Manufacturing

- Arrived from the Latin word "*manu factus*", meaning "made by hand".
- Manufacturing is the process of converting raw materials into products.

Production Processes

Project- or Job-Based Production

- **Project-based production** is one-of-a-kind production in which only one unit is manufactured at a time. This type of production is often used for very large projects or for individual customers. Because the customer’s needs and preferences play such a decisive role in the final output, it’s essential for the operations manager to maintain open and frequent communication with that customer. The workers involved in this type of production are highly skilled or specialists in their field.

The following are examples of project- or job-based production:

- custom home construction
- haircuts
- yachts

Production Processes

Batch Production

- **Batch production** is a method used to produce similar items in groups, stage by stage. In batch production, the product goes through each stage of the process together before moving on to the next stage. The degree to which workers are involved in this type of production depends on the type of product. It is common for machinery to be used for the actual production and workers participate only at the beginning and end of the process.

Examples of batch production include the following:

- bakeries
- textiles
- furniture

Production Processes

Mass Production

- **Mass production** is used by companies that need to create standardized products in large quantities as economically as possible. Products are mass produced in order to generate the inventory needed to meet high market demand. This type of production usually requires heavy investment in machinery and equipment; workers are generally needed to assemble component parts to make the finished good.

The following goods are mass produced:

- toilet paper
- cell phones
- automobiles

Production Processes

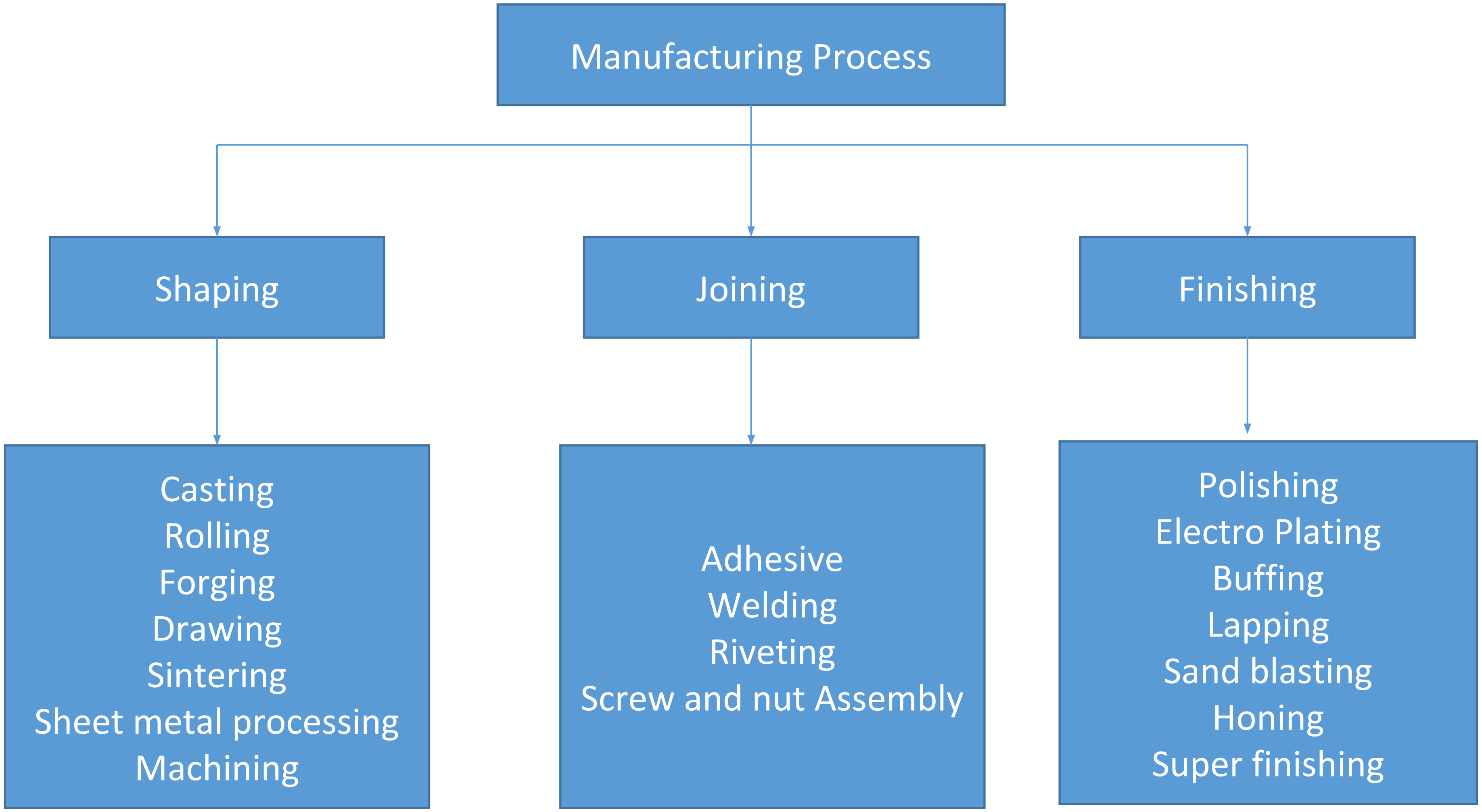
Flow or Continuous Production

- **Flow production**, also known as continuous production, occurs when a process runs twenty-four hours a day. Companies whose products are homogeneous use this production approach to reduce cost and increase efficiency. These systems are highly automated, and workers act as monitors rather than as active participants.

