MODULE-1

INTRODUCTION & BASIC MATERIALS USED IN FOUNDRY

Introduction

Manufacturing is a process of converting raw materials into finished product. It includes design and manufacturing of goods using various production methods and techniques. The above figure illustrates the manufacturing process. Every product requires material from which the product is made and also requires a method to convert raw material into desired product. We need machines to convert the materials to get desire shape and size. To convert the raw material into the product using machine and methods we require men to operate the machines and to apply the methods. Money is the essential input required for purchasing raw materials, machines and man power.

Classification of manufacturing process:

a. Casting
b. Forming
c. Machining
d. Joining

a. Casting:

In casting process, the molten metal is poured into a mould cavity and is allowed to solidify after solidification, the casting is removed from the mould and cleaned, finally machined to the required shape and size and inspected before use. They are further classified into 2 types

1. Expandable mould
2. Permanent mould

1. Expandable mould

Here, the mould is prepared from sand, plaster or any other similar material which can break easily to remove the solidified part, in other words a new mould has to be prepared for each new casting. Eg: Green sand, dry sand, plaster, etc.

2. Permanent mould

Here, the mould is fabricated out of steel and can be used repeatedly to produce many castings. Eg: Gravity die casting, continuous casting, pressure die casting, centrifugal casting.

b. Forming

In forming process, the desired shape and size are obtained through the plastic deformation of material. The type of loading may be tensile, compressive, shearing or combination of these loads, unlike machining technique. In this process no material is removed and wasted.

1. Hot working

In this process deformation of metal takes place above its re-crystallization temperature.
Eg: Forging, rolling, extrusion, etc.

2. Cold working

In this process deformation of metal takes place below its re-crystallization temperature.
Eg: Bending, wire drawing, etc.

c. Machining process

The process of removing the unwanted material from a given work piece to give it to a required shape and size is known as machining. The unwanted material is removed in the form of chips from the blank material by a harder tool, so as to obtain a final desired shape.

1. Traditional or conventional machine

In this process a cutting tool is used to remove excess material from the work piece. The tool is rigidly mounted on the machine. Eg: Turning, milling, drilling, grinding, etc.

2. Non-Traditional or non-conventional machine

In this process, a layer of electron beam, chemical erosion, electric discharge and electro chemical energy is used instead of traditional cutting tool.

d. Joining

In this process, two or more pieces are joined together to produce the required shape and size of the product. The joint can be either permanent or temporary.

1. Permanent joint

In this joining, it can be done by pouring metals together i.e. welding, gas welding, etc.

2. Temporary joint

In this, it can be done by nuts, bolts, screws, adhesive (gum) bonding, soldering, brazing, etc.

Schematic representation of the classification of manufacturing process.

a) **CASTING**	**Expandable mould**	a. Sand casting (green sand, dry sand) b. Shell casting c. Foam casting d. Investment casting
	Permanent mould	a. Gravity die casting b. Pressure Die casting c. Centrifugal casting
b) **FORMING**	**Hot working**	a. Forging b. Rolling c. Extrusion
	Cold working	a. Wire drawing b. Bending c. Swaging d. Roll forming
c) **MACHNNG**	**Conventional Machining**	a. Turning b. Milling c. Grinding d. Taping e. Drilling
	Non-Conventional Machining	a. Laser beam b. Electro polishing c. Ultrasonic machining d. Water jet machining e. Electro discharge f. Electro chemical
d) **JOINING**	**Permanent Joining**	a. Welding b. Gas welding c. Friction
	Temporary Joining	a. Soldering b. Brazing c. Adhesive bonding

Selection of a process for production

Selection of a particular process for manufacturing to produce a given component depends on several factors. Some of the important factors to be considered are:

1. Shape to be produced
2. Quantity to be produced
3. Type of material
4. Surface finish and dimensional tolerance
5. Technical viability of the process
6. Economic consideration

1. **Shape to be produced**

The shape of the component place a very important role in selection of the process if the shape is simple it can be machined from raw material or it can be forged or extruded however, when the shape is highly complex and intricate, casting is best suited.

2. **Quantity to be produced**

The quantity required is also an important factor for small quantities. Casting may not be required or economical, while for large quantities it is best suited.

3. **Type of material**

The type of material and its properties such as ductile, hardness, toughness, brittleness, are the contributing factor. Very hard materials cannot be machined easily. Brittle materials cannot be mechanically worked.

4. **Surface finish and dimensional tolerance**

The surface finish and dimensional tolerance limits the selection of process considerably. Eg: Commercial sand casting processes cannot be used for high degree of surface finish and tolerance are required, if they are used. Machining may become mandatory otherwise one has to use die casting or investment casting to overcome this problem. Similarly hot working may not give good surface finish and dimensional tolerance. It should be definitely be followed by cold working finishing operation.

5. **Quality and property requirement**

A defect free product with a specific property serves its purpose for long life. Properties of cast materials are generally used when compare to that of mechanically worked materials, also castings gives a lot of defects, hence a process that gives better property and quantity should be selected.

6. **Technical viability of the process**

The process selected must be technically viable i.e. we should be in a position to manufacture the components using this process without much difficulty.

7. **Economic consideration**

Customers often demands for product with more features and performance at reduced price, hence a low cast production process should be selected, but at the same time see that no compromise is made in terms of ***quality***.

INTRODUCTION TO CASTING

In this process, components are produced by pouring molten metal into a contoured cavity followed by cooling to a solid mass.

1. The cold solid mass represents the configuration of the cavity and is the required shape of the component.
2. The components thus produced are called as **casting**.
3. The cavity compound to shape of the component is called **mould.**
4. The mould can be made of refractory material or metal.
5. The mould made out of refractory material is called **sand moulds** and that of made out of metal is called **metal moulds or dies.**
6. Cooling of liquid metal to solid metal is termed as **phase transformation**. The place where this activity is carried out is referred to as **foundry.**
7. In short, casting process involves shaping of the metal by using a mould cavity and hot metal.
8. In this process, the final shape is realized without using any other mechanism unlike in other processes, except the conversion of liquid metal to solid metal.

Steps involved in making a casting

1. Pattern
2. Mould preparation
3. Core making
4. Melting and pouring
5. Cleaning and Inspection

1. Pattern

A pattern is a replica of the object is to be cast. It is used to prepare a cavity into which the molten metal is poured. A skilled pattern maker prepares the pattern using wood, metal, plastic or any other material. Many factors like durability, allowance for shrinkage and machining, etc., are considered when making a pattern.

2. Mould preparation

It involves for making a cavity by packing sand around a pattern enclosed in a supporting metallic frame. When the pattern is removed from the mould an exact shaped cavity remains into which the molten metal is poured. Gating and risering are provided at suitable locations in the mould.

3. Core making

In some cases a hole or a cavity is required in the casting. This is obtained by placing a core in the mould cavity. The shape of the core corresponds to the shape of the hole required. The mould is cleaned & finished before metal pouring.

4. Melting and pouring

Metals or alloys of the required composition are melted in a furnace and poured in to the mould cavity. Many factors like temperature of molten metal, pouring time, turbulence, etc should be considered while making & pouring.

5. Cleaning and Inspection

After the molten metal is solidified and cooled, the rough casting is removed from the mould, cleaned and dressed (removing cores, adhered sand particles, gating, risering system, fins, blisters, etc from the casting surface) and then sent for inspection to check for dimensions or defects like blow holes, crakes, etc.

Procedure for making a casting

a. Mould box

It is usually a metallic frame used for making for holding a sand mould. The mould box has two parts. The upper part is called **"Cope"** and the lower part is called **"Drag".**

b. Parting line

It is the zone of separation between a cope & drag position of the mould in sand casting.

c. Sprue/Runner

It is a vertical passage through which the molten metal will enter the gate.

d. Pouring basin

The enlarge position of the sprue with its top into which the molten metal is poured.

e. Gate

It is a short passage way which carries the molten metal from the runner sprue in to the mould cavity.

f. Riser

A riser or a feed head is a vertical passage that stores the molten metal ands supplies the same to the casting as it solidifies.

g. Mould cavity

The space in a mould that is filled with molten metal to form the casting upon solidification.

