NAME :
ROLL NO :

FOUNDRY

PATTERNS

Patterns is the principal tool during the casting process. It may be defined as model of anything, so constructed that it may be used for forming an impression called mould in dump sand or other suitable material. The process of making pattern is called pattern making.

Pattern material should be:

1. Easily worked, shaped and joined
2. Light in weight
3. Strong, hard and durable
4. Dimensionally stable
5. Easily available and low cost
6. Repairable and reused
7. Able to take good surface finish

PATTERN MATERIALS

1. **Wood**

Wood is the most common material for pattern. It is easy to work and readily available. Wood has its disadvantage- it is readily affected by moisture. It changes its shape and size due to the effect of moisture in the moulding sand. Also it wears out quickly as a result of sand abrasion. So they are generally used when small number of castings are to be produced.

2. Metal

Metal is used when a large number of castings are desired. Metal patterns do not change its shape when subjected to moist conditions. Metal patterns are very useful in machine moulding because of their accuracy, durability and strength. Commonly metal patterns are cast from a wooden pattern called "*master pattern*". Metals used for patterns include steel, brass, cast iron, aluminium and white metal.

3. Plastics

Plastics are used as pattern material because they do not absorb moisture, are strong and dimensionally stable, resistant to wear, have a very smooth and glossy surface and are light in weight. Because of its glossy surface it can easily withdraw from the mould and no dry or liquid parting compound is necessary.

4. Rubbers

Certain types of rubbers such as silicon rubber are favoured for forming a very intricate type of die for investment casting. This material is available in two parts, binder and hardener. They are in liquid form. When they are mixed together and poured over a master pattern or into a die a solid pattern is produced.

5. Plasters

Gypsum cement known as plaster of paris is used for making patterns and core boxes. It has high compressive strength. It can be readily worked with wood tools.

6. Waxes

The material generally used are several types of waxes and other additives. The waxes commonly used are paraffin wax, shellac wax, bees wax etc. normally formation of wax patter is by injecting liquid or semiliquid wax into a split die.

PATTERN ALLOWANCES

Allowances should be allowed for shrinkage, draft, finish, rapping, and distortion.

1. **Shrinkage Allowance**

As metal cools and solidifies it shrinks and contracts in its size. To compensate for this a pattern is made larger than the finished casting by means of a shrinkage or contraction allowance. The pattern maker allows this by using shrinkage or contraction rule.

2. **Draft Allowance**

When a pattern is drawn from a mould, there is some possibility of injuring the edges of the mould. This danger is greatly decreased if the vertical surface of the pattern is tapered inward slightly. This slight taper inward on the vertical surface of a pattern is known as draft. Draft may be expressed in mm per metre on a side or degrees. The draft depends upon:

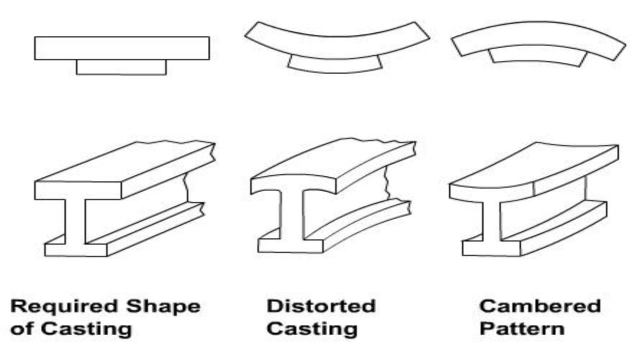
i. Length of the vertical side
ii. Intrincity of the pattern
iii. The method of moulding

3. **Machining Allowance**

Rough surface of the castings are machined to make the surface finish. The extra amount of metal provided on the surface to be machined is called machining allowance. The machine allowance depends upon:

i. The kind of metal to be used
ii. The size and shape of the casting
iii. Method of moulding

4. **Distortion or Camber Allowance**



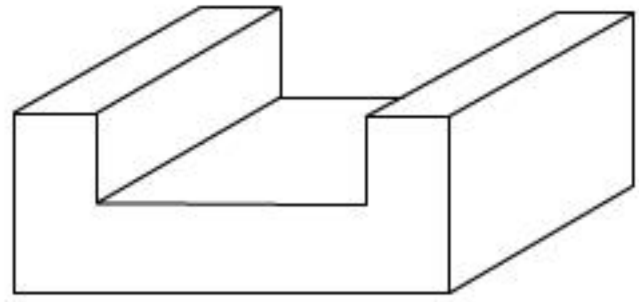
Some castings, because of their size, shape and type of metal, tend to wrap or distort during the cooling period. This is a result of uneven shrinkage. It is due to uneven metal thickness or to one surface being more exposed than the other, causing it to cool rapidly. The shape of the pattern is thus bent in the opposite direction to overcome this distortion. This feature is called distortion or camber allowance.