Examples of flow production:

- gas and oil
- steel
- chemicals

Classification of Manufacturing Process



Selection of a process for production

There are hundreds of manufacturing processes. You are likely to already be familiar with the most common, e.g. casting, forming, molding and machining. For any given product, there will be multiple manufacturing processes that you'll need to select from. The process you choose will depend on many factors called the *process selection drivers*. These process selection drivers include the following:

- Quantity of the product
- Cost for tooling, manufacturing machines and equipment
- Time required for processing
- Level of skilled labor required
- Process supervision
- Energy consumption
- Availability of material and cost of material
- Capabilities required to processes material
- Product dimensions and size
- Surface finish required
- Design tolerances
- Waste produced by the process
- Maintenance costs
- Other costs

Selection of a process for production

STEP 1: Selection criteria

- The first step in manufacturing process selection is to establish selection criteria based on key process selection drivers: manufacturing volumes, value of the product, part geometry, required tolerances, and required material. The material choice will be very effective in narrowing your options down. This is because many processes work exclusively with certain materials. For example injection moulding can only be used with *polymers*, whilst die casting can only be used with *metals*. Your material choice will instantly rule out a vast number of unsuitable processes.
- The expected manufacturing volume will further narrow down your process options. For a large quantity, a manual production process like manual machining would be completely impractical. Instead you would need to consider an automated process such as molding. The geometry and tolerances required for a product will also filter out many processes that would be unable to achieve the desired accuracy.

Selection of a process for production

STEP 2: Identify processes

- After applying STEP 1, a smaller range of processes will be available. At this point you should ideally work with an experienced manufacturer to identify those processes that can satisfy the required quantity, material requirements, and part geometry.

STEP 3: Evaluate processes

- After identifying the potential processes for manufacturing a product, it is time to evaluate them based on less broad parameters, such as process capability, processing time, tooling and equipment cost, degree of automation available, skill required for operation, waste produced after processing, and post processing required. It is a good idea to create a decision matrix with a score or value for each of these important elements.

Selection of a process for production

STEP 4: Selection

- You should now be able to use the weighted decision matrix you created in STEP 3 to identify the best process for your application. If you carefully evaluate each element, giving extra weight to those elements that are most important, the result will be a single process that will produce the part required to the standard required for an acceptable cost of production.
- As mentioned earlier, it is important that you work with experienced manufacturers or a manufacturing engineer to help you identify potential processes, evaluate each process effectively, and select the best process so that you and your customers will be happy with the final product.

Introduction of casting

- A process based on the property of liquid to take up the shape of the vessel containing it.
- A cavity of desired shape is made, contained in a mold.

History of Casting

Ancient process, started 5000 years ago.

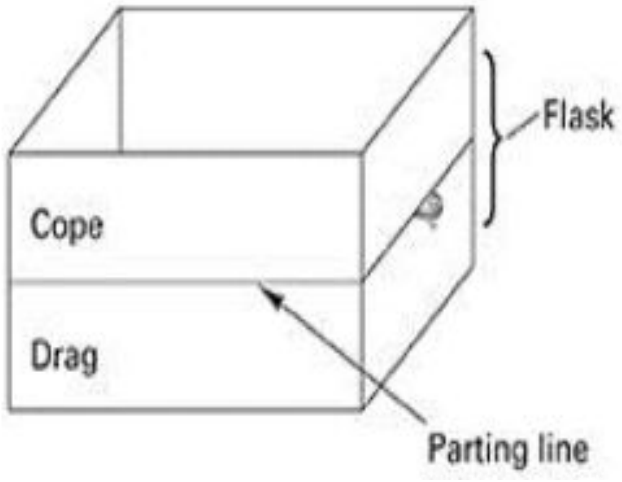
Jaivana- 50 tons cannon was built in 17th century in Jaipur.

Used for making arrows, coins, knives etc.

World's largest Cannon in Jaipur, made by casting

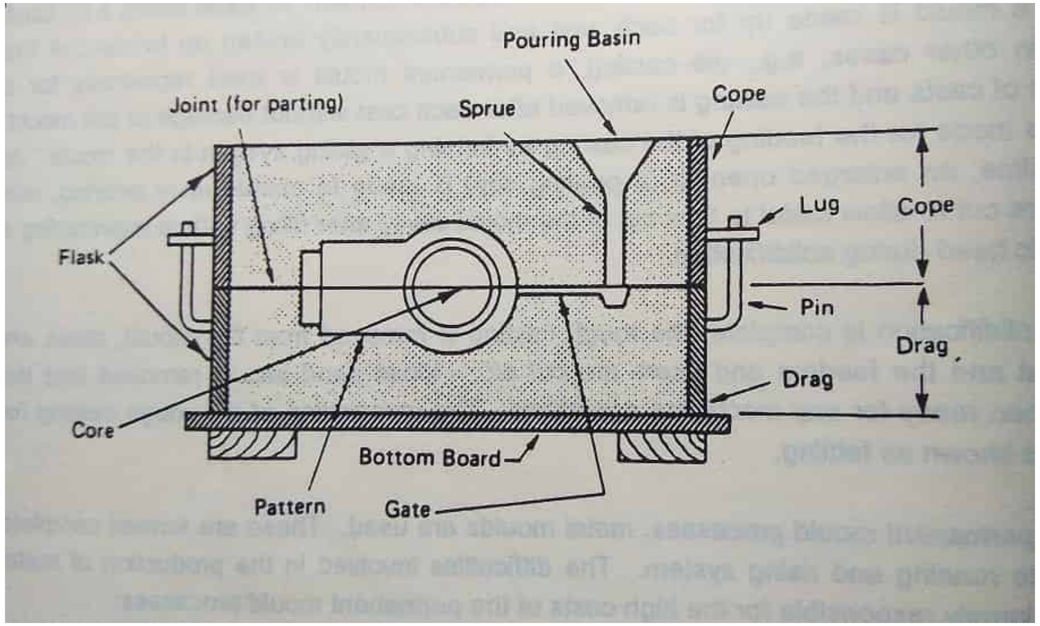
Basic terms used in Casting

1. Pattern: Replica of the desired part
2. Mold- Container with a cavity within. Divided in two halves: Cope and Drag.
3. Gating system- Network of channels that deliver molten metal to the cavity.