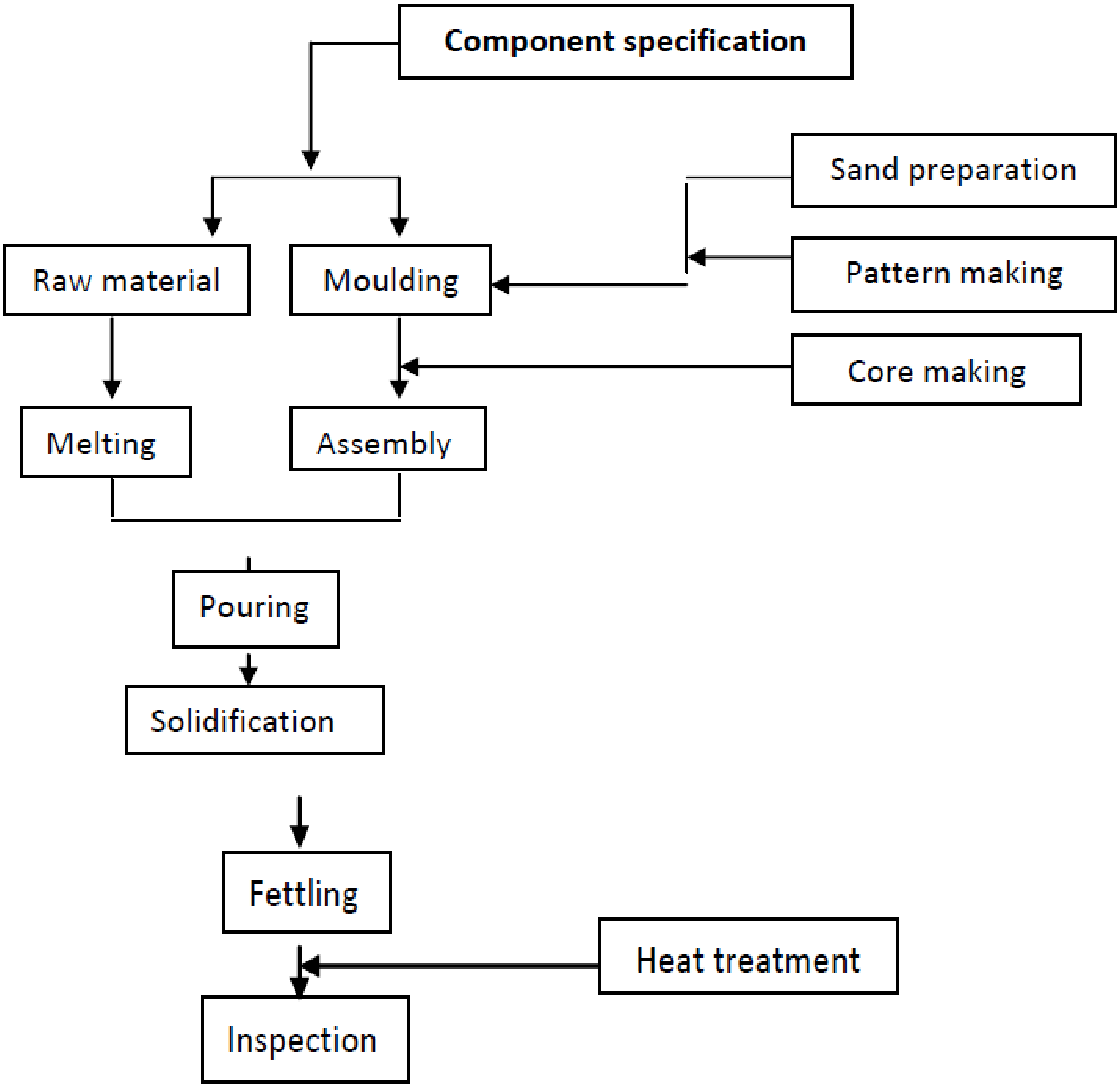
h. Core

A core is performed by using a mass of sand placed in the mould cavity to form hollow cavity in the castings.

i. Core print

It is a projection attached to the pattern to help for support and correct location of core in the mould cavity.

FLOW CHART INDICATING THE STEPS IN A CASTING



Varieties of Components produced by casting process

- Casting is the 1st step and the primary process for shaping any material. All materials have to be cast before it is put in use.
- The ingots produced by casting process are used as raw material for secondary processes like machining, forging, rolling, etc.
- To list the components produced by casting is an endless process, a few major components produce by casting are given below:

a. **Automotive sector**: A few parts like brake drum, cylinder, cylinder linings, pistons, engine blocks, universal joints, rocker arms, brackets, etc.
b. **Aircraft:** Turbine blades, casting, etc.
c. **Marine:** Propeller blades
d. **Machining:** Cutting tools, machine beds, wheels and pulleys, blocks, table for supports, etc.
e. **Agriculture & rail road equipments:** Pumps and compressor, frames, valves, pipes and fittings for construction.
f. Camera frame, parts in washing machine, refrigerator & air-conditioners
g. Steel utensil & a wide variety of products.

Advantages and limitations of casting process

Following are a few advantages and limitations of casting process.

Advantages:

- Casting is the basic and versatile (flexible) manufacturing process.
- Difficult shapes can be easily cast.
- Large, hollow & intricate shapes can be easily cast.
- Casting provides freedom of design with respect to shape, size and quality of the product.
- Some metals that cannot be machined can be produced by casting to the required shape.
- Heavy objects can be produced only by casting process.
- Controlled mechanical & metallurgical properties can be obtained.
- Casting process is most suitable for mass production.
- A large variety of alloying composition & properties can be obtained.
- Directional properties can be obtained in certain cases by controlled cooling.
- Parts with close dimensional tolerance & ready to use can be produced by special casting methods.

Disadvantages OR Limitations

- ✓ Casting process is an elaborate process and involves operations.
- ✓ It requires large infrastructure like casting section, melting, pattern, core section, cleaning, finishing, and inspection.
- ✓ Very high investment is required.
- ✓ Casting process is not economical & viable for small scale operations.
- ✓ The man power requirement is large.
- ✓ High care is required in handling chemicals and molten metal.
- ✓ The actual casting operation cannot be automated.
- ✓ Generally most operations may be casting or one of type i.e. mould has to be prepared for each casting.
- ✓ Great care is required in controlling the cooling rate to obtain defect free casting.
- ✓ Very difficult to cast thin sections.

PATTERNS:

Definition: Pattern is a tool used to produce the mould cavity. It is a mould making tool. The shape of the pattern is the same as that of the component or casting, but the size will be slightly larger than the casting. Pattern is also referred to as the positive replica of the casting. A number or castings can be made using a single pattern.

Functions of a pattern: The basic functions of a pattern are;

- To produce the mould cavity faithfully.
- To establish parting line.
- To promote production of quality casting
- To incorporate gating system and riser.
- To bring economy to the process.
- To have provision for core prints.

Materials used for Patterns: Before selecting a particular material, a few factors are to be considered, they are:

a) Number of castings to be produced.
b) Degree of accuracy and surface finish of casting required.
c) Shape and size of the casting.
d) Re-usability of pattern, so that they will provide a repeatable dimensionally acceptable.
e) Type of mould material used- clay or resin.
f) Type of moulding selected – green sand moulding, investment process etc.

The following materials are used for making patterns:-

a) **Wood** – Well seasoned teak wood is used for the pattern. Wood is soft, light and easy to work and takes the shape easily. Used for producing smaller number of castings. Large and small patterns can be made. It wears out faster, cannot withstand rough handling and can absorb moisture.
b) **Metal** – Is stronger than wood, but heavier than wood. Can maintain dimensions accurately for a very long time. Does not absorb moisture. Used to produce large number of castings. Has longer life. It is difficult to repair. Bigger sized patterns cannot be made using this.
c) **Wax** – Is a low melting point material. Imparts good surface to the mould. Can be recovered and used again and again. Used in investment casting moulding. A combination of paraffin, wax, bees wax, etc. is used for making the pattern.
d) **Plastics** – Plastic material is a compromise between wood and metal. Thermosetting resins like phenolic resin, epoxy resin, foam plastic etc. are used as materials for making pattern. It is strong and light in weight. Does not absorb moisture during its use and storage. Gives good surface finish to castings. Thin sections are difficult to cast using plastics. Initially plastic patterns have to be cast and finished to desired shape and size. This leads to the increase in cost of the final cast product.
e) **Plaster** – Gypsum or plaster of Paris is another pattern material capable of producing intricate castings to close dimensional tolerances. They are strong, light in weight, easily shaped, gives good surface finish. However, they used for small castings only. Plaster readily mixes with water and when allowed sets and becomes hard. Normally plaster is used for producing master dies and moulds.

Various Pattern allowances and their importance:

Pattern has the same shape as that of the casting but the dimensions will be generally more than that of the casting. This extra dimension from the required value, given on the pattern is called as ***"allowances".*** These allowances need to be given on the pattern due to metallurgical and mechanical reasons. The different types of allowances are;

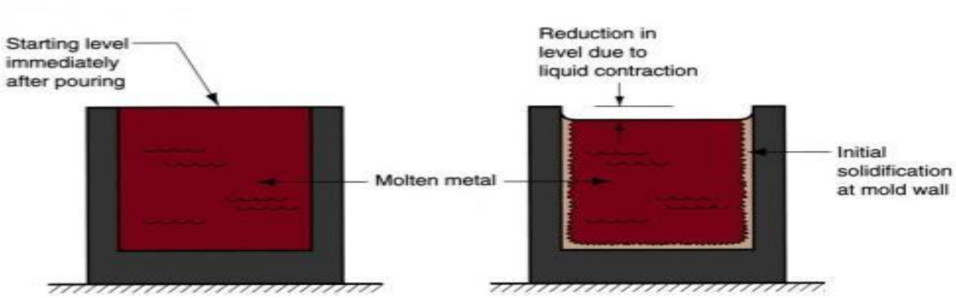
a) Shrinkage allowance
b) Draft allowance
c) Machining allowance
d) Scale & Grinding allowance
e) Distortion allowance

a) **Shrinkage allowance:** All metals and alloys undergo decrease in volume when cooled from liquid temperature to room temperature. This change in volume of metal or alloy is called as ***"shrinkage"***. Fig. 1 shows the variation of shrinkage as a function of temperature. As the molten metal is cooled from its superheat temperature, the volume starts decreasing continuously till it reaches room temperature. This is a natural phenomenon. Shrinkage of metal or alloy takes place in three stages viz. liquid to liquid, liquid to solid and solid to solid. The first two are taken care of by providing risers in the castings. The last one is taken care of by providing shrinkage allowance on the pattern.

