Metal Casting and Solidification

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Syllabus

- **Moulding materials: Properties, preparation & testing:**
- Functional requirements of moulding materials, moulding practice & special requirements of core sands, foundry sands & binders, sand preparation & systems, silica programme.

Molding Material and Properties:

A large variety of molding materials is used in foundries for manufacturing molds and cores. They include molding sand, system sand or backing sand, facing sand, parting sand, and core sand. The choice of molding materials is based on their processing properties. The properties that are generally required in molding materials are:

1. Refractoriness:

It is the ability of the molding material to with stand high temperatures (experienced during pouring) with out

1. Fusion,
2. Cracking, buckling or scabbing,
3. Experiencing any major physical change.

- Silica sand has a high refractoriness.

2. 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.

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.
- Green strength helps in making and handling the moulds.

4. Dry Strength:

- A mould may either intentionally be dried, or a green sand mould may lose its moisture and get dried while waiting for getting poured or when it comes in contact with molten metal being poured.
- The sand thus dried must have dry strength to
    1. Withstand erosive forces due to molten metal,
    2. Withstand pressure of molten metal,
    3. Retain its exact shape, and
    4. 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.
- In the absence of adequate hot strength, the mold may

1. enlarge
2. Break
3. get cracked.
4. erode

6. Collapsibility:

- Collapsibility determines the readiness with which the molding sand,
    1. Automatically gets collapsed after the casting solidifies, and
    2. Breaks down in knock out and cleaning operations.
- If the mould or core does not collapse, it may restrict free contraction of solidifying metal and cause the same to tear or crack.

7. Flowability:

- It is the ability of the molding sand to get compacted to a uniform density.
- Flowability assists molding sand to flow and pack all-around the pattern and take up the required shape.
- Flowability increases as clay and water contents increase.

8. Adhesiveness:

It is the property of molding sand owing to which, it

1. Sticks with the walls of molding boxes,
2. Thus makes it possible to mold cope and drag.

9. Fineness:

- Finer sand mould resist metal penetration and produce smooth casting surfaces.
- Fineness and permeability are in conflict with each other and hence they must be balanced for optimum results.

10. Chemical inertness

- The sand must not react with the metal being cast. This is especially important with highly reactive metals, such
as magnesium and titanium

11. Cohesiveness

- This is the ability of the sand to retain a given shape after the pattern is removed.

12. AVAILABILITY/COST

- The availability and cost of the sand is very important because the amount of sand required is three to six times the weight of the casting. Although sand can be screened and reused, the particles eventually become too fine and require periodic replacement with fresh sand.
- In large castings it is economical to use two different sands, because the majority of the sand will not be in contact with the casting, so it does not need any special properties. The sand that is in contact with the casting is called *facing sand*, and is designed for the casting on hand. This sand will be built up around the pattern to a thickness of 30 to 100 mm (1.2 to 3.9 in). The sand that fills in around the facing sand is called *backing sand*. This sand is simply silica sand with only a small amount of binder and no special additives.

MOULDING MATERIALS

- Material should be such that the mould cavity retains its shape till the molten metal has solidified. Moulding materials are:
- 1.Metal & alloys
- 2. Wax
- 3. Plaster
- 4. Sand (Silica, Zircon, Olivine,
- Chromite, magnesite, etc.)

Natural Moulding Sand Composition & Properties

Properties	Iron Base	Copper Base(Brass)
1. AFS Fineness no.	70-80	20-30
2. Clay %	15-18	17-19
3. Grain Shape	Sub-angular	Sub-angular
4. Moisture %	6	7
5. Permeability	75	250
6. G.C.S. p.s.i.	7.0	10
7. Sinter Point °C	1200	1250

TYPES OF MOULDING METHODS

1) ***Green sand moulding:***

- Sand in moist condition
- 5% water, 15 to 30% clay
- Used for both mould making & core making
- Moisture & permeability are controlled to prevent casting defects
- Poured in green condition
- Used for producing simple, small & medium sized castings

2) Dry Sand Moulding:

- Green sand moulds when dried fully results in dry sand moulding.
- One can have semi-dried or skin dried mould depending on extent of drying.
- Green strength & rigidity are higher than green sand.
- Less defects
- Silica flour added for good strength, erosion resistance & good surface finish.

