5. Molding and Core sands

Types of molding sand, Ingredients of molding sand and properties. Core sand, ingredients and properties. Core making, core blowing machines.

Types of molding sand:

- Molding sands may be classified according to their use into a number of varieties, as given below:
  - Green sand
  - Dry sand
  - Loam sand
  - Facing sand
  - System sand
  - Parting sand and
  - Core sand

Green sand:

- By green sand we denote sand in its natural, more or less moist state.
- It is a mixture of silica sand with 18 to 30 percent clay, having a total water of from 6 to 8 percent.
- The clay and water furnish the bond for green sand.
- It is fine, soft, light and porous.
- Being dampened, it retains the shape, the impression given to it under pressure when squeezed in the hand.
- Molds prepared in this sand are known as green sand molds.

Dry sand:

- Green sand that has been dried or baked after the mold is made is called dry sand.
- These are suitable for large castings.
- Molds prepared in this sand are known as dry sand molds.

Loam sand:

- It has high clay content, as much as 50 percent and dries hard.
- This is particularly employed for loam molding usually for large castings.
Facing sand:

- It forms the face of the mold.
- It is used directly next to the surface of the pattern and it comes into contact with the molten metal when the mold is poured.
- It must possess high strength and refractoriness.
- It is made of silica sand and clay, without the addition of used sand.
- Different forms of carbon are used to prevent the metal from burning into the sand.
- The layer of molding sand usually ranges from 20 to 30 mm.
- It is about 10 to 15 percent of the whole molding sand used in the foundry.
- A facing sand for green sand molding of cast iron may consist of 25 percent fresh and specially prepared sand, 70 percent old sand, and 5 percent sea coal.

Backing sand or floor sand:

- It is used to back up the facing sand and to fill the whole volume of the flask.
- Old, repeatedly used molding sand is mainly employed.
- It is sometimes called black sand because of the fact that old, repeatedly used molding sand is black in color due to the addition of coal dust and burning on coming in contact with molten metal.

System sand:

- The sand used to fill the whole flask in machine molding is called system sand.
- In mechanical sand preparation and handling units, no facing sand is used, the used sand is cleaned and reactivated by the addition of water binders and special additives is known as system sand.
- As the whole mold is made of this system sand, the strength, permeability and refractoriness of the sand must be higher than those of backing sand.

Parting sand:

- It is used to keep the green sand from sticking to the pattern and
- Also to allow the sand on the parting surface of the cope and drag to separate without clinging
- It is clean clay-free silica sand, which serves the same purpose as parting dust.

Core sand:

- It is used for making cores and sometimes called oil sand.
- This is silica sand mixed with core oil composed of linseed oil, resin, light mineral oil and other binding materials.
Pitch or flours and water may be used in large cores for the sake of economy.

Molding sand properties:

The properties that are generally required in molding materials are:

1. 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.
   - Sands with poor refractoriness may burn on to the casting.
   - It is measured by the sinter point of the sand rather than its melting point.

2. Permeability or porosity:
   - 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.

3. 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.

4. 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.
5. 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.

6. 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.

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.

9. Reclamation:
   - It should be reclaimed and reused.

Besides these specific properties the molding material should be cheap, reusable and should have good thermal conductivity.

**Molding Sand Composition:**

The main ingredients of any molding sand are:

1. Base sand,
2. Binder, and
3. Moisture
4. Miscellaneous materials

1. **Base Sand**

   - Silica sand is most commonly used base sand.
   - Other base sands that are also used for making mold are
     - Zircon sand,
     - Chromite sand, and
     - Olivine sand.
   - Silica sand is cheapest among all types of base sand and it is easily available.
2. Binder:

Binders are of many types such as:

- Clay binders,
- Organic binders and
- Inorganic binders

Clay binders are most commonly used binding agents mixed with the molding sands to provide the strength.

The most popular clay types are:

- Kaolinite or fire clay \((\text{Al}_2\text{O}_3 \ 2 \text{SiO}_2 \ 2 \text{H}_2\text{O})\) and
- Bentonite \((\text{Al}_2\text{O}_3 \ 4 \text{SiO}_2 \ n\text{H}_2\text{O})\)

Of the two the Bentonite can absorb more water which increases its bonding power.