5. Rapping Allowance

When a pattern is rapped in the mould before it is withdrawn, the cavity in the mould is slightly increased. In every cases where casting must be uniform and true to pattern, rapping or shake allowance is provided for by making the pattern slightly smaller than the actual size to compensate for the rapping of the mould.

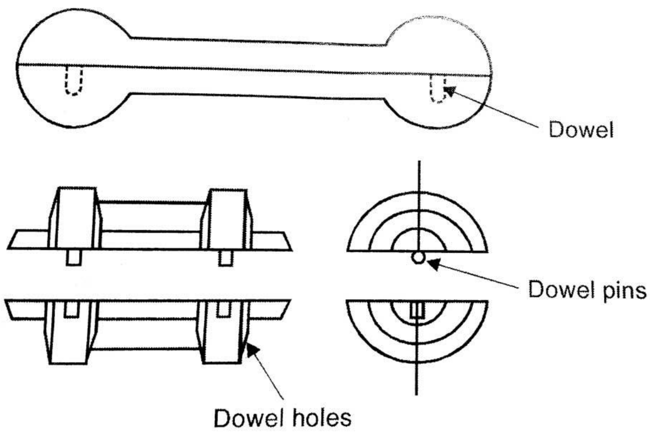
TYPES OF PATTERNS

1. **Solid Pattern (One Piece Pattern)**



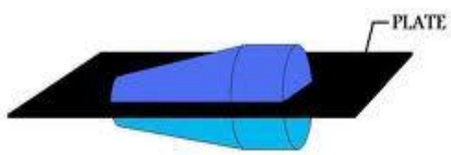
A pattern that is made without joints, partings or any loose pieces in its construction is called a single piece or solid pattern. These patterns are cheaper. When using such patterns, moulder has to cut his own runners and feeding gates and risers. This operation takes more time and they are not recommended except for limited production. Single piece pattern are usually used for large castings of simple shapes.

2. **Split Pattern**



Many patterns cannot be made in single piece because of intricate design or unusual shape. To eliminate this difficulty split patterns are employed to form the mould. These patterns are usually made in two parts. One part will produce the lower half of the mould, and the other, the upper half. The two parts are held in position by means of dowel pins fastened in one piece and fitting holes drilled in the other. The surface formed at the line of separation of the two parts is called the parting surface or parting line.

3. **Match Plate Pattern**



MATCH PLATE PATTERN

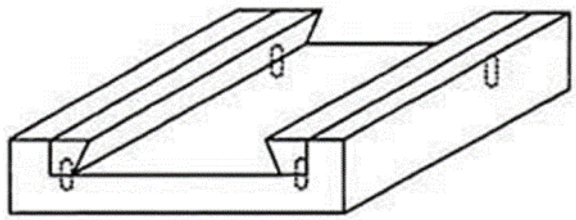
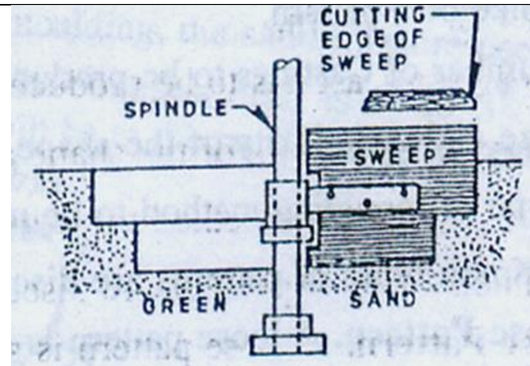
When one half of the split pattern mounted on one side of a plate and the other half is directly opposite on the other side of the plate, the pattern is called match plate pattern. A single pattern or a number of patterns may be mounted on a match plate. The pattern is made of metal and the plate may be either wood or metal. The match plate has runner and gates attached with it. When the match plate is lifted off the mould, all patterns are drawn, and the cope or upper half of the mould matches perfectly with the drag or lower half. Match plate patterns are usually preferred for the production of small castings on mass scale. Piston rings of IC engines are produced by using match plate patterns.

4. **Sweep Patterns**

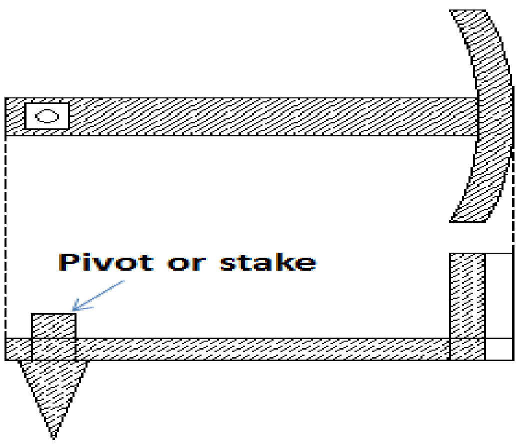
Symmetrical castings can be produced by using this pattern. Symmetrical board is mounted on one part of the pattern. Sweep board is made to rotate in its axis. Sweep board is made to the required shape of casting. The required mould cavity can be obtained by rotating the sweep board and removing the sand.

