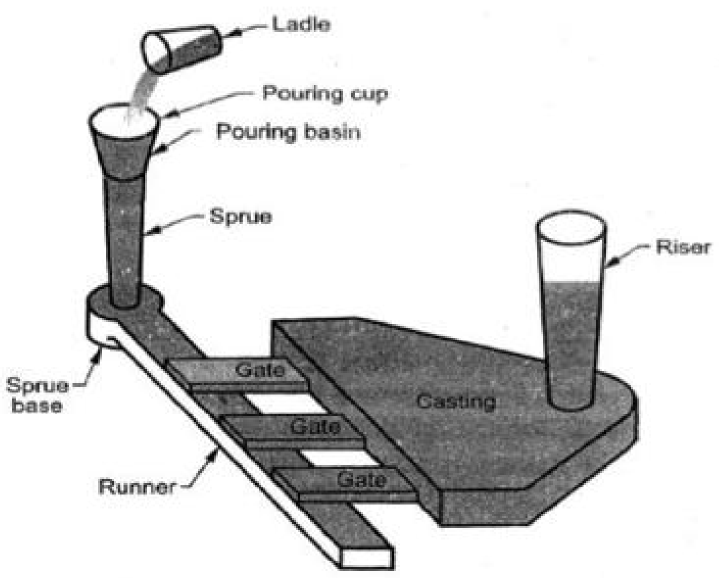


Fig. 2.34: Components of gating system

a. **Pouring cups and basins**

Pouringcup :

- A pouring cup is a funnel shaped cup which forms the top portion of the sprue.
- It makes easier for the ladle or crucible operator to direct the flow of metal from crucible to sprue.

Pouring basins:

- The molten metal is not directly poured into the mould cavity. It is poured into a pouring basin which acts as a reservoir from which it moves smoothly into the sprue.
- It prevents the slag from entering the mould cavity.
- It holds back the slag and dirt, which floats on the top and allows only the clean metal to enter into the sprue.
- The basin is cut in various shapes into the cope directly.

b.Sprue:

- Sprueis the channel through which the molten metal is brought into the parting plane where it enters the runner and gates.
- The sprue may be square or round and is generally tapered downwards, to avoid aspiration of air and metal damage.
- Sprues up to 20 mm diameter are round in section, whereas larger sprues are generally rectangular.

In a rectangular sprue, there is less turbulence.

c. Runner

- In large casting, molten metal is generally carried from the sprue base to several gates around the cavity through a passage called as runner.
- Depending upon the shape of the casting, the runner may be located in the cope or drag part.
- To avoid aspiration and turbulence, it should be streamlined.

d.Gates

- A gate is a channel which connects runner with the mould cavity, through which molten metal flows to fill the mould cavity.
- The location and size of the gates are so arranged that, they can feed liquid metal to the casting at a rate consistent with the rate of solidification.
- More than one gate is employed to feed a fast freezing casting.
- The gate should not have sharp edges as they may break during pouring and thus carried with the molten metal into the cavity.
- The gates should be located where they can be easily removed without damaging the casting.
- Ingate is the end of the gate where it joins the mould cavity and through which the molten metal will be introduced into the mould cavity.
- The leading edge of the molten metal flowing in a stream follows the path of least resistance and continues to build up kinetic energy. If a runner extension is used, the Kinetic energy may be absorbed hence causing a smoother flow of metal in the runners and into the mould cavity.
- Gate ratio is the ratio of sprue base area to the addition of total runner area and the total ingate area.
- Choke is that part of the gating system which has the smallest cross-sectional area. Its function is to control the flow rate of metal and to hold back slag, foreign particle, etc. And float these in the cope side of runner.

The major types of gates are as follows :

a.Parting line gates

b. Bottom gates

c. Top gates

d. Side gates

a. **Parting line gates :**

- These gates enter the mould cavity along the parting line separating the cope and drag portions of the mould. Refer Fig. 2.35.
- These gates are the simplest in nature and construction.
- Such gates are commonly used and are found to give satisfactory service except when the mould is very deep.

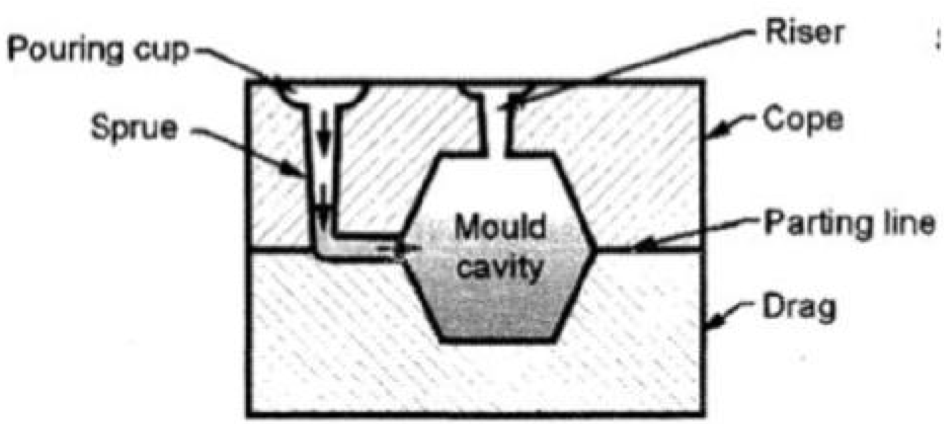


Fig. 2.35: Parting line gate

b. Top gates:

- Top gate is also called as drop gate because the molten metal just drops on the sand in the bottom of the mould: Refer Fig. 2.36.
- A top gate simplifies the moulding with low consumption of additional metal.
- There is lot of turbulence in this system.

