PRODUCTION TECHNOLOGY

UNIT-I

MANUFACTURING PROCESSES - AN INTRODUCTION:

Manufacturing is an activity of making goods and articles by hand or machines at competitive price. The manufacturing also involves assembly of parts to make products. The quantity of articles made by hand in a given time is limited i.e., productivity of such activities (manual production} is smaller than the production carried out by machines.

Transformation of raw material into finished product can be carried out by different processes.
All the manufacturing processes can be grouped into two main categories.

1, Primary manufacturing processes, and
2. Secondary manufacturing processes.

Primary manufacturing processes are involved in changing the initial material into semi finished Products which are further processed to get final products with required size and shape. However, in certain cases, parts produced by primary processes need not required further processing, and can be used as final product.
Examples : Casting, rolling, forging and extrusion.

Secondary manufacturing processes are intended to obtain final products with accurate site, shape and desired surface finish, These processes take the products of primary processes and convert them into usable products with required specifications. All machining processes and few forming Processes (coining, drawing, sheet forming ate.) are examples of secondary manufacturing processes.

TYPES OF MANUFACTURING PROCESSES:

The primary object of manufacturing is to produce a component having desired geometry, Size and finish. The manufacturing processes {primary and secondary processes) can be classified as:
1. Casting (solidification process) - starting material is liquid.
2. Metal forming or metal working processes - starting material is solid which has sufficient plasticity.
3. Machining or metal cutting - starting material is a solid from which extra material is removed.
4. Powder metallurgy or particulate process - starting material is a powder. Powder is compacted into desired shape and heated (sintered).
5. Joining and assembly processes – Joining two or more parts in order to create a new product.
6. Surface treatment processes - intended to remove dirt, oil and other contaminants from surface.
Certain processes such as heat treatment or sintering are intended to improve the properties of work materials. These processes do not alter the shape of the products.

Metal Casting

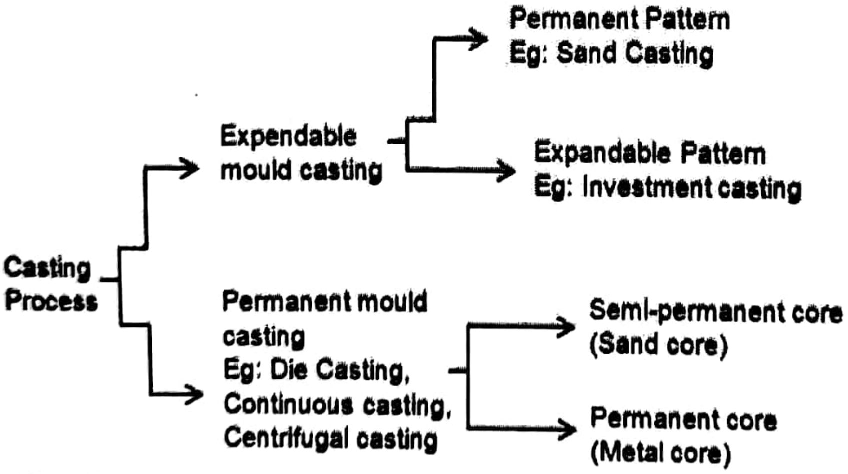
Casting:

The first traces of the Sand Moulding were found during 645 B.C. With technological advances, metal casting is playing a greater role in our everyday lives and is more essential than it has ever been.

Metal Casting is one of the oldest materials shaping methods known. Casting means pouring molten metal into a mold with a cavity of the shape to be made, and allowing it to solidify. When solidified, the desired metal object is taken out from the mold either by breaking the mold or taking the mold apart. The solidified object is called the casting. By this process, intricate parts can be given strength and rigidity frequently not obtainable by any other manufacturing process. The mold, into which the metal is poured, is made of some heat resisting material. Sand is most often used as it resists the high temperature of the molten metal. Permanent molds of metal can also be used to cast products

The casting processes can be broadly classified into

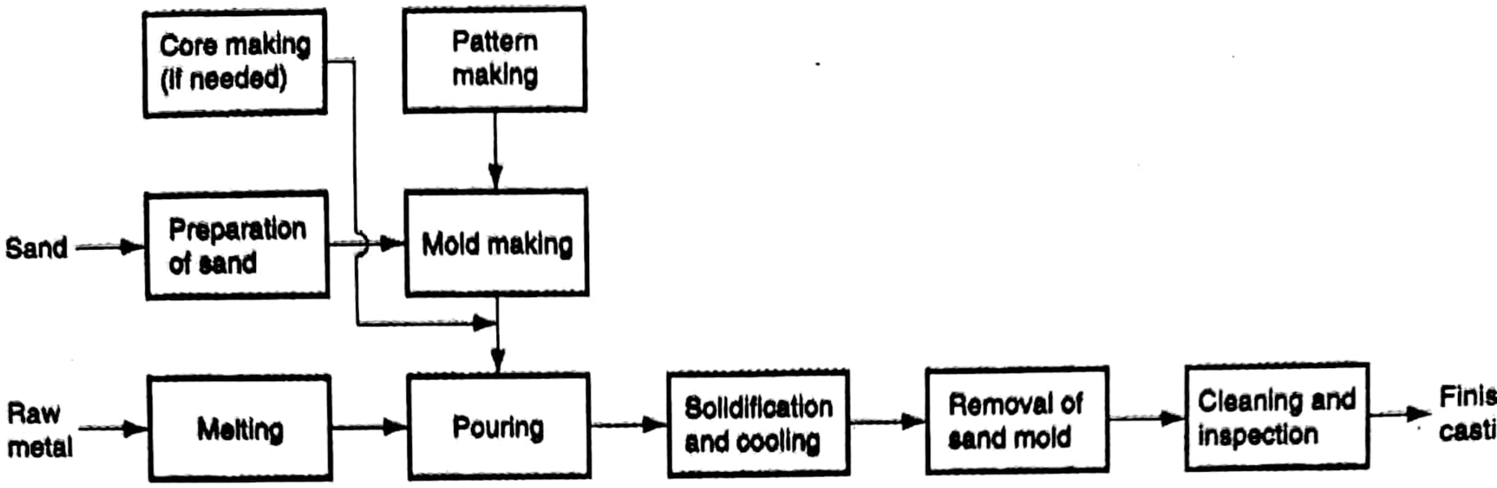
1. Expendable mold casting
2. Permanent mold casting



Expendable Mold Casting: Expendable mold casting is a generic classification that includes sand, plastic, shell, plaster, and investment (lost-wax technique) molds. All these methods use temporary, non-reusable molds. After the molten metal in the mold cavity solidifies, the mold is broken to take out the solidified cast. Expendable mold casting processes are suitable for very complex shaped parts and materials with high melting point temperature. However, the rate of production is often limited by the time to make mold rather than the casting itself. Following are a few examples of expendable mold casting processes.

Permanent Mold Casting processes: Permanent mold casting processes involve the use of metallic dies that are permanent in nature and can be used repeatedly. The metal molds are also called dies and provide superior surface finish and close tolerance than typical sand molds. The permanent mold casting processes broadly include pressure die casting, squeeze casting, centrifugal casting, and continuous casting.

Steps involved in making a casting



The basic steps in making sand castings are

(i) Pattern making
ii) Core making
(iii) Moulding
(iv) Melting and pouring
(v) Cleaning

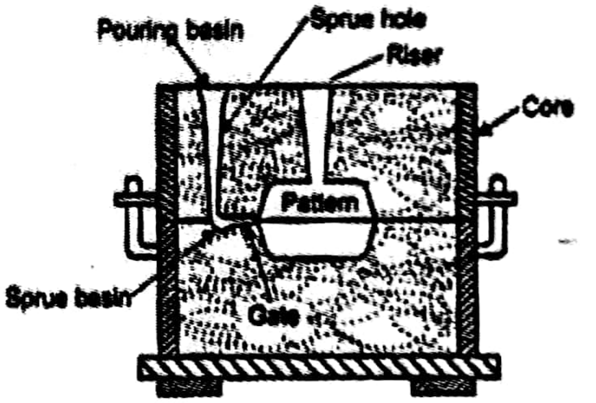


Fig.1.1 Method of sand casting

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

(ii) 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.

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

(iv) Melting and Pouring

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

Cleaning

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

Advantages of metal casting

The metal casting process is extensively used in manufacturing because of its many advantages.

1. Molten material can flow into very small sections so that intricate shapes can be made by this process. As a result, many other operations, such as machining, forging, and welding, can be minimized or eliminated.
2. It is possible to cast practically any material that is ferrous or non-ferrous..
3. As the metal can be placed exactly where it is required, large saving in weight can be achieved.
4. The necessary tools required for casting molds are very simple and inexpensive. As a result, for production of a small lot, it is the ideal process.
5. There are certain parts made from metals and alloys that can only be processed this way.
6. Size and weight of the product is not a limitation for the casting process.

Limitations

1. Dimensional accuracy and surface finish of the castings made by sand casting processes are a limitation to this technique. Many new casting processes have been developed which can take into consideration the aspects of dimensional accuracy and surface finish. Some of these processes are die casting process, investment casting process, vacuum-sealed molding process, and shell molding process.
2. The metal casting process is a labor intensive process

Pattern making

A pattern is the principal tool during the casting process. A pattern is a model or the replica of the object (to be casted). It is embedded in molding sand and suitable ramming of molding sand around the pattern is made. The pattern is then withdrawn for generating cavity (known as mold) in molding sand. Thus it is a mould forming tool.

Pattern is the model or the replica of the object to be cast. It may be defined as a model or form around which sand is packed to give rise to a cavity known as mold cavity in which when molten metal is poured, the result is the cast object. When this mould/cavity is filled with molten metal, molten metal solidifies and produces a casting (product). So the pattern is the replica of the casting. A pattern prepares a mold cavity for the purpose of making a casting. It may also possess projections known as core prints for producing extra recess in the mould for placement of core to produce hollowness in casting. It may help in establishing seat for placement of core at locating points on the mould in form of extra recess. It establishes the parting line and parting surfaces in the mold. It may help to position a core in case a part of mold cavity is made with cores, before the molding sand is rammed.

Pattern should have finished and smooth surfaces for reducing casting defects. Runner, gates and risers used for introducing and feeding molten metal to the mold cavity may sometimes form the parts of the pattern. It is the first step in casting is pattern making. The pattern is a made of suitable material and is used for making cavity called mould in molding sand or other suitable mould materials. When this mould is filled with molten metal and it is allowed to solidify, it forms a reproduction of the, pattern which is known as casting

FUNCTIONS OF A PATTERN

1. A Pattern prepares a mould cavity for the purpose of making a casting.
2. A Pattern possesses core prints which produces seats in form of extra recess for core placement in the mould.
3. It establishes the parting line and parting surfaces in the mould.
4. Runner, gates and riser may form a part of the pattern.
6. Properly constructed patterns minimize overall cost of the casting. Pattern may help in establishing locating pins on the mould and therefore on the casting with a purpose to check the casting dimensions.
7. Properly made pattern having finished and smooth surface reduce casting defects.

COMMON PATTERN MATERIALS

The common materials used for making patterns are wood, metal, plastic, plaster, wax or mercury.

1. Wood

Wood is the most popular and commonly used material for pattern making. It is cheap, easily available in abundance, repairable and easily fabricated in various forms using resin and glues. It is very light and can produce highly smooth surface. Wood can preserve its surface by application of a shellac coating for longer life of the pattern. But, in spite of its above qualities, it is susceptible to shrinkage and warpage and its life is short because of the reasons that it is highly affected by moisture of the molding sand. After some use it warps and wears out quickly as it is having less resistance to sand abrasion. It can not withstand rough handily and is weak in comparison to metal. In the light of above qualities, wooden patterns are preferred only when the numbers of castings to be produced are less. The main varieties of woods used in pattern-making are shisham, kail, deodar, teak and mahogany.

Advantages of wooden patterns

1. Wood can be easily worked.
2. It is light in weight.
3. It is easily available.
4. It is very cheap.
5. It is easy to join.
6. It is easy to obtain good surface finish.

7. Wooden laminated patterns are strong.
8. It can be easily repaired

Disadvantages

1. It is susceptible to moisture.
2. It tends to warp.
3. It wears out quickly due to sand abrasion.

It is weaker than metallic patterns.

2. Metals

Metallic patterns are preferred when the number of castings required is large enough to justify their use. These patterns are not much affected by moisture as wooden pattern. The wear and tear of this pattern is very less and hence posses longer life. Moreover, metal is easier to shape the pattern with good precision, surface finish and intricacy in shapes. It can withstand against corrosion and handling for longer period. It possesses excellent strength to weight ratio. The main disadvantages of metallic patterns are higher cost, higher weight and tendency of rusting. It is preferred for production of castings in large quantities with same pattern. The metals commonly used for pattern making are cast iron, brass and bronzes and aluminum alloys.

