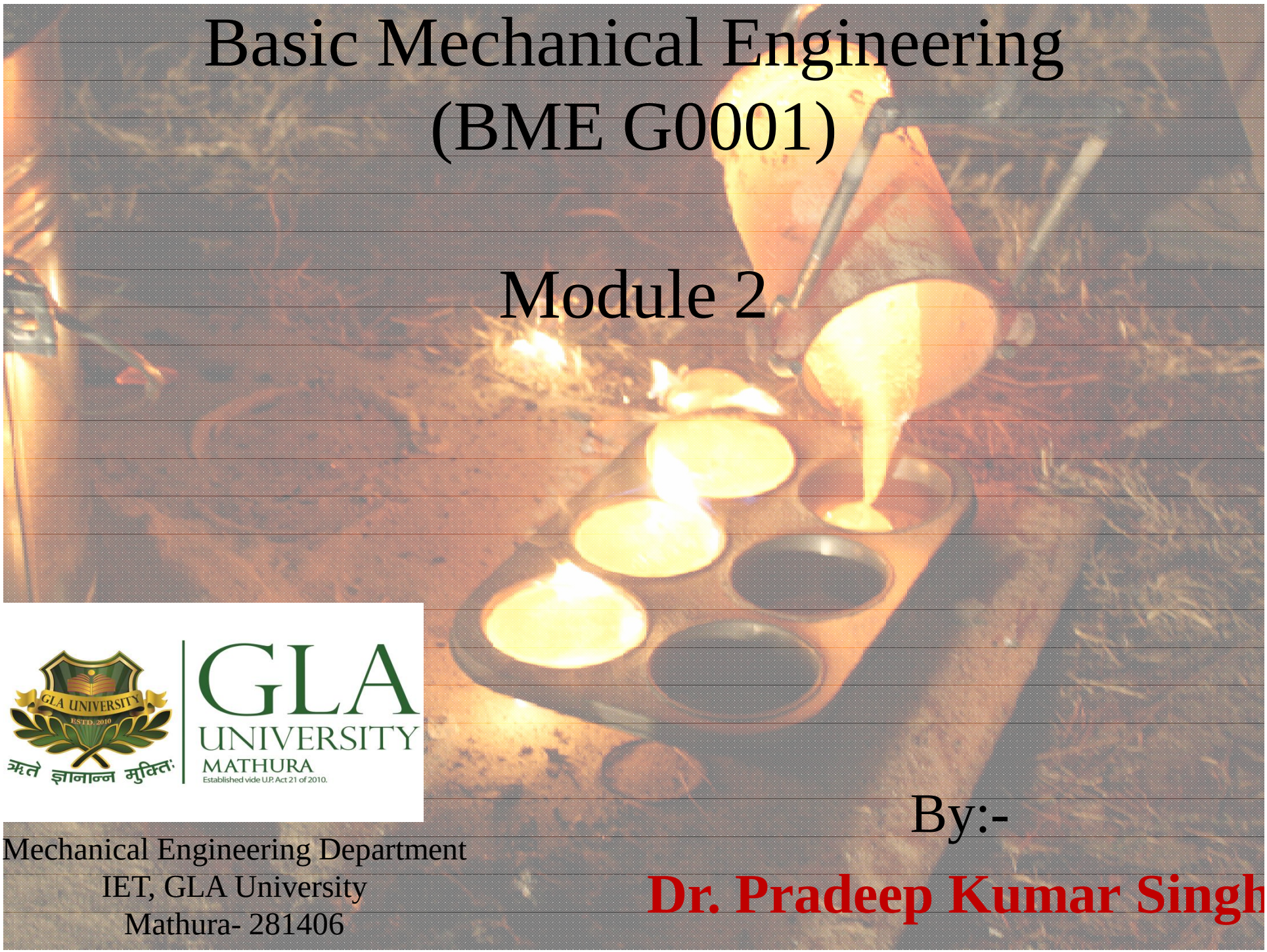
Basic Mechanical Engineering (BME G0001)

Module 2



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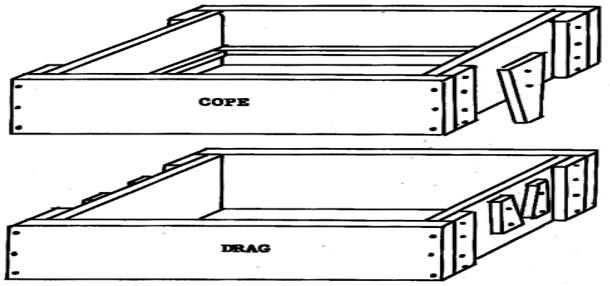
CASTING

- **Casting** is a manufacturing process in which a liquid/molten material is usually poured into a mold, which contains a hollow cavity of the **desired shape** and then allowed 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 part is also known as a ***casting***.
- Metal Casting is one of the earliest metal shaping technique known to human being.
- It was discovered probably around **3500 BC** in Mesopotamia.



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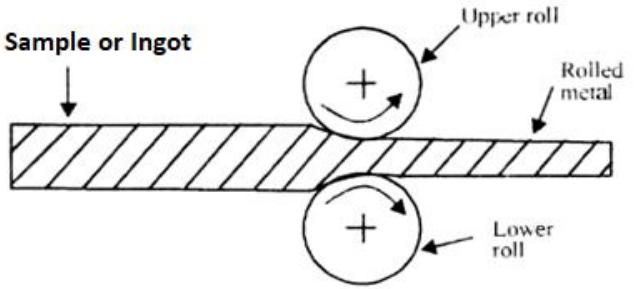
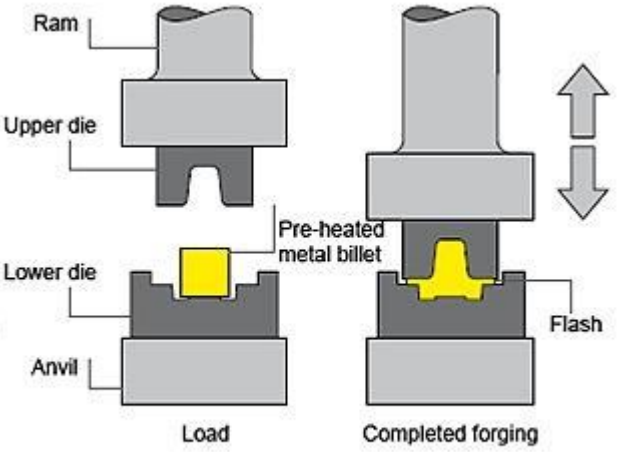
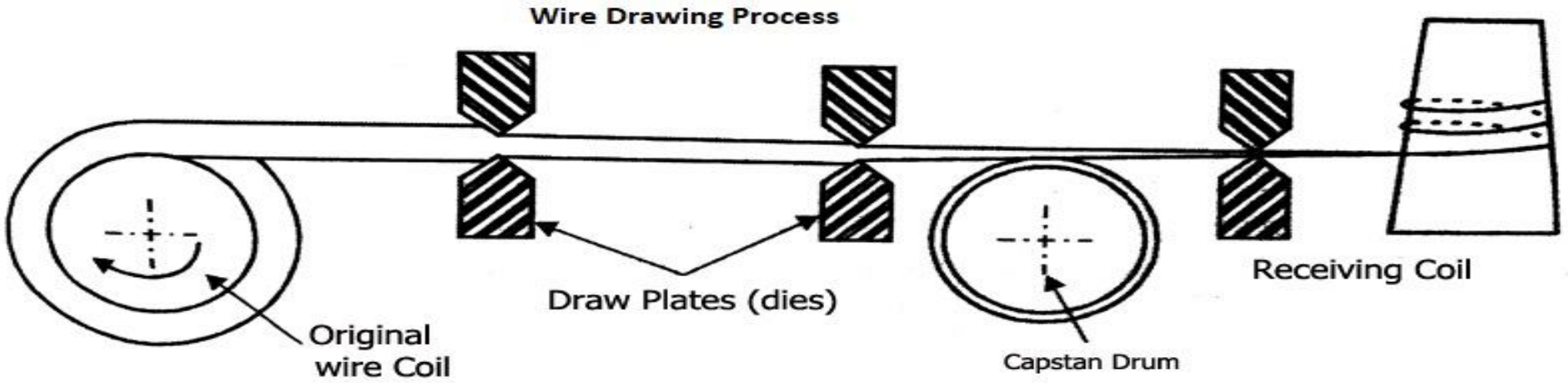
- By this process, complex/Intricate parts can be given strength and rigidity frequently which are not obtainable by any other manufacturing process such as Rolling, Forging, Wire Drawing etc.
- The mold, into which the metal is poured, is made of some **heat resisting material** (Sand, Nickel based alloys, Cobalt Chromium Nickel based alloys).