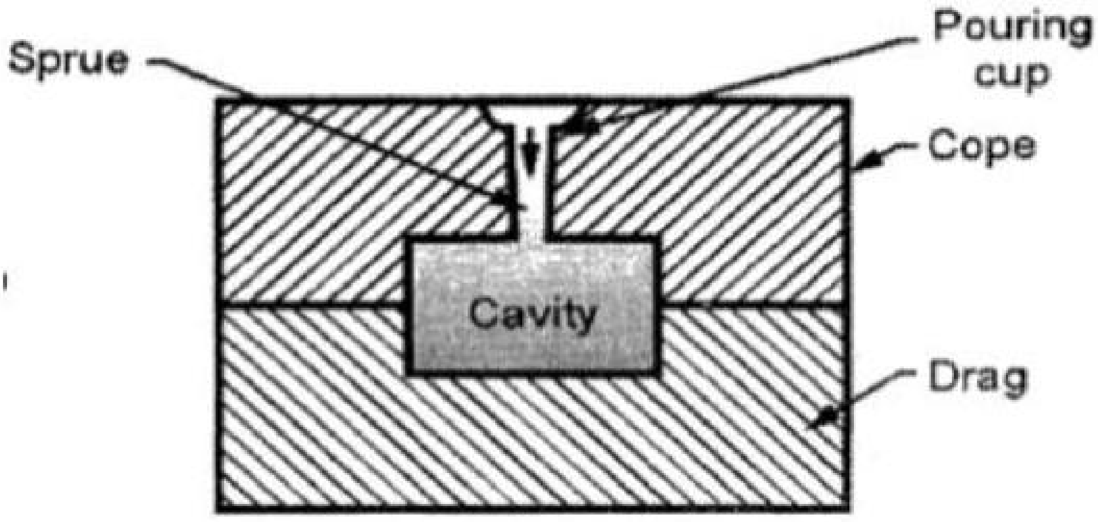


Fig. 2.36: Top gate

- Also, the dropping liquid metal stream erodes the mouldsurface .
- It is not favorable for non-ferrous casting.

Top gates are further classified as :

- Pencil gate
- Edge gate
- Gate with Strains core
- Finger gate
- Ring gate

Wedge gate

c. Bottom gates :

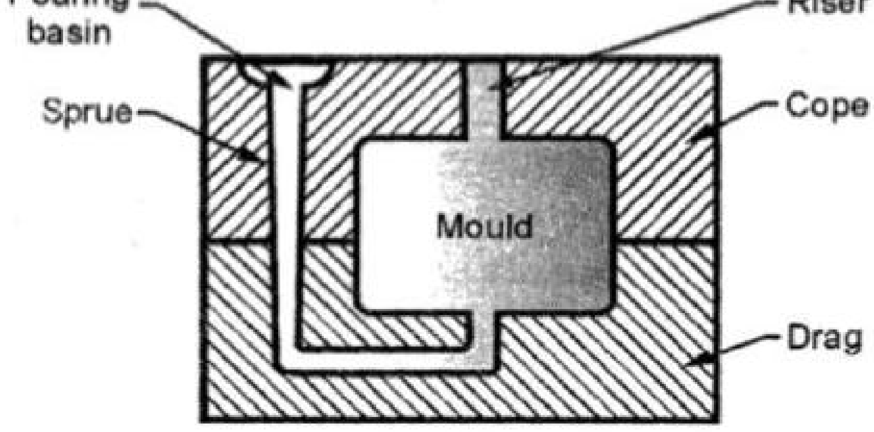


Fig. 2.37: Bottom gate

- A bottom gate is provided in the drag half of the mould. Refer Fig. 2.37.
- In this, liquid metal fills rapidly the bottom portion of the mould cavity and rises steadily and gently up the mould walls.
- Bottom gates provide less turbulence and erosion in the mould cavity.
- It is not used in large and deep casting because the metal cools gradually as it rises up.

d. Side gates:

- Side gates are provided on either left or right side of the casting.
- Hence, the metal enters into the mould cavity from sides. It enters near the bottom first, and then as the level of the metal rises in the mould the incoming molten metal starts entering near the surface of the rising metal. Refer Fig. 2.39

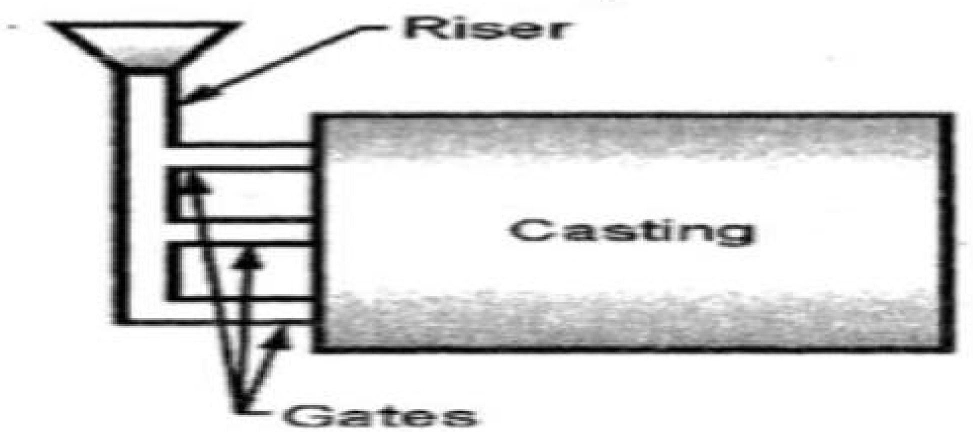


Fig. 2.38: Side gate

e. Riser or Feeder Head:–

A riser is a passage of sand made in the cope to permit the molten metal to rise above the highest point in the casting after the mould cavity is filled up. Refer Fig. 2.35.

– This metal in the riser compensates the shrinkages as the casting solidifies.

The functions of risers are as follows :

o To feed metal to the solidifying casting, so that shrinkage cavities are got rid of.

o It permits the escape of air and mould gases as the mould cavity is being filled with the molten metal.

The functions of risers are as follows :

o It promotes directional solidification.

o Also, it shows that the mould cavity has been completely filled or not.

A casting solidifying under the liquid metal pressure of the riser is comparatively sound.

According to the location of riser, it is classified as

1)Top riser

2)Side riser. The side risers are further classified as

a)open risers and

b)blind risers

1.Top riser:

- It is also called as dead riser or cold riser. It is located at the top of the casting. Refer Fig. 2.39 (a).
- These types of risers fill up the coldest metal and are likely to solidify before casting.
- By using a top riser there is more saving of material as compared to other risers.

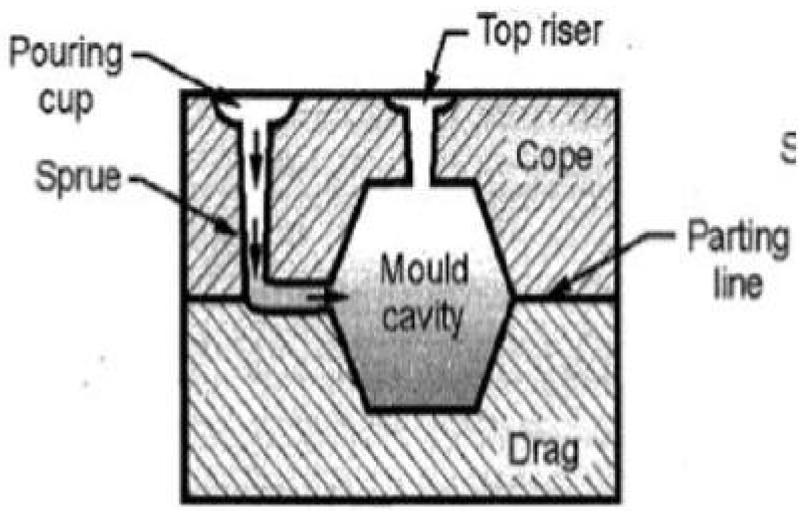


Fig. 2.39 (a): Top riser

2.Side riser:

- It is also called as live riser or hot riser. It is located between runners and casting. Refer Fig. 2.39 (b).
- It is filled at the last and contains the hottest metal.