**Moisture:**

- Clay acquires its bonding action only in the presence of the required amount of moisture.
- When water is added to clay, it penetrates the mixture and forms a microfilm, which coats the surface of each flake of the clay.
- The amount of water used should be properly controlled.
- This is because
  - A part of the water, which coats the surface of the clay flakes, helps in bonding, while
  - The remainder helps in improving the plasticity.

**Miscellaneous materials:**

- In addition to silica and clay, oxide of iron, limestone, magnesia, soda, and potash are found in the molding sand.
- These should be below 2 percent.

A typical composition of molding sand is given in table 5.1

<table>
<thead>
<tr>
<th>Table 5.1 A Typical Composition of Molding Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molding Sand Constituent</td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>Silica sand</td>
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<tr>
<td>Clay (Sodium Bentonite)</td>
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<tr>
<td>Water</td>
</tr>
</tbody>
</table>
Core:

- Cores are primarily used to produce hollow shapes in castings.
- In certain cases, a large number of cores may be assembled together to obtain the mold cavity, called core sand molding.

Core sand ingredients:

Core sand mixture consists of

- Sand grains
- Binders for green and baked strength and
- other additives for special purposes

Binders:

Core binders serve to hold the sand grains together and impart sufficient strength to the cores and to provide the desired degree of collapsibility. They are classified as:

- Organic binders
- Metallo organic binders
- Inorganic binders

Organic binders:

- These are combustible, and are destroyed by heat.
- Hence they contribute a good degree of collapsibility to the core sand.
- Core oils (manufactured by blending linseed oil, soya oil, fish oil and petroleum oil), cereals, resins, plastics, dextrin, molasses, lignin, etc. are some of the types used.

Metallo organic binders:

- Compounds such as sodium perborate and magnesium dioxide are used as binders.
- Some times the baking can be eliminated completely.

Inorganic binders:

- Bentonite, fire clay, sodium silicate are some of the compounds used
- These are not preferred due to their poor collapsibility.

Properties of core sand:

- It should have sufficient green strength
- It must be permeable to allow the core gases to escape easily
- It should have high refractoriness to withstand high temperature of the molten metal
- It must be sufficiently low in residual gas-forming materials to prevent excess gas from entering the metal
- It should be more collapsible than molds
- It must be stable with a minimum of contraction and expansion to make a true form of casting
- It must be strong enough to retain its shape without deforming

**Core making:** consists of the following operation:

- Core sand preparation
- Core molding
- Baking and
- Core finishing

- The first step in core making is to prepare a homogeneous mixture so that the core will be of uniform strength throughout, generally using roller mills or core mixers suitably
- Cores are then molded manually or with machines using core boxes
- Then the prepared cores are placed on core carriers and baked in core ovens to remove the moisture and to develop the strength of the binder at temperatures from 150°C to 400°C, depending on the type of binder used, the size of cores, and the duration of baking time.
- The baked cores are smoothened by filing the rough places and removing unwanted fins. Cores made in two or more pieces must be glued together with dextrin or other water soluble binders.
- Finally a fine refractory coating (applied by brushing, dipping, or spraying) or core wash (finely ground graphite, silica, mica, zircon, flour and a rubber-base chemical spray are used as core washes) to the surface is applied to prevent the metal penetration into the core to have smoother surface to the casting.

![Figure 5.1 Core making](image-url)
Core blowing machine:

- A rapid method for the production of small and medium-sized cores is available with core blowing machine.
- As special core boxes and equipment are needed, this is not suitable for small quantities.
The figure 5.3 shows the construction of a typical core blowing machine.

1. The sand reservoir is first moved to the position beneath the hopper where it is filled with core sand mixture.
2. Then the reservoir is moved back to the blowing position.
3. The core box is placed on the table, located and pressed up against the blow plate.
4. The compressed air at pressures ranging from 6 - 8 atmospheres is introduced above the sand in the reservoir.
5. This causes the core box to be rapidly filled with sand mixed with air.
6. Suitable vents provided in the core box allow the air to escape, but prevents the escape of sand grains.
7. The core box is filled and rammed in less than a few seconds and the table is lowered to enable the removal of cores.
6. Furnaces

Classification, Oil fired furnaces, Electric furnaces – Arc, resistance and induction furnaces, Cupola construction.

Melting Practices:

- Melting is an equally important parameter for obtaining a quality castings.
- A number of furnaces can be used for melting the metal, to be used, to make a metal casting.
- The choice of furnace depends on the type of metal to be melted.