Rolling Process



Forging Process



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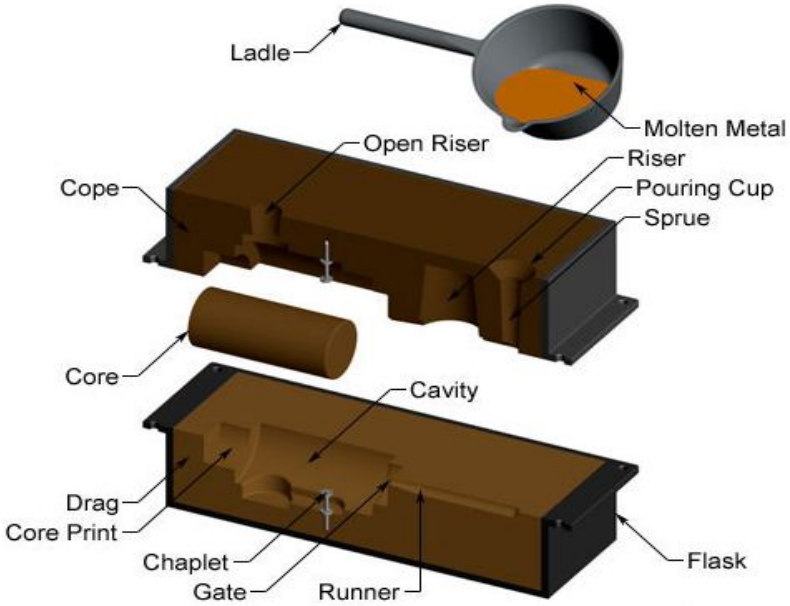
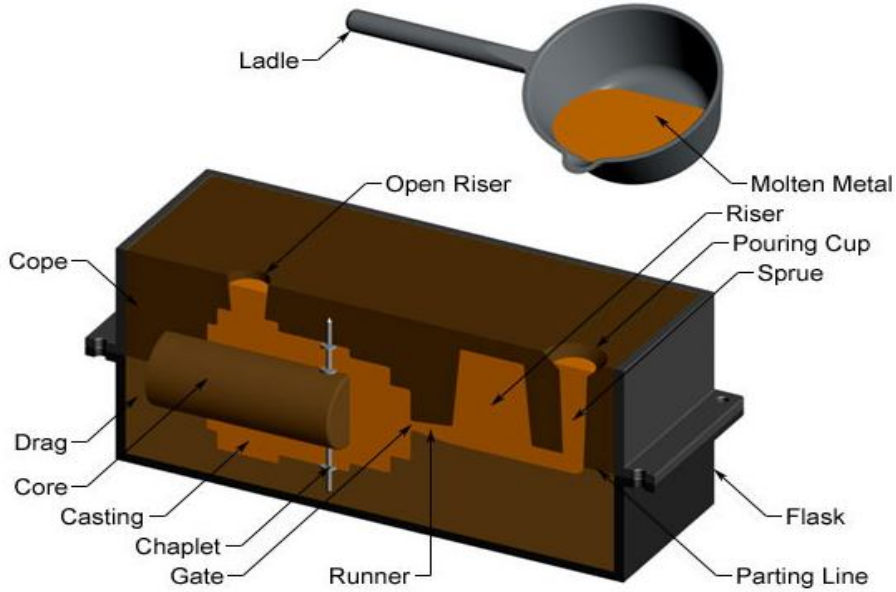
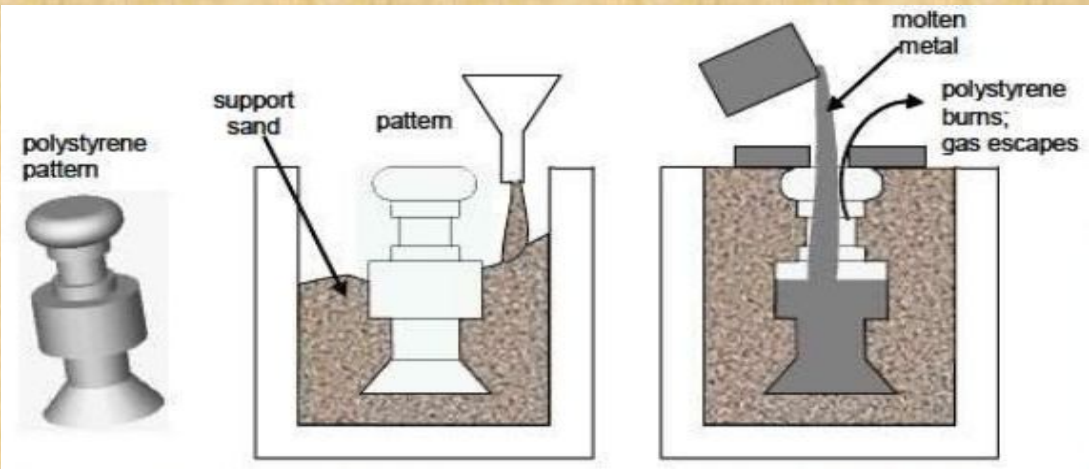
- Sand (**Temporary mold)** is most often used as it resists the high temperature of the molten metal.
- **Permanent molds** of metal (Stainless Steel, Nickel based alloys, Cobalt Chromium Nickel based alloys, molybdenum titanium alloys) can also be used to cast products.





