

MANUFACTURING PROCESS

The process of converting raw materials, components, or parts into finished goods that meet a customer's expectations or specifications is known as manufacturing process. Manufacturing commonly employs a man-machine setup with division of labor in a large scale production.

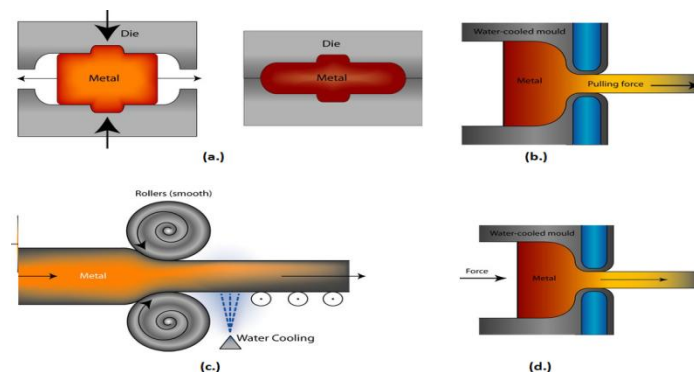
CLASSIFICATION OF MACHINING PROCESS:

The manufacturing processes can be classified as:

1. Forming Processes
2. Moulding Processes
3. Machining Processes
4. Assembly Processes
5. Finishing Processes.

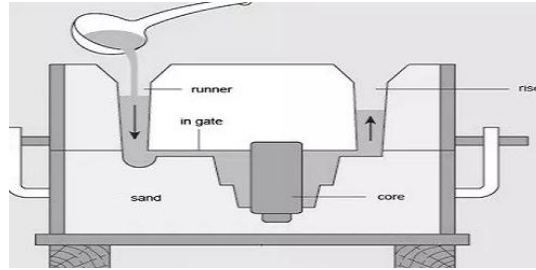
1. Forming Processes:

In the metal industry, some of the primary forming operations may take place such as the rolling of basic shapes in steel, aluminium etc. Some of the common shapes so obtained from these processes are bars, sheets, billets, I-beams etc. Which are standard shapes. These shapes can be used for further processing. Other forming processes may be drop-forging, stamping, extrusion, press work, punching, drawing etc.



2. Moulding Processes:

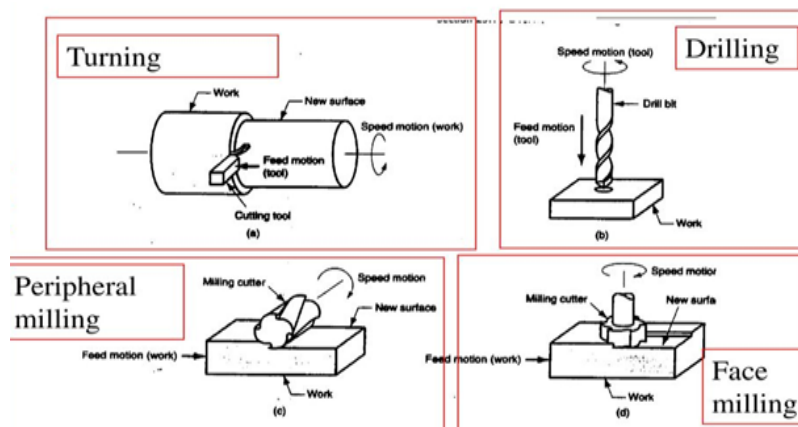
Some products require moulding processes such as sand casting, die-casting etc. to get basic shape or form which may or may not require further processing. The selection of the particular process will depend upon to size of the job, quantity to be produced, accuracy, and complexity desired and economy.



3. Machining Processes:

Metal machining is accomplished through basic machine tool processes which involve the generation of cylindrical surfaces, flat surfaces, complex curves and holes. The machine tools selected to accomplish this task depend on the size and shape of the part to be machined, the quality of finish required and production rate required.

The examples of such processes are: turning, shaping, drilling, boring, grinding etc. In these machining operations metal is removed from the part in the form of small chips by the cutting action of tool. The cutting action is accomplished by either rotating or reciprocating action of the tool relating to the part.



4. Assembly Processes:

These processes assemble the parts and materials using welding, riveting, soldering, brazing, mechanical fastening and adhesive joining etc.

5. Finishing Processes:

These processes are carried out for the aesthetic aspects, to achieve accuracy, surface finish or to increase life of the product. Such processes include cleaning, blast-ing, deburring, puffing, honing, lapping, polishing, painting etc.

INTRODUCTION TO CASTING PROCESSES

Casting manufacturing is a process in which liquefied material, such as molten metal, is poured into the cavity of a specially designed mold and allowed to harden. After solidification, the work piece is removed from the die to undergo various finishing treatments or for use as a final product.

Casting methods are typically used to create intricate solid shapes, and cast products are found in a wide range of applications, including automotive components, aerospace parts, electronics, mechanical devices, and construction supplies.

Selection of Casting Processes

Different casting processes are available for utilization, and their suitability is influenced by a number of factors including the following:

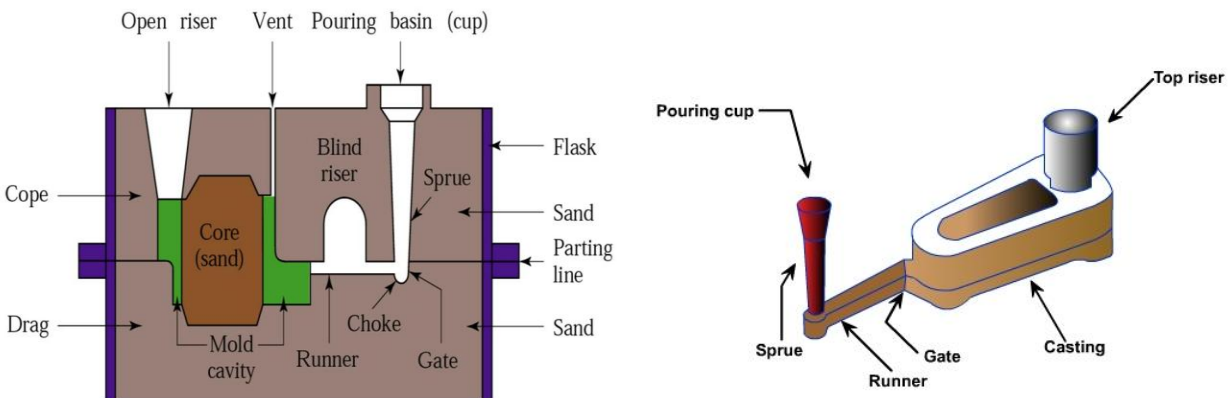
1. Quantity of castings
2. Manufacturing cost
3. Product material
4. Dimensional accuracy required
5. Surface finish required