Basic steps in Casting

1. Pattern making
2. Mold making
3. Melting of metal and pouring
4. Cooling and solidification of metal
5. Cleaning of casting and inspection



Pattern

- Replica of the desired product
- Has somehow different dimensions than the actual part to be manufactured
- Used to form the mold cavity

Pattern Materials

Requirements:

1. Easily shaped, worked, machined and joined
2. Resistant to wear and corrosion
3. Resistant to chemical action
4. Dimensionally stable
5. Easily available and economical

Pattern Materials

1. Wood:

- Easy availability, low weight and low cost
- Can be easily shaped
- More than 90% castings use wood patterns
- Absorbs moisture. So, distortions and dimensional changes occur
- Relatively lower life, hence suitable for small quantity production

Pattern Materials

2. Metal:

- Used for large quantity production and for closer dimensional tolerances
- Longer life
- Aluminum is mostly used.
- Other metals: cast iron, brass etc.

3. Plastic:

- Low weight, easier formability, smooth surfaces and durability
- Do not absorb moisture. So, dimensionally stable
- Corrosion resistance

Pattern Materials

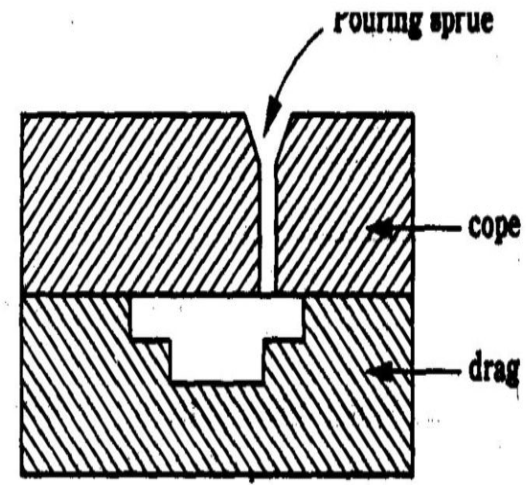
4. Polystyrene:

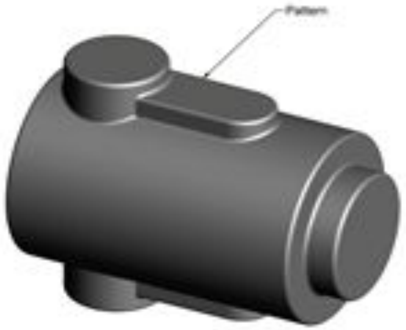
- Changes to gaseous state on heating
- Disposable Patterns. Hence, suitable for single casting.
- When molten metal is poured into cavity, polystyrene transforms to gaseous state.
- Used mostly for small and complicated shaped castings.

Pattern Types

1.Single piece pattern:

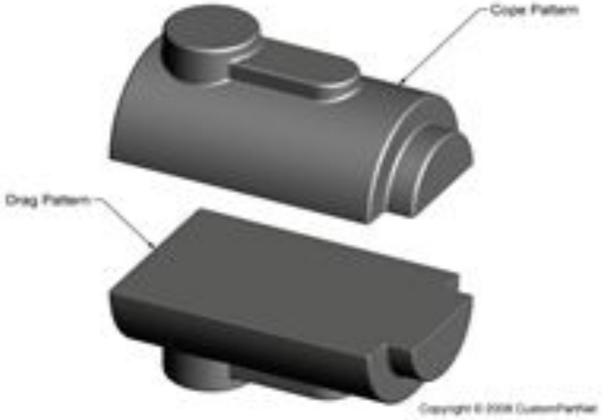
- Used for simple shaped & large castings.
- Pattern and cavity produced by it are completely in the lower flask (i.e. drag)
- Causes difficulty in making the mold.





2.Split pattern:

- Split pattern models the part as two separate pieces that meet along the parting line of the mould
- Two parts are aligned by Dowel pin



Pattern Types

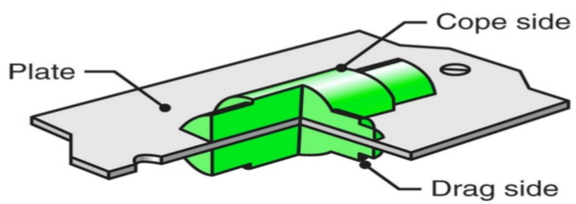
3.Loose Piece pattern

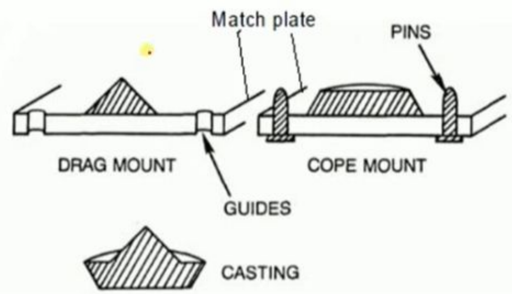
- As pre The name Pattern Contain One or more than one loose piece
- Loose piece is used to make removal of pattern easy from mould box
- loose pieces are attached to main body with the help of dowel pins or wire
- First main pattern is drawn and then carefully loose pieces
- Moulding with this pattern is expensive and require more skill

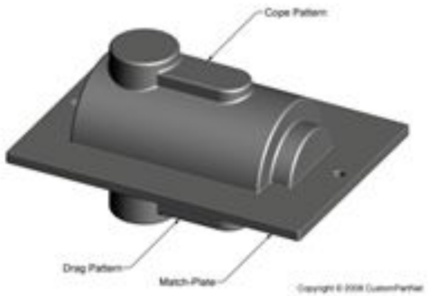
4. Match-plate pattern:

- Similar to a split pattern, except that each half of the pattern is attached to opposite sides of a single plate.
- Match plate confirms the parting line
- Ensures proper alignment of the mould cavities in the cope and drag and the runner system can be included on the match plate.
- Used for larger production quantities.
- Ic Engines piston rings

A typical metal match-plate pattern used in sand casting.