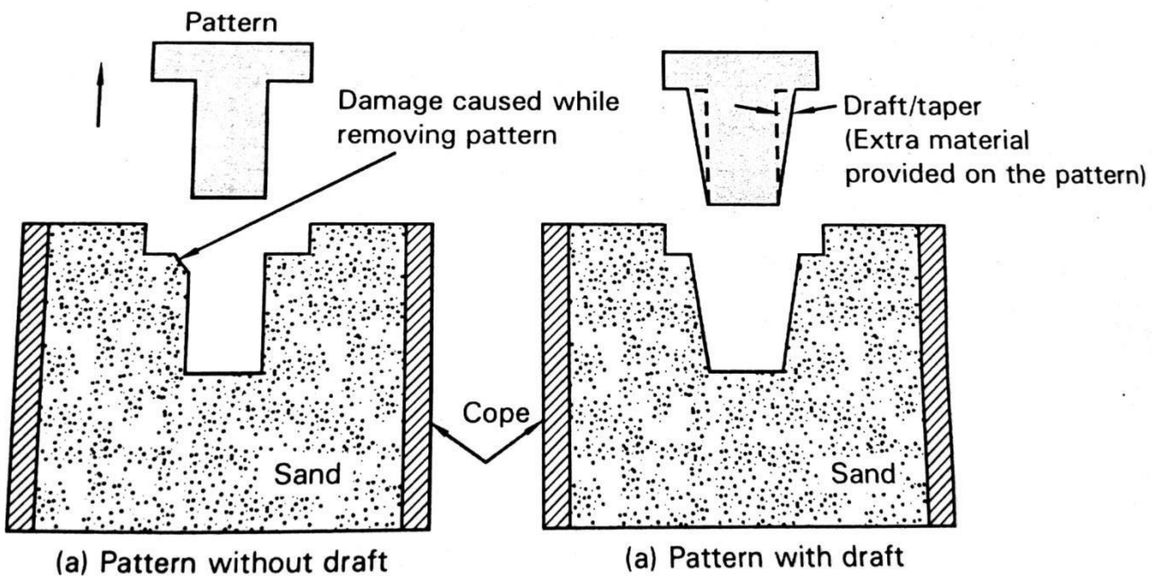
This is also referred to as pattern shrinkage allowance. The value of this depends on the nature of the metal or alloy. This allowance when given on to the pattern, will increase its size. Pattern maker‟s scale is available to facilitate easy and direct measurement. Pattern shrinkage for some metals is:

Ex.	Cast steel	3-5 mm per 100mm length
	Aluminium	3-4 mm per 100mm length
	Cast iron	2-3 mm per 100mm length

Shrinkage Allowance



b) **Draft allowance:** It is the allowance given to the vertical surface of the pattern to facilitate easy removal of the pattern from the mould cavity, without causing any damage to the mould. This allowance depends on the type of moulding. Fig. 2 and 2a, 2b & 2c shows the method of draft allowance given in patterns. Damage is caused to the vertical pattern portions of the mold, when there is no draft. Hence by giving taper or draft on the vertical portions of the pattern there is no damage caused to the mould when the pattern is lifted upwards.



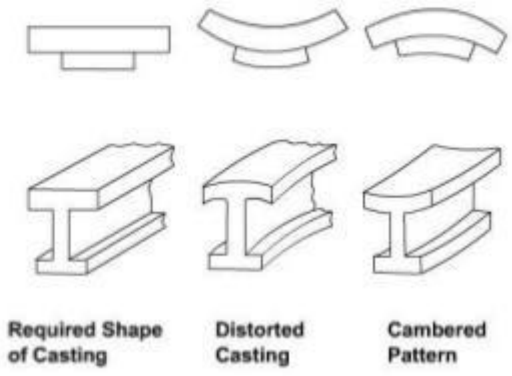
Draft allowance in pattern

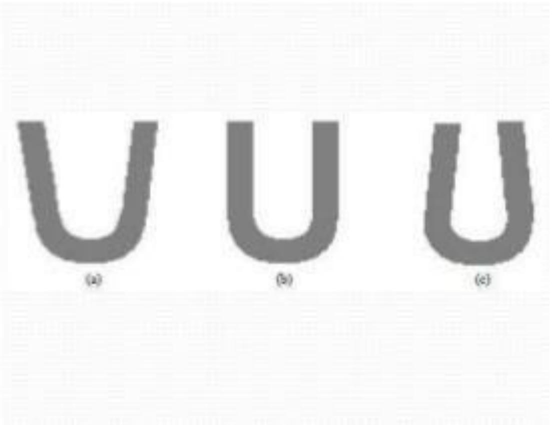
c) **Machining allowance:** Most of the castings will have more than one surface that needs machining. The dimensions get reduced after machining. Hence, the size of the pattern is made larger than required. During machining, this extra material on the casting is removed. This allowance depends on the nature of the metal and the dimensions of the castings. Typical machining allowances are:

Ex.	Cast Iron	1-10 mm
	Cast steel	**3-**12 mm
	Aluminium	**1.**5-4.5 mm
	Alloys	**1.**5-4.5 mm
	Brass, Bronze, etc	**1.**5-5 mm

d) **Scale & Grinding allowance:** Most of the castings undergo heat treatment and due to higher temperatures scales are formed on the surface. This needs to be removed by grinding operation. In addition, sometimes surface roughness or imperfection needs to be removed by grinding operation. Hence, the size of the casting is made slightly bigger than the required to accommodate this. The magnitude of this extra allowance is 0.2 -3 mm.

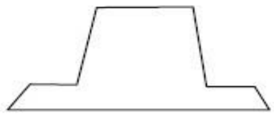
e) **Distortion allowance:** Casting having shapes such as C, U and large plate, loose their shapes during solidification. The loss of shape is referred to as *distortion*. This is due to the shrinkage stresses present during solidification. To take care of this, the pattern is given an allowance in the direction opposite to the expected distortion. This is referred to as *distortion allowance.* More or experience is essential is addition to the design knowledge in arriving to this allowance. Fig. shows the distortion allowance.





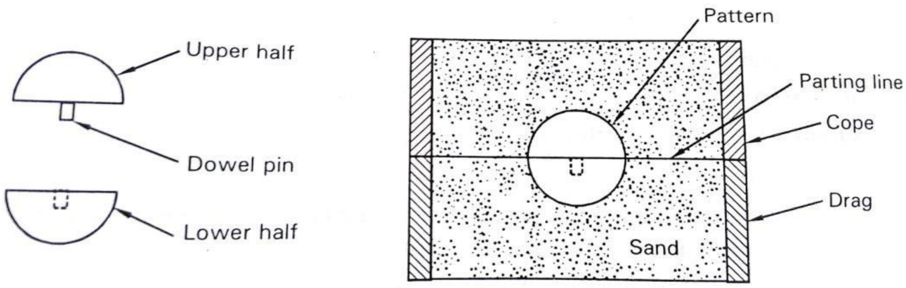
Classification of patterns: Patterns are of various types. But the selection of a particular type of pattern depends upon the type of moulding process employed, shape and size of the casting required. Some of the commonly sued patterns are discussed.

a) **Single piece pattern**: Single piece pattern also called, solid pattern the simplest type made in one piece without any joints or loose pieces. Used for simple shape and large size castings. It can be made easily. Fig. Shows the single piece pattern.



Single piee pattern

b) **Split pattern**: Consists of pattern in two halves joined by a pin. It is used to prepare moulds using hand. It is used popularly in hand moulding. The split can be at two or more planes. The split in the pattern facilitates easy moulding. Fig. shows the split pattern.

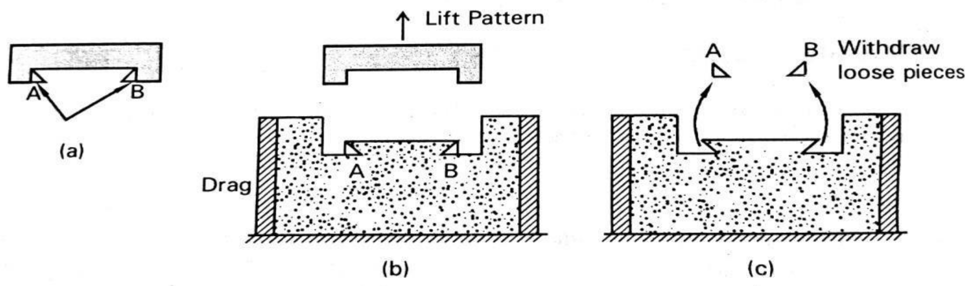


(a) Two halves of split pattern

(b) Split pattern placed in mould

Split pattern

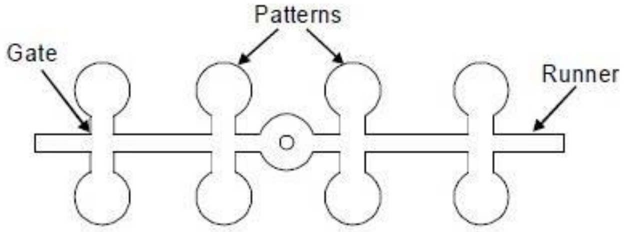
c) **Loose piece pattern**: Pattern consists of a main body to which small projection pieces are attached. These pieces can be removed from the mould after removing the main body. This type of pattern is used to get undercut portions in the castings. Fig. shows the loose piece pattern.



Loose piece pattern

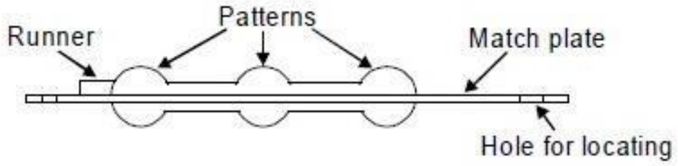
d) **Cope & Drag pattern:** It is basically a two part pattern (split type). Each half is fixed to a metal plate separately with gates, runners and risers. These two plates with patterns are used to make moulds in a moulding machine, separately to get bottom and top mould cavities. The bottom portion is called as the drag portion and the top portion is called as the cope portion. Hence the names cope and drag pattern. The two moulds are prepared separately using separate machines and assembled. This type of pattern is used to produce large number of castings. Fig. Shows the cope & drag pattern.

e) **Gated pattern**: This consists of a number of patterns attached with runner, ingate, sprue and risers. A cope & drag pattern may be used for this purpose. A machine is used for making the moulds. More number of castings can be produced per mould. Size of the casting is small. Fig shows the gated pattern.



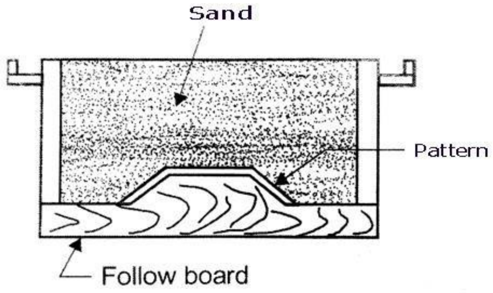
Gated pattern

f) **Match plate pattern**: This consists of two parts of the pattern mounted on either surfaces of a metal plate. It is basically a split pattern. The two parts are perfectly aligned. It is used in a moulding machine. Both cope and drag boxes are made in the same machine one after the other. When the two boxes are closed, the desired mould is obtained. Fig. shows the match plate pattern.