3. Plastics

Plastics are getting more popularity now a days because the patterns made of these materials are lighter, stronger, moisture and wear resistant, non sticky to molding sand, durable and they are not affected by the moisture of the molding sand. Moreover they impart very smooth surface finish on the pattern surface. These materials are somewhat fragile, less resistant to sudden loading and their section may need metal reinforcement. The plastics used for this purpose are thermosetting resins. Phenolic resin plastics are commonly used.

These are originally in liquid form and get solidified when heated to a specified temperature. To prepare a plastic pattern, a mould in two halves is prepared in plaster of paris with the help of a wooden pattern known as a master pattern. The phenolic resin is poured into the mould and the mould is subjected to heat. The resin solidifies giving the plastic pattern.

4. Plaster

This material belongs to gypsum family which can be easily cast and worked with wooden tools and preferable for producing highly intricate casting. The main advantages of plaster are that it has high compressive strength and is of high expansion setting type which compensate for the shrinkage allowance of the casting metal. Plaster of paris pattern can be prepared either by directly pouring the slurry of plaster and water in moulds prepared earlier from a master pattern or by sweeping it into desired shape or form by the sweep and strickle method. It is also preferred for production of small size intricate castings and making core boxes.

5. Wax

Patterns made from wax are excellent for investment casting process. The materials used are blends of several types of waxes, and other additives which act as polymerizing agents, stabilizers, etc. The commonly used waxes are paraffin wax, shellac wax, bees-wax, cerasin wax, and micro-crystalline wax.

Waxes use helps in imparting a high degree of surface finish and dimensional accuracy castings. Wax patterns are prepared by pouring heated wax into split moulds or a pair of dies. The dies after having been cooled down are parted off. Now the wax pattern is taken out and used for molding. Such patterns need not to be drawn out solid from the mould. After the mould is ready, the wax is poured out by heating the mould and keeping it upside down. Such patterns are generally used in the process of investment casting where accuracy is linked with intricacy of the cast object.

FACTORS EFFECTING SELECTION OF PATTERN MATERIAL

1. Number of castings to be produced. Metal pattern are preferred when castings are required large in number.
2. Type of mould material used.
3. Kind of molding process.
4. Method of molding (hand or machine).
5. Degree of dimensional accuracy and surface finish required.
6. Minimum thickness required.
7. Shape, complexity and size of casting.
8. Cost of pattern and chances of repeat orders of the pattern

Types of pattern

1. Single piece pattern (or) solid pattern

This is the simplest type of pattern, exactly like the desired casting. For making a mould, the pattern is accommodated either in cope or drag. Used for producing a few large castings, for example, stuffing box of steam engine. Refer Figure 1.2

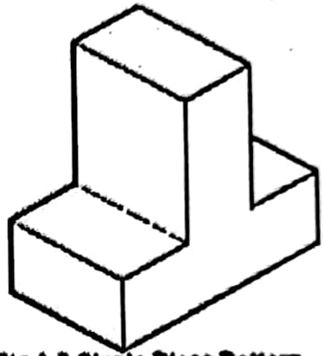


Fig.1.2 Single Piece Pattern
or
Solid Pattern

2. Split pattern or Cope and drag pattern

These patterns are split along the parting plane (which may be flat or irregular surface) to facilitate the extraction of the pattern out of the mould before the pouring operation.
The two part of the pattern are joined together with the help of dowel pins.
For a more complex casting, the pattern may be split in more than two parts. Refer Figure 1.3

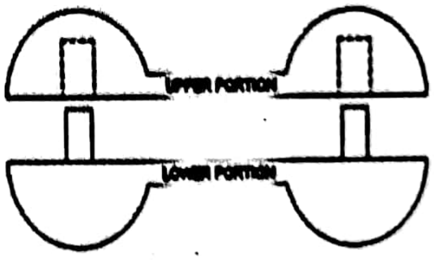


Fig.1.3 Split Pattern

3. Match Plate pattern

A match plate pattern is a split pattern having the cope and drags portions mounted on opposite sides of a plate (usually metallic), called the "match plate" that conforms to the contour of the parting surface. The gates and runners are also mounted on thematch plate, so that very little hand work is required. This results in higher

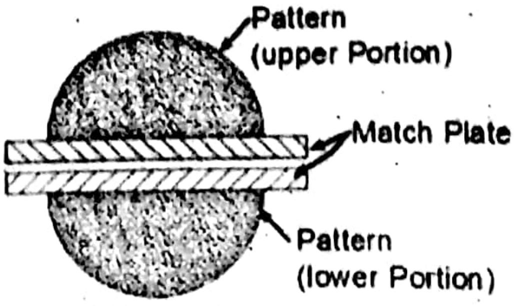


Fig.1.4 Match Plate Pattern

productivity. This type of pattern is used for a large number of castings. Several patterns are mounted on one match plate if the size of the casting is small. Generally match plate pattern are used for moulding by moulding machine. Piston rings of I.C. engines are produced by this process. Refer Figure 1.4

4. Loose piece pattern

When a one piece solid pattern has projections or back drafts which lie above or below the parting plane, it is impossible to with draw it from the mould. With such patterns, the projections are made with the help of loose pieces. A loose piece is attached to the main body of the pattern by a pin or with a dovetail slide. While moulding, the sand was rammed properly, then the loose piece was removed. One drawback of loose feces is **that their shifting is possible during ramming. Refer Figure 1.5**

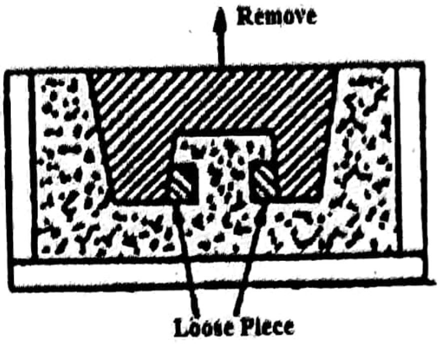


Fig. 1.5 Loose Piece Pattern

5. Gated pattern

A gated pattern is simply one or more loose patterns having attached gates and runners. Because of their higher cost, these patterns are used for producing small castings in mass production systems and on molding machines. Refer Figure 1.6

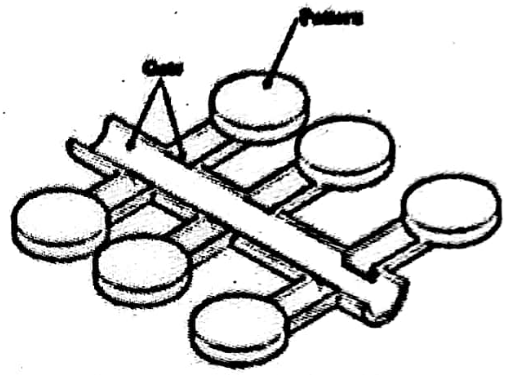


Fig. 1.6 Gated Pattern

6. Sweep pattern

A sweep is a section or board (wooden) of proper contour that is rotated about one edge to shape mould cavities having shapes of rotational symmetry. This type of pattern is used when a casting of large size is to be produced in a short time. Large kettles of C.I. are made by sweep patterns. Refer Figure 1.7

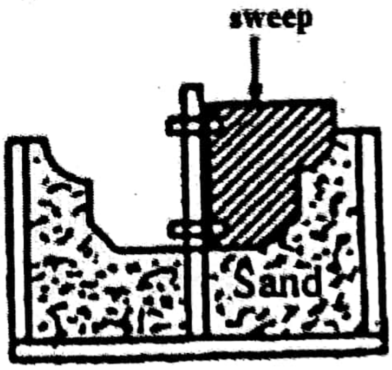


Fig.1.7 Sweep Pattern

7. Skeleton pattern

For large castings having simple geometrical shapes, skeleton patterns are used. Just like sweep patterns, these are simple wooden frames that outline the shape of the part to be cast and are also used as guides by the molder in the hand shaping of the mould. This type of pattern is also used in pit or floor molding process. Refer Figure 1.8

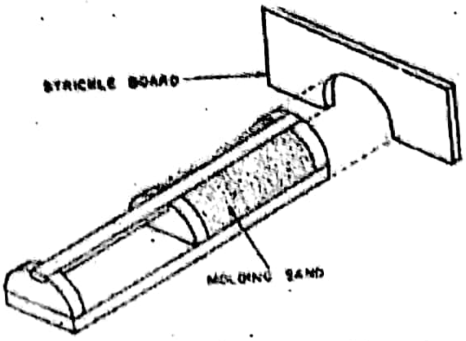


Fig. 1.8 Skeleton Pattern

8. Segmental pattern

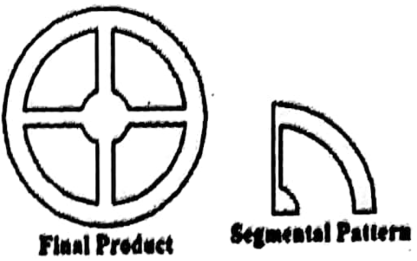


Fig.1.9 Segmental Pattern

Its function is similar to sweep pattern in the sense, that both employ a part of the pattern instead of a complete pattern, for getting the required shape of the mould. The segmental pattern is in the form of a segment, (refer figure 1.9) and is used for making moulding parts having circular shapes. To create the mould, it is rotated about the post in the same way as in sweep pattern, but it is not revolve continuously about the post to prepare the mould. Rather it prepares the mould by parts. When one portion of the mould is completed, the pattern is lifted up and moves to the next portion to make the next segment of the mould. This process is continued until the entire mould is completed. Example of product: Big gears and wheel rims (refer figure 1.9).

9. Shell pattern

It is a hollow pattern. The outer shape is used as mould, the core is placed inside the pattern, and hence it is also named as block pattern. This pattern is made of two half similar to split pattern but only for curved path, joined by dowel pin (refer figure 1.10. Example of product: curved drainage fitting.

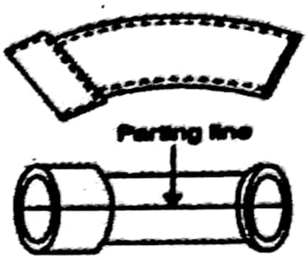


Fig.1.10 Shell Pattern

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

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.

The rate of contraction with temperature is dependent on the material. For example steel contracts to a higher degree compared to aluminum. To compensate the solid shrinkage, a shrink rule must be used in laying out the measurements for the pattern. A shrink rule for cast iron is 1/8 inch longer per foot than a standard rule. If a gear blank of 4 inch in diameter was planned to produce out of cast iron, the shrink rule in measuring it 4 inch would actually measure 4 -1/24 inch, thus compensating for the shrinkage. The various rate of contraction of various materials are given below

C.I., Malleable iron = 10 mm/m
Brass, Cu, Al = 15 mm/m
Steel = 20 mm/m
Zinc, Lead = 25 mm/m

2. Machining Allowance

In case the casting designed to be machined, they are cast over-sized in those dimensions shown in the finished working drawings. Where machining is done, the machined part is made extra thick which is called machining allowance.

Machining allowance is given due to the following reasons:

1. Castings get oxidized inside mould and during heat treatment. Scale thus formed requires to be removed.
2. For removing surface roughness, slag, dirt and other imperfections from the casting.
3. For obtaining exact dimensions on the casting.
4. To achieve desired surface finish on the casting.

The dimension of the pattern to be increased because of the extra metal required (i.e. finish or machining allowance) depends upon the following factors:

1. Method of machining used (turning, grinding, boring, etc.). Grinding removes lesser metal than turning.
2. Characteristics of metal (ferrous or non-ferrous, hard and easily machinable or soft). Ferrous metals get oxidised, aluminium does not.
3. Method of casting used. Centrifugal casting requires more allowance on the inner side. Die castings need little machining, sand castings require more.
4. Size and shape of the casting. For long castings, warpage is more and greater allowance is required. Thicker sections solidify late and impurities tend to collect there. This necessitates more machining allowance.
5. Degree of finish required. A higher degree of finishing requires more machining allowance.