DIFFERENT TYPES OF CASTING PROCESSES:

- 1) Sand casting: also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 70% of all metal castings are produced via a sand casting process; Sand casting is relatively cheap and sufficiently refractory even for steel foundry use.
- 2) Die casting: Die casting Die casting is a metal casting process that is characterized by forcing molten metal under high pressure into a mold cavity. The mold cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mold during the process.
- 3) Permanent mold casting: is metal casting process that employs reusable molds ("permanent molds"), usually made from metal. The most common process uses gravity to fill the mold, however gas pressure or a vacuum are also used. A variation on the typical gravity casting process, called slush casting, produces hollow castings

- 4) Investment casting: is an industrial process based on and also called lost-wax casting, one of the oldest known metal-forming techniques. From 5,000 years ago, when bees wax formed the pattern, to today's high-technology waxes, refractory materials and specialist alloys, the castings allow the production of components with accuracy, repeatability, versatility and integrity in a variety of metals and high-performance alloys.
- 5) Centrifugal casting: Centrifugal casting or roto-casting is a casting technique that is typically used to cast thinwalled cylinders. It is noted for the high quality of the results attainable, particularly for precise control of their metallurgy and crystal structure.

TERMS INVOLVED IN CASTING



1. **Flask:** A metal or wood frame, without fixed top or bottom, in which the mold is formed. Depending upon the position of the flask in the molding structure, it is referred to by various names such as drag- lower molding flask, cope- upper molding flask, cheek - intermediate molding flask used in three piece molding.
2. **Pattern:** It is the replica of the final object to be made. The mold cavity is made with the help of pattern.
3. **Parting line:** This is the dividing line between the two molding flasks that makes up the mold.
4. **Molding sand:** Sand, which binds strongly without losing its permeability to air or gases. It is a mixture of silica sand, clay, and moisture in appropriate proportions.
5. **Facing sand:** The small amount of carbonaceous material sprinkled on the inner surface of the mold cavity to give a better surface finish to the castings.

6. **Core:** A separate part of the mold, made of sand and generally baked, which is used to create openings and various shaped cavities in the castings.
7. **Pouring basin:** A small funnel shaped cavity at the top of the mold into which the molten metal is poured.
8. **Sprue:** The passage through which the molten metal, from the pouring basin, reaches the mold cavity. In many cases it controls the flow of metal into the mold.
9. **Runner:** The channel through which the molten metal is carried from the sprue to the gate.
10. **Gate:** A channel through which the molten metal enters the mold cavity.
11. **Chaplets:** Chaplets are used to support the cores inside the mold cavity to take care of its own weight and overcome the metallo static force.
12. **Riser:** A column of molten metal placed in the mold to feed the castings as it shrinks and solidifies. Also known as "feed head".
13. **Vent:** Small opening in the mold to facilitate escape of air and gases.

STEPS IN MAKING SAND CASTINGS

There are six basic steps in making sand castings:

1. Patternmaking
2. Core making
3. Molding
4. Melting and pouring
5. Cleaning

1. Pattern making: a pattern is a replica of an object 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 other materials with the help of machines and special tools. Many factors like durability, allowance for shrinkage and machining etc are considered while making a pattern.

2. Molding: mould preparation involves forming a cavity by packing sand around a pattern enclosed in a supporting metallic frame called flask (mould box). 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.

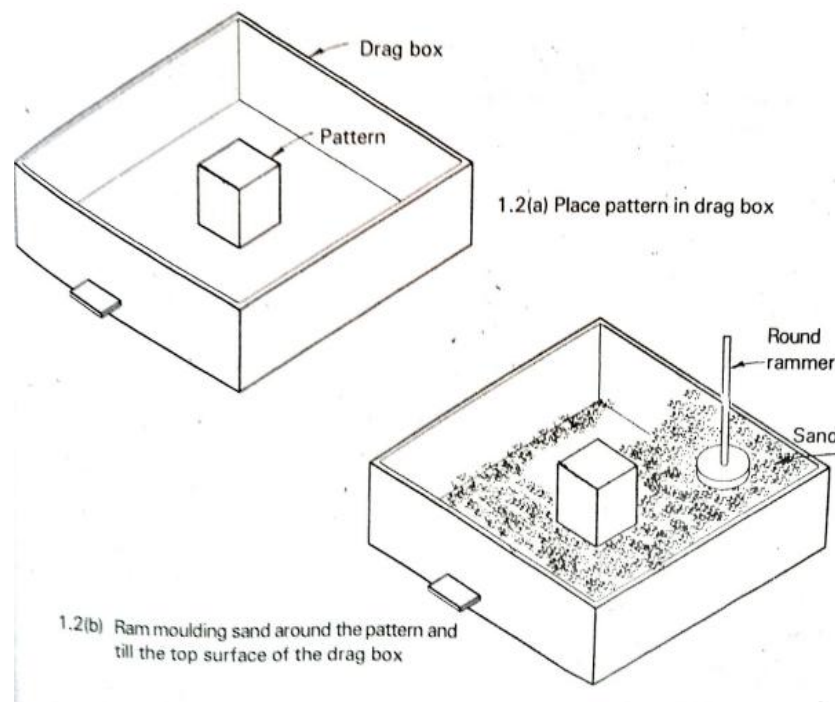
3. Core making: Cores are forms, usually made of sand, which are placed into a mold cavity to form the interior surfaces of castings. Thus the void space between the core and mold-cavity surface is what eventually the casting becomes.

3. 4. Melting and Pouring: metals or alloys of the required composition are melted in a furnace and then transferred (poured) into the mould cavity. Many factors like temperature of molten metal, pouring time, turbulence etc, should be considered while melting and pouring.