PATTERN

- **Model** or the **replica** of the **object** (to be casted) **except** for the **various allowances** a pattern exactly resembles the casting to be made.
- embedded in molding sand and suitable ramming of molding sand around the pattern is made.
- pattern is then withdrawn for generating cavity (known as mold) in molding sand in which when molten metal is poured, allowed to solidify, produces a casting (product).
- may also possess **projections** known as core prints for producing extra recess in the mould for **placement of core** to produce **hollowness** in casting.



OBJECTIVES OF A PATTERN

- prepares a mould cavity for the purpose of making a casting.
- possesses core prints which produces seats in form of extra recess for core placement in the mould to produce hollow castings.
- establishes the parting line and parting surfaces in the mould.
- Runner, gates and riser may form a part of the pattern.
- Properly made pattern having finished and smooth surface reduce **casting defects i.e Overall Cost**.

COMMON PATTERN MATERIALS

- **Wood:** Preferred when the **numbers of castings** to be produced are **less**.
  - **Shisham**
  - **Deodar**
  - **Teak Wood**
  - **Mahogany**
- **Metal:** Preferred when the **number of castings** required is **large** enough to justify their use.
  - **Cast Iron**
  - **Brasses and Bronzes**
  - **Aluminum Alloys**
- **Plastic:** Polystyrene, Polyethylene, Polypropylene etc.
- **Plaster**
- **Wax**

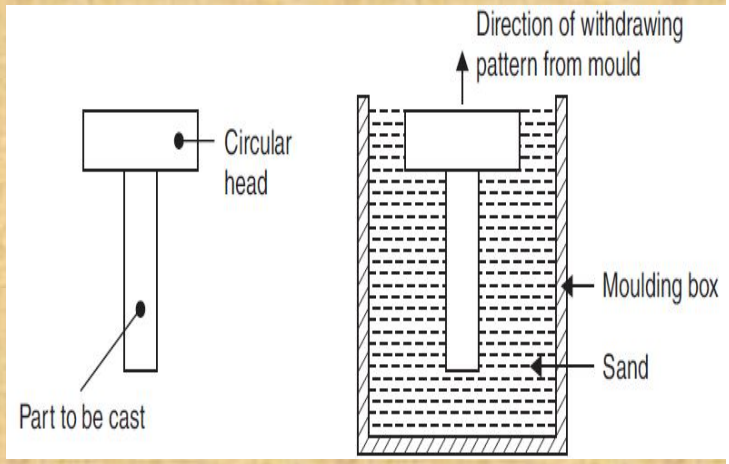
SELECTION OF PATTERN MATERIAL

- Number of castings to be produced.
- Metal pattern are preferred when castings are required large in number.
- Type of mould material used.
- Degree of dimensional accuracy and surface finish required.
- Minimum thickness required.
- Shape, complexity and size of casting.
- Cost of pattern and chances of repeat orders of the pattern

TYPES OF PATTERN

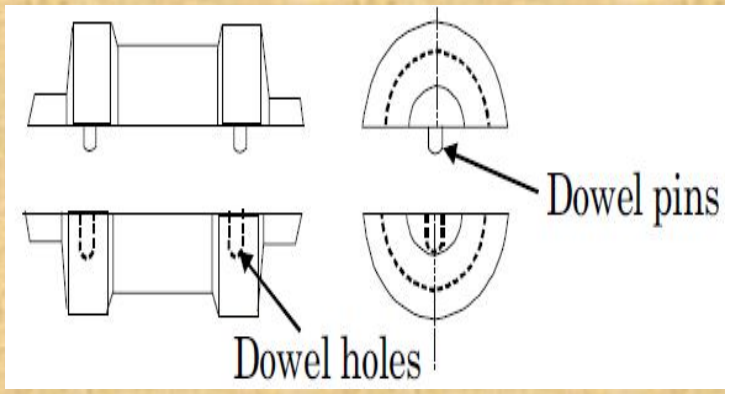
1. Single-piece or solid pattern:

- Solid pattern is made of single piece without joints, partings lines or loose pieces.
- It is the simplest form of the pattern.



2. Two-piece or split pattern:

- When solid pattern is difficult for withdrawal from the mold cavity, then solid pattern is splited into two parts.
- Split pattern is made in two pieces which are joined at the parting line by means of dowel pins.



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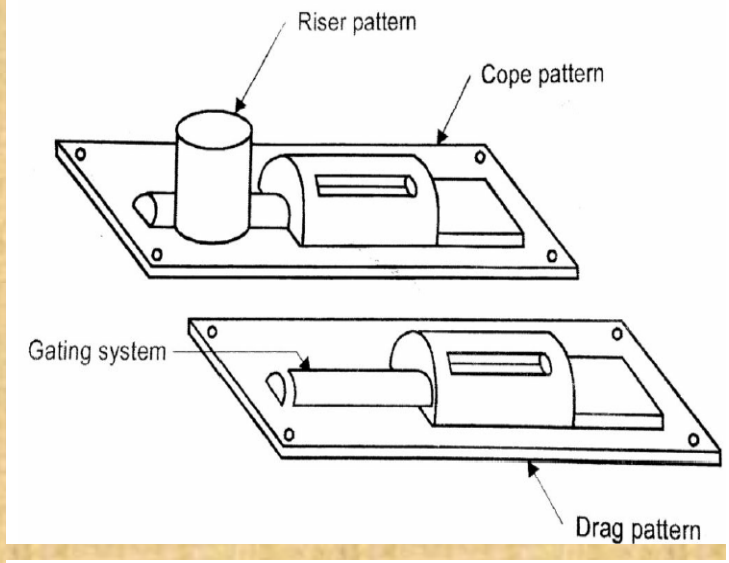
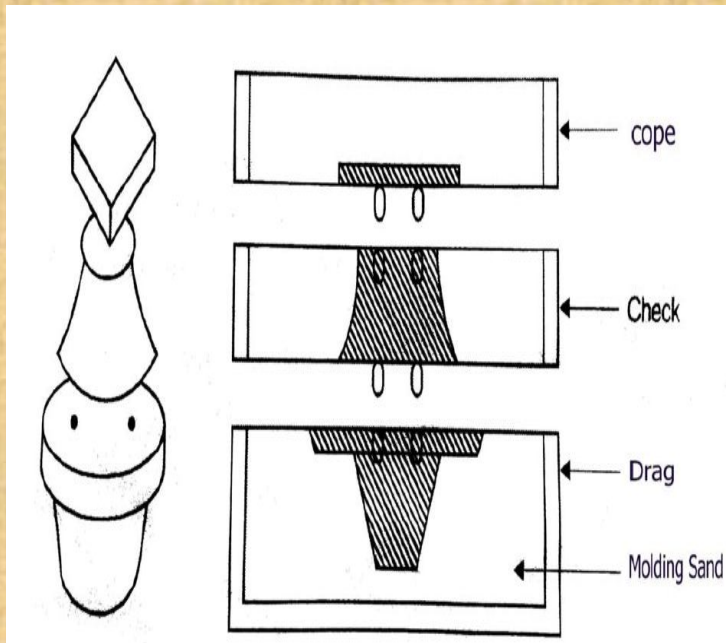
3. Cope and drag pattern :

- When the **complete mould** is **too heavy** to be handled by **one operator,** the **pattern** is made up of **two halves**, which are **mounted** on **different plates**.
- **Cope** and **drag** part of the mould are prepared separately.