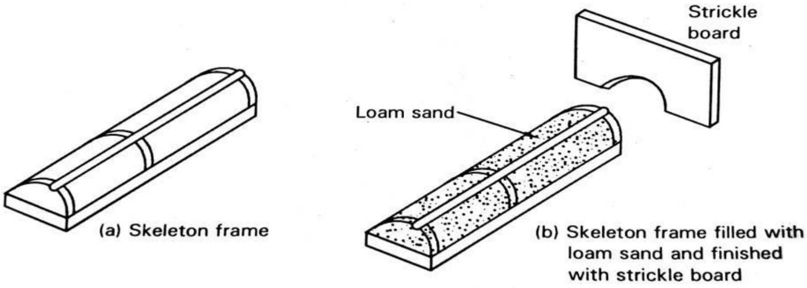
Match plate pattern

g) **Follow board pattern**: When the shape of the pattern is such that it cannot be held stable in its position, a wooden board conforming to the contour of the pattern is used to rest the same in correct position and moulding is carried out. Such a pattern which needs a follow board is referred to as follow board pattern. Follow board holds the pattern till the moulding is over. Even for moulding thin sections follow board is used. Fig. shows the follow board pattern.



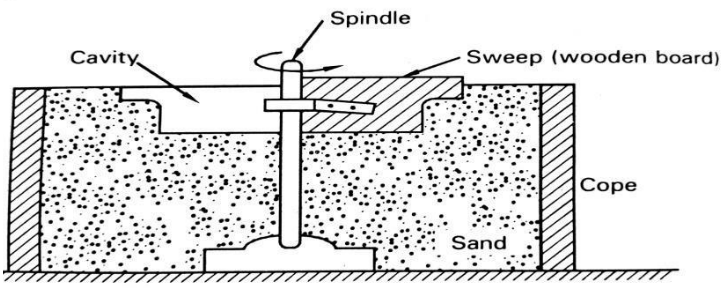
h) **Skeleton pattern**: It consists of a number of wooden pieces assembled together to form the desired shape. The assembly resembles a skeleton. The skeleton portion is then covered with thin boards. This type of arrangement is used for heavy and big castings and the numbers

required is only a few. Material saving for the pattern is achieved and the cost of pattern is reduced. Used for simple shapes. Ex. Water pipe bends, frames, calve bodies can be cast.
Fig. shows the Skeleton pattern.



Skeleton pattern

i) **Sweep pattern**: Makes use of a thin board of wood conforming to the outer contour of the casting. It is used when the casting has a surface of revolution contour such as cylindrical, bell shape, etc. Can be used for small or big castings and the number of castings is not a problem. Saves pattern material. It is easy to handle and store. It can be used for making cores. Fig. shows the sweep pattern.



Sweep pattern

BIS color coding of Patterns: For easy recognition of different portions of the pattern, standard colour codes have been recommended for the finished wooden pattern. The standard colour code adopted by the American Foundry men"s Society (AFS) is being used all over the world. Each colour conveys how the castings will be.

Sl. No.	Colour	Casting position
1	Black	Casting surface to be left unfinished
2	Red	Surface of casting to be machined
3	Red stripes on yellow background	Loose pieces & seats
4	Yellow	Core prints and seats for loose core prints
5	Diagonal black stripes on a yellow base	Stop offs (portions of a pattern that form a cavity which are filled with sand before pouring). They are reinforcements to prevent delicate portions of the pattern.

Due to extensive use of metal and plastic patterns, the colour code is used less now a days.

BINDER: The sand used for preparing moulds is a mixture of *silica sand* (of all the various sand like zircon, olivine, magnesite etc., silica sand is the widely used), *binder* and *additives*.
Moulding sand = Silica sand + Binder + Additives

A hard mould is the primary requirement is making any castings, and binders serve the purpose. A binder is a material used to produce cohesion or bind the sand particles (silica sand) together thereby imparting strength to the sand. Clay binders (Bentonites) are the most widely used for bonding moulding sands. But, clay activates or tends to bind sand particles only in the presence of water (moisture). The amount of water added to clay should be based on experimental trials because, if too little water is added, the sand will lack strength as the bond between the sand is low. On the other hand, too much water causes sand to reach semi liquid state thereby making it unsuitable for moulding. In other words, for a given percentage of clay, there is an optimum percentage of water that gives favorable properties to the moulding sand. For good moulding sand, clay may vary in the range 6-12% and moisture from 3-5%.

Types of binders used in moulding sand: Binders are classified into two types:

a) Organic binders and
b) Inorganic binders.

Organic group of binders include:

- Dextrin – made from starch
- Molasses – a byproduct of sugar industry
- Cereal binders – gelatinized starch and gelatinized flour
- Linseed oil – a vegetable oil
- Resins – urea formaldehyde, phenol formaldehyde etc.

Inorganic group of binders include:

- Clay binders – bentonite, fire clay, etc
- Portland cement
- Sodium silicate etc.

ADDITIVES:

Additives are generally added to develop certain new properties, or to enhance the existing properties of the moulding sand. They do not form a compulsory constituent to the moulding sand. However, its addition improves the quality of the moulding sand and hence the casting obtained.

Note: Additives do not impart any binding qualities.

A few commonly used additives used and their properties are mentioned below:

(a) Sea Coal

- It is a finely powdered bituminous coal.
- Its addition ranges from 2-8% by weight of sand.
- Enhances peeling property of castings.
- Improves surface finish of castings
- Prevents sand burn out.

(b) Silica Flour

- It is pulverized silica added in ranges of 5-10% based on sand weight.
- Resists metal penetration in the mould walls.
- Improves surface finish.

(c) Wood Flour (Cellulose material)

- It is a pulverized soft wood (fibrous material)
- Added in ranges of 1-2% by weight of sand.
- Controls sand expansion created by temper water.
- Absorbs excess water and improves flowability of sand during moulding process.
- Improves collapsibility of moulds/cores.

(d) Iron Oxide

- Develops hot strength to moulding sand.
- Aid in the thermal transfer of heat from the mould-metal interface and provides stability to the moulds dimensional properties

SAND MOULDING

Sand Moulding: A mould is a cavity created using metal or refractory sand. The shape of the cavity corresponds to the shape of casting except the dimensions. A mould is referred to as the negative replica of the casting. Mould made of metal is called as metal or metallic moulds and the ones made by using sand is called sand moulds.

Sand moulds or non metallic moulds:

- Sand moulds are made using a mixture of refractory sand along with a binder, additive and water.
- This mixture is referred to as moulding sand.
- A mould cavity is prepared using this moulding sand.
- They are also referred to as non-metallic moulds or refractory moulds.

Moulding sands may be:

- ***Natural sand:***
  - Occur readily in nature and contains all the ingredients in the right proportion.
  - The sand can be directly used to prepare the mould.
- ***Synthetic sand:***
  Are prepared by making different ingredients (sand, binder, water, etc.) in the correct proportion and then used for preparing the moulds.

Properties of moulding sand: An important property of a moulding sand is that, it should produce a sound casting, i.e. a good casting.
To achieve this, the moulding sand should posses the following desired properties:

1. ***Flowability:***
   - ➢ It is the ability of the sand to flow easily and cover all the contours on the pattern, thus take the desired shape.
   - ➢ The sand with good flowability gets compacted to a uniform density.
   - ➢ Energy during ramming gets easily transmitted through the sand if the flowability is good.
   - ➢ Clay and water additions influence flowability.

   Good moulding sand should have good flowability property.

2. ***Green Strength:***
   - ➢ It is the strength of the sand when in moist condition or green condition (after compaction).
   - ➢ A mould with adequate green strength will retain its shape, does not distort and will not collapse while handling it.
   - ➢ A mould with adequate green strength resists metallostatic pressure and sand erosion while molten metal is flowing in the mould.

   Good moulding sand should have good green strength property.

3. ***Dry strength:***
   - It is the strength of the sand when there is no moisture in the sand i.e. in the dry condition.
   - Hence, a good moulding should be able to develop good dry strength.
   - By heating the mould to approximately 200°C, all the moisture in the sand can be removed, the strength of such dried sand represents dry strength.
   - Dry sand enhances strength of the mould.
   - Resistance to erosion is improved considerably.
   - Shape of the mould is retained easily in the dry condition.

4. ***Hot Strength:***
   - It is the strength of the sand mould at high temperature above 100°C i.e. if the hot strength of sand is good at 200°C, it means that the sand has the necessary strength when sand is heated and held at 200°C.
   - When molten metal is poured into the cavity, the mould gets heated up.
   - If the sand does not have sufficient strength at this temperature it will induce casting defects.

   Hence, sand should have adequate strength at elevated temperature.

5. ***Permeability:***
   - It is the ability of the sand/mould to allow easy escape of gases/vapour through it.
   - When molten metal comes in contact with the mould and core surface, moisture, binders and additives present in them produce gases and vapour.
   - These tend to go through vents and also pass through the mould surface.
   - The sand surface should allow the gases/vapour to escape.
   - If these are entrapped in the casting, defects will appear in the casting as pores.

   Hence, good moulding sand should have good permeability.

6. ***Collapsibility:***
   - It is the ability of the moulding sand to collapse after the casting solidifies. It should break down into pieces at the knock out and cleaning stages, easily.
   - Easier the mould breaks, higher is the collapsibility property of the sand.
   - If the mould or core sand does not collapse easily, it may obstruct/restrict the contraction of the solidifying casting and result in cracks/tear in the casting.

   Hence, the collapsibility of the sand should be good.

7. ***Bench line:***
   - It is the ability of the moulding sand to retain its properties during its storage.
   - The sand should posses fairly good bench life.

   A good moulding sand should have good bench life.

8. ***Coefficient of expansion:***
   - Moulding sand should have very low expansion characteristics otherwise sand expansion will occur.
   - Lower the value of expansion, lesser is the problem of expansion defects in the mold. Lesser is the cracking tendency of the mold.

9. ***Adhesiveness:***
   - It is the property of the moulding sand owing to which the surfaces of the mould are held together.
   - It is because of this property that the sand sticks to the walls of the boxes.

   A good moulding sand should have good adhesiveness.

10. ***Durability:***
    - It is the ability of the sand to withstand repeated cycles of heating and cooling and still retain its properties.
    - The sand should be reusable i.e. should be able to reclaim the sand.