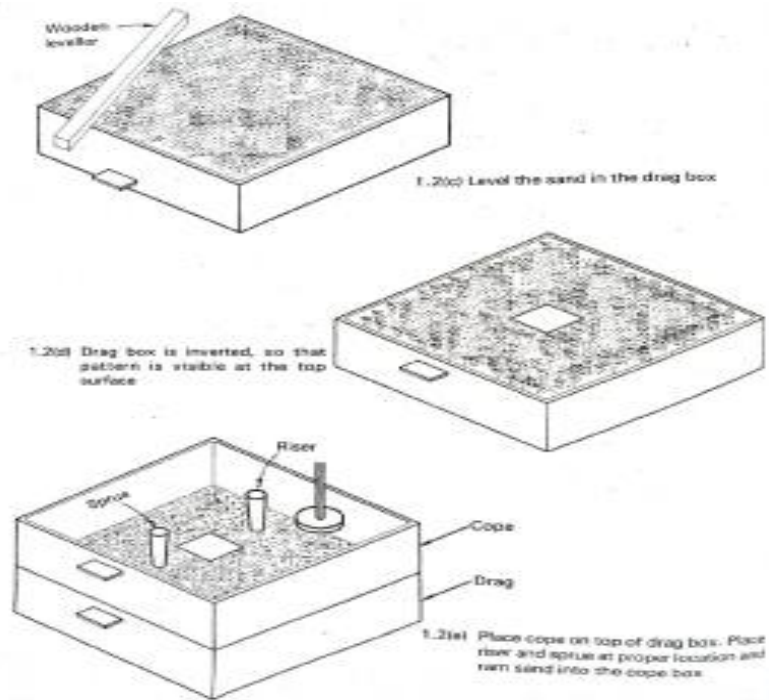
5. Cleaning and Inspection: after the molten metal has solidified and cooled, the rough casting is removed from the mould, cleaned and dressed (removing cores, adhered sand particles, gating and risering systems, fins, blisters etc, from the casting surface) and then sent for inspection to check for dimensions or any defects like blow holes, cracks, etc.

PROCEDURE FOR MAKING A CASTING:

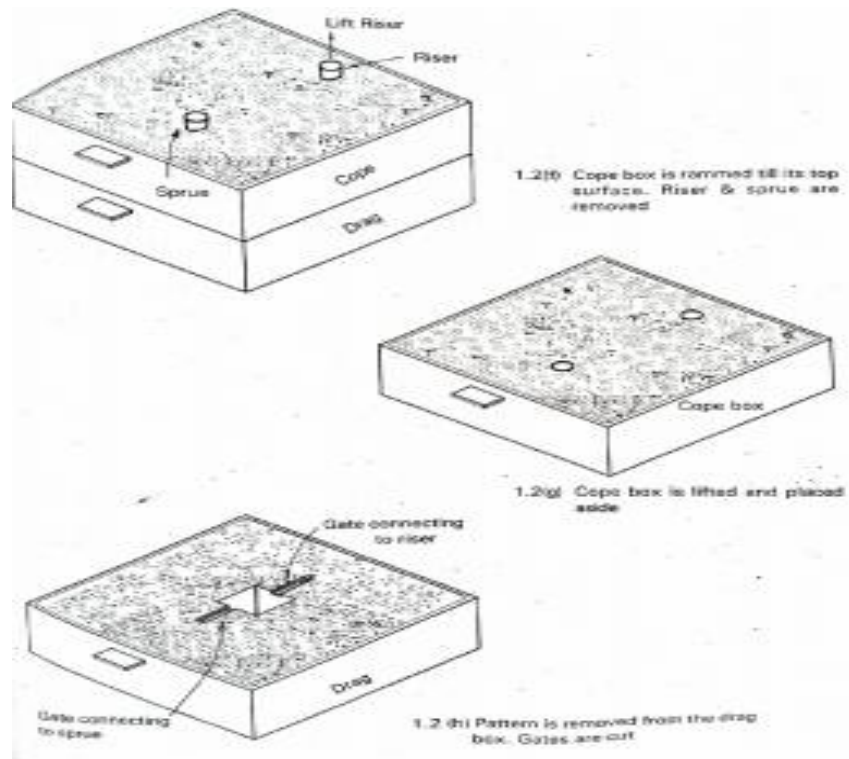
- a. Place the pattern in the drag box
- b. Ram moulding sand around the pattern and till the top surface of the drag box



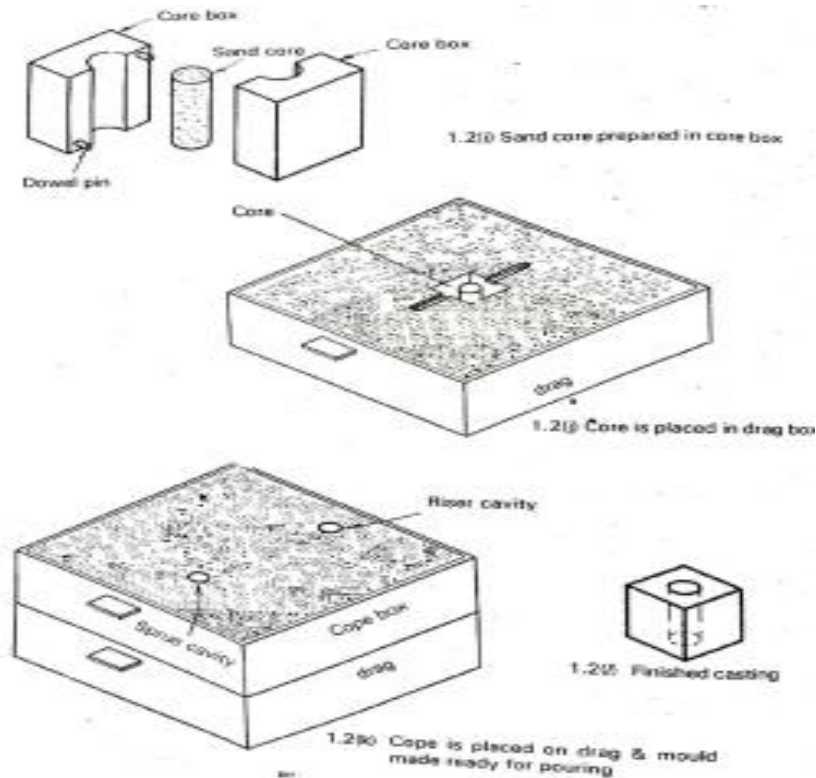
- c. Level the sand in the drag box
- d. Drag box is inverted, so that pattern is visible at the top surface.
- e. Place the cope on top of the drag box. Place riser and sprue at proper location and ram sand into the cope box.



- f. Cope box is rammed till its top surface. Riser & sprue are removed.
- g. Cope box is lifted and placed aside
- h. Pattern is removed from the drag box. Gates are cut.