Some of the furnaces used in metal casting are as following:

1. Crucible furnaces
2. Cupola
3. Induction furnace
4. Reverberatory furnace

1. Crucible Furnaces:

- Crucible furnaces are small capacity typically used for small melting applications.
- Crucible furnace is suitable for the batch type foundries where the metal requirement is intermittent.
- The metal is placed in a crucible which is made of clay and graphite.
- The energy is applied indirectly to the metal by heating the crucible by coke, oil or gas.

Coke-Fired Furnace

- Primarily used for non-ferrous metals
- Furnace is of a cylindrical shape
- Also known as pit furnace
- Preparation involves: first to make a deep bed of coke in the furnace
- Burn the coke till it attains the state of maximum combustion
- Insert the crucible in the coke bed
- Remove the crucible when the melt reaches to desired temperature
Oil-Fired Furnace:

- Primarily used for non-ferrous metals
- Furnace is of a cylindrical shape

Advantages include:

- No wastage of fuel
- Less contamination of the metal
- Absorption of water vapor is least as the metal melts inside the closed metallic furnace

2. Cupola:

- Cupola furnaces are tall, cylindrical furnaces used to melt iron and ferrous alloys in foundry operations.
- Alternating layers of metal and ferrous alloys, coke, and limestone are fed into the furnace from the top.
- A schematic diagram of a cupola is shown in figure 6.2.
- This diagram of a cupola illustrates the furnace's cylindrical shaft lined with refractory and the alternating layers of coke and metal scrap.
- The molten metal flows out of a spout at the bottom of the cupola.

Description of Cupola

- The cupola consists of a vertical cylindrical steel sheet and lined inside with acid refractory bricks. The lining is generally thicker in the lower portion of the cupola as the temperature are higher than in upper portion
- There is a charging door through which coke, pig iron, steel scrap and flux is charged
- The blast is blown through the tuyeres
- These tuyeres are arranged in one or more row around the periphery of cupola
- Hot gases which ascends from the bottom (combustion zone) preheats the iron in the preheating zone
- Cupolas are provided with a drop bottom door through which debris, consisting of coke, slag etc. can be discharged at the end of the melt
- A slag hole is provided to remove the slag from the melt
- Through the tap hole molten metal is poured into the ladle
- At the top conical cap called the spark arrest is provided to prevent the spark emerging to outside

![Figure 6.2 Schematic of a Cupola](image)
Operation of Cupola:

i) The cupola is charged with wood at the bottom.

ii) On the top of the wood a bed of coke is built.

iii) Alternating layers of metal and ferrous alloys, coke, and limestone are fed into the furnace from the top.

iv) The purpose of adding flux is to eliminate the impurities and to protect the metal from oxidation.

v) Air blast is opened for the complete combustion of coke.

vi) When sufficient metal has been melted that slag hole is first opened to remove the slag.

vii) Tap hole is then opened to collect the metal in the ladle.

3. Induction furnace

- Induction heating is a heating method.

- The heating by the induction method occurs when an electrically conductive material is placed in a varying magnetic field.

- Induction heating is a rapid form of heating in which a current is induced directly into the part being heated.

- Induction heating is a non-contact form of heating.

The heating system in an induction furnace includes:

i) Induction heating power supply,

ii) Induction heating coil,

iii) Water-cooling source, which cools the coil and several internal components inside the power supply.

- The induction heating power supply sends alternating current through the induction coil, which generates a magnetic field.

- Induction furnaces work on the principle of a transformer.

- An alternative electromagnetic field induces eddy currents in the metal which converts the electric energy to heat without any physical contact between the induction coil and the work piece.

A schematic diagram of induction furnace is shown in figure 6.3.

- The furnace contains a crucible surrounded by a water cooled copper coil.

- The coil is called primary coil to which a high frequency current is supplied.
By induction secondary currents, called eddy currents are produced in the crucible.

High temperature can be obtained by this method.

Induction furnaces are of two types:

i) Cored furnace and

ii) Coreless furnace

Cored furnaces are used almost exclusively as holding furnaces. In cored furnace the electromagnetic field heats the metal between two coils.

Coreless furnaces heat the metal via an external primary coil.

Advantages:

- Induction heating is a clean form of heating
- High rate of melting or high melting efficiency
- Alloyed steels can be melted without any loss of alloying elements
- Controllable and localized heating

Disadvantages:

- High capital cost of the equipment
- High operating cost