4. Three-piece or multi-piece pattern:

- **Some patterns** are of **complicated** in **shape**, hence **can not be made** in one or two pieces **because of** difficulty in withdrawing the pattern.
- Hence made in **either three pieces** or in **multi-pieces**.



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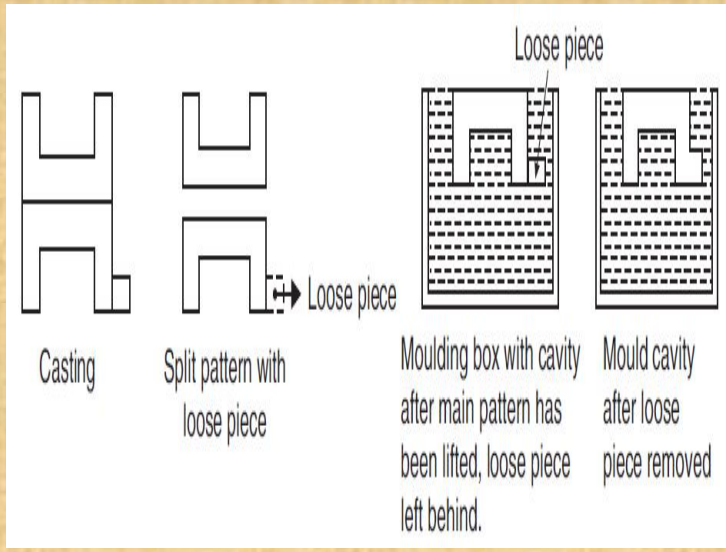
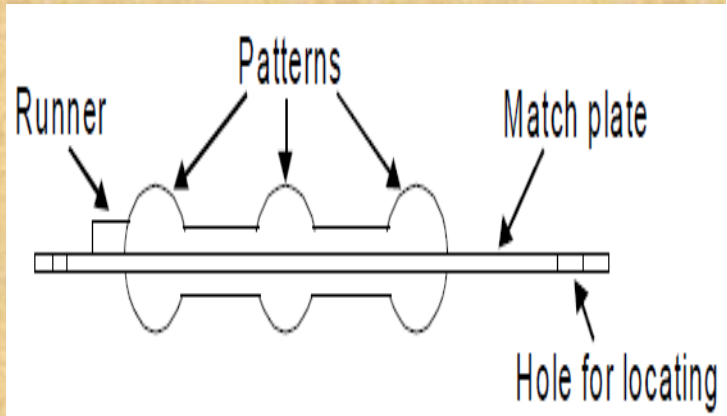
5. Loose-piece Pattern :

- It is used when **pattern** is **difficult for withdrawal** from the mould.
- **Loose pieces** are **provided** on the pattern and they are the **part of pattern**.
- **Main pattern** is **removed first** leaving the loose piece portion of the pattern in the mould.
- **Finally** the **loose piece** is **withdrawal separately** leaving the intricate mould.



6. Match plate pattern:

- Made in **two halves** and mounted on the **opposite sides** of a **wooden** or **metallic plate**, known as **match plate**.
- **Gates and runners** are also attached to the plate and this pattern **recommends** for **Machine Molding**.



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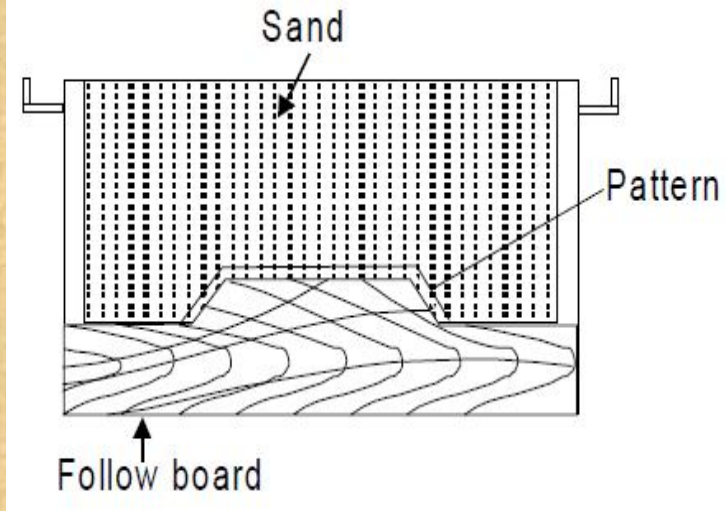
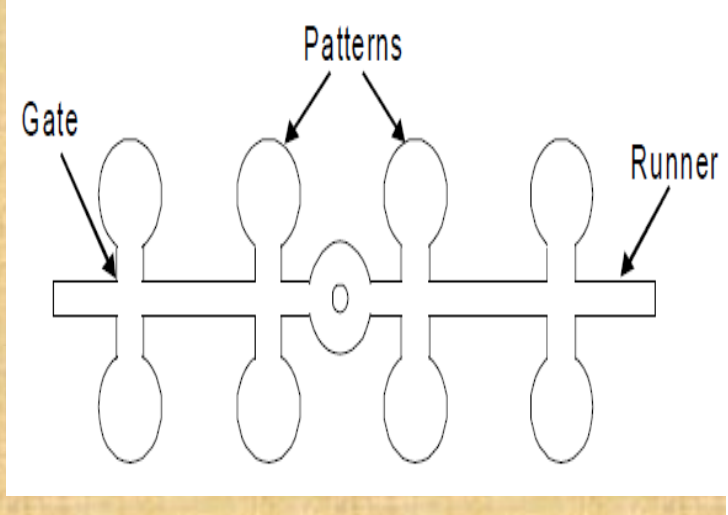
7. Follow board pattern:

- When the use of solid or split patterns becomes difficult, a **contour** corresponding to the **exact shape** of **one half of the pattern** is **made** in a **wooden board**, which is called a **follow board**
- it acts as a molding board for the first molding operation.



8. Gated pattern:

- In the **mass production** of **casings**, multi cavity moulds are used.
- Such moulds are formed **by joining** a **number of patterns**, **gates** and providing a **common runner** for the molten metal.
- These patterns are **made of metals**, and **metallic pieces** to **form gates and runners** are attached to the pattern.