- i. Sand core prepared in core box.
- j. Core is placed in drag box.
- k. Cope is placed on drag & mould made ready for pouring.



ADVANTAGES OF CASTING PROCESS:

1. Molten metal flows into small ant section in the molten cavity. Hence any complex shape can be easily produced.
2. Practically any material can be casted.
3. Ideal method is by producing small quantities
4. Due to small cooling rate from all directions, the properties of casting are same in all directions.
5. Any size of casting can be produced up to 200 tons.
6. Casting is the often cheapest and most direct way of producing a shape with certain desired mechanical properties.
7. Certain metals and alloys such as highly creep resistant metal-based alloys for gas turbines cannot be worked mechanically and can be cast only.
8. Casting is best suited for composite components requiring different properties in various directions.

LIMITATIONS OF CASTING PROCESS:

1. With normal sand casting process, the dimensional accuracies and surface finish is less.
2. Defects are unavoidable.
3. Sand casting is labor intensive.

PATTERN:

Pattern is replica or model of object which to be created. It is used to make hollow cavity in sand mold in which molten metal is poured and allow solidifying to create object. The size and shape of cast object is highly depends of shape and size of pattern. Mostly pattern are made by aluminum, wood, wax etc. Metal pattern are used for mass production. The pattern making is most critical work in casting because the object is highly depended on it.

A good pattern should follow following requirements.

- Low cost and easy to cast.
- Easy to repair.
- It should light in weight which makes it easy to handle.
- It should able to withstand ramming forces without deformation.
- It should does not change its dimensions in presence of moisture.
- It should be easily removable from mould.
- It should have long life without change in its dimensions.

Functions of the Pattern

1. A pattern prepares a mold cavity for the purpose of making a casting.
2. A pattern may contain projections known as core prints if the casting requires a core and need to be made hollow.
3. Runner, gates, and risers used for feeding molten metal in the mold cavity may form a part of the pattern.
4. Patterns properly made and having finished and smooth surfaces reduce casting defects.
5. A properly constructed pattern minimizes the overall cost of the castings.

PATTERN MATERIALS:

Patterns may be constructed from the following materials. Each material has its own advantages, limitations, and field of application. Some materials used for making patterns are: wood, metals and alloys, plastic, plaster of Paris, plastic and rubbers, wax, and resins. To be suitable for use, the pattern material should be:

1. Easily worked, shaped and joined
2. Light in weight
3. Strong, hard and durable
4. Resistant to wear and abrasion.
5. Resistant to corrosion, and to chemical reactions
6. Dimensionally stable and unaffected by variations in temperature and humidity
7. Available at low cost.

TYPES OF PATTERN MATERIALS

1) Wood:

Wood is one kind of material which easily available, cheap, but it absorption moisture. As a result dimension change in the mould cavity.

Ex: Tack wood.

Advantages:

- a. Wood is available in plenty compared to other materials
- b. Light in weight
- c. Comparatively inexpensive
- d. Good workability
- e. Can be repair

Disadvantages:

- a. Poor in strength
- b. Affected by moisture of the moulding sand causing swelling and distortion.
- c. Less resistant to wear and chemical actions.
- d. Not suitable for long production runs.

2) Metal:

Metal have all preferred properties which above explained. So that casted product surface finished is better.

Ex: Brass, cobalt, aluminium etc.

Advantages:

- a. Metals are strong
- b. Wear resistant
- c. Dimensionally stable under changing humidity
- d. Gives good surface finish to castings
- e. Suitable for mass production.

Disadvantages:

- a. Metals are heavy
- b. Costlier
- c. Tendency to rust during long storage periods.
- d. Initially they have to be cast or machined to the desired shape and size. This leads to the increase in cost of the final cast product.

3) Plastics:

This pattern is preferred where wax pattern are not suitable. Plastic materials are a compromise between wood and metal. Thermosetting resins like phenolic resin, epoxy resin, foam plastic etc are used as materials for making pattern.

Ex: Polystyrene, PVC, Epoxy-resin etc.

Advantages:

- a. Moderately strong and light in weight.
- b. Does not absorb moisture during its use and storage.
- c. Gives good surface finish to castings.

Disadvantages:

- a. Initially plastic patterns have to be cast and finished to desired shape and size. This leads to increase in cost of the final cast product.
- b. Thin sections are difficult to cast using plastics.

4) Wax:

Wax is a re-usable material. It is light in weight, gives good surface finish and suitable for complex shapes. Withdrawal of wax pattern from the mould is easier compared to other pattern materials. This is done by inverting the mould box and heating it to a suitable temperature. The wax melts and drops down leaving a fine finished cavity in the mould.

PATTERN ALLOWANCES

Pattern allowance is a vital feature as it affects the dimensional characteristics of the casting. Thus, when the pattern is produced, certain allowances must be given on the sizes specified in the finished component drawing so that a casting with the particular specification can be made. The selection of correct allowances greatly helps to reduce machining costs and avoid rejections. The allowances usually considered on patterns and core boxes are as follows:

1. Shrinkage or contraction allowance
2. Draft or taper allowance
3. Machining or finish allowance
4. Distortion or camber allowance
5. Rapping allowance.

1. Shrinkage or Contraction Allowance:

The various metals used for casting contract after solidification in the mould. Since the contraction is different for different materials, therefore it will also differ with the form or type of metal. All most all cast metals shrink or contract volumetrically on cooling.

The metal shrinkage is of two types:

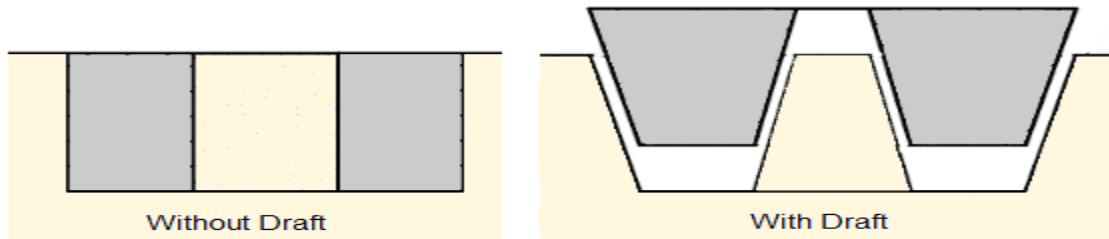
- i. Liquid Shrinkage: it refers to the reduction in volume when the metal changes from liquid state to solid state at the solidus temperature. To account for this shrinkage; riser, which feed the liquid metal to the casting, are provided in the mold.
- ii. Solid Shrinkage: it refers to the reduction in volume caused when metal loses temperature in solid state. To account for this, shrinkage allowance is provided on the patterns.