5. Loose Piece Pattern

Loose piece pattern is suitable for producing complicated shape castings. Removal of this pattern from the mould is very easy. First, the main part of the pattern is removed from the mould. Then the remaining loose pieces are removed from the mould. It is very difficult to handle this pattern and its cost is high.

 Fig. 3.6. Loose-piece Pattern.	
Loose Piece Pattern	Sweep Pattern

6. Segmental Pattern



Segments are used in this pattern. Large wheel, Rim and gear wheel castings are produced by using segmental pattern. This type of patterns is held in position with the help of pivoted axis and radial arm. The sand near the pattern is packed. Then the segment is rotated.

MOULDING SAND

The mould into which the molten metal is poured is made of some refractory material. Sand is most often used as it is readily available, easy to pack to shape, porous and resistant to high temperature.

TYPES OF MOULDING SAND

Moulding sand may be classified into a number of verities according to their use. They are described below

Green Sand

It is a mixture of silica sand with 18 to 30% clay, 6 to 8% water. The clay and water furnish the bond for green sand. It is fine, soft, light and porous. Moulds prepared in this sand are known as green sand moulds.

Dry Sand

Green sand that has been dried or baked after the mould is prepared is called dry sand. They are suitable for large castings. Moulds prepared in this sand are known as dry sand moulds.

Loam Sand

Loam sand is high in clay as much as 50% or so and dried hard. This is particularly used for loam mouldings, usually for large castings.

Facing Sand

Facing sand forms the face of the mould. It is used directly next to the surface of pattern and it comes into contact with the molten metal when the mould is poured. So it must pocess 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 facing sand in a mould usually ranges from 20 to 30 mm.

Backing Sand

Backing sand or floor sand is used to back up the facing sand and to fill the whole volume of the flask. Old repeatedly used moulding sand is mainly employed for the purpose. The backing sand is sometimes called black sand because it is black in colour due to the addition of coal dust and burning with the contact of molten metal.

System Sand

In mechanical foundries, where machine moulding is employed system sand is used to fill the whole flask. In mechanical foundries no facing sand is used. The used sand is cleaned and reactivated by the addition of water, binders and special additives. This is known as system sand. Since the whole mould is made of this system sand the strength, permeability and refractoriness of the sand must be higher than those of backing sand.

Parting Sand

Parting sand is used to keep the green sand from sticking to the pattern and also allow the sand on the parting surface of the cope and drag to separate without clinging. This is clean clay free silica sand.

Core Sand

Sand is used for making cores is called core sand. Sometimes it is called oil sand. This is silica sand mixed with core oil which is composed of linseed oil, resin, light mineral oil and other binding materials.

PROPERTIES OF MOULDING SAND

1. **Porosity or Permeability**

The sand must be sufficiently porous to allow the gases or moisture present or generated within the moulds to be removed freely when the molten metal is poured. This property of the sand is called porosity or permeability.

2. Flowability

Flowability of moulding sand refers to its ability to behave like a fluid, so that, when it is rammed it will flow to all portions of the mould and pack all around the pattern. High Flowability is required for moulding sand to get uniform density and to obtain good impression of the pattern in the mould.

3. Adhesiveness

The property of the sand particles to stick on other bodies is termed as adhesiveness. Moulding sand must have sufficient adhesive to hold the sand mass in the moulding box and to prevent its falling out from the box when it is turned over or conveyed.

4. <u>Cohesiveness or Strength</u>

This is the ability of the sand particles to stick together. Insufficient strength may lead to collapse of the mould during conveying, turning over or closing.

The strength of the moulding sand must be sufficient to permit the mould to be formed to desired shape and to retain this shape even after the molten metal is poured in the mould. This property of the sand in its green or moist state is known as green strength. The strength of the sand that has been dried or baked is called dry strength. It must have strength to withstand the erosive forces due to molten metal and retain its shape.

5. <u>Refractoriness</u>

The property of the sand to withstand high temperature of the molten metal without fusing is termed as refractoriness. Moulding sand with a poor refractoriness may burn on to the casting.

6. <u>Plasticity</u>

The property of acquiring predetermined shape under pressure and to retain it when the pressure is removed is termed as plasticity. Moulding sand must have sufficient plasticity to get good impression of the pattern.

7. <u>Chemical Stability</u>

The property of the sand to resist chemical reaction with the molten metal is termed as chemical stability.

GREEN SAND MOULDING

Green sand moulds are prepared with natural moulding sands. To make the green sand mould the sand must be properly tempered before it can be used. If the sand is too dry additional amount of water is added and if too wet dry sand is added until it has proper temper. The surface of the mould which comes in contact with the molten metal is the most important part in the green sand moulds. In order to give the casting a clean and bright surface and to prevent the sand from burning on the face of the mould a layer of facing sand is given surrounding the pattern. Facing sand mixtures for iron castings generally contains some finely ground bituminous coal known as sea coal and new sand.