The risers are further classified as

- open risers
- blind risers

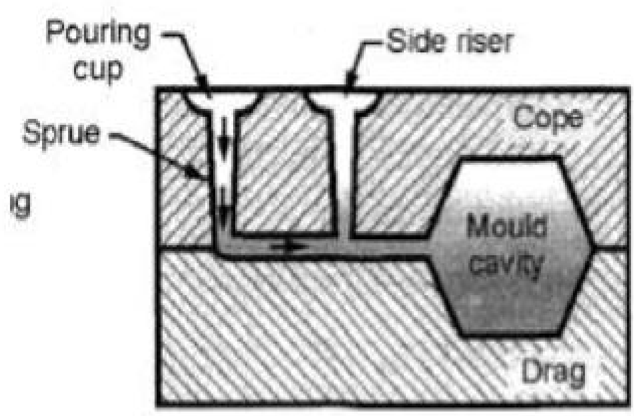


Fig. 2.39 (a): Side riser

2(b)Open risers:

- These risers are open to atmosphere at the top surface of the mould. Refer Fig. 2.40.

- The liquid metal in the riser is fed to the solidifying casting under the force of gravity and atmospheric pressure till the top surface of riser solidifies.
- It is connected to either at the top of cope or on the side of the parting line. Generally, open riser is cylindrical.
- These type of risers are easy to mould.

Blind risers:

- Blind risers do not break to the top of the cope and are entirely surrounded by the moulding sand. Refer Fig. 2.40.
- As it is closed at the top, a vent or permeable core at the top of riser may be provided to have some exposure to the atmosphere.
- It is also connected at the top of the cope or on the side of the casting at the parting line or in the drag.
- Blind riser is a rounded cavity and it associates a slow cooling rate. Also, it is more efficient.

These risers are difficult to mould.

Design of Riser

- The risers are designed to solidify last so as to feed enough metal to enough sections of the casting. For this purpose, they should loose heat at a slower rate.
- The amount of heat content is proportional to the volume of metal and rate of heat dissipation depends upon the surface area of the riser.
- Hence, for a given size, the riser should be designed with a high volume to surface area ratio.
- This will reduce the loss of heat, so that the riser will remain hot and the metal in molten state as long as possible.

- To satisfy this condition the riser is spherical or cylindrical in shape. Rectangular shapes are insufficient hence they are not used. Similarly, spherical shapes are difficult to mould hence the common shape of riser is cylindrical.

Casting Processes

Following are the various casting processes which are commonly used:

a. Sand mould casting

b. Plaster mould casting

c. Metallic mould casting

I. Permanent mould casting

II. Slush casting

III. Pressure die casting

d. Centrifugal casting

e. Investment casting

f. Continuous casting

g. C02 - mould casting.

h. Ceramic mould casting

Shell Moulding

- Shell moulding is suitable for thin walled articles.
- It consists of making a mould that has two or more thin shell like parts consisting of thermosetting resin bonded sand.
- Silica sand is mixed with synthetic resin to form a mixture.
- The mixture must be dry and free flowing

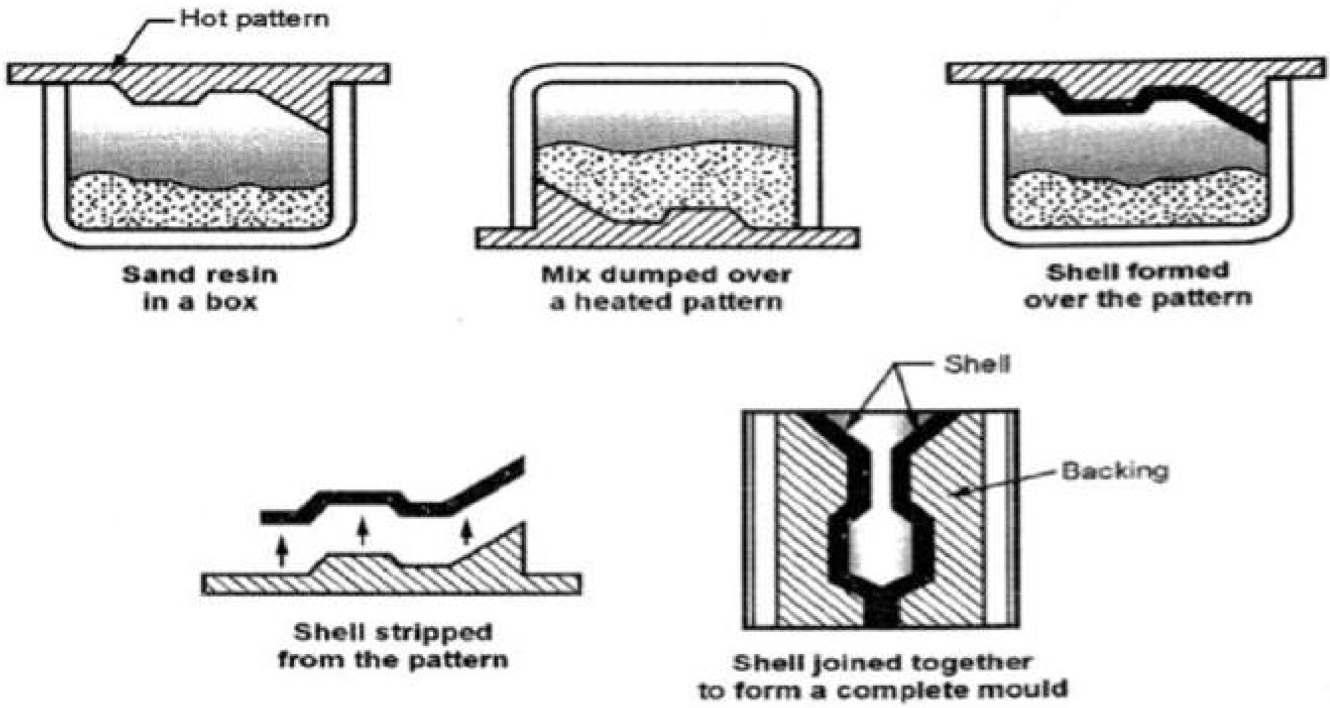


Fig. 2.33: Shell moulding process

Shell moulding process

Procedure of making shell mould:

Fig. 2.33 shows the making of a shell mould and shell core.