Table: rate of contraction of various metals

Material	Dimension	Shrinkage allowance (inch/ft)
Grey Cast Iron	Up to 2 feet 2 feet to 4 feet over 4 feet	0.125 0.105 0.083
Cast Steel	Up to 2 feet 2 feet to 6 feet over 6 feet	0.251 0.191 0.155
Aluminum	Up to 4 feet 4 feet to 6 feet over 6 feet	0.155 0.143 0.125
Magnesium	Up to 4 feet Over 4 feet	0.173 0.155

2. Draft or Taper Allowance:

It is a taper which is given to all the vertical walls of the pattern for easy and clean withdraw of the pattern from the sand without damaging the mould cavity. It may be expressed in millimeters on a side or in degrees. The amount of taper varies with the type of patterns. The wooden patterns require more taper than metal patterns because of the greater frictional resistance of the wooden surfaces.



3. Machining or Finish Allowance:

The allowance is provided on the pattern if the casting is to be machined. This allowance is given in addition to shrinkage allowance. The amount of this allowance varies from 1.6 to 12.5 mm which depends upon the type of the casting metal, size and the shape of the casting. The ferrous metals require more machining allowance than non ferrous metals.

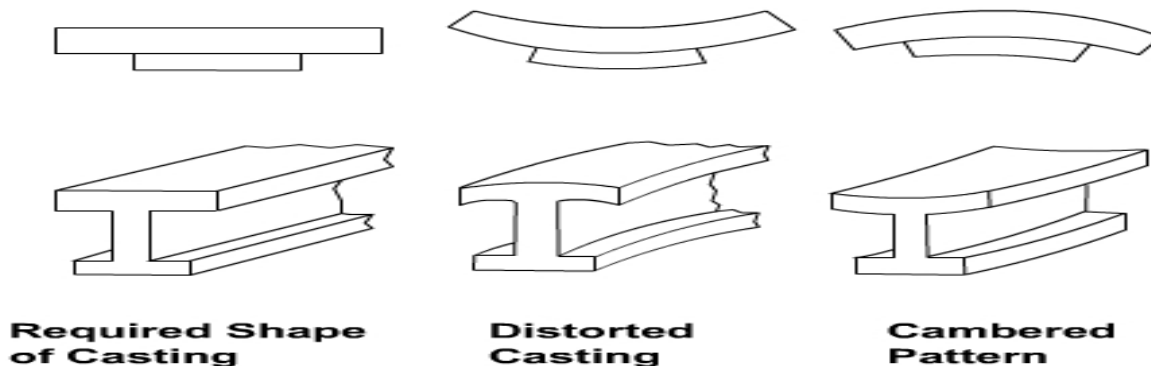
Table: Machining allowance for various metals

Material	Dimensions (in mm)	Machining allowance (in mm)
Cast Iron	Up to 300	2.5
	300 to 600	4.0
Aluminium	Up to 300	1.5
	300 to 600	3.0
Cast Steel	Up to 300	3.0
	300 to 600	4.5

4. Distortion or Camber Allowance:

This allowance is provided on patterns used for casting of such design in which the contraction is not uniform throughout.

Sometimes castings get distorted, during solidification, due to their typical shape. For example, if the casting has the form of the letter U, V, T, or L etc. it will tend to contract at the closed end causing the vertical legs to look slightly inclined. This can be prevented by making the legs of the U, V, T, or L shaped pattern converge slightly (inward) so that the casting after distortion will have its sides vertical.



5. Rapping Allowance:

This allowance is provided in the pattern to compensate for the rapping of mould because the pattern is to be rapped before removing it from the mould.

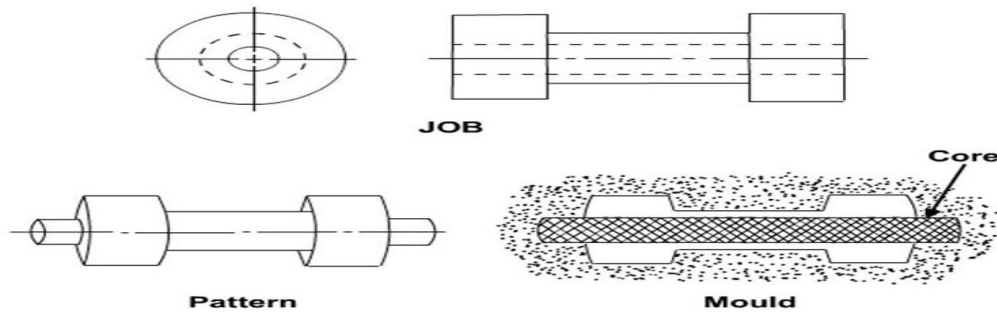
Before the withdrawal from the sand mold, the pattern is rapped all around the vertical faces to enlarge the mold cavity slightly, which facilitate its removal. Since it enlarges the final casting made, it is desirable that the original pattern dimension should be reduced to account for this increase.

Core and Core Prints:

Castings are often required to have holes, recesses, etc. of various sizes and shapes. These impressions can be obtained by using cores. So where coring is required, provision should be made to support the core inside the mold cavity. Core prints are used to serve this purpose. The core print is an added projection on the pattern and it forms a seat in the mold on which the sand core rests during pouring of the m old.

The core print must be of adequate size and shape so that it can support the weight of the core during the casting operation. Depending upon the requirement a core can be placed

horizontal, vertical and can be hanged inside the mold cavity. A typical job, its pattern and the mold cavity with core and core print is shown in Figure below.



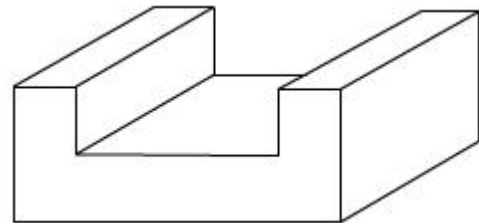
TYPES OF PATTERN

Patterns are of various types, each satisfying certain casting requirements

1. Single piece pattern
2. Split or two piece pattern
3. Match plate pattern

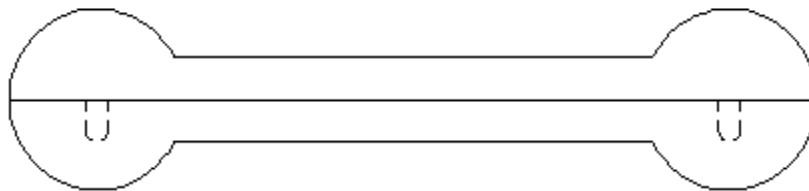
1. Single Piece Pattern:

It is simplest type of pattern which is made in single piece. It is used for simple objects. It is either placed into cope or in drag according to the simplicity of operation. It is used to cast stuffing box of steam engines.