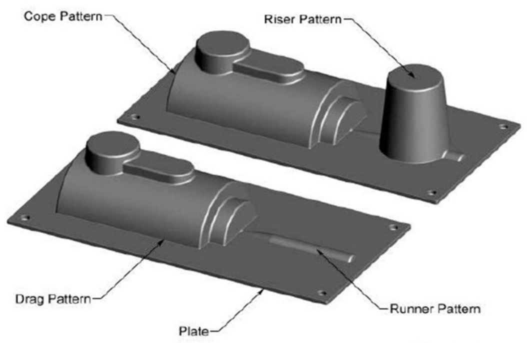


Pattern Types

4. Cope-Drag pattern:

- It is similar to split pattern
- Each half of the pattern is attached to a separate plate and the mould halves are made independently.
- .Pattern is made in two halves and split along parting line
- These two halves are known as cope and drag
- There moulding done independently
- After moulding they are assembled to form complete mould box
- Often desirable for larger castings

Cope and Drag Pattern



Pattern Types

5. Gated pattern:

- In this patters of gate and riser or runner are permanently attached to regular pattern
- They are used to manufacture multiple casting in on time
- Each pattern is connected with common runner .
- Suitable for pouring small castings and for mass production
- It save labour and time

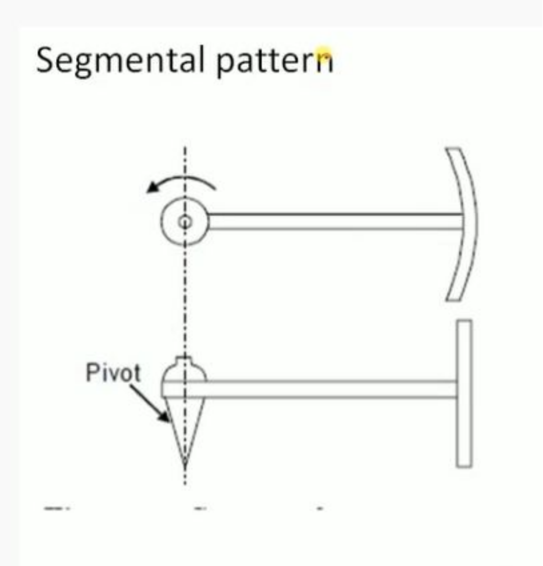
Pattern Types

6. Segmental pattern

Patterns of this type are generally used for circular castings.

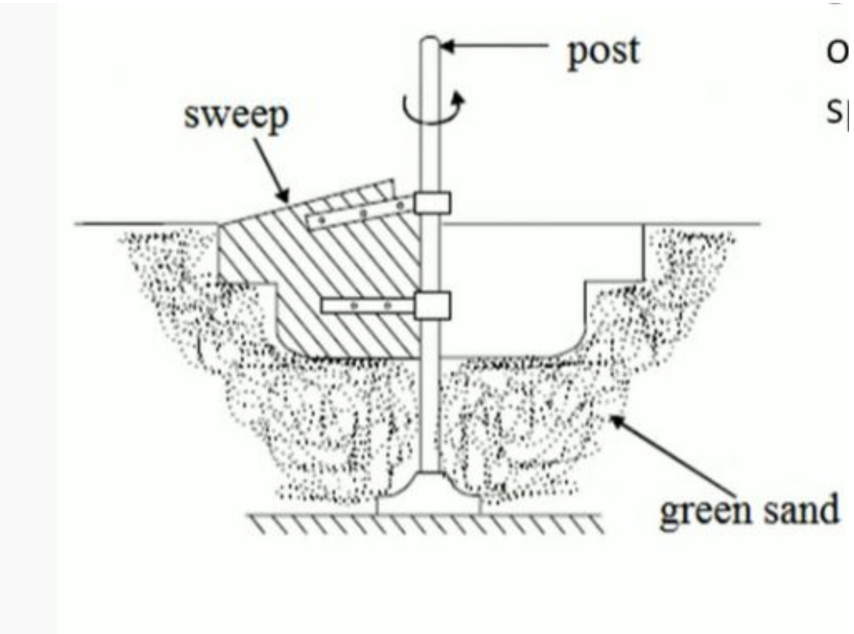
For example wheel rim, gear blank etc. Such patterns are sections of a patterns so arranged as to form a complete mould being moved to form each section of the mould.

The movement of segmental pattern is guided by the use of central pivot.



7. Sweep Patterns

Sweep Patterns are used for forming large circular moulds of symmetric kind by revolving a sweep attached to a spindle.



Pattern Allowances

1. Shrinkage or contraction allowance
2. Draft or taper allowance
3. Machining or finish allowance
4. Distortion or camber allowance
5. Rapping allowance

Pattern Allowances

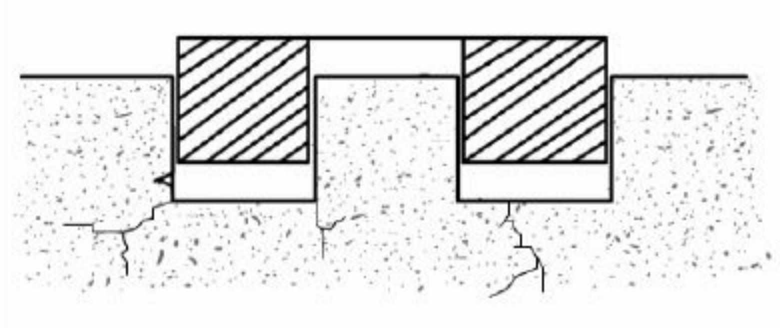
<u>1. Shrinkage Allowance</u>:

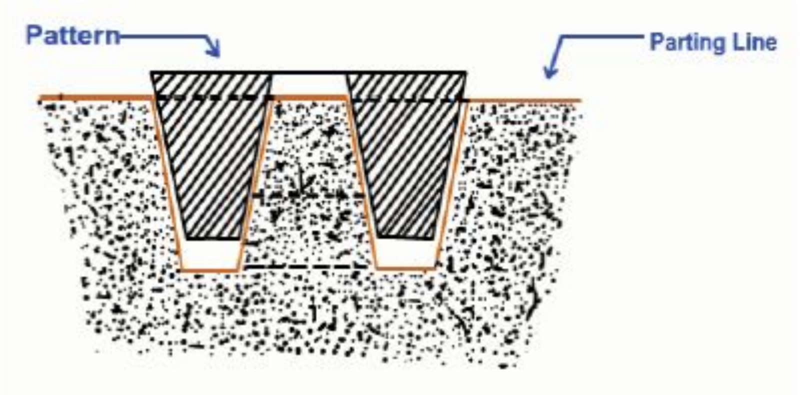
- Shrinkage means contraction of metal on solidification
- All metals shrink after solidification. (Except grey cast iron that expands on solidification).
- It is expressed in mm/m.
- Shrinkage allowance Differs from material to material.
- Positive type of allowance.