Requirements of base sand: For producing good casting the sand has to fulfill the following:-

Base Sand:

- *Should be sub angular (grain size)*
- *Should be good grain distribution*
- *Should have high refractoriness*
- *Should have low impurities*
- *Should have low expansion characteristics*
- *Should be thermally stable.*

BASE SAND:

It is a mass of refractory grains. Grains are formed due to the withering action of rocks. It is available in plenty in nature along se beaches, deserts, etc. Bas sand refers to sand grains without any other ingredients. They are normally oxides of elements.

Types of base sand:

1) Silica Sand
2) Olivine Sand
3) Chromite Sand
4) Zircone Sand

1. **Silica Sand:** Silica sand is essentially silicon dioxide (SiO_2) found in nature on the bottom and banks of the rivers, lake and seashore. Silica deposits tend to have varying degree of organic and mineral contaminants like limestone, magnesia, soda and potash that must be removed prior to its use, otherwise which affects castings in numerous ways.

   Silica sand is available in plenty, less expensive and possess favorable properties. But its high thermal expansion leads to certain casting defects; the reason for which not being used in steel foundries. However, silica sand when mixed with certain additives like wood flour, cereals, (corn flour) saw dust, etc., defects can be eliminated. These additives burn by the heat of the molten metal thereby creating voids that can be accommodated the sand expansion.

2. **Olivine sand:** Olivine sand is typically used in non-ferrous foundries. With its thermal expansion about half of that of silica sand makes it suitable for production of steel castings also. But the high cost restricts its wide use.

3. **Chromite sand:** This is African sand with cost being much higher compared to other sands. Due to its superior thermal characteristics, it is generally used in steel foundries for both mould and core making.

4. **Zircon sand:** Zircon or zirconium silicate possesses most stable thermal properties of all the above discussed sand. The choice for this type of sand arises when very high temperatures are encountered and refractoriness becomes a consideration. But the major disadvantage is that, zircon has trace elements of uranium & thorium which is hazardous in nature, thereby restricting its use in foundries.

TYPES OF SAND MOULDS: Moulds prepared with sand are called ***"sand moulds"*** or ***"temporary moulds",*** (when moulds are with metal, it is called metallic moulds or permanent moulds) as they are broken for removing the casting. The different types of sand moulds are:-

- Green sand mould
- Dry sand mould
- No bake sand mould

Green Sand mould: The moulding sand is in the moist state at the time of metal pouring. The main ingredients of green sand are silica sand, clay and moisture (water). Additives may be added in small quantity to obtain the desired properties of mould/casting. Nearly 60% of the total castings are prepared from green sand moulds.

Advantages:

- Prepared for simple, small and medium castings
- Suitable for mass production
- Least expensive
- Sand can be reused many times after reconditioning with clay & moisture.

Disadvantages:

- Moulds/cores prepared by this process lack in permeability, strength and stability.
- They give rise to many defects like porosity, blow holes, etc.
- Moulds/cores cannot be stored for long time.
- Not suitable for large castings.
- Difficult to cast thin and intricate shapes.

Dry sand mould: The dry sand mould is prepared in the normal manner as that of green sand mould, i.e., by mixing base sand, clay, water and other additives. Strength is realized after baking the mould in the oven, to remove moisture present in them. Baking is carried out for 6-12 hours at 200-300ºC, depending on the size of the mould and type of metal being poured.

Advantages:

- Moulds are stronger than green sand moulds.
- Surface finish of the casting is better.
- Defects related to moisture are eliminated.

Disadvantages:

- Production is slower, labour and cost due to baking process.
- Under baked or over baked moulds is another disadvantage.
- Not suitable for large & heavy castings as they are difficult to bake.

No Bake sand moulds: A no bake or self setting sand mould is one that does not require baking. The main ingredients are base sand, binder (resin type), hardener and a catalyst or accelerator. The bonding strength developed in moulds by means of a self-setting chemical reaction between binder and hardener. In some cases, a catalyst or an accelerator is added to speed up the chemical reaction.

Advantages:

- Higher strength about 50 to 100 times that of green sand moulds.
- Patterns can be stripped within a few minutes after ramming, which is not possible in green and dry sand mould.
- Moulds can be stored for longer periods.
- Highly simplified moulding.
- Better dimensional accuracy & stability.
- Improve casting quality.
- Surface finish is excellent.

Disadvantages:

- Use of resin and catalyst causes lot of environmental problem both within (i.e. during mixing & pouring) and outside (dumping of sand).
- Resins and catalysts are expensive.
- Unsafe for human operators.
- Due to high strength & hardness, reuse of sand is slightly difficult.

MOULDING SAND MIXTURE INGREDIENTS FOR DIFFERENT SAND MIXTURES

A moulding sand is a mixture of base sand, binder and additives. Ingredients for dry sand mixture are similar to that of green sand.

a. Ingredients for Green Sand Mixture

Green sand mixture is composed of base sand, binder, moisture and additives.

Base Sand: Silica sand is used as the base sand. It possesses favourable properties, inexpensive and can be reused many number of times. The amount of silica sand added may vary depending on the requirements.

Binder: Bentonite (clay binder) is the widely used binder for bonding sand particles. It is activated in the presence of water. A best bond between the sand can be obtained with bentonite varying from 6-12% and water 3-5%.

Additives: Additives are added in small quantities to develop certain new properties or to enhance the existing properties of moulding sand. Sea coal, silica flour, wood flour and iron oxide are commonly used additives.

b. Ingredients for No-bake sand mixture:

Of all the various no-bake sand mixture, viz., Furan system, Phenolic urethane system, Alkyd system, sodium silicate binder system, etc. Ingredients of Alkyd binder system which is one of the most widely used binder system is discussed below.

Base sand: Silica sand is used as the base sand.

Binder: The alkyd binder system consists of three parts:

Part – A (binder)
Part – B (hardener)
Part – C (catalyst)

Part – A (binder): The binder is alkyd resin which is obtained by reacting linseed oil with a polybase acid like iso-pathalic and solvents like turpentine, kerosene or mineral spirit to improve flowability. Its addition ranges from 2-5% based on weight of sand.

Part – B (hardener): The hardener is a reacted product between cobalt/lead salts and napthanic acid. Its addition ranges from 5-10% based on weight of binder.

Part – C (catalyst): Methylene-diphenyl-Di-isocyanate commonly known as MDI is used as catalyst to speed up the chemical reaction. It addition ranges from 20-25% based on weight of binder.

METHODS USED FOR SAND MOULDING

The various sand moulding methods are:-

- Bench moulding
- Floor moulding
- Pit moulding &
- Machine moulding

Bench Moulding: Bench moulding is preferred for small jobs and is carried out on a bench of convenient height. The bench moulder (mould maker) prepares the mould manually while standing.

Floor Moulding: Floor moulding is preferred for large size moulds that cannot be carried out on benches. In most of the foundries, moulding is carried out on floors irrespective of the size of jobs.

Pit moulding: Large castings that cannot be accommodated in mould box (flasks) are made in pits dug on the floor. The pits form the drag part of mould and a separate cope box is placed above the pit. The mould maker enters the pit and prepares the mould. The cope box is rammed using dry sand with risers placed at suitable location.

The walls of the pit are lined with brick and the bottom is covered with moulding sand with connecting vent pipes to the floor level for easy escape of hot gases. A crane is used for handling the cope box and other operations.

Machine moulding: In bench, floor and pit moulding, all the operations viz., ramming, withdrawing pattern, rolling flasks, etc., are done manually by mould makers. But when large number of castings are to be produced manual operations consumes more time and also accuracy and uniformity of moulding varies. To overcome this difficulty, machine moulding is used. The operations perform by machines includes:

- Ramming moulding sand: By jolt operations or Jolt squeeze machines.
- Rapping the pattern: Patterns are rapped in the sand with vibrators that are operated electrically or by compressed air.
- Removal of pattern: By raising or lowering the mould, or by raising or lowering the pattern.

CORES

Cores are used in the mould to produce mainly hollow castings. It is the only method through which cavities can be produced in the casting without machining.

Core sand is used to prepare the core. A core consists of base sand, a binder and water if required. Special types of binders are used for the purpose. Core sand is filled in a metal or wooden die then rammed to get the desired geometry of the die. The shaped sand represents green core. This core gains strength after suitable treatments, depending on the type of binder used.

TYPES OF CORES

Cores are classified based on:

a) **Condition of core:**	i. Green sand core	- contains moisture
	ii. Dry sand core	- Cores does not contain moisture, core in the dried form
b) **Binder used**	i. Resin bonded core	- contains resin as binder
	ii. Sodium silicate core	- contains sodium silicate as the binder
	iii. Oil bonded core	- contains oil as binder
	iv. Shell core	- contains urea/phenol formaldehyde resin as binder
c) **Hardening process used**	i. CO_2 process	- uses co_2 gas to harden the sand
	ii. No bake oil	- uses air to harden the sand
	iii Furan no bake	- uses heating to harden the sand
	iv. Nishiyama	- uses chemical reaction to harden the sand
	v. Fluid sand	- uses chemical reaction to harden the sand
d) **Shape & position** position **of the core**	i. Horizontal core	- core placed in horizontal
	ii. Vertical core	- core placed in vertical position
	iii. Balanced core	- core hanging on one side
	iv. Hanging core	- core suspended from the top.

Green sand core: A green sand core is composed of a mixture of silica sand, binder (bentonite), moisture and additives. The preparation of green sand core is similar to that used for green sand mould.

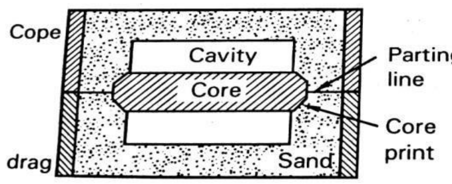
Dry sand core: The sand used for preparing a dry sand core is different from that used for dry sand moulds. A dry sand core is composed of a mixture of silica sand and binder. The binder may be sodium silicate, Portland cement, linseed oil, mineral oil, natural resins, etc.

Binder used : explained above.