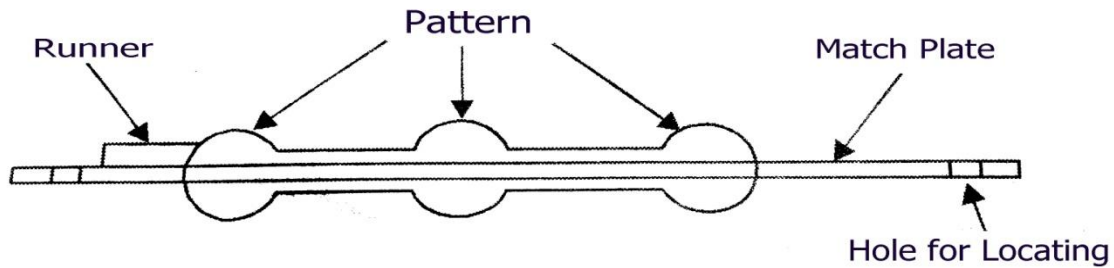
2. Split or Two Piece Pattern:

These patterns are made into two or more pieces. The first half of pattern placed into cope and other half into drag. It is used for complex objects where removal of single piece pattern from mould is impossible. When pattern is made in more than three parts cheeks are also used for easy removal.



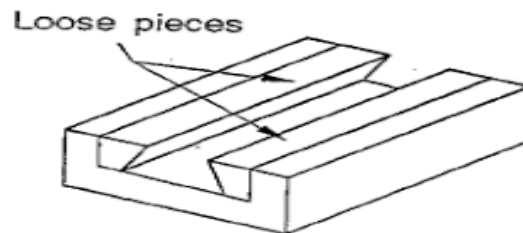
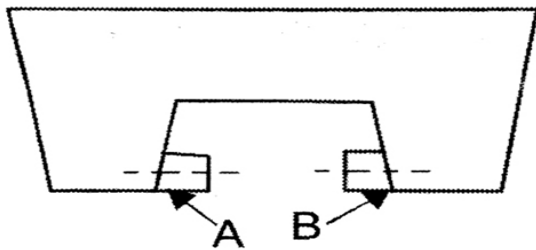
3. Match Plate Pattern:

Match plate pattern is a split pattern in which cope and drag section mounted on opposite sides of a plate. The plate is known as match plate. These will make easy to cast any shape with high production rate. Mostly runner, gates etc. are also mounted on same plate which will easy to mould making work. These patterns are used for mass production.



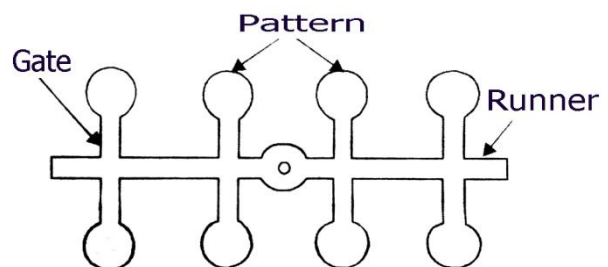
4. Loose Piece Pattern:

When removal of pattern is impossible due to an extended surface at either upper half or lower half, the extended part made as loose piece so this extended part can be removed first before removal of whole pattern. This will make easy removal of pattern without effect on the cavity. These patterns are known as loose piece pattern.



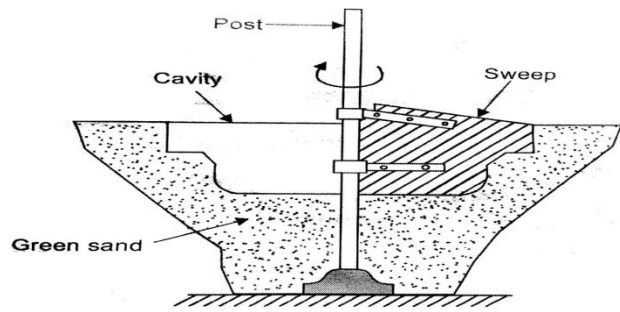
5. Gated Pattern:

These are simply more than one loose piece which are attached with a common gating system. These are used for mass production. It is used to produce small size cavities into one mould.



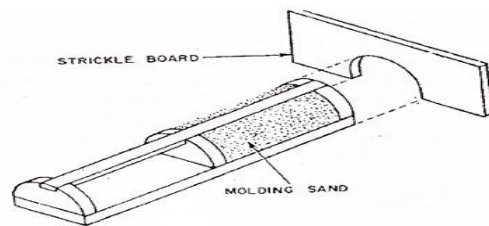
6. Sweep Pattern:

These patterns are used for large rotational symmetrical casting. A sweep is a section of large symmetrical object which is rotated along a edge into sand which make a large symmetrical mould. These patterns makes easy pattern making work of large objects.



7. Skeleton Pattern:

These patterns used for large simple castings. In these patterns, skeleton like structure made by using simple pattern sections. These will save both time and material.



BIS COLOR CODING FOR PATTERNS AND CORE BOXES:

Black Colour: The surfaces which are to be left unmachined are painted with black colour.

Red Colour: The surfaces which are to be machined are painted with Red colour.

Yellow Colour: The core prints and seats for loose core prints are painted with Yellow colour.