Blackings or mineral coatings are applied on the surface of the mould to produce a smooth skin on the casting. They may be applied wet or dry. For use in wet state some additives are employed- clay, gum and other substances being mixed with water are used. When used dry, they are dusted over the mould face.

<u>Advantages of Green Sand Moulding</u>

- Green sand moulding is the least expensive method.
- No baking or drying is required.
- Less mold distortion than dry sand moulding.
- Dimensional accuracy is good across parting line.
- Flasks are ready for reuse in minimum time.

<u>Disadvantages of Green Sand Moulding</u>

- Erosion of the mould is common in the production of large castings.
- Does not impart good surface finish on casting.
- Dimensional accuracy decreases when weight of the casting increases.
- Moulds pocess lower strength, sand control is difficult.

Methods of Green Sand Moulding

1. Open Sand Method:

The entire mould is made in the foundry floor or in a bed of sand above floor level. No moulding boxes is necessary and the upper surface of the mould is open in air. The sand may be rammed lightly, just enough to support the weight of the metal only. After proper levelling, the pattern is pressed in the sand bed for making mold. The pouring basin is built up at one end of the mold and overflow channel is cut at the sides. This method is mainly used for simple castings.

2. Bedded-in Method:

In this method, the pattern is pressed or hammered down to the sand in the foundry floor or in a drag, which is partially filled to form the mould cavity. To ensure that the san d is properly compacted, careful ramming of the sand close the pattern is necessary. As a check, the pattern can be drawn and the mold cavity surface is tested for soft spots. All soft spots should be filled with extra sand and the pattern again pressed downward until properly rammed mold cavity is obtained.

After joint has been smoothed and parting sand is spread, a cope is placed over the pattern. The cope is rammed up, runners and risers are cut, and the cope box is lifted. The pattern is drawn out and the surface of both parts of the mould finished. The cope is replaced in its correct position to complete the mold.

3. Turn Over Method:

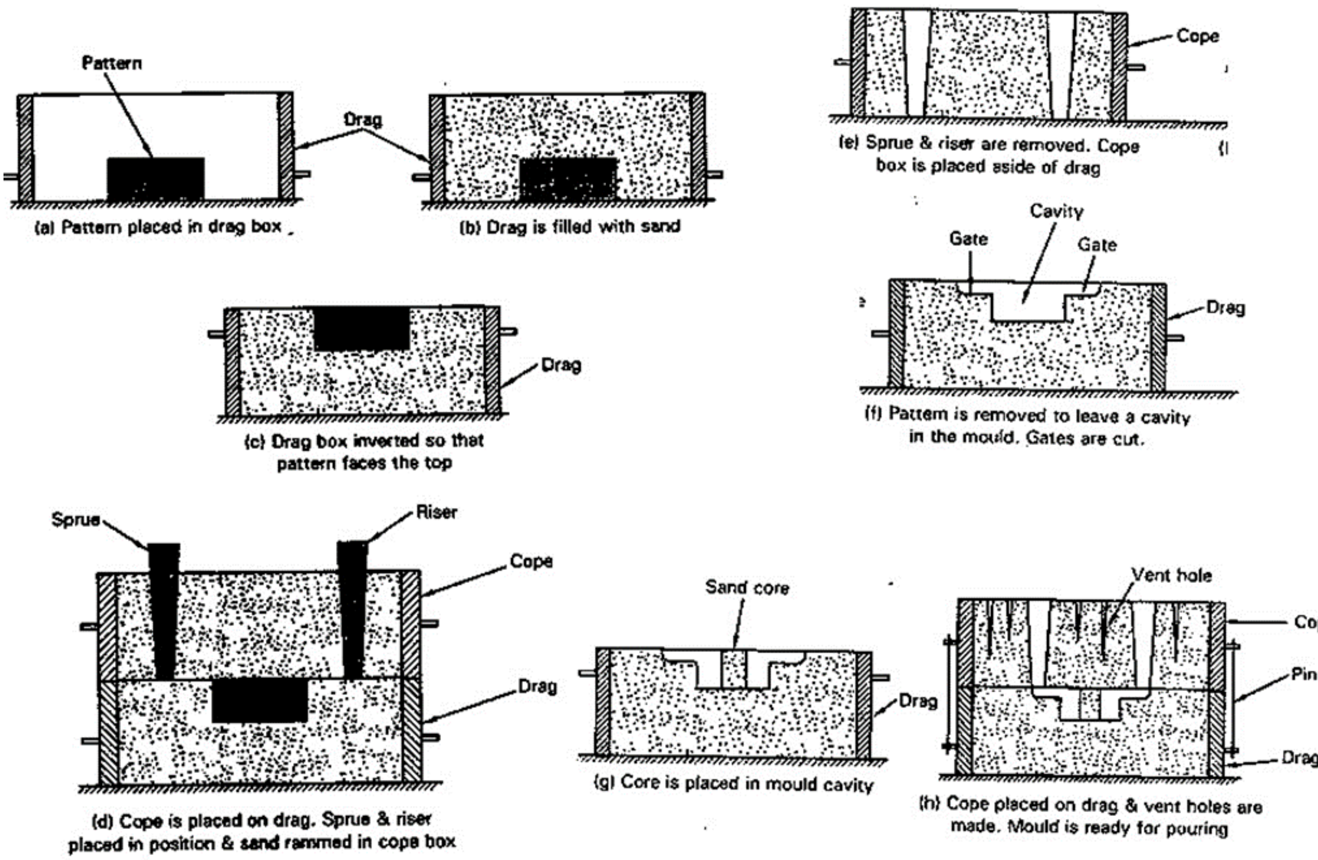
This method is commonly used and most suitable for split patterns as well as for solid patterns. One half of the pattern is placed with its flat surface on the moulding board, and drag is rammed and rolled over. It is now possible to place the other half of the pattern and a cope box in proper position. After ramming, the cope is lifted off and the two halves of the pattern are rapped and drawn separately. The cope is next replaced on the drag to assemble the mould.