- Metal pattern is heated to about 175°C to 350°C and clamped over a box containing sand mixture.
- The box and pattern are inverted for a short time. The mixture when comes in contact with hot pattern, it causes an initial set and binds up a coherent sand shell next to the pattern, which takes 5 to 10 seconds only.
- The thickness of this shell is about 6 to 8 mm and is dependent on pattern temperature, dwell time on the pattern and sand mixture.
- The box and pattern are brought in its original position.
- The shell of resin bonded sand is retained on pattern surface while unaffected sand falls into the box.
- The shell on the pattern IS cured by heating it m oven from 250°C to 350ocfor 1 to 3 minutes. The assembly is removed

from oven and the shell is stripped off from pattern by ejector pins.

- In order to obtain clean stripping, a silicon parting agent may be sprayed on the pattern.
- The shell halves are assembled with clamps supported in a flask with baking materials.
- The mould is now ready for pouring.

Advantagesof shell moulding:

- Very high surface finish is obtained.
- Sand handling is minimum.
- Permeability of the shell is high; hence gases escape readily through them.
- Less floor area is required.
- Casting defects are minimum.

Limitationsof shell moulding:

- The pattern equipment cost is more.
- Not economical for fewer casting.
- Complicated jobs cannot be moulded.
- Weight and size of casting are limited.

Applicationsof shell moulding:

- It is used where greater dimensional accuracy and smoother surface finish are required as in automobile casting.

Also, used for casting steel, iron or non-ferrous alloys

Investment Casting

➢ Investment casting process is also known as lost-wax process.

➢ The term investment refers to a clock or special covering apparel.

➢ In investment casting, the clock is a refractory mould which surrounds the pre coated wax pattern.

➢ A wax pattern must be made for every casting and gating system also.

➢ A wax pattern is invested by liquid mould material which is latter allowed to be set and form a hard layer around the pattern.

➢ A mould cavity is then obtained by melting the wax pattern.

➢ The steps in an investment casting process are as follows (Refer Fig. 2.56)

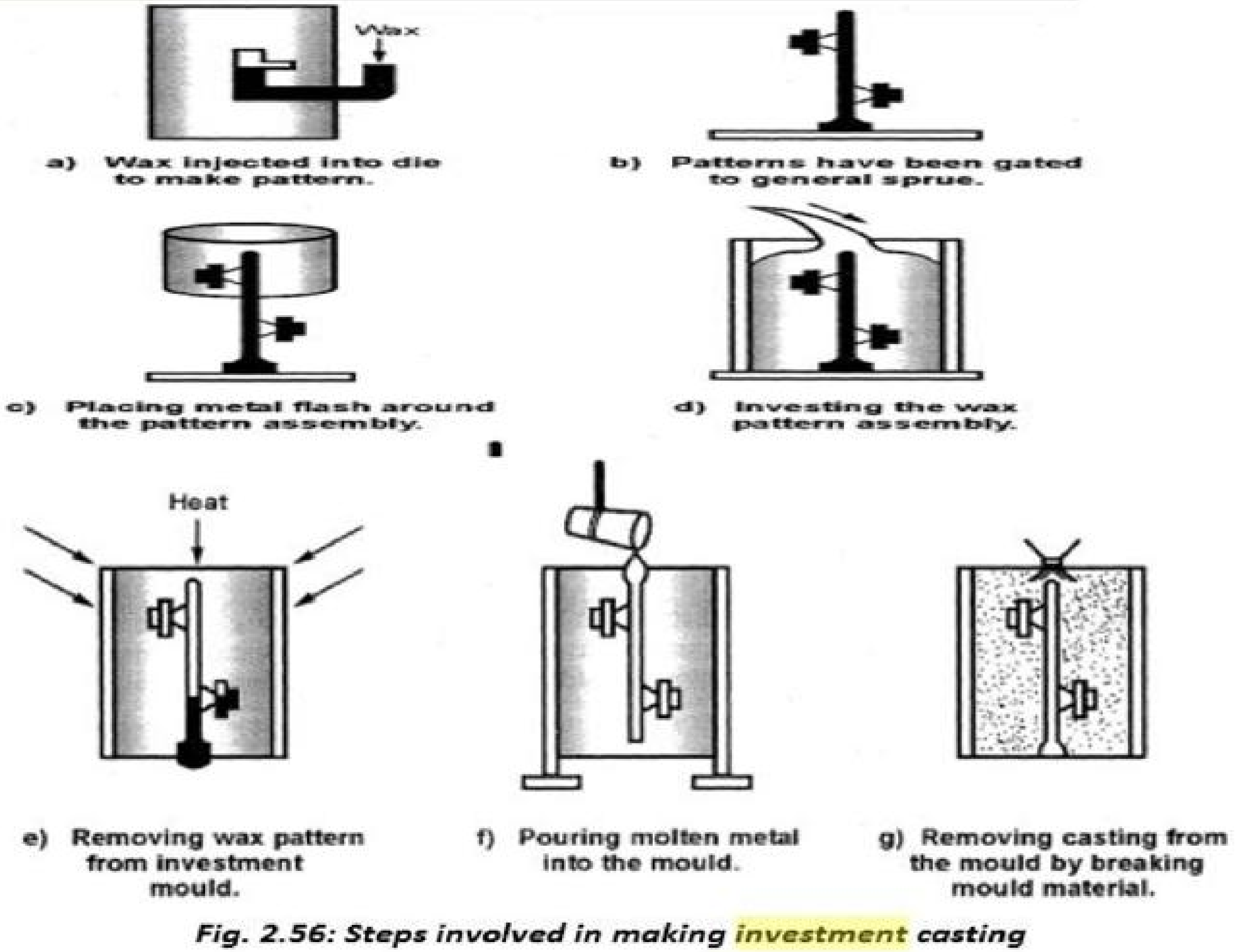


Fig. 2.56: Steps involved in making investment casting

a. **Die making :**

- A die for casting the wax pattern is made.
- These dies can be made by using a metallic master pattern and casting a low melting point alloy around it.

b. Wax patterns and gating systems :

- Wax patterns and gating systems are produced from the metal dies by injection.
- Wax is injected into the die at a temperature of 70°C to 80°C and at a pressure of 8 to 150 kg/cm2.

c. Assembling the wax patterns:

- The wax patterns so made are then attached to wax gates and Sprues already made with the help of heated tool known as hot wire welder.