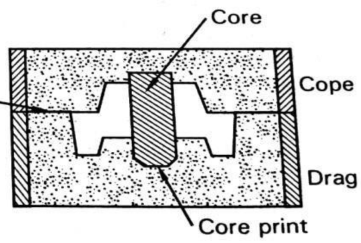
Hardening process used : explained above

Shape and position of the core:

a. **Horizontal core:** The core is placed horizontally in the mould, it is known as horizontal core. The core prints are provided at both ends of the core to rest in the seats initially provided by the pattern. These core prints helps the core to be securely and correctly positioned in the mould cavity.

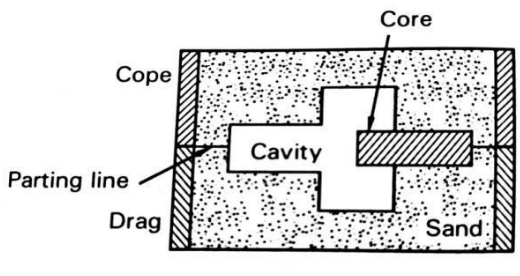


Horizontal core



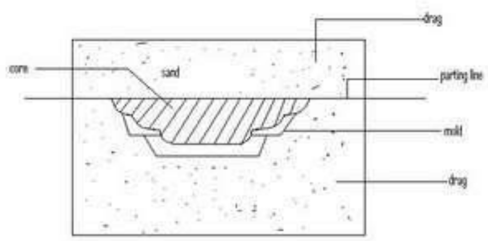
Vertical core

b. **Vertical core**: When the axis of the core is vertical, it is known as vertical core.
c. **Balanced core**: A balanced core is one that is supported from its one end only. Such cores are used when the cavity required is only to a certain depth.

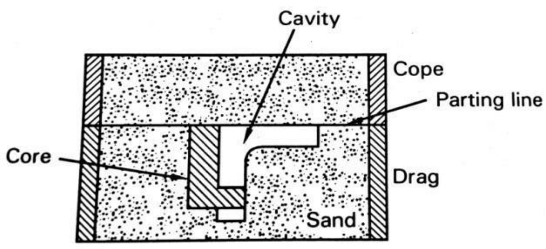


Balanced core

d. **Hanging core**: The core is supported from the top, the core hangs vertically from the mould and the core may be provided with a hole for molten metal to flow.

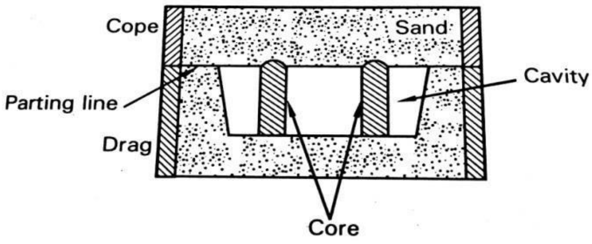


e. Drop core: Drop core is used when the axis of the desired hole does not co inside with the parting line of the mould, i.e., the core is required to be placed either above or below the parting line.



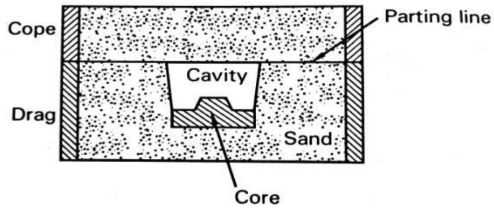
Drop core

f. Kiss core: In some cases, pattern cannot be provided with core prints and hence no seat will be available as a rest for the core. In such cases, the core is held in position between the cope and the drag by the pressure exerted from the cope on the drag. Such a core is called a kiss core and is shown in fig.



Kiss core

g. Ram-up core: When a core is to be placed in an inaccessible position, it is difficult to place it after ramming the mould. The core used in this case is called a ram-up core and is placed in the mould along with the pattern before ramming fig.



Ram-up core

METHOD OF MAKING CORES

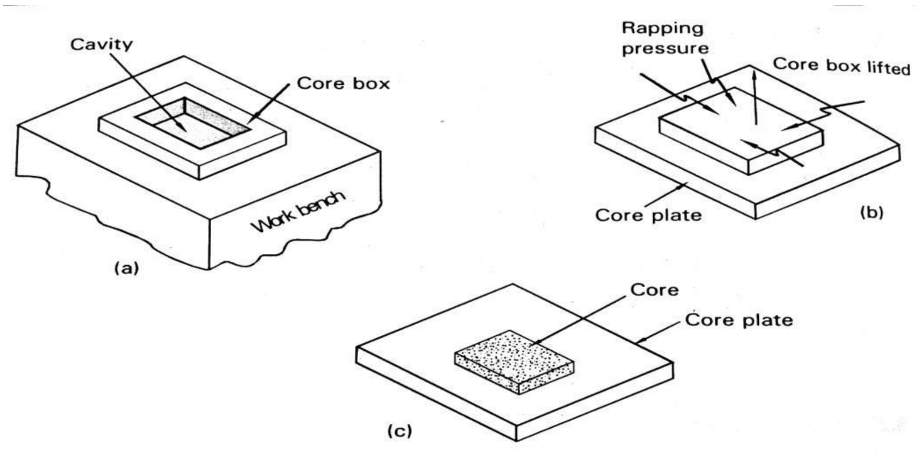
Core making consists of the following four steps:

1. Core sand preparation
2. Core making
3. Core baking
4. Core finishing

1. **Core sand preparation:** The core sand of desired type (dry sand) and composition along with additives is mixed manually or using muller of suitable type.
2. **Core making:** Cores are prepared manually or using machines depending on the needs. Machine like jolt machine, sand slinger, core blower, etc., are used to for large scale continuous production, while small sized cores for limited production are manually made.

A core box is similar to a pattern that gives a suitable shape to the core fig. shows a core box used to produce rectangular shaped cores. The procedure involved for preparing core is as follows:

- The prepared core sand mixture is rammed manually into the core box.
- The core box is inverted over a core plate and rapped in all direction using wooden mallet.
- The box is lifted vertically to leave the core on the core plate.
- The core along with the core plate is sent for baking.



Core making

3. **Core baking:** Cores are baked in ovens in order to drive away the moisture in them and also to harden the binder thereby imparting strength to the core. The temperature and duration for baking may vary from 93-232^oC and from a few minutes to hours respectively depending on the size of the core and type of binder used.

4. **Core finishing:** The baked cores are finished by rubbing or filing with special tools to remove any fins, bumps, loose sand or other sand projection from its surface. The cores are also checked for dimensions and cleanliness. Finally, if cores are made in parts, they are assembled by using suitable pastes, pressed and dried in air before placing them in mould and cavity.

BINDERS USED FOR CORES

Binders used for core making are of various types: each type used to provide some desired property to a core for particular use or set of conditions. The core binders commonly used are discussed below:

a) Binders that become firm at room temperature.

The binders that come under this group include:

- **Sodium silicate**
  Sodium silicate is mixed with silica sand to prepare a core of desired shape and size. Vent holes are made in the core after which carbon-dioxide gas is passed through it. The core hardens rapidly within a few seconds after gassing is stopped.
- **Port Land Cement**
  Port land cement is mixed with silica sand and water to prepare a core of desired shape

after which it is made to set (dry) in a room for about 72 hours. The strength develop with this binder is very high and hence, preferred for heavy steel and gray iron castings.

- **Rubber Cement (Rubber latex)**
  Bonding of cores with this binder is a patented process. Silica sand is mixed with water, and then the rubber latex (obtained from plant) is added. The core is rammed and allowed to harden at room temperature.
- **Synthetic resins (No bake binders)**
  Synthetic resins like phenol and urea formaldehyde are used as binders. They are mixed with hardeners and/or catalyst to bring about a chemical reaction. Strength development in cores takes place within a few minutes after mixing.

b) Binder that become firm on baking

This group of binders does not develop their strength by chemical or physical changes, rather they become hard on heating (baking). Binders materials of this group include:

- Vegetable oils ex. Linseed oil
- Marine animal oil ex. Whale oil
- Cereal binder
- Dextrin made from starch
- Molasses (by product of sugar industry)
- Pitch (a coal tar product)
- Protein binders ex. Gelatin & glues.

c) Binder that harden on cooling after being heated

A binder that softens on heating and hardens on cooling includes natural resins like:

- Gum resins – obtained by tapping the living tree and distilling the gum.
- Wood resins – obtained from pine stump wood.
- Limed wood resins – these are wood resins treated with lime
- Coal tar resins – a product of coal tar industry.

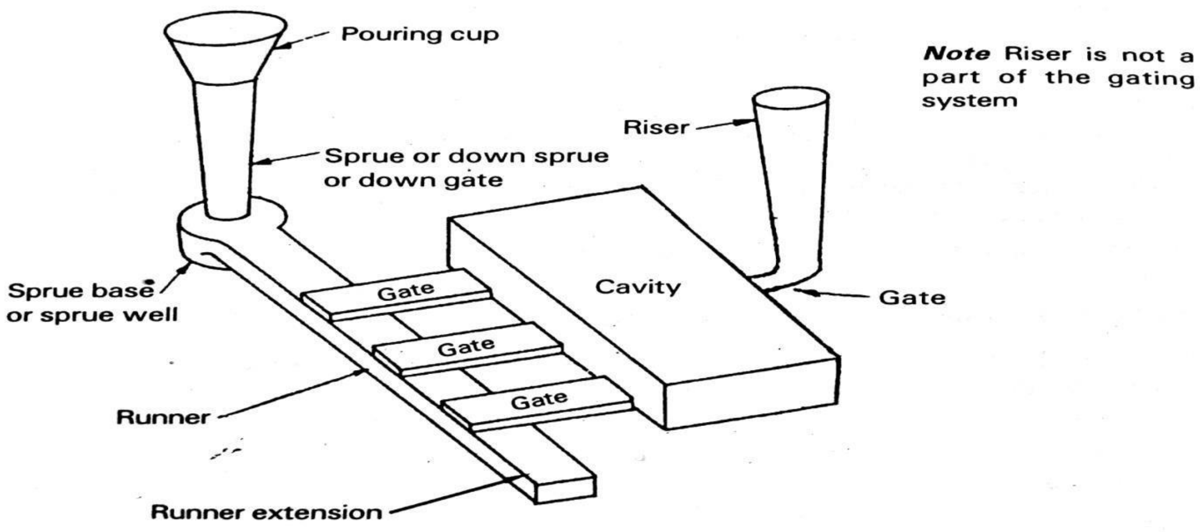
d) Other binders

- Clay binders – bentonite mixed with water.
- Saw dust and wood floor – although not pure binders (they provide little adhesive strength), they serve to improve the collapsibility of the core.