Green Sand Moulding Procedure

First one half of the pattern is placed with its flat surface on a moulding board. Then the drag is placed on the board with the pins downward. After powdering the pattern with lycopodium, talc or graphite, a 15 to 20 mm layer of facing sand is riddled over the pattern. The drag is then filled by green sand mixture. After the sand is rammed, a strickle is used to scrap off the excess sand. The vent holes are provided by sticking the mold with a fine stiff wire at numerous places. The vent holes permit the escape of gases generated in the mold when the molten metal comes in contact with moist sand.

The drag is rolled over and the upper surface is sprinkled with parting sand. The remaining half of the pattern and the cope section of the flask are then assembled. Runner and riser pins are placed at appropriate places and the cope is filed with molding sand and rammed properly. Excess sand above the cope is levelled. Runner and riser is removed. The cope usually carries a series of cross bars to give support to the moulding sand, which is further supported by pieces of bent iron called lifters or gaggers. A funnel shaped opening known as pouring basin is cut at the top of the sprue.

Now cope is turned over and kept in a board. Patterns are carefully removed from cope and drag. Passage for the molten metal into the mould cavity known as gate is prepared on the top of the drag. Loose particles of sand are removed by a jet of air and the surfaces of mould are brushed or dusted with blackings. The core is kept in position and the cope is kept back in position on the drag and clamped. The mould is now ready for pouring molten metal.



DRY SAND MOULDING

In dry sand moulding a different sand mixture is used and all parts of the mould are dried in an oven before being reassembled for casting. The sand used for dry sand mould depends upon added binding materials such as flour, resin, molasses or clay. The amount of binder is determined by the size of casting being made. Metal flasks must be used for dry sand moulds to withstand the heat in the oven. Before drying the inside surface, dry sand moulds are coated with wet blackings- a mixture of carbon black and water with a small addition of gum. These gives a smoother surface to the casting. These molds can be held for any period of time before pouring.

Advantages of Dry Sand Moulding

- They are stronger than green sand moulds and thus they are less susceptible to damage in handling.
- Overall dimensional accuracy of the mould is better than that of green sand moulding.
- Surface finish of the castings is better.

Disadvantages of Dry Sand Moulding

- Castings are more susceptible to hot tears.
- Distortion is greater than that of green sand moulds.
- Processing cycle are longer than for green sand moulds.
- Production is slower than that of green sand moulds.

SHELL MOULDING

Shell moulding is also known as *Croning process or C-process*. The mould is formed from a mixture of fine sand and thermosetting resin binder that is placed against a heated metal pattern, preferably made of grey cast iron. The metal pattern is heated about 200-300^{0}C, the melting point of resin. Before the sand mixture is deposited, the pattern is preconditioned by spraying silicon dissolved in acetone. The process is necessary to ensure that the shells do not stick with the pattern.

When the mixtures are heated on this manner the resin cures, causing the sand grains to stick together forming a sturdy shell. The shell has about 4-12 mm thickness, depending on the heating period. It conforms exactly to the dimensions and shape of the pattern and constitutes half of the mould. The shell is then stripped mechanically. After that cores required are set, the two halves of the mould are secured together, placed in a flask and backup material is added. Then the mould is ready for pouring.