Assembling fixtures are used to minimize the operation time.

d. Pre coating :

- The wax assembly is dipped into slurry of a refractory coating material.
- Typical slurry consists of 325 mesh silica flour suspended in ethyl silica solution of suitable viscosity to produce uniform coating.

e. Investing :

- The coated wax assembly is then invested in the mould. This is done by inverting the wax assembly on a table, surrounding it with a paper lined steel flask and pouring the investment moulding mixture around the pattern.
- The whole system is then vibrated and then the material settles by gravity and the mould is then allowed to air-set.

f. Wax melting :

- The wax is melted out of the hardened mould by heating it in an inverted position at about 200°C.
- Sometimes, the wax may be reused.

g. Pouring :

- Prepared moulds are first preheated to a suitable temperature between – 540°C to 1 040°C and the metal is gravity poured into the sprue.
- Air pressure may then be applied to the sprue with force to fill the mould cavity.

h. Cleaning and inspection :

- After solidification, the casting is vibrated to separate itself from the investment material.
- The gates, risers, etc. are then chipped off.
- The castings are then subjected to sand blasting.
- Then they are inspected through the specified inspection method.

Advantages ofinvestment casting :

- Better dimensional accuracy with close tolerances can be achieved.
- Complicated shapes and complex contours can be easily cut.
- Extremely thin sections up to 0.75 mm can be cast.
- Surface finish of the casting is very high.
- Castings are sound and free from defects.

Limitationsof investmentcasting :

- Size of the casting to be made is limited.
- Suitable only for small sized casting.

- Moulds used are single purpose only.
- Cost of investment material is high.
- It is a time consuming process.

Applicationsof investmentcasting :

- Parts for aerospace industry, aircraft engines, frames, fuel systems, etc.
- Parts for food and beverage machinery, computers and data processing equipment, machine tools and accessories.
- Nozzles, buckets, blades, etc. for gas turbines.
- Costume jewellery can be made.

Centrifugal Casting

- Centrifugal casting is also known as liquid forging.
- In this process mould is rotated at high speed and molten metal is poured into it. Due to the centrifugal force, the molten metal is directed outwards from the centrei.e. towards the inner surface of the mould with high pressure.
- Hence, a uniform thickness of metal is deposited all along the inner surface of the mould, where it solidifies and the impurities being lighter remains nearer to the rotation axis.
- This process produces casting with greater accuracy and better physical properties.
- This method is mainly suitable for producing casting of symmetrical shapes.

Centrifugal casting processes can be classified as :

a. True centrifugal casting

b. Semi -centrifugal casting

c. Centrifuging

a. **True centrifugal casting :**

- An important feature of true centrifugal casting is that, the axis of rotation of the mould and that of the casting are the same.
- Also there is no need of central core for producing central hole.
- The axis of rotation· of the mould may be horizontal, vertical or inclined at any suitable angle.
- During the operation, moulding flask is properly rammed with sand to confirm to the outer contour of the casting to be made.
- The flask is then dynamically balanced to reduce undesirable vibrations during the process.

True centrifugal casting :

- The finished flask is mounted between the rollers and the mould is rotated slowly. Refer Fig. 2.53.
- The molten metal is poured into the revolving mould.
- The centrifugal force throws the metal towards the outer walls.

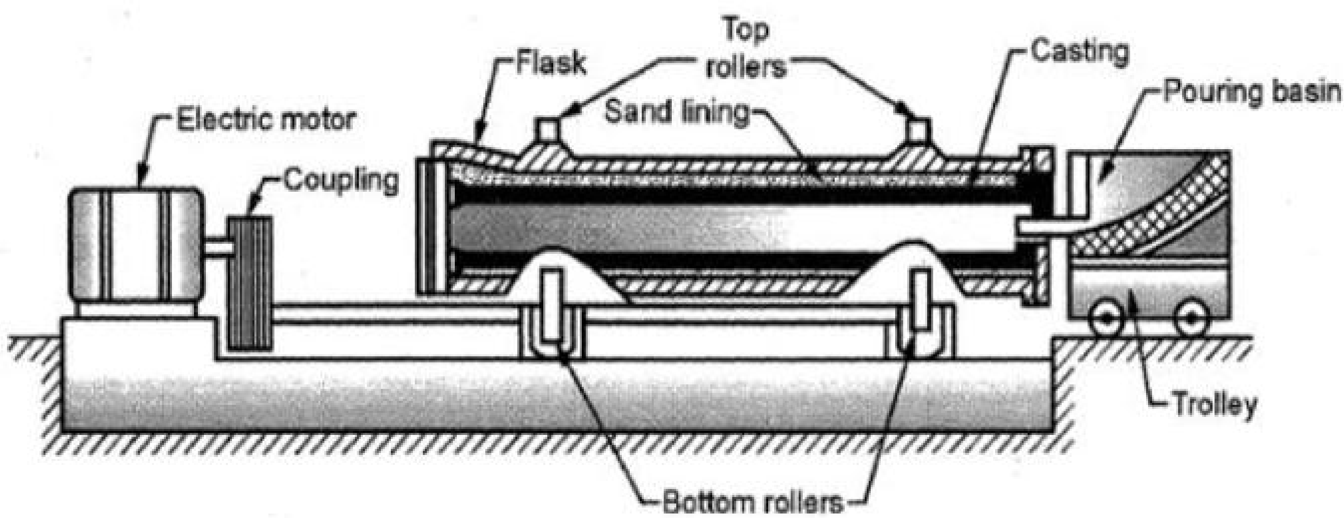


Fig. 2.53 : Horizontal true centrifugal casting machine

True centrifugal casting :

- The amount of the metal poured determines the thickness of the casting.
- After pouring is completed; the mould is rotated at its original speed, till it solidifies to form the required casting. The outer surface of the mould is water cooled, therefore metal solidifies quickly.
- The casting machine is mounted on wheels with pouring ladle which has a long spout exceeding till the other end of the casting to be made.
- This method is used to cast hollow cylindrical objects such as hollow pipes, gun barrels, liner bushes, etc.

Semi centrifugal casting:

- In semi-centrifugal casting method the mould is completely full of metal as it is spun about its vertical axis and risers and core may be employed
- Rotational speed for these methods is not as great as for the true centrifugal process.
- The molten metal 1s poured through a central sprue. Refer Fig. 2.54.