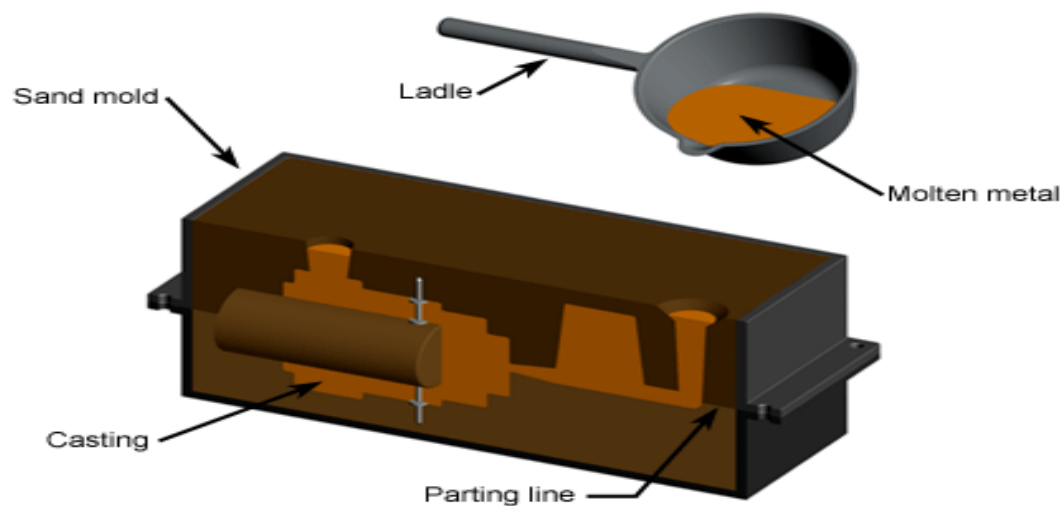
Yellow base with red strips: the seats for loose pieces are marked with red strips on yellow base.

Yellow base with black strips: the stop offs are indicated by diagonal black strips on yellow base.

No color: the parting surface is indicated by any color.

SAND MOULDING

- Sand molded casting, popularly known as sand casting, is a metal casting process in which sand is used as the mold material. A factory where sand casting is carried out is known as a **sand casting foundry**. Sand casting has been used for a long time and different foundries use different base sands for the process. Each one of the base sands has its own characteristics and benefits.
- Sand casting, the most widely used casting process, utilizes expendable sand molds to form complex metal parts that can be made of nearly any alloy.



- Sand casting is used to produce a wide variety of metal components with complex geometries. These parts can vary greatly in size and weight, ranging from a couple ounces to several tons. Some smaller sand cast parts include components as gears, pulleys, crankshafts, connecting rods, and propellers.
- Larger applications include housings for large equipment and heavy machine bases.
- Sand casting is also common in producing automobile components, such as engine blocks, engine manifolds, cylinder heads, and transmission cases.

TYPES OF BASE SANDS:

Here are the different types of base sands used for sand casting:

1. Silica Sand:

- One of the most commonly used base sands is silica sand. This sand can be easily found at the beach or river beds.
- Silica deposits tend to have varying degree of organic and mineral contaminants like limestone, magnesia, soda and potash that must be removed prior to use, otherwise which affect castings in numerous ways.
- Silica sand is available in plenty, less expensive and possess favorable properties that are essential to make a good casting.
- But it's high thermal expansion leads to 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) and saw dust etc, defects can be eliminated.

2. Olivine sand:

- Olivine sand is typically used in non-ferrous foundries.
- It offers high thermal conductivity and fusion points, and a low thermal expansion.
- Olivine sand is quite popular in Europe-based sand foundries.
- But the high cost restricts its wide use.

3. Chromite sand:

- One of the African expensive base sands used in foundries.
- Due to its superior thermal characteristics, it is generally used in steel foundries for both mould and core making.

4. Zircon sand:

- Zircon possesses most stable thermal properties of all the above discussed sands.
- The choice of 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 and Thorium which is hazardous in nature thereby restricting its use in foundries.

TYPES OF SAND MOULDS

The various types of moulding sand are

1. Green sand
2. Dry sand
3. Loam sand
4. Parting sand
5. Facing sand
6. Backing sand
7. System sand
8. Core sand

1. Green Sand

- Green sand is a mixture of silica sand and clay. It constitutes 18 % to 30 % clay and 6 % to 8 % water.
- The water and clay present is responsible for furnishing bonds for the green sand.
- It is slightly wet when squeezed with hand. It has the ability to retain the shape and impression given to it under pressure.
- It is easily available and has low cost.
- The mould which is prepared in this sand is called green sand mould.
- It is commonly used for producing ferrous and non-ferrous castings

2. Dry Sand

- After making the mould in green sand, when it is dried or baked is called dry sand.
- It is suitable for making large castings.
- The moulds which is prepared in dry sand is known as dry sand moulds.
- If we talk about the physical composition of the dry sand, than it is same as that of the green sand except water.

3. Loam Sand

- It is a type of moulding sand in which 50 % of clay is present.
- It is mixture of sand and clay and water is present in such a quantity, to make it a thin plastic paste.
- In loam moulding patterns are not used.
- It is used to produce large casting.

4. Parting Sand

- Parting sand is used to prevent the sticking of green sand to the pattern and also to allow the sand on the parting surface of the cope and drag to separate without clinging.
- It serves the same purpose as of parting dust.
- It is clean clay free silica sand.

5. Facing Sand

- The face of the mould is formed by facing sand.
- Facing sand is used directly next to the surface of the pattern and it comes in direct contact with the molten metal, when the molten metal is poured into the mould.
- It possesses high strength and refractoriness as it comes in contact with the molten metal.
- It is made of clay and silica sand without addition of any used sand.

6. Backing Sand

- Backing sand or flour sand is used to back up facing sand.
- Old and repeatedly used moulding sand is used for the backing purpose.
- It is also sometimes called black sand because of the addition of coal dust and burning when it comes in contact with the molten metal.

7. System Sand

- In mechanical sand preparation and handling units, facing sand is not used. The sand which is used is cleaned and reactivated by adding of water, binder and special additives. And the sand we get through this is called system sand.
- System sand is used to fill the whole flask in the mechanical foundries where machine moulding is employed.
- The mould made with this sand has high strength, permeability and refractoriness.

8. Core Sand

- The sand which is used to make core is called core sand.
- It is also called as oil sand.
- It is a mixture of silica sand and core oil. Core oil is mixture of linseed oil, resin, light mineral oil and other binding materials.
- For the sake of economy, pitch or flours and water may be used in making of large cores.

REQUIREMENTS/PROPERTIES OF MOULDING SAND:

The moulding is a process of making a cavity or mould out of sand by means of a pattern. The molten metal is poured into the moulds to produce casting.

1. Porosity or permeability: It is the property of sand which permits the steam and other gases to pass through the sand mould. The porosity of sand depends upon its grain size, grain shape, moisture and clay components are the moulding sand. If the sand is too fine, the porosity will be low.

2. Hot strength: As soon as the moisture is eliminated, the sand would reach at a high temperature when the metal in the mold is still in liquid state. The strength of the sand that is required to hold the shape of the cavity is called hot strength.

3. Plasticity: It is that property of sand due to which it flows to all portions of the moulding box or flask. The sand must have sufficient plasticity to produce a good mould.