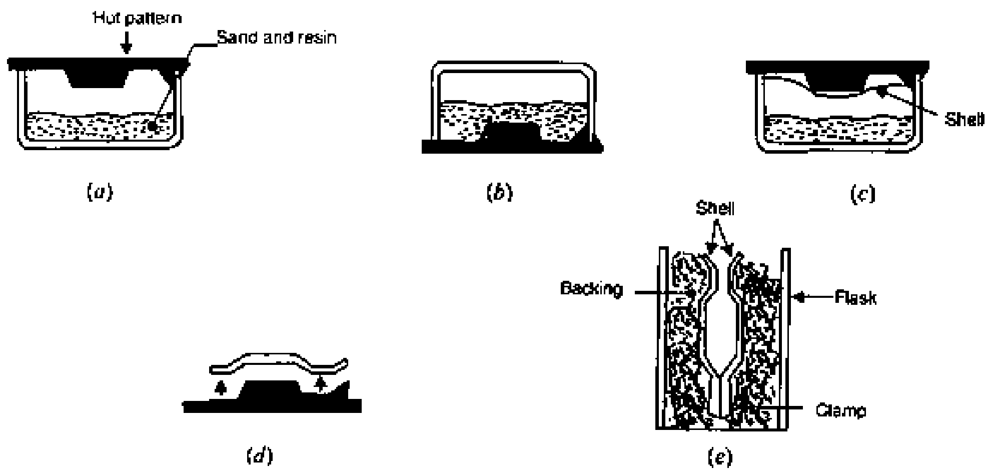


Fig. 4.12. Shell moulding process.

Advantages
- Saving of material
- Thin sections can be cast
- Machining of casting is reduced
- Better surface finish obtained
- Floor space and sand quality are reduced
- Shells can be stored and transported
- Productivity can be exceed that of conventional casting.

Disadvantages
- High pattern cost
- High resin cost
- High equipment cost
- Uneconomical for small runs
- Maximum casting size and weight are limited
- Shrinkage factors vary with casting.

PLASTER MOULDING

In this method, the mould is prepared by gypsum or plaster of paris. The plaster of paris is mixed with talc, asbestos, fibers, silica and a controlled amount of water to form a slurry. This slurry is poured over the metallic pattern confined in a flask. The mould is vibrated and the slurry is allowed to set. The pattern is removed after about 30 minutes when the setting is completed. The mould is dried by slowly heating it to about 200^0C. Inserts and cores are placed, cope and drag matched by guide pins. Molten metal is then poured into the mould. Finally the casting is cooled in the mould and taken out. Castings are then trimmed of gates, sprues and flash.

Advantages

- Wrapping and distortions of thin sections can be avoided since plaster has no chilling tendency.
- A high degree of dimensional accuracy and surface finish is obtained and machining cost is therefore eliminated.
- Highly suitable for the production of fine forms such as ornaments, statues, jewelry etc.

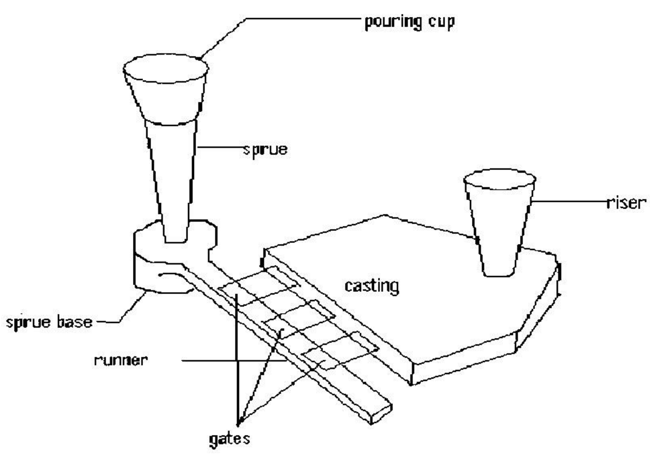
Limitations

- Low permeability of plaster of paris
- Suitable only for nonferrous castings owing to the fact that plaster of paris destroys at 1200^0C.

SAND CASTING

Sand moulds are prepared in a specially made box called moulding box or moulding flask, which is open at the top and bottom. It is made in two parts and held in alignment by pins. The top part is called the *cope* and the lower part is called *drag*. These flasks are made of wood or metal.

Gating System



Components of Gating System

The passage for molten metal to the mould cavity is known as gating system. It consists of a pouring basin, sprue and gate. Pouring basin is made at the top of the mould. The main purpose of pouring basin is to help to maintain the required rate of flow of molten metal into the mould cavity. It also prevents slag from entering the mould cavity. Sprue is the vertical passage that passes through the cope and connects the pouring basin with the gate. Gate is the passage through which the molten metal flows from the sprue base to the mould cavity.

Riser

Riser is the passage made in the cope to permit the molten metal to flow after the mould cavity is filled up. If the molten metal does not appear in the riser, it indicates that mould cavity is not filled up completely. The riser also acts as a reservoir and feed molten metal into the mould cavity to compensate for the solidification shrinkage of castings. Riser also serves as a vent for steam and gases generated as the mould cavity is being filled up with molten metal.

Core

Core is a prepared solid mass of dry sand, having shape of the internal cavity or hole in the casting. Cores are made separately using core boxes and are kept in the mould after the pattern is removed. The projections on the pattern intended to get impression in the mould, which support and hold the core are known as core prints.