The standard machining allowances for different metals and alloys are shown below

Material Cast	Overall length of external surface, cm			
	0 – 30	30 – 60	60 – 105	105 – 150
Al alloys	1.6	3.2	3.0	4.8
Brass, Bronze	1.6	3.2	3.0	4.8
Cast Iron	2.4	3.2	4.8	6.4
C.S	3.2	4.8	6.0	9.6

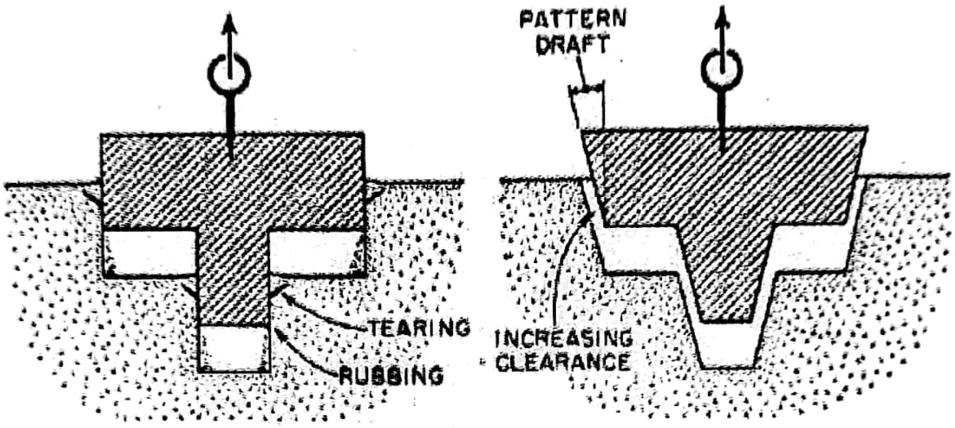
3. Draft Allowance or Taper Allowance

When a pattern is drawn from a mould, there is always a possibility of damaging the edges of the mould. Draft is taper made on the vertical faces of a pattern to make easier drawing of pattern out of the mould (Fig. 1.3). The draft is expressed in millimeters per metre on a side or in degrees.

The amount of draft needed depends upon (1) the shape of casting, (2) depth of casting, (3) moulding method, and (4) moulding material.

Generally, the size of draft is 5 to 30 mm per metre, or average 20 mm per metre. But draft made sufficiently large, if permissible, will make moulding easier. For precision castings, a draft of about 3 to 6 mm per metre is required.

Table shows different taper allowances used for different moulding methods.



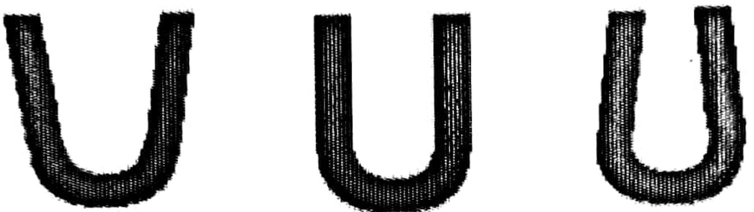
TAPER ALLOWANCES USED FOR DIFFERENT MOULDING METHODS.				
Height of Pattern mm	Shell Moulding	Sand Moulding		
		Metal	Wood	
		Machine drawn	Manual drawn	Machine drawn
Up to 20	0 45"	1 30"	3	3
20 to 50	0 30"		1 30"	1 30"
100 to 200	0 20"	0 30"	0 45"	0 45"

4.Rapping or Shaking Allowance

When the pattern is shaken for easy withdrawal, the mould cavity, hence the casting is slightly increased in size. In order to compensate for this increase, the pattern should be initially made slightly smaller. For small and medium sized castings, this allowance can be ignored. But for large sized and precision castings, however, shaking allowance is to be considered. The amount of this allowance is given based on previous experience.

5. Distortion or Camber Allowance

Sometimes castings, because of their size, shape and type of metal, tend to warp or distort during the cooling period depending on the cooling speed. This is due to the uneven shrinkage of different parts of the casting. Expecting the amount of warpage, a pattern may be made with allowance of warpage. It is called camber. For example, a U-shaped casting will be distorted during cooling with the legs diverging, instead of parallel (Fig. 1.4). For compensating this warpage, the pattern is made with the legs converged but, as the casting cools, the legs straighten and remain parallel.



Casting without camber
Actual casting
Pattern with camber allowance

TYPICAL DISTORTION ALLOWANCE.							
Length in MM		3000			6000		
Wall Thickness in MM		12	25	50	12	25	50
Distorsion allowance for depth, in MM	450	12	8	3	27	20	50
	600	7.5	5	2	18	12.5	5

CONSTRUCTION OF A PATTERN :

The pattern maker, before making patterns should study the blue print and he has to decide the way in which it can be handled. This consideration is important because the cost of moulding depends to a great extent on Proper construction of a pattern ; and better the Pattern, the better will be the castings.

The following factors should be considered while making a pattern
- Type of metal to be cast.
- Number of castings required to be produced.
- Method of moulding, and
- Pattern allowances.

The sequence of operations involved in pattern making are
1. Pattern layout, and
2, Shaping the pattern.

Pattern Layout:

One of the most important steps in the construction of (wooden) patter is an accurate layout. The reproduction of the blue print to a full size scale on suitable board (layout board) is called layout of a pattern. Pattern maker must be able to make full size layout drawing from the information contained in blue print. The core prints and other additional features of the pattern are to be included in the layout.

The following steps are common to all pattern layouts and should be followed for each new layout

1. Study the working drawing (blue print) and select a suitable layout board which can be accommodate a full-size drawings of at least two views (in most cases three views) of the required pattern,
2. Select a working face and plane a working edge straight; smooth and square with the face of the board. Plane a working end straight, smooth and square with both the faces and working edge. The working edge and end will serve as reference surfaces for making the layout.
3. Start the layout of a symmetrical pattern from centre line,
4. Select the proper contraction rule for making layout measurements.
5. Mark straight line with knife edge and circles {arcs} with divider
6. Colour the layout marks in black so that they may be readily seen and finishing marks in red for emphasis.
7. Preserve the layout until the pattern has been constructed and approved

Moulding material

In foundry, various types of materials are playing a vital role in the manufacturing of casting product.

These are grouped in to two categories: (1) Basic and (2) Auxiliary

Basic moulding materials includes silica sands, which forms the base and the various binders Auxiliary groups include various additives which impart desired properties to the moulding and core sand.

The essential constitutions of a moulding sand are: Silica sand, Binder, Additives and water

Silica sand is widely used moulding material. It has 80 to 90 % of silicon dioxide also gives refractoriness to the sand. A typical mixture by volume could be 89% sand, 4% water, 7% clay. Control of all aspects of the properties of sand is crucial.

It has the following advantages.

1. Cheap, plentiful and easily available
2. High softening temperature and thermal stability
3. Easily moulded, reusable and capable of giving good

Binder: In sand casting, the sand must contain some type of binder that acts to hold the sand particles together. Clay serves an essential purpose in the sand casting manufacturing process, as a binding agent to adhere the molding sand together. In manufacturing industry other agents may be used to bond the molding sand together in place of clay.

Additives: Additives impart to the moulding sand special properties (strength, thermal stability, permeability, refractoriness, thermal expansion etç....)

Sand: based on the amount of clayey content, they contain. The moulding sands are classified as follows:

1.Silica sand	Upto 2% clay
2.Lean or weak sand	2 to 10% clay
3.Moderately strong sand	10 to 20% clay
4.Strong sand	Upto 30% clay
5.Extra strong sand (loam sand)	Upto 50% clay

There are three types of sand

1. Natural sand
2. Synthetic sand
3. Chemically coated sand

Naturally Bonded- Naturally bonded sand is less expensive but it includes organic impurities that reduce the fusion temperature of the sand mixture for the casting, lower the binding strength, and require higher moisture content.

Synthetic Sand- Synthetic sand is mixed in a manufacturing lab starting with a pure (SiO_2) sand base. In this case, the composition can be controlled more accurately, which imparts the casting sand mixture with higher green strength, more permeability, and greater refractory strength. For these reasons, synthetic sand is mostly preferred in sand casting manufacture.

Chemically coated sand: clean silica grains are sometimes coated with a non-thermosetting hydrocarbon resin, which act as a binder. An additional binder in the form of clay can also be used. The advantage of this sand is that the carbon in the resin which is an excellent refractory surrounds the sand grains and does not allow the molten metal to reach the sand grains. This produces casting with clean surface as the sand does not get fused in them. The moisture content in this sand is kept to above 3%

Olivine Sand : This sand is complex mix of ortho-silicates of Iron and Magnesium (Mg_2SiO_4: Fosterite, Fe_2SiO_4:Fayalite). This is prepared from the mineral Dunite. Olivine sand does not contain free-silica. And hence does not react with basic metals.
It has a melting point of 1800°C.

Chromite Sand : It is a solid solution of complex metallic oxides having spinel structure. It has low silica content and exhibits very good thermal conductivity. In India availability of this sand is limited. In Odisha however, Chromite deposits are there. Chromite sand is produced by crushing Chromite ore.

Typical composition is: Cr_2O_3: 44%, Fe_2O_3: 28%, SiO_2: 2.5%, CaO: 0.5%, Al_2O_3+MgO: 25%

Zircon Sand: It is a combination of Zirconia (ZrO_2) 67% and Silica (SiO_2) 33%. The specific gravity is twice that of silica sand. It has a very high melting point of 2600 °C and a low coefficient of thermal expansion: 0.25% at 900 °C. Due to excellent quality and limited

availability, it costs six times that of Silica sand. Supply is restricted by BARC due to the use of zirconia in nuclear applications. In India it is available in the Quilon beaches of Kerala and Gopalpur beaches of Odisha.
Typical composition of Quilon sand is: ZrO_2: 66.25%, SiO_2: 30.96%, Al_2O_3: 1.92%, Fe_2O_3: 0.74%

Zircon sand is used as wash and facing sand in casting. It is also used in precision castings.

Chamotte Sand: These are obtained by calcining Al_2O_3-SiO_2 above 1100 °C. Chamotte sand has a melting point of 1750 °C and a coefficient of thermal expansion 0.5% at 900 °C. It has a very coarse grain size. Hence it is used in heavy castings (especially steel).

Moulding sand has maximum strength at maximum moisture content of 4% for lean sands and of 6 to 7 % for loam sands. A typical green sand moulding sand for gray iron moulding are given as below

Silica sand = 68 to 86%
Clay = 10 to 20%
Water = 3 to 6%
Additives = 1 to 6%

Binder:

In sand casting, binders are used to hold the sand particles together. There are two types" namely (1) organic binder and (2) inorganic binder. Among these two organic binders are mainly used for core baking.

Clay binders are the most common inorganic binders. Clay are formed by the weathering and decomposition of rocks. The common types of clay used in moulding sand are: Fireclay, Kaolinite, Illite and Bentonite. Kaolinite and Bentonite clays are most popular, because they have high thermochemical stability.

Fire-clay : It is a refractory clay usually found in the coal measures

Kaolinite : It is one of the decomposition products of the slow weathering of the granite and basalt (a kind of black rock). It is the main constituent of china fire clay. Its melting point is 1750 to 1787 C

Its general composition is $Al_2O_3\ 2SiO_2\ 2H_2O$

Illite : It is formed from the weathering of mica rocks. Its particle size is about the same as the kaolinite clay and has similar moulding properties

Its general composition is $K_2O\ Al_2O_3\ SiO_2\ H_2O$

Bentonite : It is formed from the weathering of volcanic or igneous rocks. It is creamy white powder. Its melting point is 1250 to 1300 C

Its general composition is $M_gO\ Al_2O_3\ SiO_2\ H_2O$

The basic constituent which gives refractoriness to a clay is alumina, Al_2O_3 of all clays, bentonite is the most commonly used clay. It needs smaller amount of water to obtain a given degree of plasticity.

Other binders can be: Portland cement and sodium silicate.

The percentage of binder in the moulding sand is of great importance. The bond must be strong enough to with stand the pressure of and erosion by the melt; however the bond must not destroy the permeability of the sand so that the gases present in the melt can be escape.

Organic binder: these binders are mostly used for making core. Cereals binders are obtained from wheat corn or rye. Resin, drying oil for example linseed oil, fish oil, soyabean oil, and some mineral oils: pitch and molasses

Additives:

Additives are added to the moulding sand to improve the properties like refractoriness, permeability and strength of the moulding sand. These are helps to give good surface finish. Additives are not for binding purpose. There are various additives to meet the good surface finish. They are:

Sea coal: It is also named as coal dust. It tends to obtained smoother and cleaner surfaces of casting and also reduces the adherence of sand particles to the casting. It also increases the strength of the moulding sand. It is added upto 8% and also improves the permeability of the moulding sand.