Material	Dimension	Shrinkage allowance (inch/ft)
Grey Cast Iron	Up to 2 feet 2 feet to 4 feet over 4 feet	0.125 0.105 0.083
Cast Steel	Up to 2 feet 2 feet to 6 feet over 6 feet	0.251 0.191 0.155
Aluminum	Up to 4 feet 4 feet to 6 feet over 6 feet	0.155 0.143 0.125
Magnesium	Up to 4 feet Over 4 feet	0.173 0.155

Pattern Allowances

2. Draft / Taper Allowance:





- Taper provided by the pattern maker on all vertical surfaces of the pattern so that it can be removed from the sand without tearing away the sides of the sand mould.
- Inner details of the pattern require higher draft than outer surfaces.
- commonly applied draft allowance is 1°to 3°
- due to draught allowance pattern can easily removed from mould box

The amount of draft depends upon-

a) The length of the vertical side of the pattern to be extracted;

b) The intricacy of the pattern;

c) The method of moulding

d) Pattern material.

Pattern Allowances

Pattern material	Height of the given surface (inch)	**Draft angle (External surface)**	**Draft angle (Internal surface)**
Wood	1	3.00	3.00
	1 to 2	1.50	2.50
	2 to 4	1.00	1.50
	4 to 8	0.75	1.00
	8 to 32	0.50	1.00
Metal and plastic	1	1.50	3.00
	1 to 2	1.00	2.00
	2 to 4	0.75	1.00
	4 to 8	0.50	1.00
	8 to 32	0.50	0.75

Pattern Allowances

3. Machining / Finishing Allowance:

- The finish and accuracy in sand casting is generally poor.
- Extra material provided on the casting to enable their machining or finishing to the required size, accuracy and surface finish.
- So it is Added in pattern dimensions.
- allowance is provided only in machining area

Amount of machining allowance depends upon:

a) Method of moulding and casting used
b) Size and shape of casting
c) Casting orientation
d) Metal used in casting
e) Degree of accuracy and finish required

Pattern Allowances

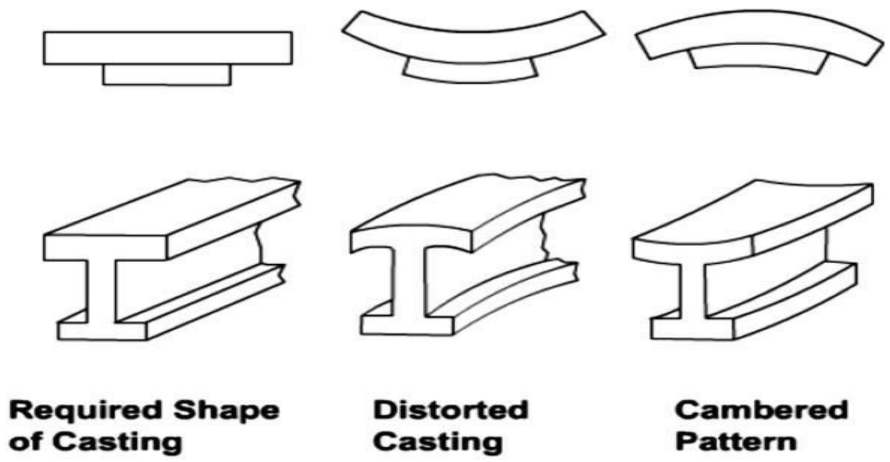
Machining allowances of various metals

Metal	Dimension (inch)	Allowance (inch)
Cast iron	Up to 12	0.12
	12 to 20	0.20
	20 to 40	0.25
Cast steel	Up to 6	0.12
	6 to 20	0.25
	20 to 40	0.30
Non ferrous	Up to 8	0.09
	8 to 12	0.12
	12 to 40	0.16

Pattern Allowances

4. Distortion / Chamber Allowance:

- Due to their typical shapes (U,V,T,L shapes) , castings get distorted during solidification.
- Distortion is observed in irregular castings so that it shrink in uneven manner
- Distortions are caused by internal stresses which are generated on account of unequal cooling of different sections of casting.
- To avoid this distortion allowance is provided
- It varies from 2 to 20 mm



Pattern Allowances

5. Rapping / shake Allowance:

- Before the withdrawal from the sand mould, the pattern is rapped all around the vertical faces to enlarge the mould cavity slightly, which facilitate its removal.
- When pattern is rapped, mould cavity is enlarged.
- To account for this increase, pattern size is reduced.
- This allowance is important in large-sized castings and precision castings.

Amount of rapping allowance depends upon:

a) Extent of rapping
b) Degree of compaction of sand
c) Size of mould
d) Sand type

COLOUR CODING FOR PATTERN

- Pattern are colored by using shellac paints.
- Colours gives protection and identifies the features of patterns.
- Colour scheme is given as bellow

Colour	Indication
Black	Unfinished surface on casting
Red	Finished surface on casting
Yellow	Core prints
Black	Parting surface
Red/yellow strips	Seats for loose piece

Types of Moulding Sand

(i) Green Sand:

- When sand is in its natural (more or less moist) state, it is referred to as green sand. It is a mixture of silica sand, with 18 to 30% clay and 6 to 8% water. The clay and water give bonding strength to green sand.
- It is fine, soft, light and porous. Being damp, it retains the shape given to it under pressure during squeezing.
- As the mould becomes dense by ramming, the structure is made porous by venting. Sharp edges are avoided in green sand moulding, because these being weak, break when hot metal is poured.
- Green sand is generally used for casting small or medium sized moulds. Larger output can be obtained from a given floor space as the cost and delay involved in drying the moulds is saved. Coal dust is mixed in green sand to prevent defects in castings.