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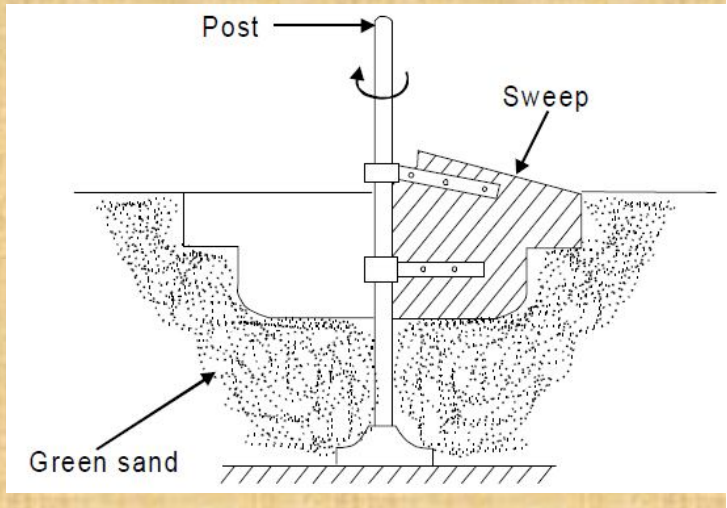
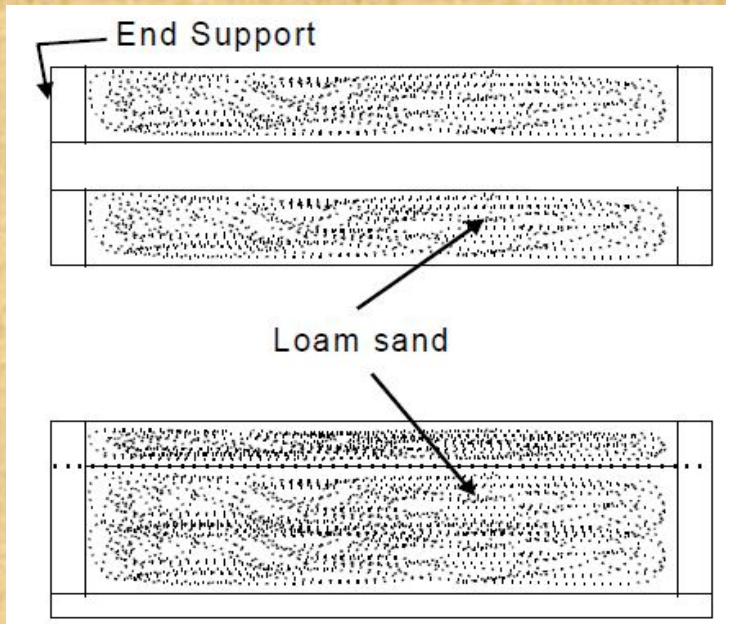
9. Sweep pattern :

- used for forming **large circular moulds** of **symmetric kind** by revolving a sweep attached to a spindle.
- **Sweep** means a template of wood or metal attached to the spindle at one edge and the other edge has a contour depending upon the desired shape of the mould.



10. Skeleton pattern :

- When only a **small number** of **large and heavy castings** are to be made, it is not economical to make a solid pattern.
- In such cases, a skeleton pattern may be used.
- It is a ribbed construction of wood which forms an outline of the pattern to be made.
- This frame work is filled with loam sand and rammed.



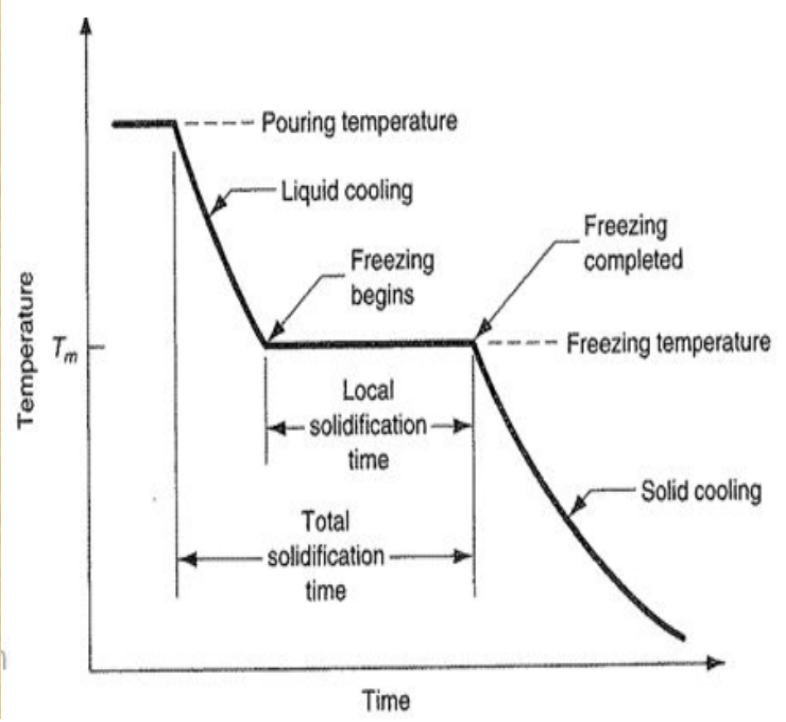
PATTERN ALLOWANCES

- The size of a pattern is never kept the same **as** that of the desired casting because of the fact that during cooling the casting is subjected to **various effects** and hence to compensate for these effects, corresponding allowances are given in the pattern.

Types of Pattern Allowances:

1. Shrinkage or Contraction Allowance:

- Practically, all common cast metals shrink a significant amount when they are cooled from the molten state.
- The **solid contraction** is taken care by the pattern makers by giving a **positive shrinkage allowance** as per **pattern marks contraction rule** in which the shrinkage of the casting metals is added.
- In general, the value varies from 10 mm. to 24 mm, depends on metal of casting.



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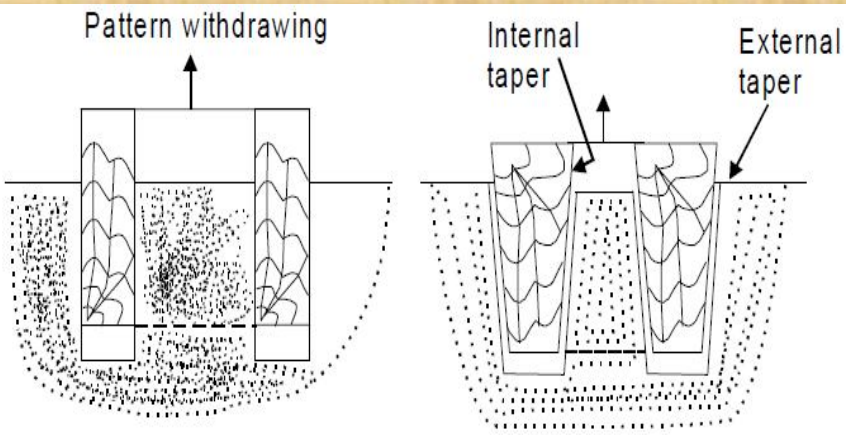
2. Machining or Finish Allowance :

- It is a **positive allowance** given to compensate for the amount of material that is lost in **machining or finishing** the casting.
- If this allowance is not given, the casting will become undersize after machining.
- The amount of this allowance depends on the size of casting, methods of machining and the degree of finish.
- In general, however, the value varies from 3 mm. to 18 mm.