Saw dust: It improves the permeability and deformability of the mould and cores. It must be dry. Instead of saw dust, Peat (fertilizer) having 70-73% of volatile (i.e. explosive) substances, not over 5 - 6% ash and 25 - 30% moisture can also be used.

Cereals: It is finely ground corn flour or corn starch. It increases the strength of the moulding sand by 0.25 - 2%. It is added about 1% with the moulding sand.

Wood flour: About 1% is added. It is ground wood particles or other cellulose materials such as grain hulls. They serve the same purpose as cereals except that they do not increase strength as like cereals

Silica flour: It is very fine powder. It is generally mixed with about twice as much conventional moulding sand to make facing sand. It is applied around the pattern. Because of its purity, it improves the strength and surface finish. It also resists metal penetration and minimizes sand expansion defects.

Special additives:

Fuel oil : It improves the mouldability of the sand Iron oxide
: It develops hot strength.

Iron oxide : It develops hot strength.

Dextrin : It increases the toughness and collapsibility and prevents sand from rapid drying.

Molasses : It is the by - product of sugar industry. It imparts high dry strength and collapsibility to mould and cores.

Moulding sand:

There are various types of moulding sand:

1. **Green sand** : It is composed of a mixture of silica sand (68 - 86%), clay (16 - 30%) and water (5 - 8%). The word "green" is associated with the condition of wetness or freshness. Hence in named as green sand
2. **Dry sand** : It is basically green sand. But mixed with 1 to 2% of cereals and 1 to 2 % of peat are added additives with the green sand also dried at 110 to 260 C for several hours. It is used for making large casting. It has greater strength and rigidity.
3. **Facing sand** :This sand is directly cover the surface of the pattern and provides a smoother casting surface and should be of fine texture. It is made of silica sand and clay. The layer of the facing sand in the mould usually ranges from 25 to 50mm.
4. **Backing sand** : This is the sand which is used to back up the facing sand and to fill the whole volume of the flask. The old sand may be repeatedly used for this purpose.
5. **System sand** :In mechanized foundries, where machine moulding is employed a so called system sand is used to fill the whole flask. Because of this, the system sand must have the higher strength, permeability and refractoriness than the backing sand.
6. **Parting sand** : Parting sand is usually applied on the pattern surface, to avoid its sticking and permit its easy withdrawal from the mould, when the pattern is made of two half with cope and drag.

   Dry parting material : charcoal, limestone, groundnut shell, talc

   and calcium sulphate

   Wet parting material : wax based preparation, petroleum jelly mixed with oil, paraffin and stearic acid

7. **Loam sand** :It consists of fine sand plus finely ground refractoriness, clay, graphite and fibrous reinforcements. In this sand percentage of clay is in the order of 50%. It is used in pit moulding process for making mould for very heavy and large parts (engine body, machine tool bed and so on ....).

Moulding sand properties:

The quality of the casting product is mainly depends on the quality of the moulding sand.

AmMoulding sand must have the following requirements:

1. It should be able to retain and reproduce the details as imparted by the pattern.
2. It should be able to retain the bulk structure.
3. It should not be too much sticky either to the pattern or to the casting.
4. It should prevent reaction with the liquid metal.
5. It should let the casting cool at an optimum rate so as to develop desired microstructure.

To achieve the above requirement, the moulding sand must have the following properties

1. Permeability or porosity
2. Plasticity or flowability
3. Adhesiveness
4. Cohesiveness or strength
5. Refractoriness
6. Collapsibility

Permeability: During pouring and subsequent solidification of a casting, a large amount of gases and steam is generated. These gases are those that have been absorbed by the metal during melting, air absorbed from the atmosphere and the steam generated by the molding and core sand. If these gases are not allowed to escape from the mold, they would be entrapped inside the casting and cause casting defects. To overcome this problem the molding material must be porous. Proper venting of the mold also helps in escaping the gases that are generated inside the mold cavity.

Flowability: It is the measure of the moulding sand to flow around and over a pattern during ramming and to uniform fill the flask. This property may be enhanced by adding clay and water to the silica sand.

Adhesiveness: This is the property of the sand mixture to adhere to another body. The moulding sand should cling to the sides of the moulding boxes so that it does not fall out when the flasks are lifted and turned over. This property depends on the type and amount of binder used in the sand mix.

Cohesiveness: This is the property of the sand mixture such that all the sand particles stick to themselves. This causes proper compacting of moulding sand and increases strength.

Green Strength: The molding sand that contains moisture is termed as green sand. The green sand particles must have the ability to cling to each other to impart sufficient strength to the mold. The green sand must have enough strength so that the constructed mold retains its shape.

Dry Strength: When the molten metal is poured in the mold, the sand around the mold cavity is quickly converted into dry sand as the moisture in the sand evaporates due to the heat of the molten metal. At this stage the molding sand must possess the sufficient strength to retain the exact shape of the mold cavity and at the same time it must be able to withstand the metallostatic pressure of the liquid material.

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.

Refractoriness: It is the ability of the molding material to resist the temperature of the liquid metal to be poured so that it does not get fused with the metal. The refractoriness of the silica sand is highest.

Collapsibility: The molding sand should also have collapsibility so that during the contraction of the solidified casting it does not provide any resistance, which may result in cracks in the castings. Besides these specific properties the molding material should be cheap, reusable and should have good thermal conductivity.

SAND TESTING

1. Molding sand and core sand depend upon shape, size composition and distribution of sand grains, amount of clay, moisture and additives.
2. The increase in demand for good surface finish and higher accuracy in castings necessitates certainty in the quality of mold and core sands.
3. Sand testing often allows the use of less expensive local sands. It also ensures reliable sand mixing and enables a utilization of the inherent properties of molding sand.
4. Sand testing on delivery will immediately detect any variation from the standard quality, and adjustment of the sand mixture to specific requirements so that the casting defects can be minimized.

Generally the following tests are performed to judge the molding and casting characteristics of foundry sands:

1. Moisture content Test
2. Clay content Test
3. Fineness test
4. Refractoriness of sand
5. Strength Test
6. Permeability Test
7. Flowability Test
8. Mould hardness Test.

Moisture Content Test

The moisture content of the molding sand mixture may determine by difference in weight of moist sand and dry sand.

1. Measurement by evaporation method:

- Sample of moulding sand weighing about 20 to 50 grams are allowed to heat at a constant temperature up to 100°C in an oven for about one hour.

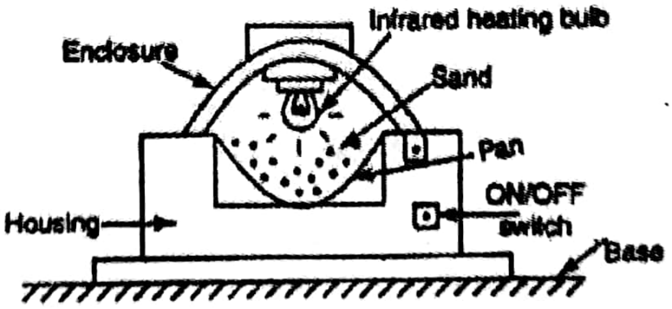


Fig.1.11 Evaporation method

- It is then cooled to a room temperature and then reweighing the molding sand.
- The moisture content in molding sand is thus evaporated.
- The loss in weight of molding sand due to loss of moisture, gives the amount of moisture which can be expressed as a percentage of the original sand sample.

2. Measurement by moisture teller method:

- Sample of moulding sand placed in teller pan having 600 mesh screens at bottom. Hot air allows blowing over the moulding sand about 3 – 6 minute, now the moisture present in the moulding sand is removed. Once the moisture is removed, weighing the sample and find the deviation in weight of sample before and after placing in the teller pan. This method was quite faster than the evaporation method.

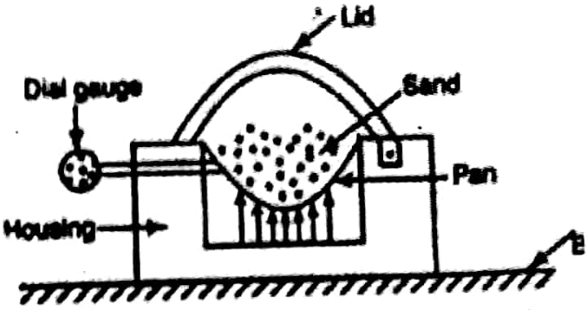


Fig.1.12 Moisture teller test

3. Measurement by moisture teller chemical reaction method:

- This is based on the principle that when water and calcium carbide react, they form acetylene gas which can be measured and this will be directly proportional to the moisture content.
- Sample of moulding sand is placed in teller pan along with calcium carbide (CaC_2). This reaction will produce C_2H_2

$$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$$

- The amount of C_2H_2 produced is directly proportional to the moisture content in the moulding sand.
- This instrument is provided with a pressure gauge calibrated to read directly the percentage of moisture present in the molding sand.

Clay Content Test

- The sample of molding sand weighing about 50 grams is mixed with water and 1% NaOH and allows stirring for 4-7 minute, and then waiting for 10-15 minute for sedimentation. Now the sand was settling down. The dirty water is present at the top portion of the pan
- The above process is repeated until to achieve clean water at the top portion of the pan. The water is drained off.
- The sand is dried and weighted. The loss of weight gives the clay content.

Refractoriness Test

- The refractoriness of the molding sand is judged by heating the A.F.S standard sand specimen to very high temperatures ranges depending upon the type of sand.
- The heated sand test pieces are cooled to room temperature and examined under a microscope for surface characteristics or by scratching it with a steel needle.
- If the silica sand grains remain sharply defined and easily give way to the needle. Sintering has not yet set in.
- In the actual experiment the sand specimen in a porcelain boat is placed into an electric furnace. It is usual practice to start the test from 1000°C and raise the temperature in steps of 100°C to 1300°C and in steps of 50° above 1300°C till sintering of the silica sand grains takes place.
- At each temperature level, it is kept for at least three minutes and then taken out from the oven for examination under a microscope for evaluating surface characteristics or by scratching it with a steel needle.

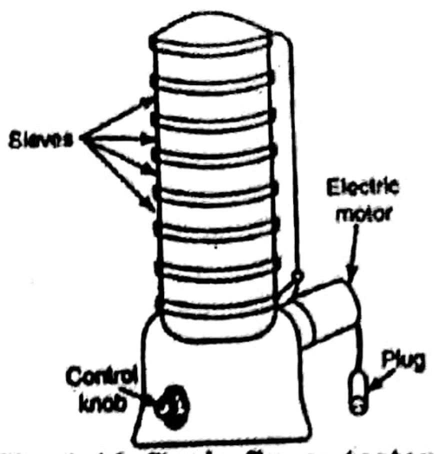


Fig. 1.13 Grain finess tester

Grain Fineness Test

- GFN is a measure of the average size of the particles (or grains) in a sand sample. The grain fineness of molding sand is measured using a test called sieve analysis.
- The test is carried out in power-driven shaker consisting of number of sieves fitted one over the other.

i. A representative sample of the sand is dried and weighed, then passed through a series of progressively finer sieves (screens) while they are agitated and tapped for a 15-minute test cycle. The series are placed in order of fineness from top to bottom.

ii. The sand retained on each sieve (grains that are too large to pass through) is then weighed and recorded.

iii. The weight retained on each sieve is carried out through calculations to get the AFS-GFN

Sieve Number	6	12	20	30	40	50	70	100	140	200	270	Pan
Weightage factor	3	5	10	20	30	40	50	70	100	140	200	300

- **Example: weight retained on each sieve is given as: 0.5, 1.0, 1.5, 2.0, 2.5, 4.5, 10, 15, 7.5, 3.5, 1.5, and 0.5**

Sieve Number	Retained sample (g)	Retained percentage (	Weightage factor ( )		
6	0.5	1	3	1.5	3
12	1.0	2	5	5.0	10
20	1.5	3	10	15.0	30
30	2.0	4	20	40	80
40	2.5	5	30	75	150
50	4.5	9	40	180	360
70	10	20	50	500	1000
100	15	30	70	1050	2100
140	7.5	15	100	750	1500
200	3.5	7	140	490	980
270	1.5	3	200	300	600
Pan	0.5	1	300	150	300
	Σ = 50	Σ = 100		Σ = 3556.5	Σ = 7113

Strength Test

- This is the strength of tempered sand expressed by its ability to hold a mold in shape. Sand molds are subjected to compressive, tensile, shearing, and bending stresses.
- The green compressive strength test and dry compressive strength is the most used test in the foundry.

Compression tests

a. A rammed specimen of tempered molding sand is produced that is 2 inches in diameter and 2 inches in height.
b. The rammed sample is then subjected to a load which is gradually increased until the sample breaks.
c. The point where the sample breaks is taken as the compression strength.