Types of Moulding Sand

(ii) Dry Sand:

- Dry sand moulding is employed for large castings. The moulds prepared in green sand are dried or baked to remove, almost, all moisture of the moist sand. The structure in the moulding boxes after drying becomes stronger and compact. Venting is therefore necessary but not to that extent, as in the case of green sand mould. For larger heavy moulds, cowdung, horse manure, etc. are mixed with the sand of coarser grains.

Types of Moulding Sand

(iii) Loam Sand:

- It is a mixture of clay and sand milled with water to a thin plastic paste, from which, moulds are built up on a backing of soft bricks.
- Loam sand contains upto 50% clay and dries hard. It also contains fire clay. It must be sufficiently adhesive to hold on to the vertical surfaces of the rough structure of the mould. Chopped stray and manure are commonly used to assist in binding. The moisture content is from 18 to 20%.
- Loam is dried very slowly and completely before it is ready for casting. It is used for casting larger regular shaped castings like chemical pans, drums, etc.

Types of Moulding Sand

(iv) Facing Sand:

- It is used directly next to the surface of the pattern and it comes into contact with the molten metal. Since, it is subjected to the most severe conditions, 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 known as facing materials, (e.g., plumbago powder, ceylon lead or graphite) are used to prevent the metal from burning into the sand. Sometimes they are mixed with 6 to 15 times fine moulding sand to make mould facings.

Types of Moulding Sand

(v) Backing Sand:

- The old, repeatedly used moulding sand, black in colour due to addition of coal dust and burning or coming in contact with molten metal is known as backing sand or floor sand or black sand. It is used to fill in the mould at the back of facing layer. It is weak in bonding strength because the sharp edges of sand grain become rounded due to high temperature of molten metal and burning of clay content.

(vi) System Sand:

- This is used in machine moulding to fill the whole flask. Its strength, permeability, and refractoriness must be higher than those of backing sand.

Types of Moulding Sand

(vii) Parting Sand:

- The moulding boxes are separated from adhering to each other by spreading a fine sharp dry sand called ‘parting sand’. Parting sand is also used to keep the green sand from sticking to the pattern. It is clean clay- free silica sand. Burnt core sand could also be used for this purpose.

(viii) Core Sand:

- It is used for making cores. It is silica sand mixed with core oil (linseed oil, rosin, light mineral oil and other binders). For the sake of economy pitch or flour and water may be used as core sand for large cores.

Types of Moulding Sand

(ix) CO_2-Sand:

- In CO_2 sand, the silica grains, instead of being coated with natural clay, are coated with sodium silicate. This mixture is first packed around the pattern and then hardened by passing CO_2 through the interstices for about a minute. The sand thus sets hard and produces a strong mould.

(x) Shell Sands:

- Shell sands are synthetic sands coated with phenol or urea-formaldehyde resins and cured against a heated pattern to produce very strong, thin shell. No back up sand is required to provide support for the weight of the casting. Since, alloys solidify at high temperatures, the resins are not dissociated. But moulds disintegrate when casting has solidified due to breaking up of chemical bond by heat from solidifying casting.

Properties of Moulding Sand

1. Porosity:

- Porosity also known as permeability is the most important property of the moulding sand. It is the ability of the moulding sand to allow gasses to pass through. Gasses and steam are generated during the pouring of molten metal into the sand cavity. This property depends not only on the shape and size of the particles of the sand but also on the amount of the clay, binding material, and moisture contents in the mixture.

2. Cohesiveness:

- Cohesiveness is the property of sand to hold its particles together. It may be defined as the strength of the moulding sand. This property plays a vital role in retaining intricate shapes of the mould.
- Insufficient strength may lead to a collapse in the mould particles during handling, turning over, or closing. Clay and bentonite improves the cohesiveness.

Properties of Moulding Sand

3. Adhesiveness:

- Adhesiveness is the property of sand due to which the sand particles sticks to the sides of the moulding box. Adhesiveness of sand enables the proper lifting of cope along with the sand.

4. Plasticity:

- Plasticity is the property of the moulding sand by virtue of which it flows to all corners around the mould when rammed, thus not providing any possibility of left out spaces, and acquires a predetermined shape under ramming pressure.

Properties of Moulding Sand

5. Flow-Ability:

- Flow-ability is the ability of moulding sand to free flow and fill the recesses and the fine details in the pattern. It varies with moisture content.

6. Collapsibility:

- Collapsibility is the property of sand due to which the sand mould collapse automatically after the solidification of the casting. The mould should disintegrate into small particles of moulding sand with minimum force after the casting is removed from it.

Properties of Moulding Sand

7. Refractoriness:

- Refractoriness is the property of sand to withstand high temperature of molten metal without fusion or soften.
- Moulding sands with poor refractoriness may burn when the molten metal is poured into the mould. Usually, sand moulds should be able to withstand up to 1650°C.

Meaning of Cores

- Core is a pre-prepared shape of the mould. It is used to provide internal cavities, recesses, or projections in the casting. It is usually positioned into a mould after the removal of the pattern.
- A core is usually made of the best quality sand and is placed into desired position in the mould cavity. Core prints are added to both sides of the pattern to create impressions that allow the core to be supported and held at both ends.