3. Draft or Taper Allowance:

- **Positive allowance** and **given** on all the **vertical surfaces of pattern** so that its **withdrawal becomes easier**.
- The normal amount of taper on the external surfaces varies from 10 mm to 20 mm/mt.
- On interior holes and recesses which are smaller in size, the taper should be around 60 mm/mt.
- These values are greatly affected by the size of the pattern and the molding method.
- In machine molding its, value varies from 10 mm to 50 mm/mt



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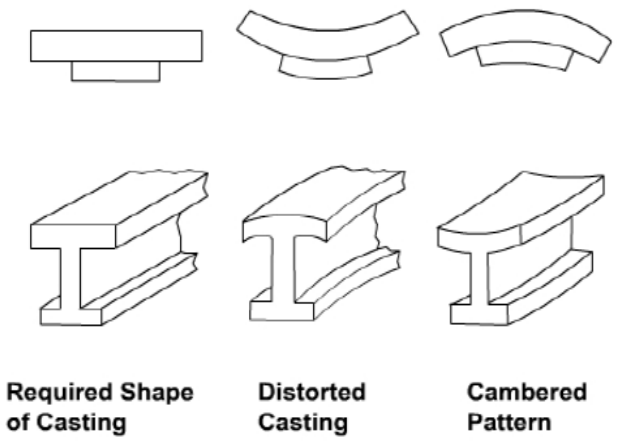
4. Rapping or Shake Allowance:

- Before withdrawing the pattern, it is rapped and thereby the size of the mould cavity increases.
- Actually by rapping, the external sections move outwards increasing the size and internal sections move inwards decreasing the size.
- This movement may be insignificant in the case of small and medium size castings, but it is significant in the case of large castings.
- This allowance is kept **negative** and hence the pattern is made slightly smaller in dimensions 0.5-1.0 mm.

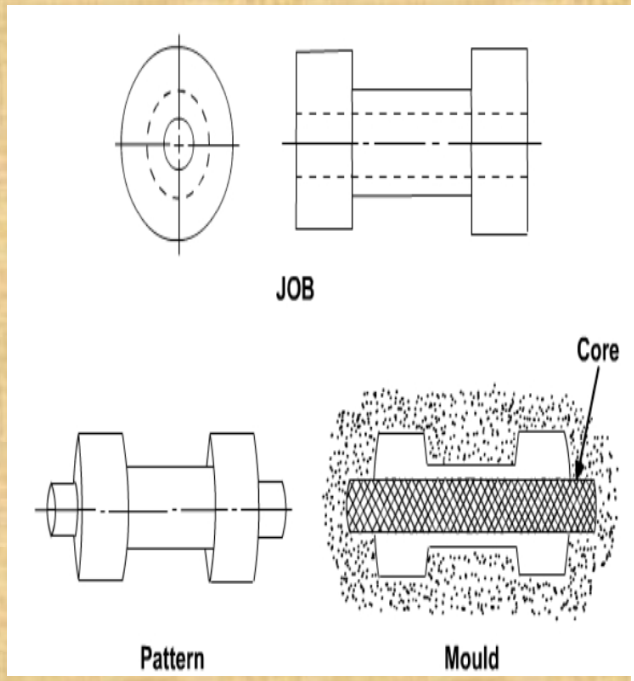
5. Distortion or Camber Allowance:

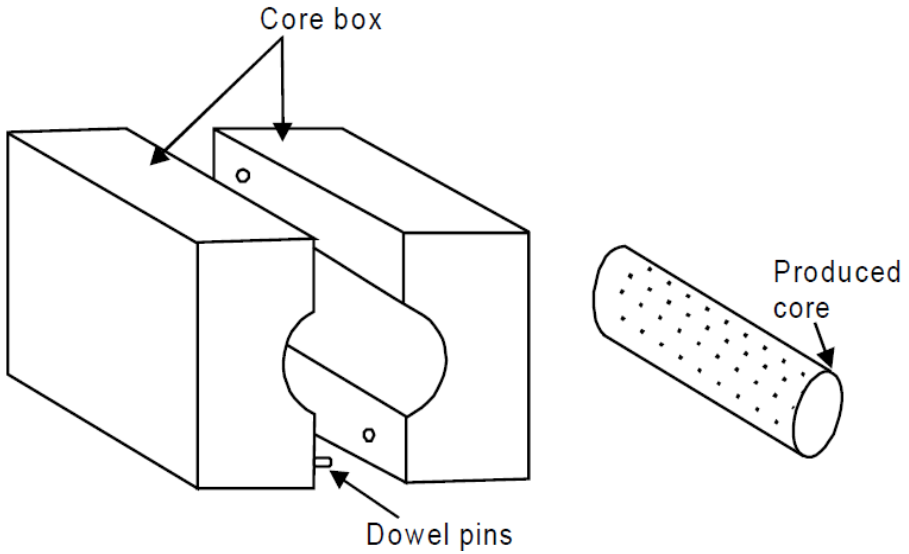
- This allowance is applied to the castings which have the tendency to **distort** during **cooling** due to **thermal stresses developed**.
- For example a casting in the form of U shape will contract at the closed end on cooling, while the open end will remain fixed in position.
- Therefore, to avoid the distortion, the legs of U pattern must converge slightly so that the sides will remain parallel after cooling.

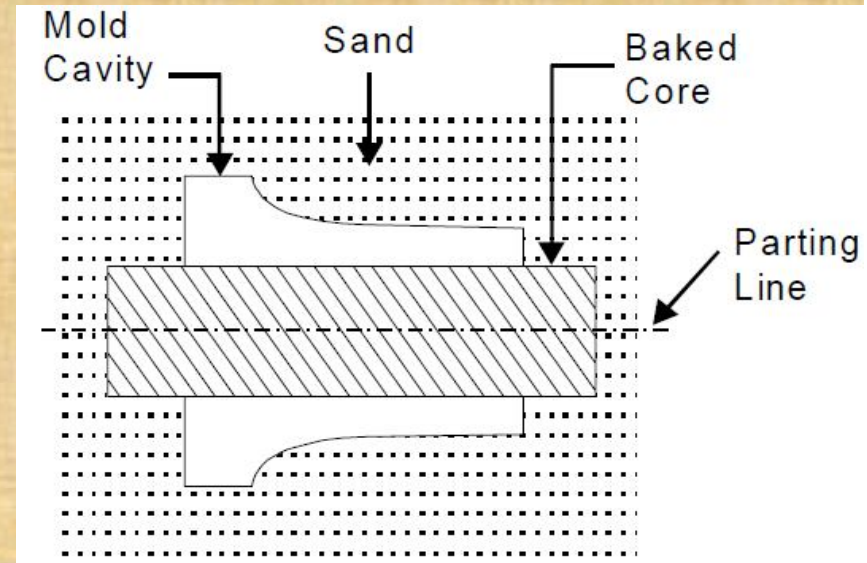


CORE AND CORE PRINTS

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







MOLDING MATERIAL

- Suitable and workable material (metallic or non-metallic) possessing **high refractoriness** in nature can be used for mould making.
- Metallic- cast iron, mild steel and alloy steels.
- Non-metallic- molding sands, plaster of paris, graphite, silicon carbide and ceramics.
- But, out of all, the **molding sand** is the most common utilized non-metallic molding material **because** of its certain **inherent properties** namely refractoriness, chemical and thermal stability at higher temperature, high **permeability** (how well gases pass through the sand) and workability along with good strength.
- Moreover, it is also highly **cheap** and **easily available**.