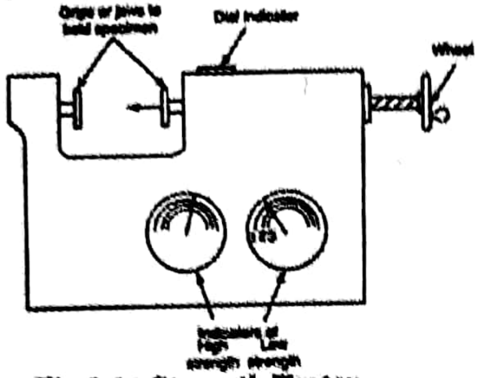
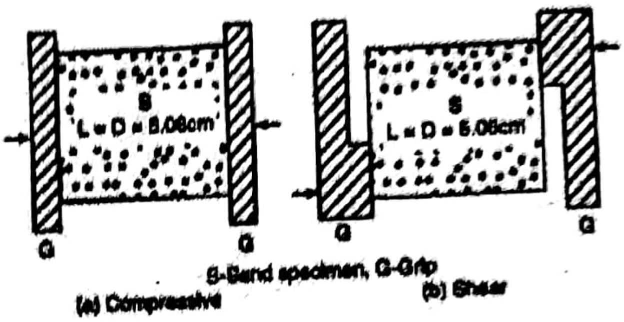


Fig.1.14 Strength Tester



(a) Compressive
(b) Shear

Fig.1.15

Shear tests

- The compressive loading system is modified to provide offset loading of the specimen.
- Under most conditions the results of shear
- tests have been shown to be closely related to those of compression tests, although the latter property increases proportionately more at high ramming densities.

- **Tensile test**
- A special waisted specimen is loaded in tension through a pair of grips.

Bending test

1. A plain rectangular specimen is supported on knife edges at the ends and centrally loaded to fracture.

Permeability Test

• Permeability of the moulding sand is determined by measuring the rate of flow of air through a compacted specimen under standard conditions. It is measured in terms of permeability number.
• A sample of moulding sand is placed in a tube. Time taken for 2000 CM^3 of air at a pressure of 10 g/cm^2 to pass through the specimen is noted
• Permeability meter consisting of the balanced tank, water tank, nozzle, adjusting lever, nose piece for fixing sand specimen and a manometer. The permeability is directly measured.
• Permeability number P is volume of air (in cm^3) passing through a sand specimen of 1 cm^2 cross-sectional area and 1 cm height, at a pressure difference of 1 gm/cm^2 in one minute.

$$P = \frac{Vh}{atp}$$

Where,

P = permeability

v = volume of air passing through the specimen in c.c. h = height of specimen in cm

p = pressure of air in gm/cm^2

a = cross-sectional area of the specimen in cm^2 t = time in minutes.

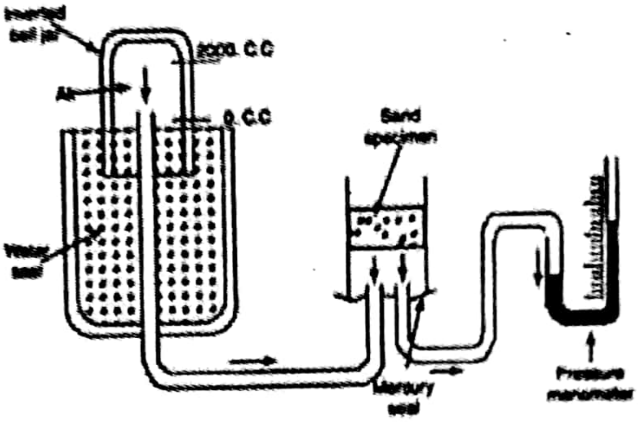


Fig. 1.16 Permeability Tester

Mold Hardness Test

- This test is performed by a mold hardness tester.
- The working of the tester is based on the principle of Brinell hardness testing machine.
- In an A.F.S. standard hardness tester a half inch diameter steel hemi-spherical ball is loaded with a spring load of 980 gm.
- This ball is made to penetrate into the mold sand or core sand surface.
- The penetration of the ball point into the mold surface is indicated on a dial in thousands of an inch.
- The dial is calibrated to read the hardness directly

i.e. a mold surface which offers no resistance to the steel ball would have zero hardness value and a mold which is more rigid and is capable of completely preventing the steel ball from penetrating would have a hardness value of 100.

The dial gauge of the hardness tester may provide direct readings

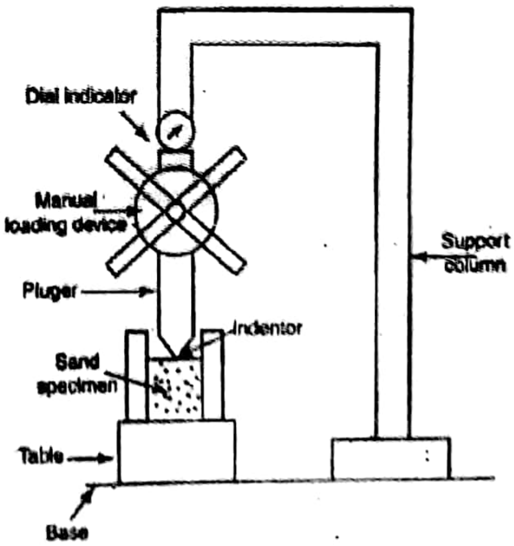


Fig. 1. 17 Mould Hardness Tester

Compatibility and flowability

- The compatibility test is widely accepted as both simple to perform and directly related to the behavior of sand in molding, particularly when involving squeeze compaction.
- A fixed volume of loose sand is compacted under standard conditions and the percentage reduction in volume represents the compatibility.

CORES

A core is a body made of refractory material, which is used for making cavity or a hole in casting. Its shape is similar to the required cavity in the casting. It is also used for making recess, projections, undercuts and internal cavities.

Core Print is a projection provided on the casting product. It forms a seat in the mould.

There are seven requirements for core:

1. Green Strength: In the green condition there must be adequate strength for handling.
2. In the hardened state it must be strong enough to handle the forces of casting; therefore the compression strength should be 100 to 300 psi.
3. Permeability must be very high to allow for the escape of gases.
4. Friability: As the casting or molding cools the core must be weak enough to break down as the material shrinks. Moreover, they must be easy to remove during shakeout.
5. Good refractoriness is required as the core is usually surrounded by hot metal during casting or molding.
6. A smooth surface finish.
7. Minimum generation of gases during metal pouring.

Purpose of cores:

1. It may form a part of green sand mould
2. Cores may be employed to improve the mould surface.
3. It helps to strengthen the mould.
4. Cores may be used to form the gating system of large size mould.
5. It acts as an internal cavity for hollow casting.

Core making material:

Core sand : It consists of refractory material such as silica sand, zircon, olivine, carbon and chamotte sand

Binder : Vegetable oil or mineral oil, core flour, resin water, fire clay bentonite, urea

Additives : Wood flour, coal powder, cow dung, straw and so on…

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Binder : Vegetable oil or mineral oil, core flour, resin water, fire clay bentonite, urea

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Core binder:

- To bind the sand grains together
- To give strength and hardness
- To prevent breaking
- To give collapsibility to core
- To prevent moisture absorption

Other binders:

Oil binders	:	1. It is commonly used binder. 2. Linseed is the example of this oil binder. 3. 0.5 to 3% is added depends on the hardness and other properties
Water soluble binder	:	1. Dextrin starch are example of water soluble binder 2. It gets hardened at 180 . Its mixing ratio is 1:8. 3. It gives green strength and edge hardness to the core
Resin binder	:	1. Phenol formaldehyde and urea are example for resin binder. 2. It gives hardness at 200 3. It gives good strength and short time to bake and less gas will be formed.
Inorganic binder	:	1. Fire clay, silica flour, kerosene etc...are the example; 2. They are used in the powder form. 3. It develops greater strength and gives smooth surface.

Types of core boxes

Half core box : It is used to form semicircular core (refer figure 1.18). After baking, if needed, the two core pieces will pasted together to form the complete core

Dump core box: This type is helpful for making complete core in polygon size like square, rectangle and so on.. (Refer figure 1.19)

Split core box: This is similar to half core box, but it has two half and it must connect by dowel pin on either side of box. After preparation, box are separated (Refer figure 1.20)

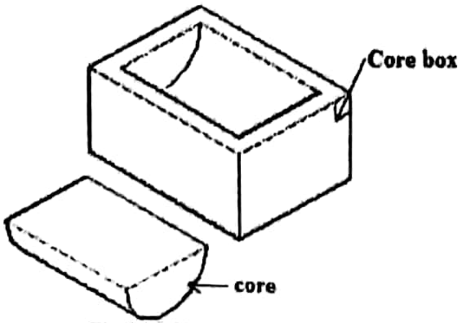


Fig.1.18 Half core box

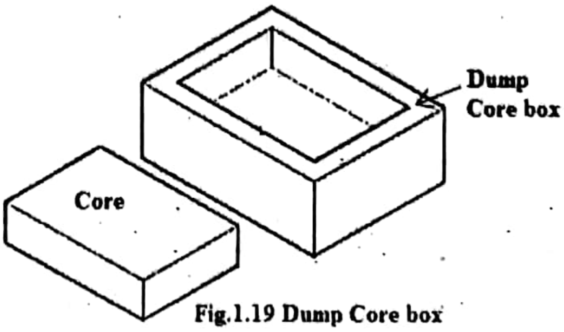


Fig.1.19 Dump Core box

Gang core box	:	During manufacturing, sometimes, we need an „n" number of cores. In that occasion, we can go for gang core box instead of any other single core box (Refer figure 1.21).
Left and right core box	:	For the preparation of curved core, the manufacturer can opt for left and right hand core box is best option for easiest preparation of core (Refer figure 1.22)
Strickle core box	:	To make an irregular shaped core, the strickle core box will fulfill the need of the manufacturer. Here, box will fill with required sand and rammed properly by using strickle board (Refer figure 1.23).

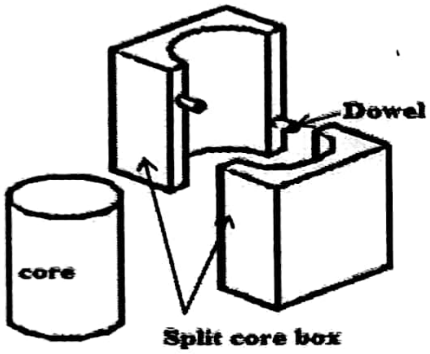


Fig. 1.20 Split core box

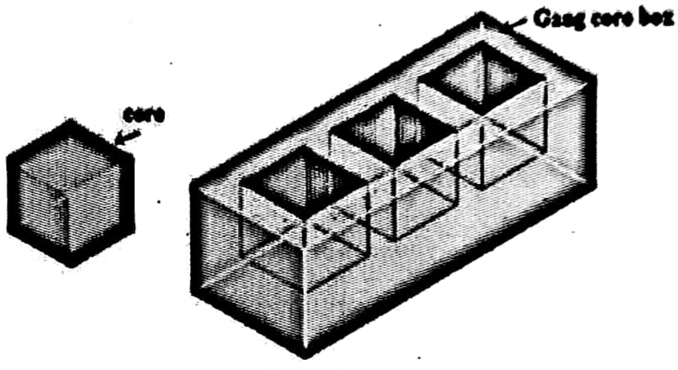


Fig. 1.21 Gang Core box

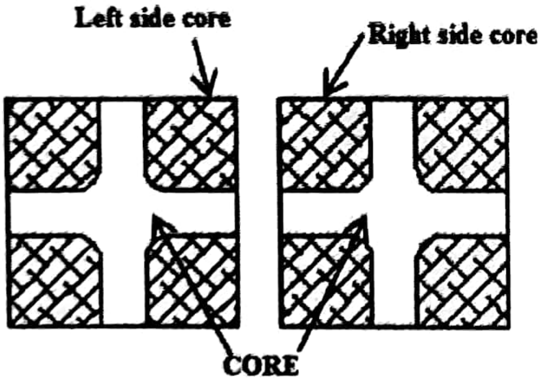


Fig.1.22 Left Hand and Right Hand core box

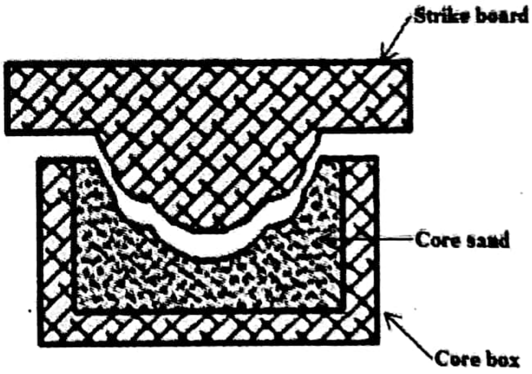
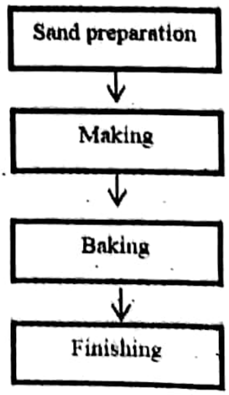


Fig. 1.23 Strike core box

Core making process:

The core may be manufactured either by manual or machine based on needed. The chart shown here are the important steps for making core.