4. Adhesiveness: It is that properties of sand due to it adheres or cling to the sides of the moulding box.

5. Cohesiveness: It is the property of sand due to which the sand grains stick together during ramming. It is defined as the strength of the moulding sand.

6. Refractoriness: The property which enables it to resist high temperature of the molten metal without breaking down or fusing.

7. Flowability: The property of the molding sand to flow and fill the narrow portions surrounding the pattern and the sand should have good flowability.

8. Surface finish: It should have the ability to produce good surface finish in the casting.

➤ **METHODS OF MOULDING:**

In general moulding methods can be classified in following six categories:

1. Floor Moulding
2. Bench Moulding
3. Pit Moulding
4. Machine Moulding.

1. Floor Molding: This type of molding is preferred for medium and large size jobs. In this method, only drag portion of molding flask is used to make the mold and the floor itself is utilized as drag and it is usually performed with dry sand.

2. Bench Molding: This type of molding is preferred for small jobs. The whole molding operation is carried out on a bench of convenient height. In this process, a minimum of two flasks, namely cope and drag molding flasks are necessary. But in certain cases, the number of flasks may increase depending upon the number of parting surfaces required.

3. Pit Molding:

In this method, the moulding is carried out in the pits and generally, very large moulds are made, the pit serving the purpose of flask. Generally, green sand is used in pit moulding but cement bonded sand sections may also be used. For large moulds, this is the only method of moulding and is quite slow and laborious.

4. Machine Moulding: The moulding is done by using a moulding machine, is called machine moulding. A moulding machine performs number of operations which does by moulder hands. The function of these machines is to pack the sand onto the pattern and draw the pattern out from the mould.

Some other operations performed by machine are ; ramming of sand, compressing the sand, forming the gate, forming the runner, drawing out the pattern without enlarging the mould cavity, etc. Machine moulding increases the production rate and productivity.

CLASSIFICATION BASED ON THE MOULD MATERIAL:

SAND MOLDING

Molding processes where a sand aggregate is used to make the mold produce by far the largest quantity of castings. Whatever the metal poured into sand molds, the product may be called a sand casting.

(a) GREEN-SAND MOLDING: Among the sand-casting processes, molding is most often done with green sand. Green molding sand may be defined as a plastic mixture of sand grains, clay, water, and other materials which can be used for molding and casting processes. The sand is called "green" because of the moisture present and is thus distinguished from dry sand.

Advantages are:

1. Great flexibility as a production process. Mechanical equipment can be utilized for performing molding and its allied operations. Furthermore, green sand can be reused many times by reconditioning it with water, clay, and ether materials. The molding process can be rapid and repetitive.

2. Usually, the most direct route from pattern to mold ready for pouring is by green –sand molding.
3. Economy, green sand molding is ordinarily the least costly method of molding.

Limitations in the use of green-sand molding are:

1. Some casting designs require the use of other casting processes. Thin, long projections of green sand in a mold cavity are washed away by the molten metal or may not even be moldable. Cooling fins on air-cooled-engine cylinder blocks and head are an example. Greater strength is then required of the mold.
2. Certain metals and some castings develop defects if poured into molds containing moisture.
3. The dimensional accuracy and surface finish of green-sand castings may not be adequate.
4. Large castings require greater mold strength and resistance to erosion than are available in green sands.

(b) DRY-SAND MOULDS:

- Dry-sand molds are actually made with molding sand in the green condition.
- The sand mixture is modified somewhat to favor good strength and other properties after the mold is dried.
- Dry-sand molding may be done the same way as green-sand molding on smaller sizes of castings.
- Usually, the mold-cavity surface is coated or sprayed with a mixture which, upon drying, imparts
- Greater hardness or refractoriness to the mold. The entire mold is then dried in an oven at 300 to
- 650 F or by circulating heated air through the mold. The time-consuming drying operation is one
- Inherent disadvantage of the dry-sand mold.

Advantages

1. Dry sand molds are generally stronger than green sand molds and therefore can withstand much additional handling.
2. Better dimension control than if they were molded in green sand.

3. The improved quality of the sand mixture due to the removal of moisture can result in a much smoother finish on the castings than if made in green sand molds. Where molds are properly washed and sprayed with refractory coatings, the casting finish is further improved.

Disadvantages

This type of molding is much more expensive than green sand molding and is not a high production process. Correct baking (drying) times are essential.

(c) SKIN-DRIED MOULDS:

The effect of a dry-sand mold may be partially obtained by drying the mold surface to some depth, 1/4 to 1 in. Skin drying may be performed by torches or electrical heating elements directed at the mold surface. Skin-dried molds must be poured shortly after drying, so that moisture from the undried sand will not penetrate the dried skin.

➤ BINDERS:

1. Binders are added to give cohesion to molding sands.
2. Binders provide strength to the molding sand and enable it to retain its shape as mold cavity.
3. Binders should be added in optimum quantity as they reduce refractoriness and permeability.
4. An optimal quantity of binders is needed, as further increases have no effect on properties of foundry sand.

The following binders are generally added to foundry sand:

- i. **Fireclay:** It is usually found near coal mines. For use in the foundry, the hard black lumps of fireclay are taken out, weathered and pulverized. Since the size of fireclay particles is nearly 400 times greater than the size of bentonite particles, they give poor bonding strength to foundry sand.
- ii. **Bentonite:** It is the most suitable material used in molding sands.
- iii. **Limonite and Kaolinite** are not commonly used as binders as they have comparatively low binding properties.

- iv. **Illite:** Illite is found in natural molding sands that are formed by the decomposition of micaceous materials due to weathering. Illite possesses moderate shrinkage and poor bonding strength than bentonite.

➤ **ADDITIVES**

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

(i) Coal dust

Coal dust is added mainly for producing a reducing atmosphere during casting. This reducing atmosphere results in any oxygen in the poles becoming chemically bound so that it cannot oxidize the metal.

(ii) Dextrin

Dextrin belongs to starch family of carbohydrates. It increases dry strength of the molds.

(iii) Pitch

It is distilled form of soft coal. It can be added from 0.02 % to 2% in mold and core sand. It enhances hot strengths, surface finish on mold surfaces.

(iv) Wood flour

This is a fibrous material mixed with a granular material like sand; its relatively long thin fibers prevent the sand grains from making contact with one another. It can be added from 0.05 % to 2% in mold and core sand. It increases collapsibility of both of mold and core.