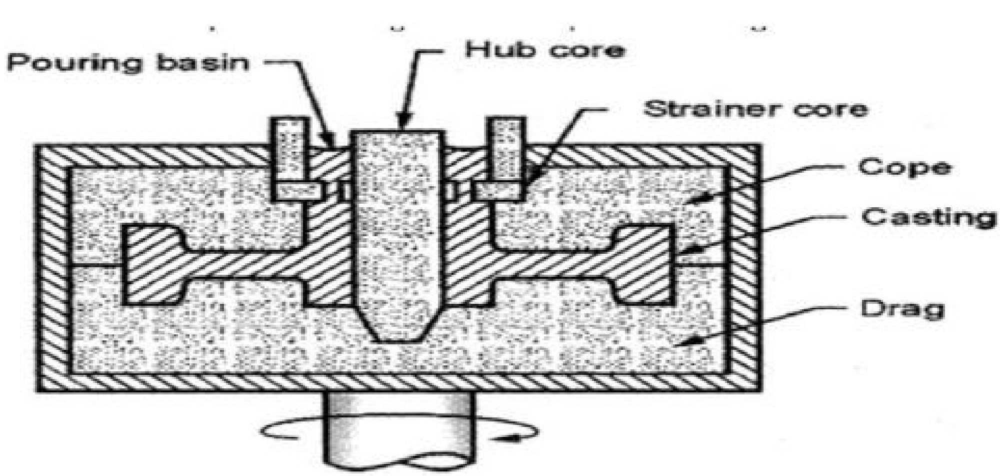


Fig. 2.54: Semi-centrifugal casting

- As the speed of rotation is low, centrifugal force and pouring pressure produced are low.
- The impurities are not collected at the centre.
- The moulds used may be of green sand, dry sand, metal or any other suitable material.
- A central core is used to form the required inner surface of the casting.
- This method is used to produce larger sized symmetrical casting such as discs, pulleys, gears, sprocket wheels, etc.

c. Centrifuging :

- In this method several casting cavities are located around the outer portion of a mould and the metal is fed to these cavities by radial gates from the centre.
- The centrifugal force produces sufficient pressure, to force the metal into the cavities.
- This method mainly differs from true centrifugal method in that, the axis of rotation and that of the mould do not coincide with each other. Refer Fig. 2.55.
- This method is also called as pressure casting

b. Centrifuging casting :

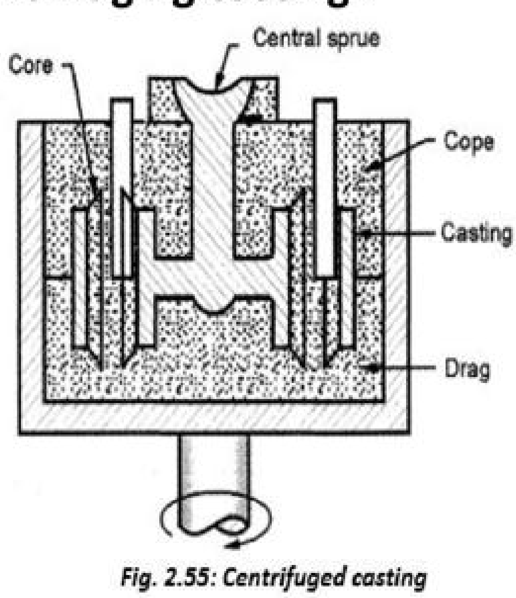
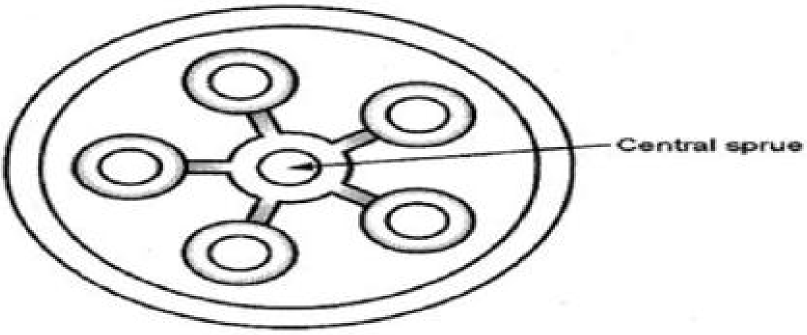


Fig. 2.55: Centrifuged casting



- The internal cavities of these castings are irregular in shape and are formed by dry sand cores.
- This method is also used for unsymmetrical objects.
- It can produce casting of irregular shapes such as bearing caps or small brackets, etc

Pressure Die-casting

- In pressure die-casting molten metal is poured by pressure into a metal mould known as die.
- Because the metal solidifies under pressure, the casting confirms to the die cavity in shape and surface finish.
- The pressure is generally obtained with the help of compressed air or hydraulically.
- The pressure varies from 70 to 5000 kg/cm2
- The main types of die-casting machines are : a. Hot chamber die-casting b. Cold chamber die-casting – The principle difference between the two methods is determined by the location of the melting pot.
- In the hot chamber method, a melting pot is included with the machine and the injection cylinder is immersed in the molten metal at all time.
- The injection cylinder is operated by either hydraulic or air pressure, which forces the metal into the dies to form a casting.

➢ Whereas, cold chamber machine consists of separate melting furnace and metal is introduced into injection cylinder by hand or mechanical means.

a. **Hot chamber Die-casting:**

➢ In this method metal is forced into the mould and pressure is maintained during solidification either by a plunger or by compressed air. Fig. 2.51 shows the main parts of hot chamber machine.

➢ The plunger acts inside a cylinder formed at one end of the goose neck type casting submerged in the molten metal.

➢ Near the top of the cylinder, for entry of molten metal, a port is provided.

➢ When the bottom of the plunger is above the port, at that time the cylinder is connected to the melting pot through this port.

➢ This downward stroke of the plunger closes this port, cuts off the supply of metal and applies pressure on the metal present in the goose

➢ Neck to force it into the die cavity through the injecting nozzle.