Sand preparation:

Sands are mixed properly to meet the requirement with the help of any one of the following mechanical means.

1. Roller mills
2. Core sand mixer

a. Vertical revolving arm type.
b. Horizontal paddle type.

In the case of roller mills, the rolling action of the mullers along with the turning over action caused by the ploughs gives a uniform and homogeneous mixture.

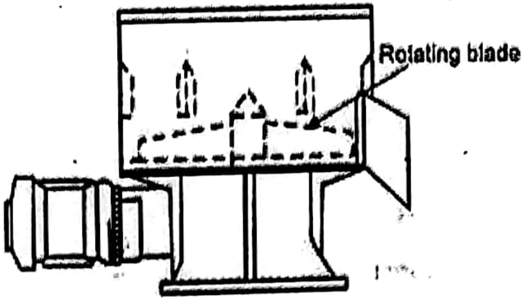


Fig.1.24 Core sand Mixer

Core making machine: It is broadly classified as follows.

- Core blowing machine
- Core ramming machine
- Core drawing machine
- Core extrusion machine

Core blowing machines:
The basic principle of core blowing consists of filling core sand into the core box by using the medium of compressed air. The velocity of the compressed air is kept high to obtain a *high* velocity of sand particles, thus ensuring their deposit in the remote comers of the core box. As the sand with high kinetic energy comes, the shaping and ramming is done simultaneously in the core box.

The core blowing machines can be classified into two basic groups.

- Small bench blowers
- Large floor blowers

Core ramming machines:
Cores can also be prepared by ramming core sands in the core boxes by machines based on the following principles.

- Jolting
- Squeezing
- Slinging

Out of these three, machines based on jolting and slinging are more commonly used for core making.

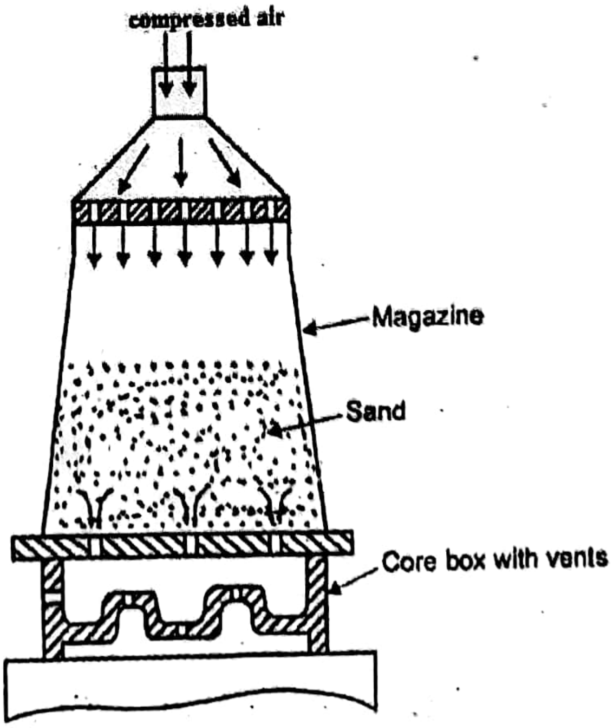


Fig.1.25 Core Blowing Machine

Core drawing machines:
The core drawing is preferred when the core boxes have deep draws. After ramming sand in it, the core box is placed

on a core plate supported on the machine bed.

A rapping action on the core box is produced by a vibrating vertical plate. This rapping action helps in drawing off the core box from the core. After rapping the box is raised leaving the core on the core plate.

Core extrusion machine:

Simple cores of regular shape uniform cross- section can be extruded easily on a core extrusion machine. Cores of square, round, hexagonal and over sections are produced made rapidly on a core extrusion machine. A core extrusion machine has a hopper through which the core sand is fed to a horizontal spiral conveyor (situated below the hopper). As the spiral conveyor is rotated. It forces core and through a die of specified shape (square, round, etc.). Long cores thus produced can be cut to the desired length.

Core baking

Cores are baked to remove the moisture and to develop the strength the strength of the binder in care ovens. The cores are dried in ovens equipped with drawers, shelves or other holding devices. They are dried in batches or continuously over moving shelves. The heat in oven is produced by burning oil or core or by electric resistance.

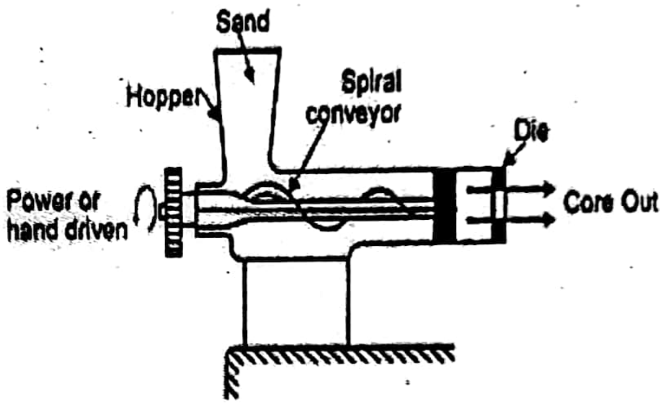


Fig.1.26 Core Extrusion Machine

The core drying time depends upon the quantity of moisture and binder used in the sand size of the core and temperature of the oven. According to the type of production, the core drying ovens or core baking ovens are classified as

- Batch type
- Continuous type
- Dielectrically heated type

Batch type ovens

These make use of portable racks. The racks loaded with cores are transported by lift trucks or mono-rail conveyors to the oven. Large cores are moved directly into the oven by rail. The racks are admitted into the oven either through two doors which swing open on hinges or through a single sliding door of counter balanced type.

Continuous type ovens

In this type oven the core racks move slowly through the oven on a continuous rail or chain. The loading and unloading are continuous. The baking time is controlled by the rate of travel of the conveyor.

The temperatures of the various parts of the oven and the conveyor speed are coordinated in such a way that the core comes out from the oven not only baked but also cooled. In some of the designs, for saving the floor space, the cores move vertically upwards through the oven and get baked. They get cooled on their return trip downwards

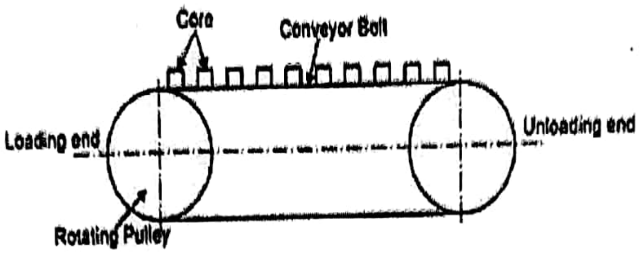


Fig.1.27 Continuous type oven

Dielectrically heated type

These are modem core ovens employed for high quality cores using plastic binders. The cores to be heated dielectrically are placed between the parallel plates or electrodes and a very high frequency current is passed. This high frequency current tends to deform the sand molecules. The sand molecules resist the deformation and required heating effect is produced. In core ovens proper temperature control is necessary for maintaining the most effective temperature.

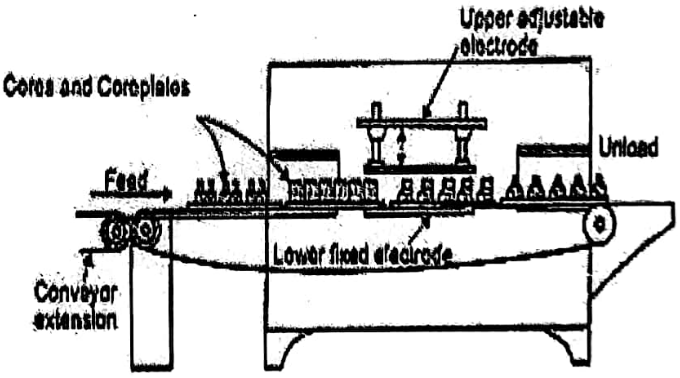


Fig.1.28 Di - electrically heated oven

Core finishing

After baking, the cores are given certain finishing operations before they are finally set in the mould. The fins, bumps or other sand projections are removed from the surface of the cores by rubbing or filing. The dimensional inspection of the cores is very necessary. Cores are also coated with refractory or protective materials to improve their refractoriness and surface finish.

TYPES OF CORES

There are many types of cores available. The selection of the correct type of core depends on production quantity, production rate, required precision, required surface finish, and the type of metal being used.

For example, certain metals are sensitive to gases that are given off by certain types of core sands; other metals have too low of a melting point to properly break down the binder for removal during the shakeout.

The cores as classified as follows.

a. According to the shape and position of the core
- Horizontal core
- Vertical core
- Hanging or cover core
- Balanced core
- Drop core or Stop off core
- Ram up core
- Kiss core

b. According to the State or condition of Core
- Green sand core
- Dry sand core
- Sodium silicate cores

c. According to the type of core-hardening process employed
- C02-process
- The hot box process
- The cold set process
- Fluid (or) Castable sand process
- Nishiyama process.
- Furan No-Bake system
- Oil-No-Bake Process

The horizontal and vertical cores are used in foundry work frequently. A horizontal core is placed horizontally in the mould. The ends of the core rest in the seats provided by core prints on the pattern.

A vertical core is placed vertically in the mould. The upper end of the core is forced in the cope and the lower end in the drag.

A balanced core is used when the casting has opening only on one side and only one core print is available on the pattern. It extends horizontally in the mould cavity.

A cover core extends vertically downwards. It is suspended from the top of the mould

A hanging core hangs from the top and does not have any support at the bottom in the drag.

A ram-up core is set in the mould with the pattern before ramming. It is used when the cored detail is located in an inaccessible position.

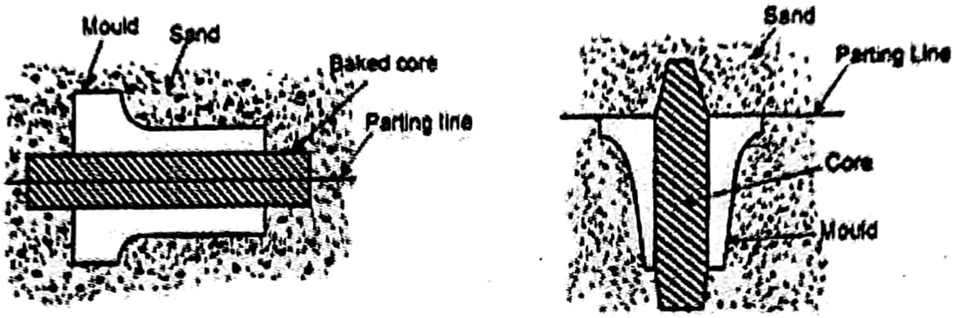
When the pattern is not provided with core prints and no seat is available for the core to rest, the core is held in position between the cope and drag simply due to the pressure of the cope. Such a core is known as 'Kiss core '.

Green sand cores

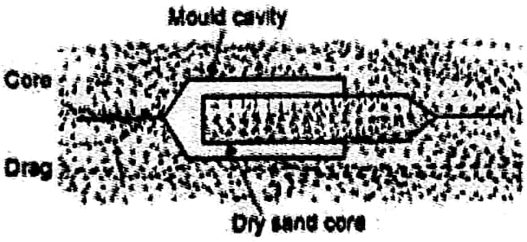
Green sand cores are formed by' the pattern itself. A green sand core is a part of the mould. It is made out of the same sand from which the rest of mould has been made.