GATING

The concept of gating is very important, as it helps one to learn the controlled flow of molten metal from the crucible or ladle into the mould cavity.

The term gating or gating system refers to all the channels or cavities through which the molten metal flows to reach and fill the mould cavity. Fig shows a simple gating system which consists of the following components.



Gating system

a. Sprue	b. Pouring cup
c. Runner	d. Ingates or Gate

a) Sprue

A sprue is a vertical passage way through which the molten metal will enter the runner. It is also called „down gate‟ or „down sprue‟. The sprue is tapered in cross-section with its bigger end at the top connected to the pouring cup while its smaller end connected to the runner.

b) Pouring cup

The enlarged portion (usually funnel shaped) of the sprue at its top into which the molten metal is poured is called pouring cup. (Fig. 15 a & b). In some cases, pouring basin is used instead of cup. The pouring basin has a larger opening as shown in fig 15(a). It makes pouring easier, eliminates aspiration (air pick-up) and reduces the momentum of the liquid flowing into the mould settling first into it.

c) Runner

The runner is a horizontal passage way through which the molten metal flows into the gates. The cross section of the runner runner may be square or trapezoid and its length is very large compared to its width.

d) Runner extension

It is a small portion of the runner that extends beyond the last gate. It is used to trap the slag in the initial molten metal.

e) Ingates

The ingates or gate is a short passageway which carries the molten metal from the runner to the mould cavity. The gates used may vary in number and depends on the size of the casting and rate of solidification of molten metal. A gate may be built as a part of the pattern or it may be cut in the mould using gate cutter tool. The combination of sprue base, runner and ingates completes the total pouring system of any casting.

RISERING

When the molten metal solidifies, it shrinks in volume. At this stage, if it does not have a source of more molten metal to feed as it shrinks, voids appear leading to defects in castings. This problem is overcome with the use of risers.

A riser or feed head is a vertical passage that stores the liquid metal and supplies (feed) the same to the casting as it solidifies. This means that the metal in the riser must stay liquid longer than the metal in the part being cast.

Requirement of a riser

a) A riser must be large enough that the casting detail it is intended to feed. This helps continuous feeding of liquid metal to the solidifying casting so that shrinkage cavities are eliminated.
b) The riser must be kept open to the atmosphere and placed in such a location that it maintains a positive pressure of liquid metal on all portions of the casting it is intended to feed.
c) A riser should be located in a position that will cause directional solidification from the casting towards it.

PRINCIPLE OF GATING SYSTEM

1. A good gating system should help easy and complete filling of the mould cavity.
2. It should fill the mould cavity with molten metal with least amount of turbulence.
3. It should prevent mould erosion and gas pickup.
4. It should establish proper temperature gradient in the casting.
5. It should promote directional solidification.
6. It should regulate the rate of flow of metal into the mould cavity.

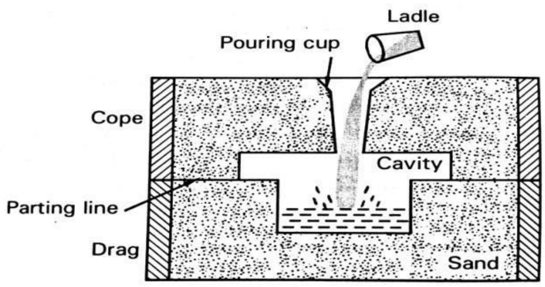
TYPES OF GATES

The common types of gate are:

1. Top Gate
2. Bottom Gate
3. Parting line Gate
4. Step Gate

1. Top Gate

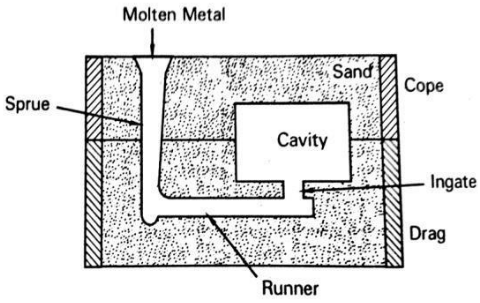
The top are used for simple casting. Molten metal flows into the mould cavity directly from the top. They are the most efficient type of gating. Simple to mould.



Top gate

2. Bottom Gate

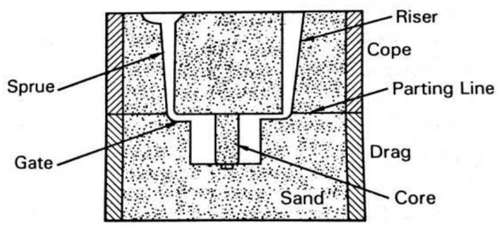
The bottom gates are used for denser metals such as steel. Molten metal flows into the mould cavity from the bottom and slowly rises up. It avoids erosion of mold taken more time in moulding. Bottom gate is shown in fig.



Bottom gate

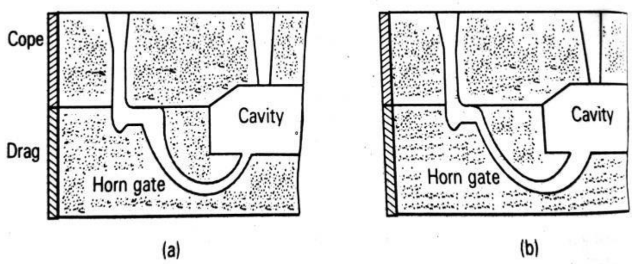
3. Parting line gate

The gates located at the junction of cope and the drag boxes. They can be easily prepared. Molten metal flows into the cavity from a certain height. These are used for most of the non-ferrous alloys and steel castings Fig.



Parting gate

4. Horn Gate



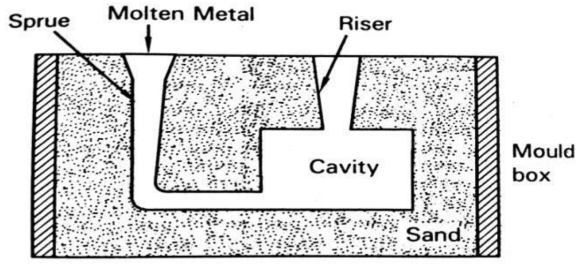
Horn gate

TYPES OF RISERS

Basically riser can be classified as open riser and blind riser. The open riser is kept open to the atmosphere at the top whereas the blind riser is close to the atmosphere.

Open Riser

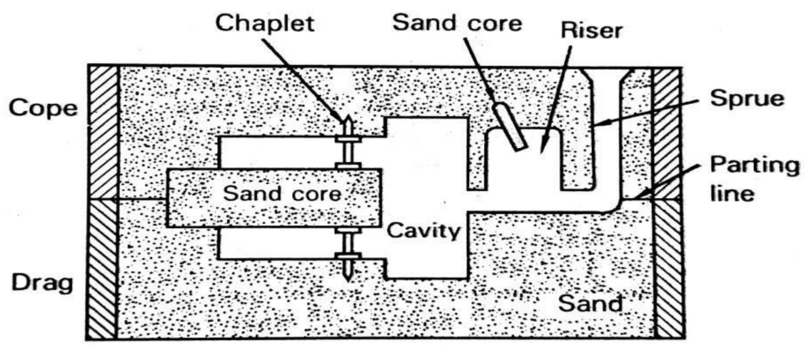
An open riser is a riser provided in the mould cavity when the top portion is open to the atmosphere. It is easy to mould. Further, an open riser can be classified as Top riser – when the riser is placed above the casting. Side riser - when the riser is placed by the side of the casting. Top risers are extensively used since its efficiency is very high. In open riser molten metal is subjected to atmospheric pressure directly.



Open riser

Blind riser

A blind riser as shown in fig. is one which is completely enclosed in the mould and not exposed to the atmosphere. Due to this, the metal in the riser cools slower and thus stay liquid longer promoting directional solidification.



Note Chaplets serve only to support the core. When the chaplet comes in contact with the molten metal, it melts and becomes part of the casting

Blind riser

FETTLING AND CLEANING OF CASTINGS

Castings are to be separated from sand mould box before the gates and risers are removed. This is referred to as fettling and cleaning of casting. The steps involved are:

Fettling

Shake out → sand, Casting and mould boxes are separated

Sand lumps are broken
Cleared of nails, wires, etc

Returned to the moulding section
to be used again

Returned to sand Muller
For reuse for moulding

→ Cleaning operation of castings

Involves

- Removing sand by shot blasting
- Removing core sand
- Removing moulding sand on the casting surface
- Removing gates and risers
- Removing fins, excess metal, sand, etc.,
- Leveling the surface by grinding
- Rectifying the casting from defects

- Cleaning operation depends on the casting shape, size, metal and the process used.
- Sand cores are removed by shaking, chipping, poking or dissolving, etc.,
- Gates, risers, fins are removed by oxy-acetylene flame cutting, hammering, abrasive grinding wheel, etc.,
- Sand sticking on the casting surface removed by shot blasting or sand blasting.

MOULDING MACHINES

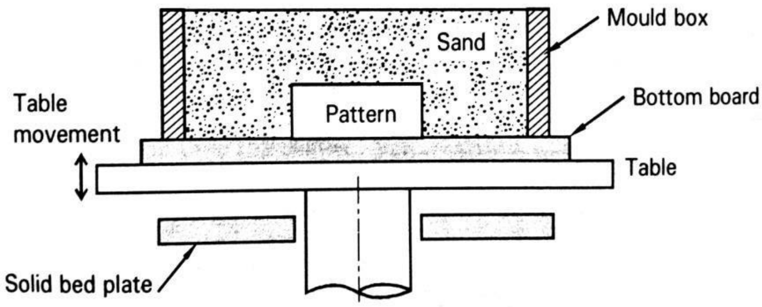
Moulding machines are used to maintain mold quality, reduce allowances, have reproducibility in molding, casting and to enhance productivity.