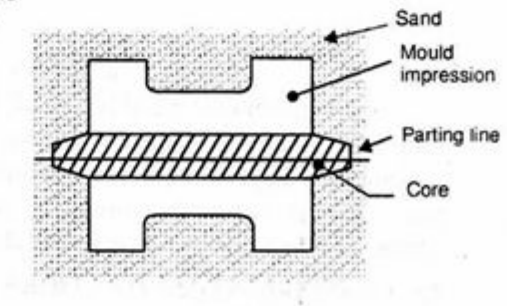
Types of cores

i) Horizontal Core:

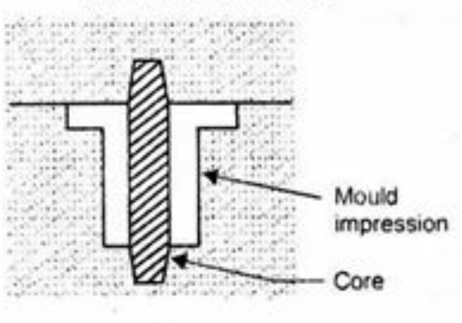
- The horizontal core is the most common type of core and is positioned horizontally at the parting surface of the mould. The ends of the core rest in the seats provided by the core prints on the pattern. This type of core can withstand the turbulence effect of the molten metal poured. A horizontal core for gear blank mould

(ii) Vertical Core:

- The vertical core is placed vertically with some of their portion lies in the sand. Usually, top and bottom of the core is kept tapered but taper on the top id greater them at bottom.



(c) Horizontal core.



(d) Vertical core.

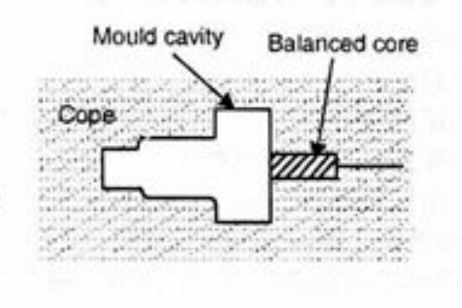
Types of cores

(iii) Balance Core:

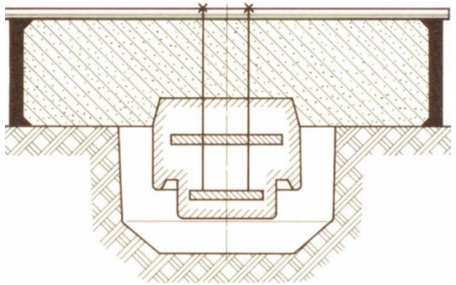
- The balance core extends only one side of the mould. Only one core print is available on the pattern for balance core. This is best suitable for the casting has only one side opening. This is used for producing blind holes or recesses in the casting.

(iv) Hanging Core:

- The hanging core is suspended vertically in the mould. This is achieved either by hanging wires or the core collar rests in the collar cavity created in the upper part of the mould. This type of core does not have bottom support.



(e) Balanced core.



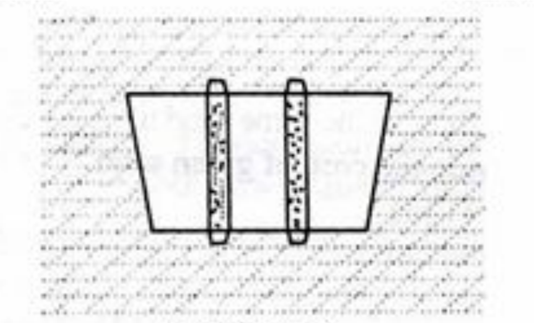
Types of cores

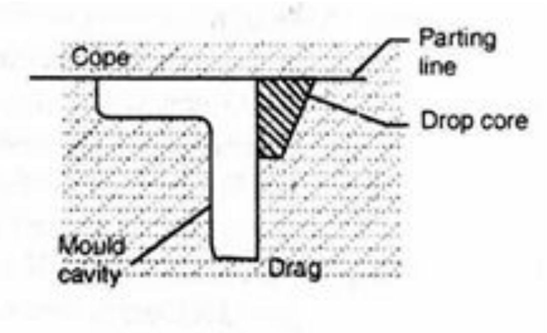
(v) Drop Core:

- The drop core is used when the core has to be placed either above or below the parting line. A drop core is shown in Fig. 3.11 (J). This core is also known as wing core, tail core, chair core, etc.

(vi) Kiss Core:

- The kiss core is used when a number of holes of less dimensional accuracy is required. In this case, no core prints are provided and consequentially, no seat is available for the core. The core is held in position approximately between the cope and drag and hence referred as kiss core.


(g) Kiss core.



(f) Drop core.

Core Materials

The compositions of core material are the mixture of sand, binders and additives. Core sands are silica, zircon, Olivine etc. and core binders are core oils, resins, molasses, dextrin etc., are generally used for preparation of core materials.
Sand contains more than 5% clay reduces not only permeability but also collapsibility and hence not suitable for core making.

The commonly used core sand is a mixture of following items:

(i) Core Sand:

- The sand may be green sand for smaller castings and mixture of fire clay, green sand and betonies for heavier casting. The cores are oven backed to dry away its moisture. The dry sand cores are strong than green and cores. Also, the sand with rounded grains is best suitable for core making as they have better permeability than the angular grains sand.

(ii) Oil Sand:

- Oil sand can be used for almost any sand casting application.

Oil sand is very popular in core making because:

(a) They get good strength.

(b) They provide excellent surface finish.

(c) They have better collapsibility after baking.

(c) The backed oil sand cores are very hard and not easily damaged in handling of mould.

The commonly used core sand is a mixture of following items

(iii) Resin Sand:

- These are thermosetting or thermoplastic binders such as rosin, phenol, urea, furan, formaldehyde etc. are used to obtain good bonds to sand. They are becoming common in use due to their high strength, low gas formation, excellent collapsibility, resistance to moisture absorption, better dimensional accuracy to casting, etc.

(iv) CO_2 – Sodium Silicate Sand:

- Silica sand and sodium silicate (3-4%) is rammed in the core and then CO_2 gas is passed through sand to make the core hard. Such types of cores are used for very large castings. They do not need to drying and hence is very fast method of core making,

The commonly used core sand is a mixture of following items:

(v) Core Binders:

- Natural sand has not sufficient binding properties and hence some binders are used to improve the binding strength of core sand. The functions of binders are to hold the sand grains together and to provide better strength to the core.