Dry sand cores

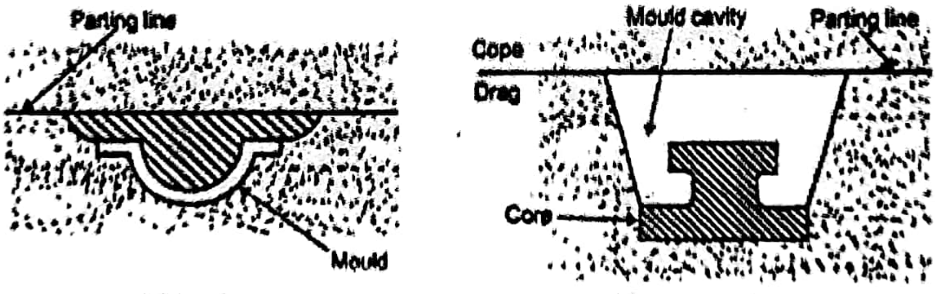
Dry sand cores, unlike green sand cores are not produced as a part of the moulding. Dry sand cores are made separately and independent of the mould. A dry sand core is made up of core sand which differs very much from the sand out of which differs very much from the sand out of which the mould is constructed.



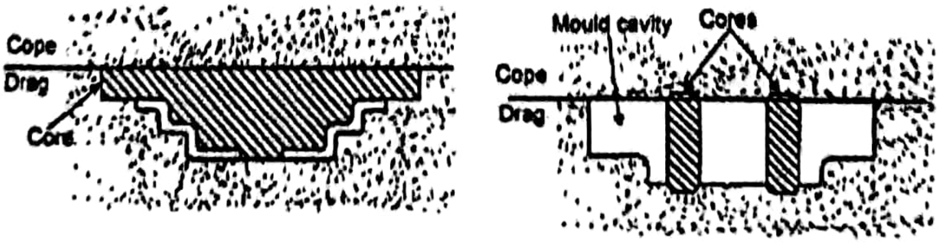
a) Horizontal core b) Vertical core



c) Horizontal core



d) Hanging core e) Ram-up core



f) Cover core e) Kiss core

Fig.1.29 Various types of cores

Oil bonded cores
Conventional sand cores produced by mixing silica sand with a small percentage of linseed oil. Oil bonded cores base themselves on the principle of the oxidation and polymerization of a combination of oils containing chemical additives which, when activated by an oxygen bearing material, set in a pre-determined time.

Resin-bonded cores
It is the type of cores phenol resin bonded sand is rammed in a core box. The core is removed from the core box and baked in a core oven at 375 to 450°F to harden the core.

Sodium Silicate and CO_2 cores
These cores use a core material consisting of clean, dry sand mixed with a solution of sodium silicate. The sand mixture is rammed into the core box. The rammed core while it is in the core box is gassed for several seconds with Carbon-di-Oxide gas. As a result a silica gel forms which binds sand grains into a strong, solid form

$$Na_2SiO_3 + CO_2 \rightarrow Na_2CO_3 + SiO_2 \text{ (Silica gel)}$$

The Hot box process
It uses heated core boxes for the production of cores. The core box is made up of cast iron, steel or aluminium and possesses vents and ejectors for removing core gases and stripping core form the core box respectively, Core box is heated from 350 to 500°F. Heated core boxes are employed for making shell cores dry resin bonded mixtures.

The cold set process
While mixing the core-sand, an accelerator is added to the binder. The sand mixture is very flowable and is easily rammed. Curing begins immediately with the addition of accelerator and continues until the core is strong to be removed from the core box. A little heating of the core hardens it completely. Cold set process is preferred for jobbing production. Cold set process is employed for making large cores.

Castable sand process
A setting or hardening agent such as Dicalcium silicate is added to sodium silicate at the time of core sand mixing. The sand mixture possesses high flowability and after being poured in the core box, it chemically hardens after a short interval of time.

Nishiyama process
Nishiyama process uses sodium silicate bonded sand, which is mixed with 2% finely powdered ferrosilicon, Hardening occurs because of exothermic reaction of silicon with NaOH produced bydrolysis in the solution of sodium silicate. Cores thus made possess short bench life.

Furan-no-bake system
The core sand mixture contains washed and dried sand with clay content less than 0.5% furan no-bake resin 2% and activator (phosphoric acid) 40%. The basic reaction between the furan resin and phosphoric acid results in an acid dehydration of the resin. The core sand mixture has high flowability and needs reduced rodding (to handle the core). Uniform core hardness, exact core dimensions, better fitting cores, lower machining and layout costs, and reduction of oven baking are some of the good characteristics of cores made by Furan-No-Bake system.

Oil-no-bake process

The process employs a synthetic oil-binder which when mixed with basic sands and activated chemically, produces cores that can be cured at room temperature.

Moulding process

The process of forming moulds is called moulding. It is an important operation involved in the casting. After preparing moulds at the moulding shop and making cores at the core room of the foundry, the next important operation is the assembly of moulds for pouring.

Moulding tools

Shovel

It is just like rectangular pan fitted with a handle. It is used for mixing the moulding sand and for moving it from one place to the other.

Riddle

It is used for removing foreign materials like nails, shot metal splinters of wood, etc., from the moulding

Rammer

It is a wooden tool used for ramming or packing the sand in the mould. Rammers are made in different shapes.

Strike-off bar

It is a cast iron or wrought iron bar with a true straight edge. It is used to remove the surplus sand from the mould after the ramming has been completed.

Vent wire

It is a mild steel wire used for making vents or openings in the mould.

Lifter

It is a metal piece used for patching deep section of the mould and removing loose sand from pockets of the mould.

Slick

Different types of slicks are used for repairing and finishing moulds.

Trowel

It contains of a flat and thick metal sheet with upwards projected handle at one end. It is used for making joints and finishing flat surfaces of a mould.

Swab

It is made of flax or hemp. It is used for applying water to the mould around the edge of the pattern.

Draw spike

It is a metal rod with a pointed or screwed end. It is used for removing the pattern from the mould.

Rawhide mallet

It is a mallet to loosen the pattern in the mould by striking slightly, so that it can be withdrawn without damaging the mould.

Gate cutter

It is a metal piece to the gate- the opening that connects tee sprue with the mould cavity.

Rapping plate (or) Lifting plate

It is used to facilitate shaking and lifting large pattern from the mould.

Spirit level

It is used to check that the sand bed, moulding box or table of moulding machine is horizontal.

Clamps

Clamps are used to hold the cope and drag of the complete mould together so that the cope may not float or rise when the molten metal is poured into the mould.

Gaggers (or) Lifters

These are iron rods bent at one or both ends. These are used to reinforce the moulding sand in the top portion of the moulding box and for supporting hanging sand.

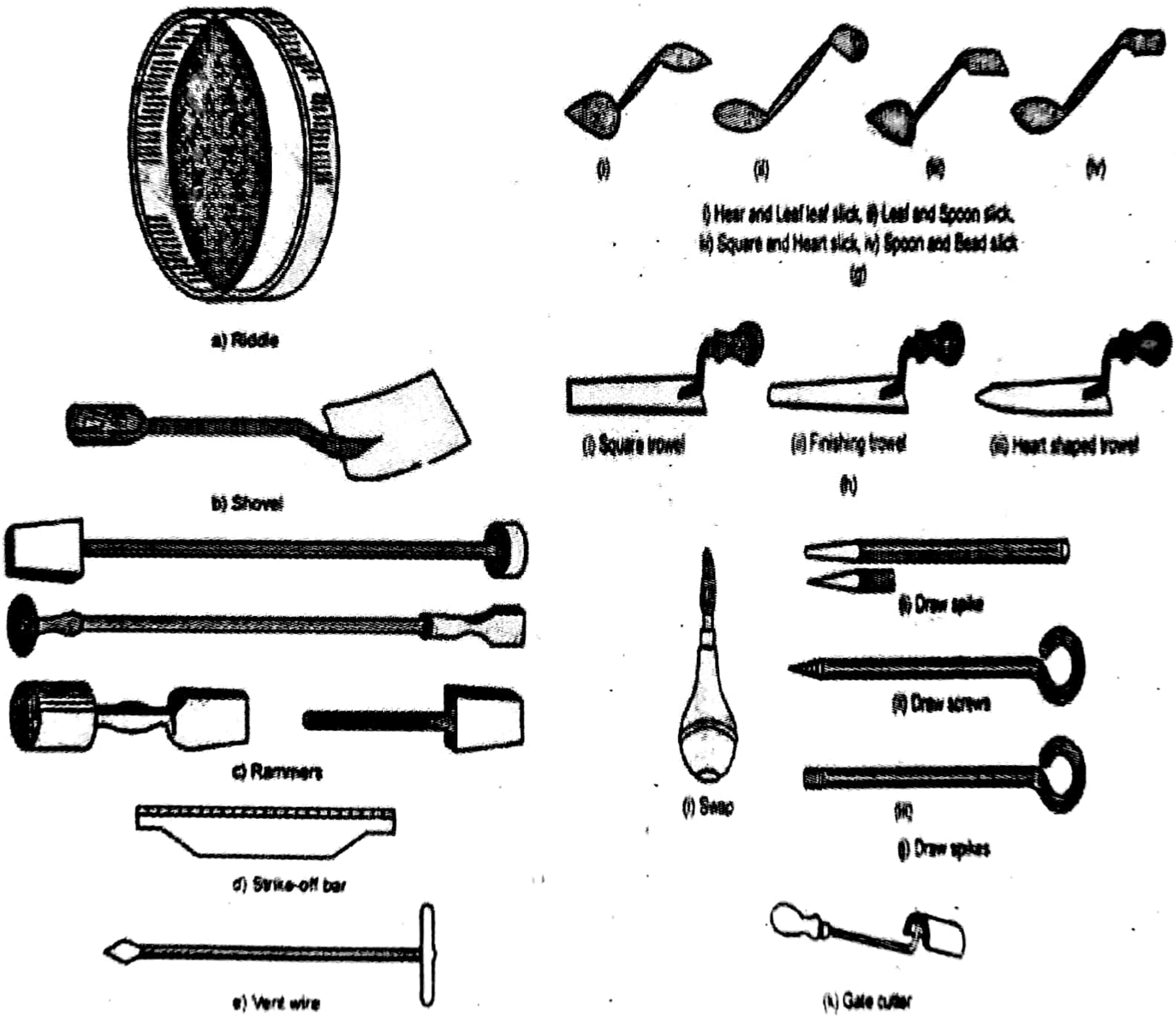
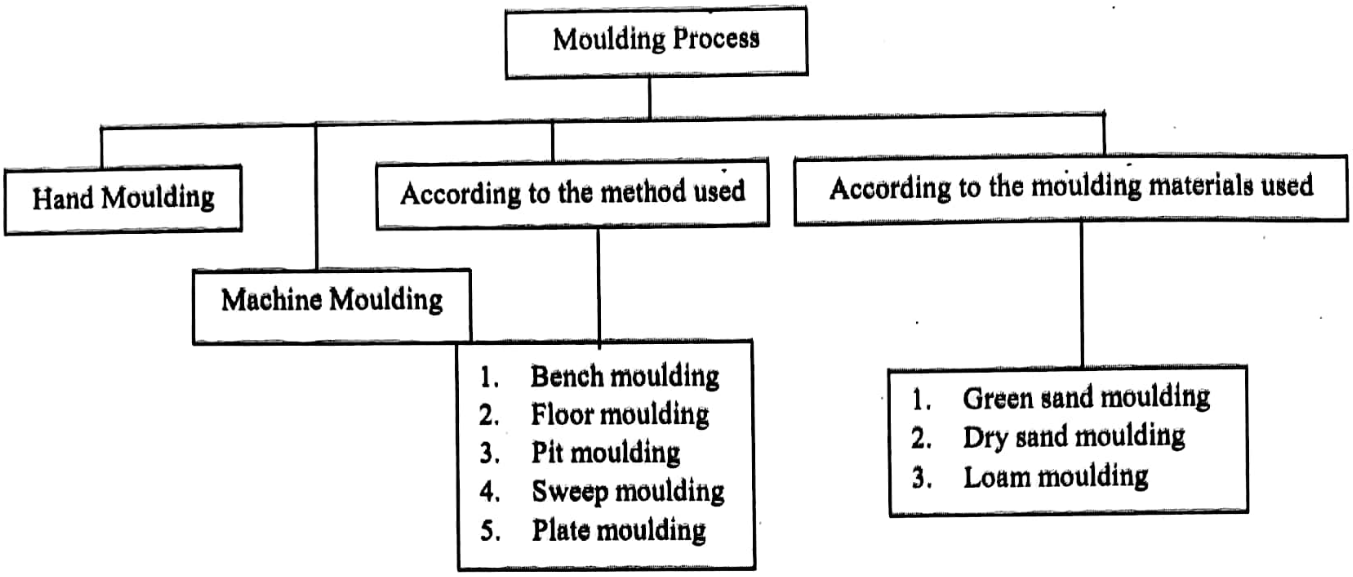


Fig. 1.30 Moulding Tools



Sand mould can be made either by manual or on moulding machine. Manual moulding is done for piece and for small lot production, whereas machine moulding is employed in large lot and mass production.