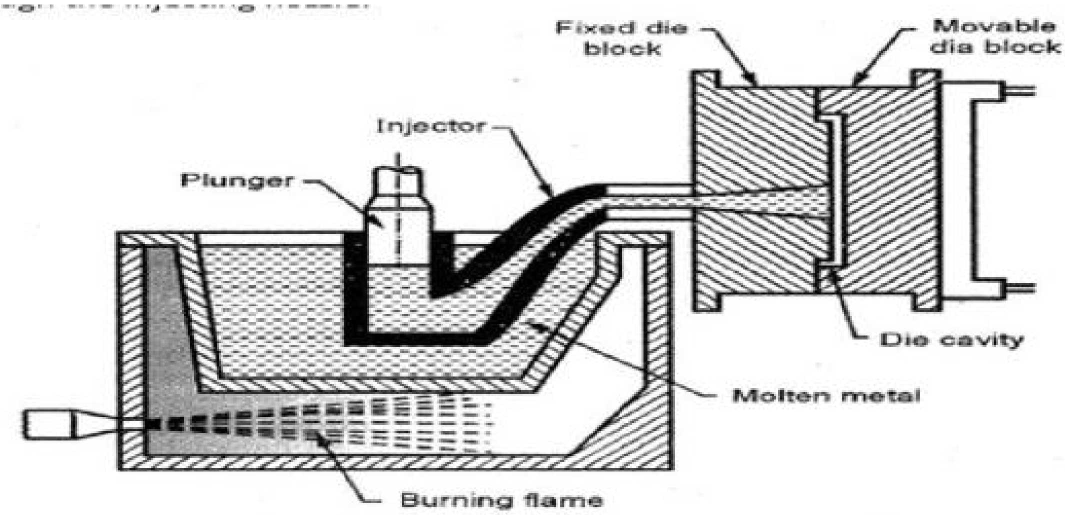


Fig. 2.51 : Hot chamber die-casting machine

➢ After sometime, the plunger is raised up, causing the remaining molten metal in the nozzle and channel to fall back into the casting.

- Before the end of upward stroke, the plunger uncovers the port, through which more amount of molten metal enters into the cylinder.
- Then the dies are opened and casting is ejected.
- These machines are generally used for producing castings of low melting point metals like zinc, tin and lead.

b. Cold chamber Die-casting:

- Fig. 2.52 shows the working principle of cold chamber machine.

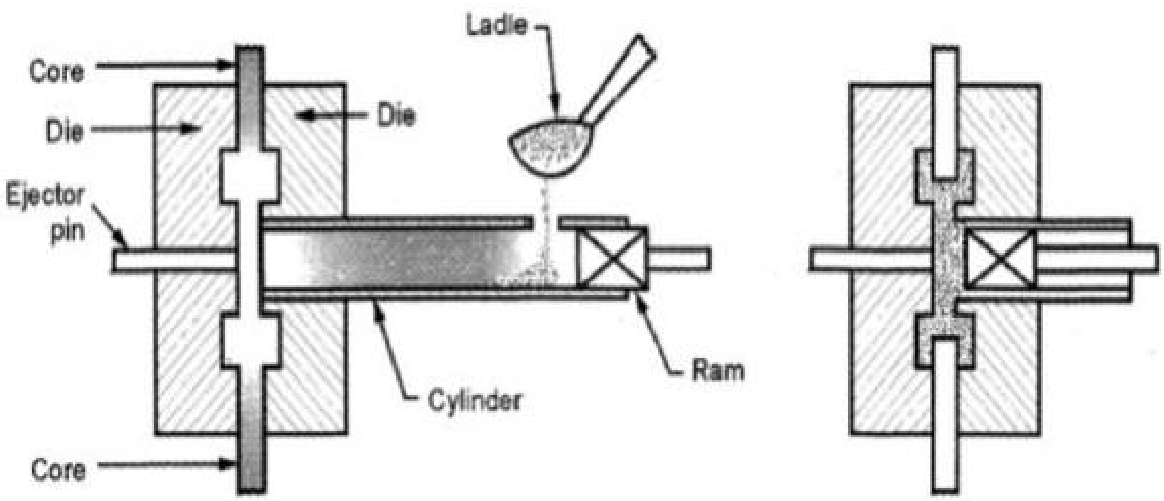


Fig. 2.52: Cold chamber die casting machine

- The machine consists of separate furnace for melting the metal.
- The metal is melted separately in the furnace and transferred to cold chamber by using small hand ladle. Refer Fig. 2.52 (a).
- After closing the die, the molten metal is poured into the horizontal chamber through the metal inlet.
- To force the metal into the die, the plunger is pushed forwards hydraulically. Refer Fig. 2.52 (b).
- After solidification, the die is opened and the casting is ejected.
- Cold chamber machines are mainly used for making castings in aluminum, brass and magnesium.

- The life of these machines is more, because the melting unit is separated from the working parts. − But, the life of die is less because the machine involves very high pressure i.e. about200 to 2000 kg/cm

Advantages of pressure die casting:

- High production rates are possible.
- Economical for large production quantities.
- Close tolerances up to ± 0.076 mm on small parts is possible.
- Good surface finish can be obtained.
- Thin sections up to 0.5 mm can be cast.·

Limitations of pressure die casting :

- Only small parts can be made.
- Only non-ferrous alloys and metals can be commercially cast.
- Due to high cost of equipment and dies, the process is economical only for mass production.

Due to entrapped air, the die castings are porous which reduces mechanical properties of the component.

Applications of pressure die casting:

- Household equipments like decorative parts, mechanical parts of mixers, fans, vacuum cleaners, washing machines, can openers; refrigerators, etc. can be made.
- Industrial equipments like motor housing, crane parts, motor, rotor fan, impeller wheel, etc. can be made.
- Automotive parts like windshield frames, window channels, bodies of fuel pump and carburetor, handles, rear view mirror parts, brake shoe (Al), etc. can be made.

- Toys like pistols, electric trains, model aircraft, automobiles, etc. can be made.
- Other parts like taps, valves, burners, fire alarm system, telephone sets, speakers, staplers, typewriters, etc. can be made

Casting Defects and Remedies

- A large number of defects occur in sand casting produced through different methods.
- These defects offer a great problem to the foundry industry.
- Casting defects are usually not accidents, they occur because some manufacturing steps are not properly controlled.
- A defect may be the result of single cause or a combination of factors.

Casting Defects and Remedies

The factors which are generally responsible for these defects are :

- Design of casting and pattern equipment
- Moulding and core making equipment
- Mould and core materials
- Metal composition
- Gating and risering
- Melting and pouring, etc.

1. **Blow holes:**

- Blow holes appear as cavities in a casting.
- These blows are normally rounded and have smooth walls.

- They are not visible from the outside.

2. Porosity :

- This defect occurs in the casting in the form of pinhole porosity or gas porosity.
- Gas porosity is more pronounced with higher melting temperature and slower solidification of metal.

3. Shrinkage :

- During solidification of metal, there is a volumetric shrinkage.
- They may exist on the surface as depression, called as surface shrinkage or with in the casting called as internal shrinkage.

4. Inclusions :

- Any separate non-metallic foreign material present in the cast metal is known as inclusions.
- These inclusions may be in the form of oxides, slags, dirt, sand or gas.