3) Loam Moulding:

- Clay is used up to 50% remaining silica sand
- Sand mixture is almost pasty
- Used for moulding large grey C.I. castings.

- Sweep or skeleton pattern may be used for moulding.
- Moulding is done in a pit under the ground level.

TYPES OF SANDS:

a) **System sand:**

- Used in mechanical sand preparation & handling system.
- No facing sand used
- Used sand is cleaned & reconditioned (Water, binder, special additives are added)

b) Parting Sand:

- Dry silica sand, burnt sand
- Sprinkled over pattern, parting surface
- Pattern & mould half box withdrawal becomes easier

c) Facing sand:

- Sand mixture just next to the pattern is known as facing sand.
- Thickness of this sand above pattern may be up to 2 to 2.5cms
- Freshly prepared synthetic sand or reconditioned sand
- It withstands the temperature & pressure of molten metal
- Retains the shape & size of mould cavity till the casting is solidified.

d) Back up sand or Backing sand:

- This supports the facing sand.

- It is the reused sand
- The bulk of the mould box is filled with backing sand & compacted.

Molding Sand Composition:

The main ingredients of any molding sand are:

- Base sand,
- Binder, and
- Moisture

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:
  1. Clay binders,
  2. Organic binders and
  3. 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 (Al_2O_3 2 SiO_2 2 H_2O) and Bentonite (Al_2O_3 4 SiO_2 nH_2O)
  - Of the two the Bentonite can absorb more water which increases its bonding power.

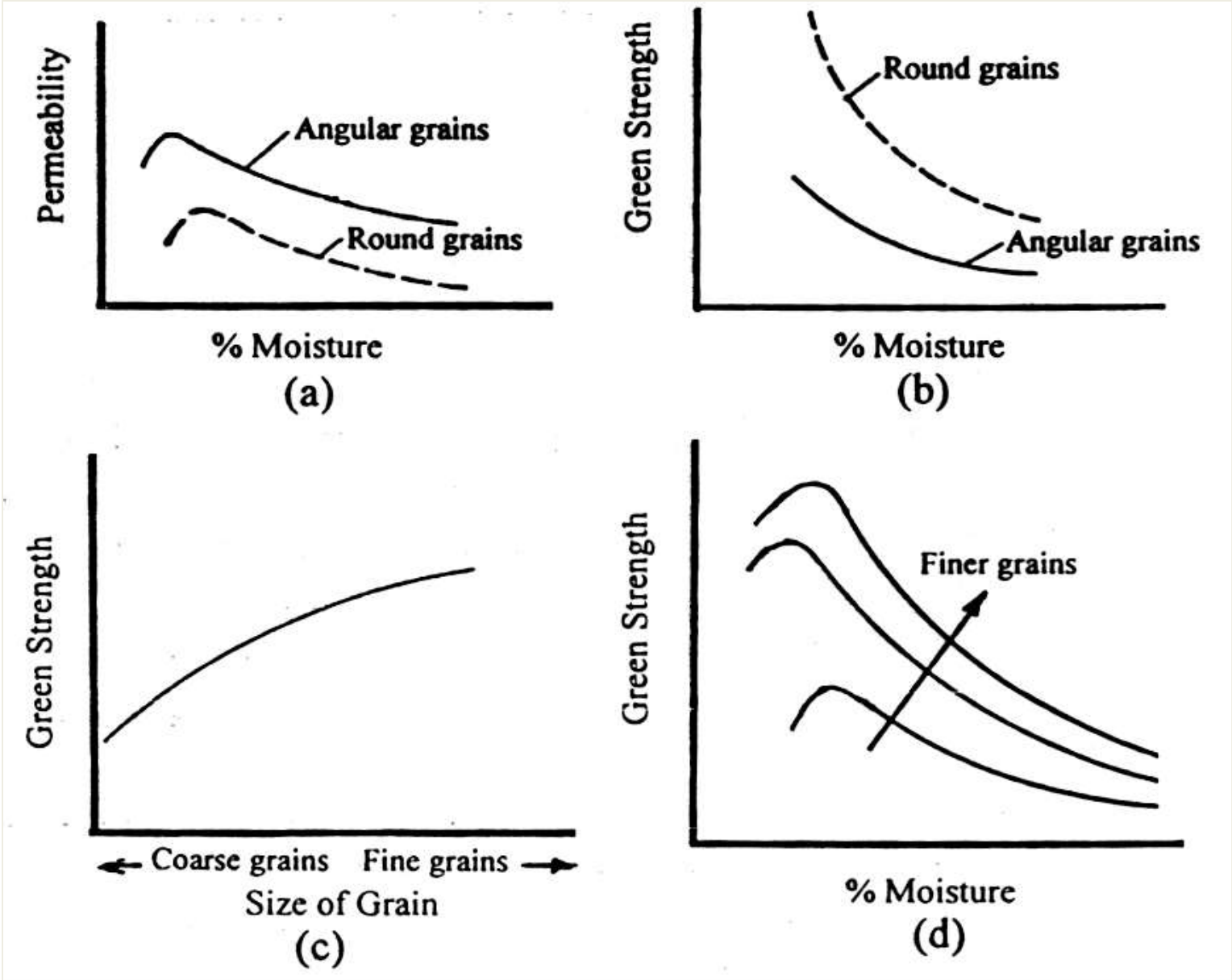
3. Moisture:

- 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.

A Typical Composition of Molding Sand:

Molding Sand Constituent	Weight Percent
Silica sand	92
Clay (Sodium Bentonite)	8
Water	4

Effect of moisture, grain size and shape on mould quality



- **Natural and Synthetic molding sand Natural molding sand:**
- The following average compositions are seen in natural molding sand: 65.5% silica grains, 21.7% clay content, 12.8% undesirable impurities.
- Too much clay content and other impurities fill up the gaps between the sand grains. This will hinder the necessary passage of steam and other gases during pouring of the mold.
- Synthetic molding sand is made by mixing together specially selected high quality clay free silica, with about 5% of clay. They are tailor made to give most desirable results.

- Some of the advantages of synthetic molding sand are:
  - Refractory grain sizes are more uniform,
  - Higher refractoriness (= 3000oF),
  - Less bonding agent is required (about 1/3rd of the clay percentage found in natural molding sand),
  - More suitable for use with mechanical equipment
- Advantages of natural molding sand:
  - 1. moisture content range is wide,
  - 2. molds can be repaired easily

• Core making:

- Generally Cores are used for making interior surfaces of hollow castings and now-a-days it is used for making exterior surfaces and for other purposes.
- Green sand cores contain ordinary molding sand and dry sand core contains hardened or baked sand.
- Core mix contains clay free silica sand. This is suitably mixed with binders, water and other ingredients to produce a core mix.
- Synthetic core binders have some unusual properties like shorter baking times and excellent collapsibilities which reduces the defect in castings.

- Urea formaldehyde binders burn out faster and collapse at lower temperature as compared to phenol formaldehyde binders. Thus urea formaldehyde binders are suitable for use at lower temperature metals like Al, Mg, thin sections of brass, bronze.

- Phenol formaldehyde binders are employed for thick sections of CI, steel castings .

- ***Binders Used in Sand Casting for Molds, Cores***

- **Clays:**
- Fire clay (kaolinite)
- Southern bentonite (calcium montmorillonite)
- Western bentonite (sodium montmorillonite)
- Secondary mica clays (illite)
- **Oils:**
- Vegetables (e.g. linseed oil)
- Marine animal (e.g., whale oil)
- Mineral (used for diluting oils given above)
- **Synthetic resins, thermosetting:**
- Urea formaldehyde
- Phenol Formaldehyde
- **Cereal binders made from corn:**
- Gelatinized starch (made by wet milling, contains starch and gluten)
- Gelatinized corn flour (made by dry-milling hominy)
- Dextrin (made from starch, a water-soluble sugar)

- **Wood –product binders:** Natural resin (e.g., rosin, thermoplastic), Sulfite binders (contain lignin, produced in the paper pulp process), Water-soluble gums, resins, and organic chemicals.
- **Protein binders (containing nitrogen):** Portland cement Pitch (a coal-tar product), Molasses (usually applied in water as a spray), Cements (e.g., rubber cement) Sodium silicate (water glass, CO2 hardening binders).

- Core characteristics:
- Good dry sand cores should have the following characteristics:

- 1.Good dry strength and hardness after baking

- 2.Sufficient green strength to retain the shape before baking

- 3.Refractoriness

- 4.Surface smoothness

- 5.Permeability

- 6.Lowest possible amount of gas created during the pouring of casting

Sand Testing

- As in Lab