Based on the nature of work place, the manual moulding can be classified as

Bench Moulding : This is done only for small work

Floor Moulding : This process is done on the foundry floor and is employed for medium sized large casting

Pit Moulding : This method is used for very large casting and is done on the foundry floor. However, a pit dug in the floor acts as the lower flask(drag) and the upper flask (cope) is placed over the pit to complete the assembly

Machine moulding: All the operations are done by machine, and then it is called as machine moulding. The operations includes – compacting the sands, rolling the mould over and drawing the pattern from the mould and so on.....

GREEN SAND MOULDING

A green sand mould is composed of a mixture of sand (silica sand SiO_2), clay (act as binder), and water. The word green is associated with the condition of wetness or freshness and because the mould is left in the damp condition, hence the name "green sand mould". This type of mould is the cheapest and has the advantage that used sand is readily reclaimed. But the mould being in the damp condition, is weak and cannot be stored for a longer period. Hence such moulds are used for small and medium sized casting.

Principal Methods of Green-sand Moulding are:

- Open-sand method
- Bedded-in-method
- Turn-over method

(i)Open-sand Method
It is simplest form of green sand moulding, particularly suitable for solid patterns. For convenience in working and pouring, the entire mould is made in the foundry floor or in a bed of sand above floor level. Moulding box is not necessary and the upper surface of the mould is open to air. After proper levelling the pattern is pressed in the sand bed for making mould. Pouring basin is made at one end of the mould, and the overflow channel cut at the exact height from the bottom face of the mould for giving necessary thickness.

(ii)Bedded-in method

In this method, the pattern is hammered down or pressed to bed it into the sand of the foundry floor or in a drag filled partially with sand to form the mould cavity. The sand should be rammed close to the pattern sand; a cope is placed over the pattern. The cope is rammed up, runners and risers are cut and the cope box is lifted. Now the pattern is withdrawn, the surfaces of drag and cope replaced in its correct position for completing the mould.

iii) Turn-over method
One pattern-half is placed with its flat side on a moulding board, a drag is rammed and rolled over. The other pattern half and a cope box are placed in position. After ramming the cope is lifted off and the two pattern halves shaken and withdrawn. Now the cope is replaced on the drag for assembling the mould.

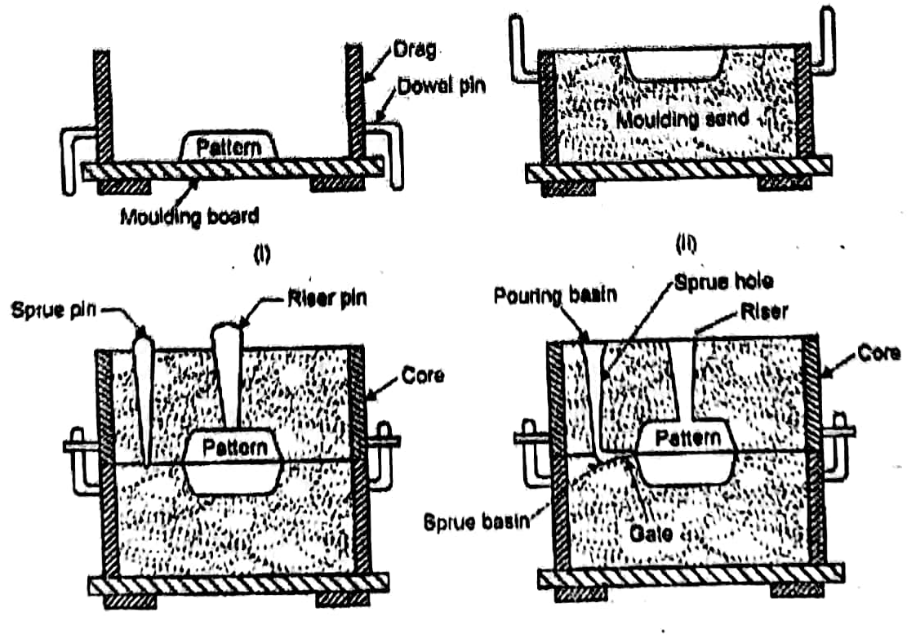


Fig. 1.31 Green sand Moulding Processes

Steps involved in Green sand moulding

1. First one half of the pattern is placed on the moulding board.
2. The drag is placed with the dowel pins down.
3. Moulding sand is filled in the moulding box to cover the pattern.
4. The drag is completely filled with sand up to the top and rammed by the peen end of the hand rammer.
5. Excess sand is levelled by a strike-off bar.
6. The drag is tilled upside down.
7. Parting sand is applied on the surface.
8. The other half of the pattern is how placed correctly on the already placed half
9. The cope is placed in position on the drag and aligned using dowel pins.
10. The sprue pin is placed vertically for the purpose of pouring the molten metal.
11. The risers are placed over the highest point of the pattern for the purpose of escaping the gases and identify the level of molten metal.
12. Again the moulding sand filled in the cope box, and rammed.
13. The riser and the sprue pin are removed.
14. The funnel shaped opening called a pouring basin is cut at the top of the sprue pinhole.
15. The cope is lifted, turned over and placed on the floor.
16. The pattern pieces are carefully removed.
17. The gate is cut that is connecting the sprue basin and the mould cluity.
18. The cope is placed carefully over the drag.
19. Pouring the molten metal.

Advantages

- Green sand moulds are softer than dry sand moulds. This allows greater freedom in construction when the castings solidify and cool.
- Green sand mou1ds are quite strong for small depths, as the gases escape from them.
- Green sand moulds do not require any backing operations or equipment, but dry sand cores are to be used.

Disadvantages

- The green sand moulds cannot be stored for long time.
- The green sand moulds are not so strong as other moulds are liable to be damaged during handling or pouring.
- The surface finish of the casting obtained from green sand mould is not very smooth.
- The green sand mould lacks permeability and strength, which causes certain defects like blow holes etc.

Moulding machine.

Moulding processes may be classified as hand moulding or machine moulding according to whether the mould is prepared by hand tools or with the aid of some moulding machine. Hand moulding is generally found to be ecoomical when the castings are required in a small number.

The main advantages of machine moulding are as follows.

- ☐ When the number of castings is substantial, the additional cost of metallic patterns and other equipment is compensated by the high rate of production, and the overall cost per piece works out lower than in the case of hand moulding.
- ☐ It affords great saving in time, especially when a large number of similar castings in small sizes are required.
- ☐ A semi-skilled worker can do the machine job whereas hand moulding requires skilled craftsmanship.
- ☐ The castings obtained are more uniform in size and shape and more accurate than those obtained by hand moulding due to steadier lift of the pattern.

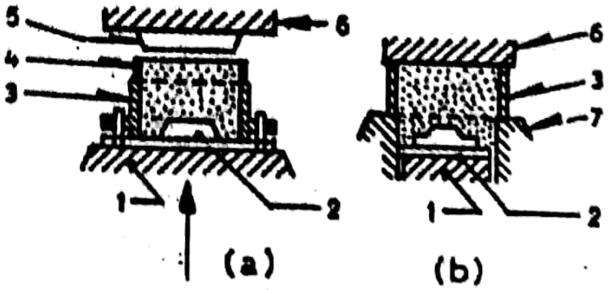
Squeezing machine

A squeeze machine is very useful for shallow patterns. A squeezer (squeeze head), plate or presser board slides inside the flask to compress the sand above and around the pattern. For squeezing action the squeeze piston may by forced upward, pushing the flask up against the squeezer or presser board the presser board being forced into the flask

The sand is rammed harder at the back of the mould and softer on the pattern face. In other words sand has greatest density at the surface where pressure is applied to sand and sand density decreases progressively towards the pattern.

Moulding force (M_f) = $P\left(\frac{\pi}{4}d^2\right) - W$

Where, P - Pressure in squeeze cylinder d - Piston diameter
W - Weight of flask pattern and sand



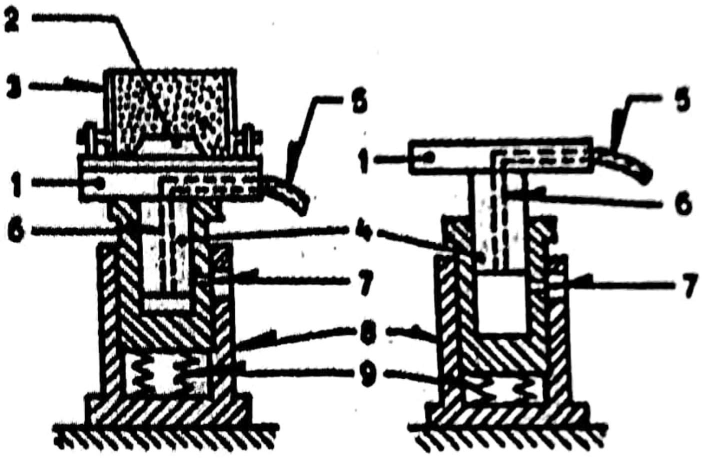
1) Table 2) Pattern 3) Flask 4) Sand Frame
5) Platen 6) Squeezer head 7) Frame

(a) Top Squeezer Machine (b) Bottom Squeezer machine

Fig.1.33 Squeeze moulding machine

JOLT MACHINE

In jolt machine, the pattern and flask are mounted in the mould plate and the flask is filled with sand. The entire assembly is raised a small amount by means of an air cylinder and is then dropped against a fixed stop. The compacting of sand is achieved by the decelerating forces acting on it. The working of a jolt moulding machine is shown in figure. The table with moulding sand is lifted by plunger to a definite height, when compressed air is admitted through pipe and channel. Next the table drops since the air is released through pipe. In falling, the table strikes the stationary guiding cylinder and this impact packs the moulding sand in the flask. Springs by cushioning the table blows, reduced noise and prevent destruction of the mechanism and the foundation. About 20 to 50 drops are needed to compact the sand and the average machine operates at about 200 strokes per minute.



1) Table 2) Pattern 3) Moulding box
4) Plunger 5) Pipe 6) Channel
7) Through hole 8) Cylinder 9) Spring

Fig. 1.34 Jolt Moulding Machine

SAND SLINGER

The sand slinger consists of a base, a sand bin, a bucket elevator, a swinging or movable arm, a belt conveyor and the sand impeller.

Prepared sand lying in the sand bin is picked up by the elevator buckets and is dropped on to the belt conveyor which takes the same to the impeller head. Inside the impeller head, rapidly rotating cup shaped blade picks up the sand and throws it downward into the moulding box as a continuous stream of sand with machine gun rapidity and great force. The sand is discharged into the moulding box at a rate of300 to 2000kg/minute.

This force is great enough

to ram the mould satisfactorily. In moulding boxes, sand is filled and rammed at the same time. The density of sand which is the result of sand's inertia is uniform throughout the mould.

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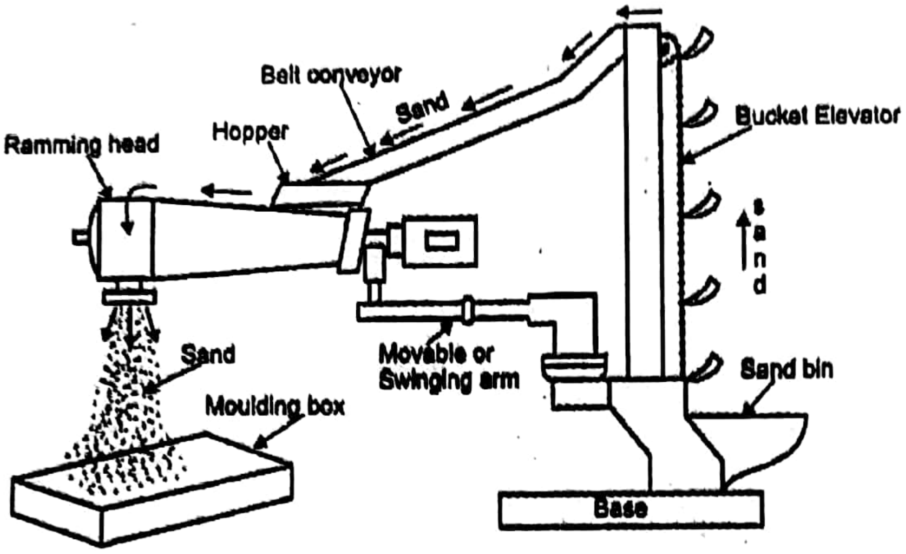

Fig. 1.35 Sand Slinger Machine