PERMANENT MOULD CASTING (GRAVITY DIE CASTING)

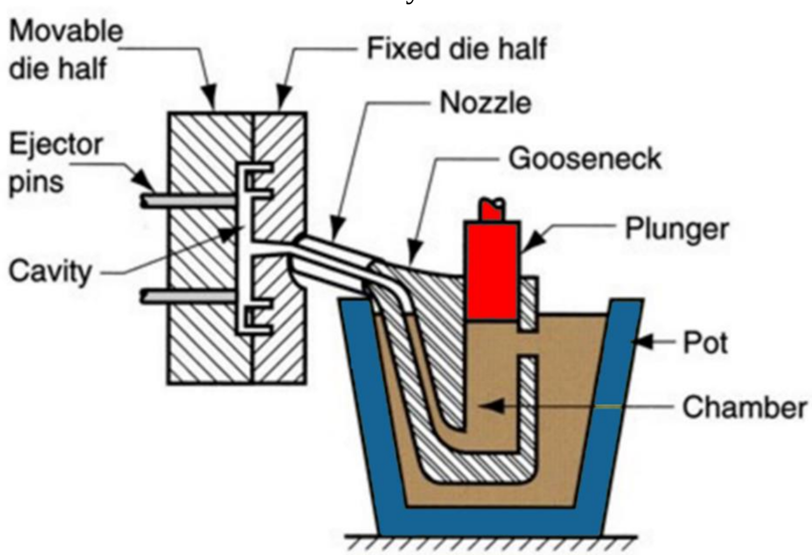
In permanent mould casting, the moulds are made of cast iron or alloy steel. It mainly differs from sand casting in that the mould is permanent one and is neither destroyed after casting. The moulds are made in two halves, hinged together to facilitate quick opening and closing and removal of casting. Pouring the molten metal into the mould cavity is achieved due to gravity, without any external pressure. Hence the process is also known as *gravity die casting*. Permanent mould is used to make castings of aluminium alloys, magnesium alloys, zinc base, lead, copper base etc.

PRESSURE DIE CASTING

Die casting is a versatile process for producing metal parts. In pressure die casting, the molten metal is forced into the mould cavity (die) under very high pressure. To general mechanisms used for producing die castings are hot chamber process and cold chamber process.

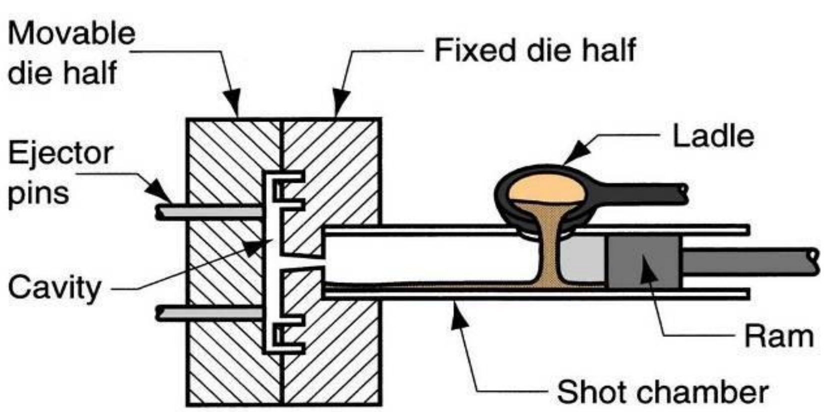
Hot Chamber Process

In hot chamber process, a port is provided near the top of the cylinder to allow the molten metal to enter into it. When the plunger is above the port, molten metal flows into the gooseneck portion. The downward stroke of the plunger closes this port and applies pressure on the molten metal. So the hot molten metal is forced into the die cavity.



The plunger is made of refractory materials and actuated by means of mechanically or hydraulically at a pressure below150 kgf/cm^2. After solidification of molten metal in the die cavity, the plunger is moved upward. Just before the end of upward stroke the plunger uncovers the port and hot molten metal enters the cylinder. After opening the die, the casting is taken out, with the help of ejector pins. This method is suitable for metals like zinc and tin.

Cold Chamber Die Casting



The cold chamber die casting machine consists of a horizontal cylinder provided with a plunger. Metal is melted separately and transferred to the cylinder by using hand ladle. After closing the die the molten metal in the cylinder is forced into the die cavity by applying pressure (300-1600 kgf/cm^2) on the plunger. After solidification the die is opened and the casting is ejected.