The following are moulding machines, classified based on the method of ramming.

a. Jolt machine
b. Squeeze machine
c. Jolt-squeeze machine
d. Sand slinger

a. Jolt Machine

The machine consists of a cylinder with two passages on for permitting compressed air at the bottom and another for air to go out. A piston is located in the cylinder and can move up and down. The piston carries a table at the top. One the top of the table a pattern can be fixed and mould box can be placed around it. A control panel is located near the machine to operate it. The machine is located on a firm and rigid concrete base. A hopper carrying sand mixture is located above the machine. By operating the lever compressed air can be made to flow through the bottom of the piston.



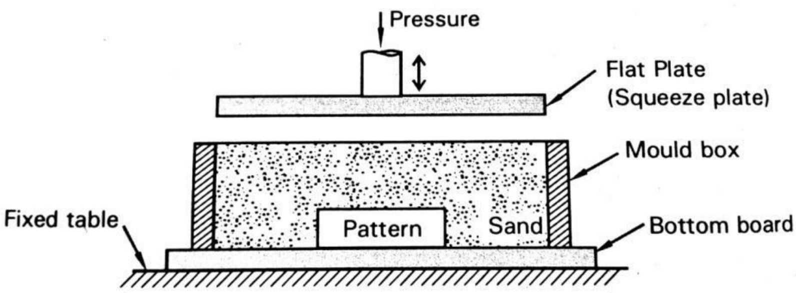
Jolt Machine

Working operation:

- First the moulding sand is filled into the box to cover the pattern.
- The pattern is placed on the table. Moulding box is placed on to the table. Compressed air let into the cylinder.
- Now the table starts moving upwards till the bottom of the piston reaches the top portion.
- At top portion the air escapes out causing a drop in the pressure inside the cylinder.
- Due to its own weight the table along with the box drops down.
- Again the compressed air lifts the piston up till top point and the box is dropped downwards.
- A jolting action is created.
- The process is repeated several times to achieve a desired hardness in the mould.
- Sand is compacted more at the bottom due to jolting action.
- Cope and drag boxes are prepared this way.

b. Squeeze Machine

It consists of a cylinder and piston assembly as in jolting machine. It has only one opening in the cylinder connected by a two way valve. Through this valve compressed air can be let inside the cylinder or let out. Thus the piston can be lifted or lowered inside the cylinder. The piston head carries a table on which the platen/board corresponding to the inside cross section of the mould box is fixed. This board when positioned above the box will squeeze the sand in it when the piston moves upwards. The platen can be swung to one side for placing the mold box and filling the sand.



Squeeze Machine

Working operation:

- First the mould box is kept on the table fixed with the pattern.
- Moulding sand is filled in the box at least 25% in excess of the box volume.
- The platen/board is brought in position above the box.
- Compressed air is then allowed inside the cylinder through the value.
- Now the piston will move upwards along with the box.
- The platen will squeeze the sand in the box during this period.
- Compacted sand will have more compaction on the top and less at the bottom due to squeezing action.
- The air pressure is released now. The piston and box move down wards.
- The box is ejected out using ejector pins.
- One half of the mould is ready now.
- Similarly next half is done and assembled.
- Two machines placed side by side are used to prepare cope and drag molds.
- Suitable for small works and shallow boxes.

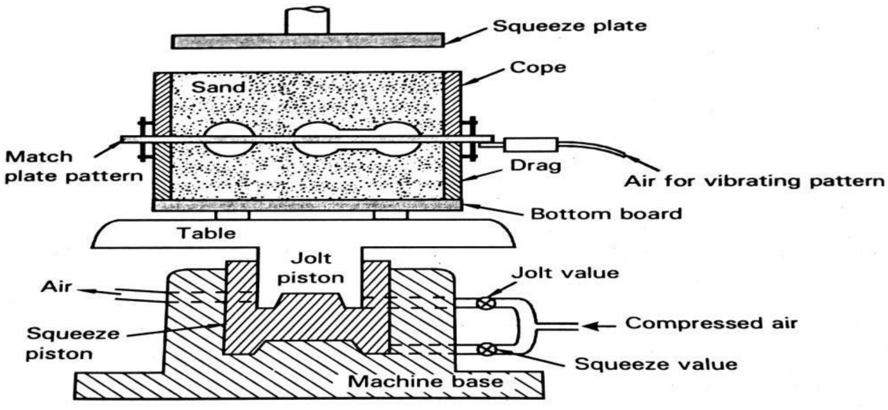
c. Jolt and Squeeze Machine

Here both jolt and squeeze action are imparted to the sand. Constructional features

- It consists of a piston **(P)** carrying a table **(T)**
- Piston is housed in a sleeve **(S)**
- Sleeve has an opening O_1 at the top and another opening (O_3) at the bottom
- Sleeve is housed in an outer casing **(C)** which has a firm base **(B)**
- The casing has 3 openings O_2, O_4 and O_5
- Opening O_4 is connected to the valve 1 referred to as Jolt valve
- Opening O_5 is connected to valve 2 referred to as squeeze valve
- Opening O_2 is the exhaust part and connects the opening O_1 Valves 1 and 2 are connected to a pipe which in turn is connected to compressed air supply.

The pattern for moulding can be mounted on the table and the moulding box can be placed in position by using locating pins.

A squeeze head at the top of the machine is used to squeeze the sand in the mould box.



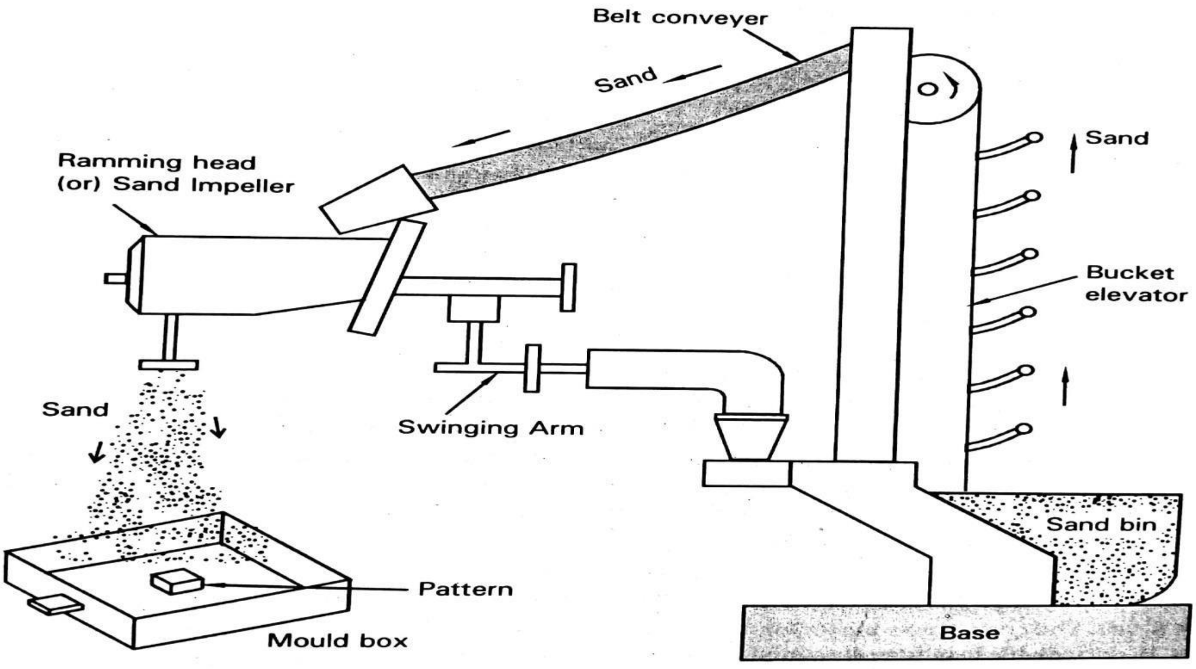
Jolt Squeeze machine

Working Operations:

To start with the piston and sleeve are in the bottom position. O_1, O_2 and O_3, O_4 are connected and are in line. By opening the valve 1, compressed air is made to pass through the opening O_4, O_3. Now the piston carrying the mould box with sand mixture moves upwards till the bottom of the piston just move above the opening O_1. Suddenly the compressed air below the piston escapes out through O_1, O_2, opening. This results in drop in the pressure inside the sleeve below the piston. Due to this the piston drops downwards causing jolting action. The sand gets compacted. Now the connection between O_1, and the sleeve chamber is cut off. Since the valve 1 connects O_4, and O_3, this will again increase the pressure inside the sleeve. This once again lifts the piston upwards. When the bottom of the piston crosses the opening O_1, the pressure drops once again causing jolting. This can be repeated several times. Now for bringing about squeezing action, valve 1 is closed and valve 2 is opened. This results in establishing connection between valve 2 and opening O_5. This causes increase in the pressure at the bottom of the sleeve. Now the piston and the sleeve now get lifted upwards. The squeeze head is brought in line with the mould box containing sand. This results in the squeezing action of the sand against the squeeze head. Squeezing action can be repeated. By this mechanism both jolting squeezing can be imparted to the sand in the mould. The hardness of the mould will be uniform throughout from top to bottom.

d. Sand Slingers:

- Sand slinger is used for large boxes for preparing large molds.
- Large amounts of sand is handled.
- Uniform ramming is obtained.
- Ramming is fast.
- Initial cost is high.
- A number of moulds can be prepared one after the other, around the slinger.



Sand slinger

Steps in moulding using sand slinger:

1. Mould boxes with patterns are kept around the base of the slinger.
2. Mixed sand is dumped in the container
3. The slinger is switched on.
4. The conveyor buckets carry sand to the top and delivers to the belt conveyor.
5. The sand is now conveyed into the horizontal hopper containing a screw conveyor.
6. At the end of the hopper an impeller keeps rotating and carries the sand mixed from the screw conveyor and throws it out.
7. The sand at high velocity is thrown above the pattern and gets consolidated.
8. Uniform hardness is obtained in the mould.