MOLDING SAND

- **Sources-** beds of sea, rivers, lakes, granulular elements of rocks, and deserts.
- Available sources (**India**):
  - Batala sand (Punjab)
  - Ganges sand (Uttar Pradesh)
  - Oyaria sand (Bihar)
  - Damodar and Barakar sands (Bengal- Bihar Border)
  - Londha sand (Bombay)
  - Gigatamannu sand (Andhra Pradesh)
  - Avadi and Veeriyambakam sand (Madras)

TYPES OF MOLDING SAND

- 1. Natural 2. Synthetic
- Natural molding sands **contain sufficient binder**.
- Synthetic molding sands are prepared artificially using basic sand molding constituents (**silica sand** in **88-92**%, **binder 6-12**%, **water or moisture** content **3-6**%) and other **additives** in proper proportion by weight
- **CONSTITUENTS OF MOLDING SAND:**

1. Silica sand:

- Silica sand in form of **granular quarts** is the main constituent of molding sand having enough refractoriness which can impart strength, stability and permeability to molding and core sand.

2. Binder:

- can be either **inorganic** or **organic** substance.
- **Inorganic**-clay sodium silicate and port land cement.
- In foundry shop, the **clay** viz. Kaolonite, Ball Clay, Fire Clay, Limonite, Fuller's earth and Bentonite **acts as binder**.
- **Organic**-dextrin, molasses, cereal binders, linseed oil and resins like phenol formaldehyde, urea formaldehyde etc.
- **Organic binders** are mostly **used** for **core making**.

CONSTITUENTS OF MOLDING SAND

3. Moisture:

- Amount of **moisture content** in the molding sand varies generally between **2-8%**.
- Amount is added to the **mixture** of clay and silica sand for **developing bonds**.
- Amount of water is held rigidly by the clay and responsible for **developing the strength in the sand**.
- Permeability **decreases** with **increasing** clay and moisture content.

4. Additives:

- Additives are the materials generally added to the molding and core sand mixture to develop some special property in the sand.
  - **Coal dust:** To de-oxidize the metal
  - **Corn flour:** To improves significantly strength of the mold and core
  - **Dextrin:** starch family of carbohydrates: **increases strength** of the molds
  - **Wood flour:** decrease expansion defects

KINDS OF MOLDING SAND

- Molding sands can also be classified according to their use into number of varieties:

1. Green sand:

- Also known as **tempered** or **natural sand.**
- which is a just prepared mixture of **silica sand** with **18-30 % clay**, having **moisture content** from **6-8%**.
- clay and water **furnish the bond** for green sand.
- Green sand is damp, when squeezed in the hand and it retains the shape and impression given to it under pressure.
- **Molds prepared by this sand** are **not requiring backing** ,hence known as **green sand molds**.
- easily available and it possesses low cost.
- **employed** for production of **ferrous and non-ferrous castings.**

2. Dry sand:

- Green sand that has been **dried or baked** in suitable oven after the making mold and cores, is called **dry sand**.
- possesses **more strength**, **rigidity** and **thermal stability.**
- **suitable** for **larger castings.**
- Mold prepared in this sand are known as **dry sand molds.**

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3. Loam sand:

- **Loam** is mixture of **sand and clay with water** to a **thin plastic paste**.
- Possesses **high clay** as much as **30-50%** and **18% water**.
- Patterns are not used for loam molding and shape is given to mold by **sweeps**.
- employed for loam molding used for large grey iron castings.

4. Facing sand:

- Facing sand is just prepared and **forms the face of the mould**.
- It is directly next to the surface of the pattern and it comes into contact molten metal when the mould is poured.
- Initial coating around the pattern and hence for mold surface is given by this sand.
- Possesses **high strength refractoriness.**
- It is made of silica sand and clay, without the use of used sand.

5. Backing or floor sand:

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

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6. Parting sand:

- **without binder and moisture** is **used** to keep the green sand **not to stick** to the pattern and also to **allow** the sand **on the parting surface** the **cope and drag** to **separate.**
- It is clean **clay-free** silica sand.

7. Core sand:

- Used for making cores , Also known as **oil sand.**
- **Highly rich silica sand** mixed with **oil binders** such as core oil which composed of linseed oil, resin, light mineral oil and other bind materials.
- **Pitch** or **flours** and **water** may **also be used** in **large cores** for the sake of economy.

PROPERTIES OF MOULDING SAND:

1. Refractoriness:

- Ability of molding sand to withstand high temperatures without breaking down or fusing thus facilitating to get sound casting.
- Degree of refractoriness depends on the SiO_2 i.e. quartz content, and the shape and grain size of the particle.
- Higher the SiO2 content and the rougher the grain volumetric composition the higher is the refractoriness of the molding sand and core sand.
- measured by the sinter point of the sand rather than its melting point.

PROPERTIES OF MOULDING SAND

2. Permeability or Porosity:

- Ability to allow the escape of any air, gases or moisture present or generated in the mould when the molten metal is poured into it.
- All these gaseous generated during pouring and solidification process must escape otherwise the casting becomes defective.
- can also be further increased by venting using vent rods

3. Cohesiveness:

- Property of molding sand by virtue which the sand grain particles interact and attract each other within the molding sand.
- Thus, the binding capability of the molding sand gets enhanced to increase the green, dry and hot strength property of molding and core sand.

4. Strength:

- To avoid pouring defects, the sand should be of sufficient strength to produce mold of desired shape and also retain this shaped even when the molten metal is poured in the moulding cavity.
  - **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.

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- **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.

5. Flowability or plasticity :

- Ability of the sand to get compacted and behave like a fluid.
- It will flow uniformly to all portions of pattern when rammed and distribute the ramming pressure evenly all around in all directions.