5. Hot tears :

- Hot tears are also called as pulls or hot cracks.
- They are supposed to be more harmful when present internally.
- Their presence is identified by an oxidized surface showing an irregular and ragged appearance on the fracture..

6. Misrun and cold shuts :

- When the molten metal fails to reach all the sections of the mould, certain part of it remains unfilled.
- This result in an incomplete casting, the defect is known as misrun.

- When two streams of molten metal approach each other in the mould from opposite directions, a physical contact between them is established.
- But, if they fail to fuse together, then it results in discontinuity between them, which is known as cold shuts.

7. Cuts and washes (scabs) :

- The cavities formed on the mould and core surfaces due to erosion are filled by the molten metal and it appears on the casting surface as an excess metal in the form of ragged parts.
- These spots are called as scabs.

8. Mismatch (Shift) :

- Shift is a misalignment between two mating surfaces, leaving a small clearance between them and changing their location.
- It occurs at· the parting surface between two parts of the mould, called as mould shift or at core prints i.e. the gap between core and core seats are called as core shift.

9. Hard spots :

- Hard spots on surfaces are generally developed on iron casting, rich in silicon content, due to local chilling of those spots by moulding sand.
- Due to this, white cast iron is formed at those places and makes them hard.

10. Warpage :

- Warpage is an undesirable deformation in the casting which may occur during or after solidification.
- The deformation takes place because of internal stresses developed in the casting due to differential solidification in various sections.

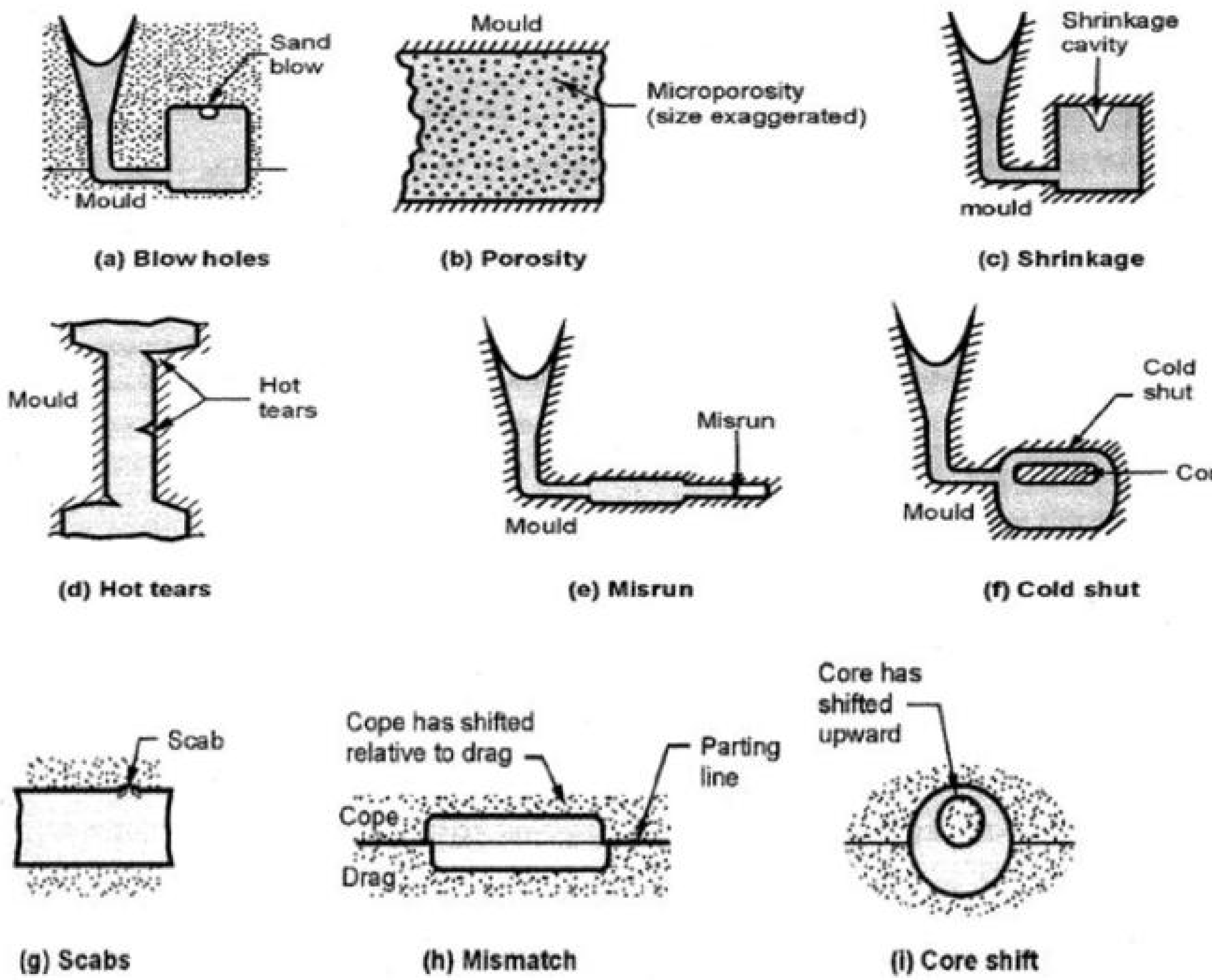


Fig. 2.58: Casting defects

Summary of Casting Processes

Process	Advantages	Limitations
Sand	Almost any metal can be cast; no limit to part size, shape, or weight; low tooling cost	Some finishing required; relatively coarse surface finish; wide tolerances
Shell mold	Good dimensional accuracy and surface finish; high production rate	Part size limited; expensive patterns and equipment
Evaporative pattern	Most metals can be cast, with no limit to size; complex part shapes	Patterns have low strength and can be costly for low quantities
Plaster mold	Intricate part shapes; good dimensional accuracy and surface finish; low porosity	Limited to nonferrous metals; limited part size and volume of production; mold-making time relatively long
Ceramic mold	Intricate part shapes; close-tolerance parts; good surface finish	Limited part size
Investment	Intricate part shapes; excellent surface finish and accuracy; almost any metal can be cast	Part size limited; expensive patterns, molds, and labor
Permanent mold	Good surface finish and dimensional accuracy; low porosity; high production rate	High mold cost; limited part shape and complexity; not suitable for high-melting-point metals
Die	Excellent dimensional accuracy and surface finish; high production rate	High die cost; limited part size; generally limited to nonferrous metals; long lead time
Centrifugal	Large cylindrical or tubular parts with good quality; high production rate	Expensive equipment; limited part shape