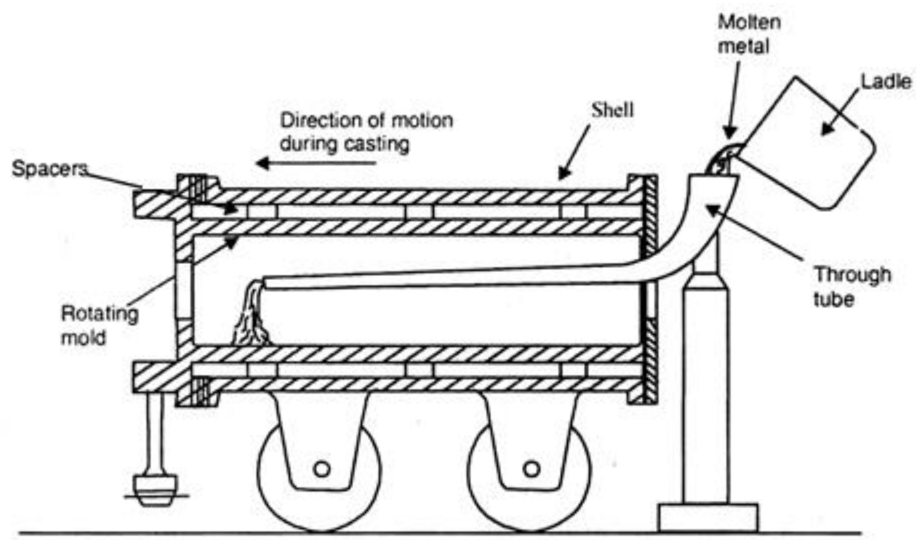
ADVANTAGES OF DIE CASTING

- Very high rate of production
- Very close dimensional tolerance
- High surface finish
- Highly economical for mass production
- Intricate shapes can be easily cast
- Thin sections that cannot be produced by any other casing method can be easily and quickly cast.

DISADVANTAGES OF DIE CASTING

- All types of alloys cannot be cast
- Not suitable for large castings
- High initial cost of die and die equipment

CENTRIFUGAL CASTING



In the centrifugal casting molten metal is poured into the moulds while they are rotating. The molten metal falling into the center of the mould at the axis of rotation is thrown out by the centrifugal force under sufficient pressure towards the periphery. The contaminants or impurities present in the metal being lighter in weight and also pushed towards the center. Solidification progress from outside to inside, thus developing an area of weakness in the center of the wall. This is caused by meeting the grain boundaries at final solidification and the entrapment of impurities in the central section. The castings are completely free from any porosity defect by the forced movement of the molten metal. The use of gates, feeders and cores are eliminated, making the method less expensive. Hollow cylindrical structures such as cast iron pipes, steel gun barrels and other symmetrical objects such as gears, disc wheels, pulleys are conveniently cast by this method.

CASTING DEFECTS

The following are the major casting defects:

1. Blow Holes

Smooth round holes below the surface of castings, which are not visible from outside are known as blow holes. They are formed by the entrapped bubbles of gases in the metal. It is caused due to excess moisture in the moulding sand, low porosity of sand, hard ramming of sand, inadequate venting etc.

2. Inclusions

Any separate non-metallic foreign material present in the casting is called inclusions. The inclusions may be in the form of oxides, slag, dirt and sand.

3. Swell

It is the localized or overall enlargement of the casting. It is caused due to loose ramming of the sand. Mould cavity enlarges under the pressure of molten metal at the place where ramming is loose, resulting the swelling of casting in those places.

4. Scab

It is the erosion or breaking down of a portion of the mould and the recess filled with metal. The main cause of this is uneven ramming.

5. Honey Combing

Number of small cavities present in the casting surface is called honey combing. It is caused by dirt held in the molten metal.

6. Drop

A drop occurs when the cope surface cracks and breaks. Thus the piece of sand fall into the molten metal. Causes of drop are low green strength, low strength of mould.

7. Pin Holes

They are small holes revealed on the surface of casting. Causes of pin holes are high moisture content of the sand, faulty metal etc.

8. Mismatch (Shift)

Castings may not match at the parting line. It is caused due to misalignment of pattern, misalignment of cope and drag, movement of mould box during pouring of molten metal etc.

9. Misrun

If the molten metal fails to reach all sections of the mould, an incomplete casting is produced. Such a defect is termed as misrun. It happens due to low fluidity of molten metal, due to low temperature, slow and intermittent pouring, presence of very thin sections etc.

10. Cold Shut

Cold shut is an external defect formed when two streams of molten metal of low temperature approach within the mould cavity, from opposite directions. The two streams of metal establish a physical contact between them, but fail to fuse together. It is caused due to low fluidity of molten metal, slow and intermittent pouring and presence of thin sections.

11. Hot Tears

These are internal or external crack on casting occurring due to unwanted cooling stresses. Causes of hot tears are very hard ramming, faulty metal, faulty design of casting, too much shrinkage of metal while solidifying.

12. Slag Holes

They are smooth depressions on the surface of casting, near the ingates. Slag holes results when the slag enters the mould cavity.

13. Fin

A thin projection of metal, which is not the part of casting is called fin. Fins are usually occurs at the parting surface of the cope and drag, mould cavity and core sections. It is caused due to insufficient weight of mould, improper clamping of moulding boxes, high pressure of molten metal, incorrect position of core etc.

14. Shrinkage Defects

Molten metal shrinks as they solidify. If the shrinkage is not compensated by risers, voids will occur on the surface or inside.

15. Rattails and Buckles

When the molten metal having very high temperature is poured into the mould cavity, a thin layer of sand expands. If the molten metal fails to compress back this layer of sand, it gets separated from the remaining sand and remains over the surface of casting. A slight compression failure of sand surface is known as rattails and severe compression failure of sand surface is known as buckles.