6. Adhesiveness :

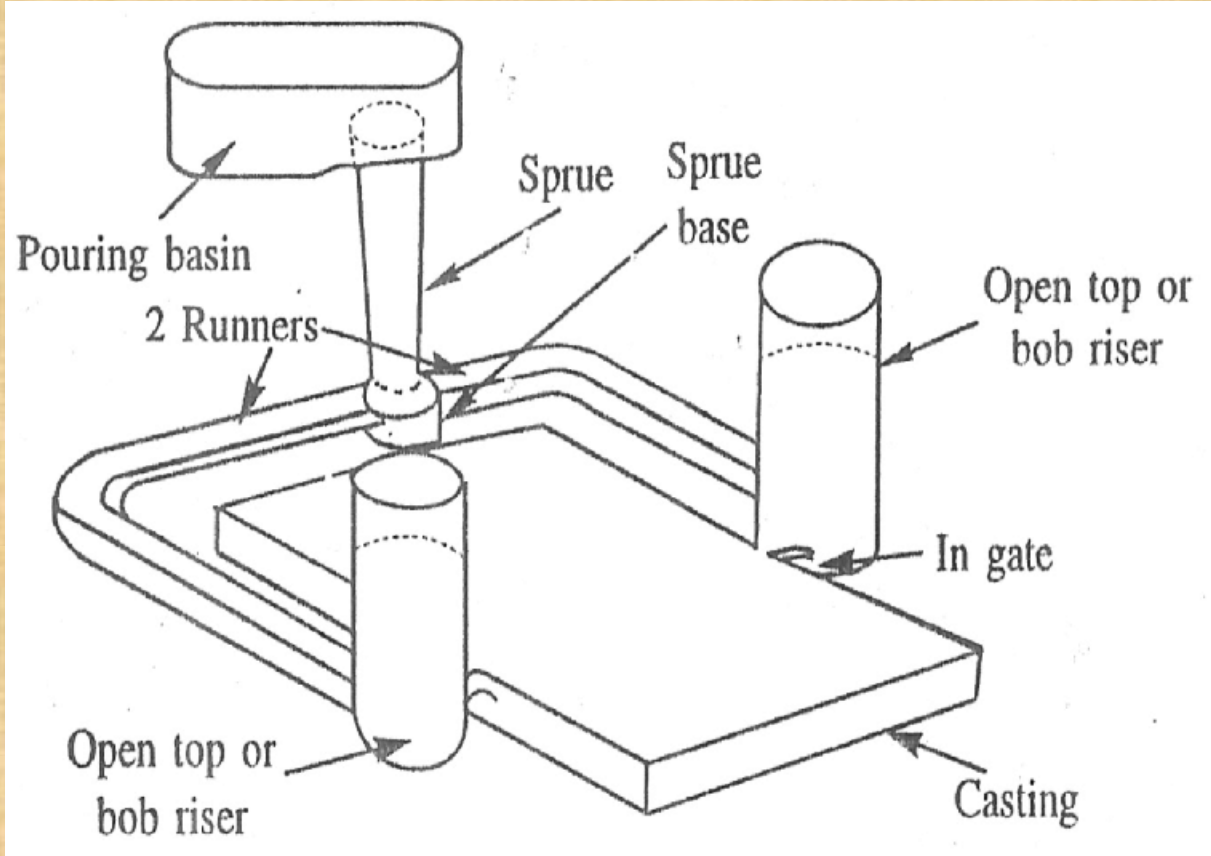
- It is property of molding sand to get stick or adhere with foreign material such sticking of molding sand with inner wall of molding box.

7. Collapsibility :

- The ability of the molding sand to collapse after solidification of the molten metal is called 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.

ELEMENTS OF GATING SYSTEM

- The gating systems refer to all those elements which are connected with the flow of molten metal from the ladle to the mould cavity. The elements of gating systems are:



1. Pouring basin or Bush or Cup:

- It is circular or rectangular in shape. It collects the molten metal, which is poured, from the ladle.

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2. Sprue:

- It is circular in cross section. It leads the molten metal from the pouring basin to the sprue well.

3. Sprue Well:

- It changes the direction of flow of the molten metal to right angle and passes it to the runner.

4. Runner:

- The runner takes the molten metal from sprue to the casting.

5. Ingate:

- This is the final stage where the molten metal moves from the runner to the mold cavity.

6. Riser:

- Riser is a source of extra metal which flows from riser to mold cavity to compensate for shrinkage which takes place in the casting when it starts solidifying. Without a riser heavier parts of the casting will have shrinkage defects, either on the surface or internally. Risers are known by different names as metal reservoir, feeders, or headers.

OBJECTIVE OF GATING SYSTEM

- To minimize turbulence to avoid trapping gasses into the mold.
- To get enough metal into the mold cavity before the metal starts to solidify.
- To avoid shrinkage.
- Establish the best possible temperature gradient in the solidifying casting so that the shrinkage if occurs must be in the gating system not in the required cast part.
- Gating system refers to all the sections, through which the molten metal passes, while entering into the mould cavity.

CASTING DEFECTS:

1. Gas Defects:

- A condition existing in a casting caused by the trapping of gas in the molten metal or by mold gases evolved during the pouring of the casting.
- The defects in this category can be classified into blowholes and pinhole porosity.
  - **Blowholes:** It is fairly large, well- rounded cavity produced by the gases which displace the molten metal at the cope surface of a casting.
  - **Pinhole:** porosity occurs due to the dissolution of hydrogen gas, which gets entrapped during heating of molten metal.

2. Shrinkage Cavities:

- These are caused by liquid shrinkage occurring during the solidification of the casting. To compensate for this, proper feeding of liquid metal is required.

CASTING DEFECTS

- For this reason risers are placed at the appropriate places in the mold.
- Sprues may be too thin, too long or not attached in the proper location, causing shrinkage cavities.
- It is recommended to use thick sprues to avoid shrinkage cavities.

3. Molding Material Defects:

- The defects in this category are cuts and washes, metal penetration, fusion, and swell.
  - **Cut and washes:**
    - These appear as rough spots and areas of excess metal, and are caused by erosion of molding sand by the flowing metal.
    - This is caused by the molding sand not having enough strength and the molten metal flowing at high velocity.
  - **Metal penetration:**
    - When molten metal enters into the gaps between sand grains, the result is a rough casting surface.
  - **Swell:**
    - Under the influence of metallostatic forces, the mold wall may move back causing a swell in the dimension of the casting.
    - A proper ramming of the mold will correct this defect.
  - **Slag Inclusions:**
    - Particles of slag, refractory materials sand or deoxidation products are trapped in the casting during pouring solidification.
    - The provision of choke in the gating system and the pouring basin at the top of the mold can prevent this defect.

4. Pouring Metal Defects:

  - **Mis-run:**
    - A mis-run is caused when the metal is unable to fill the mold cavity completely and thus leaves unfilled cavities.

Contd.

- A mis-run results when the metal is too cold to flow to the extremities of the mold cavity before freezing.
- Long, thin sections are subject to this defect and should be avoided in casting design.

– **Cold shut:**

- A cold shut is caused when two streams while meeting in the mold cavity, do not fuse together properly thus forming a discontinuity in the casting.
- When the molten metal is poured into the mold cavity through more-than-one gate, multiple liquid fronts will have to flow together and become one solid.

5. Shift:

– **Mold shift:**

- The mold shift defect occurs when cope and drag or molding boxes have not been properly aligned.

– **Core Shift:**

- A misalignment between cores may give rise to defective casting.

6. Hot Tear: A crack develops in a casting due to high residual stresses is called hot tear.

7. Porosity:

- This indicates very small holes uniformly dispersed throughout the casting.
- It arises when there is a decrease in gas solubility during the solidification.

8. Scar:

- A shallow blow, usually found on the flat casting surface is referred to as a scar.

9. Drop:

- An irregular shaped projection on the cope surface of a casting is called Drop.

Contd.

10. Dross: Lighter impurities appearing on the top of the surface of the casting are called dross.

11. Dirt: Sometimes sand particle dropping out of the cope get embedded on the top of a casting. When removed, these leave small angular holes known as dirt.