There are two types of binders used are:

a. Inorganic Binders:

They include fire clay, bentonite, limonite, silica powder, iron oxide, aluminum oxide, etc. They are very fine powder and popularly used.

b. Organic Binders:

They include core oils like petroleum oil, vegetable oil, linseed oil, corn oil, molasses and dextrin. Organic binders get harder rapidly and provide good strength.

The commonly used core sand is a mixture of following items

- **(vi) Core Additives:**

In addition to core sand and core binder, some additives are used to improve the special properties of the core.

- **The additives are:**

(a) Kaolin or fire clay to improve stability.

(b) Iron oxide (Fe_2O_3) and aluminum oxide (Al_2O_3) to improve hot strength.

(c) Zircon flour and pitch flour to improve refractoriness.

(d) Molasses to improve binding properties.

(e) Organic additives to improve collapsibility like raw dust.

(f) Silica powder, paints and graphite bonded with resin are used to improve the surface finish.

Core Chaplets

- If the core length is long and the end supports are at higher distances to each other, the core will sagging during pouring of hot molten metal.
- In such cases, chaplets are used to overcome these defects. Chaplets are so designed to provide the support to the core and restrict them from sagging.
- The chaplets are made of the same material as the casting metal so as to become an integral part of the casting. Some commonly used chaplets are shown n Fig.

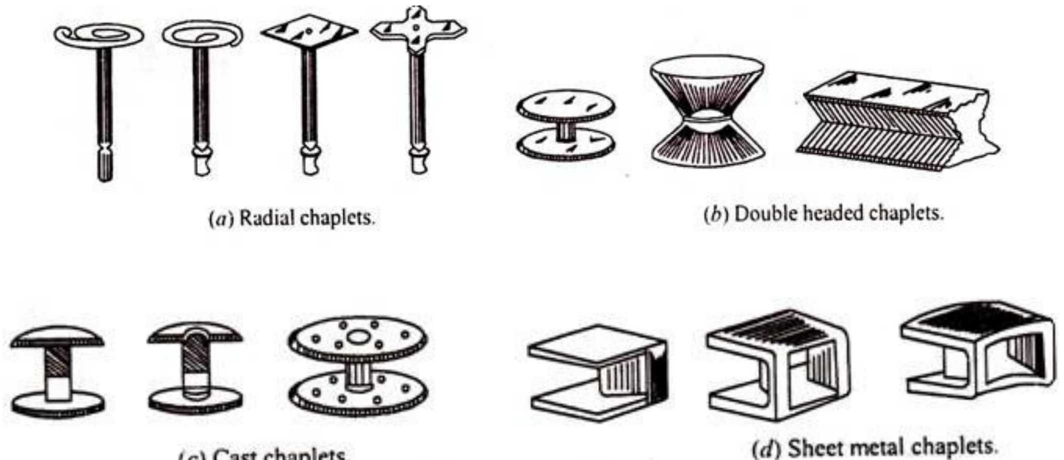


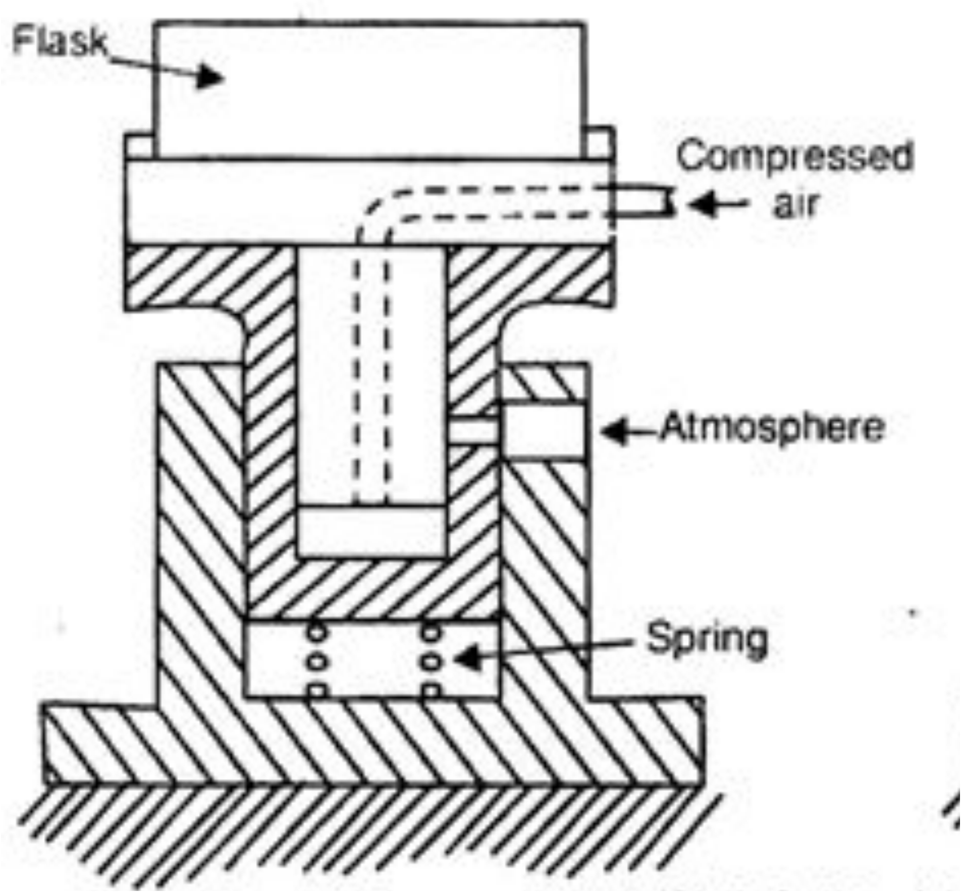
Fig. 3.14. Various types of chaplets.

Types of Moulding Machines

1. Jolt Machine:

- This machine is equipped with adjustable flask lifting pins to permit the use of flasks of various sizes within the capacity of the machine. The flask is placed on the machine table and during operation the machine table raises the flask at short distance and then the flask is allowed to fall freely under gravity.
- This sudden action causes the sand to be packed evenly around the pattern. The density of the sand is greatest around the pattern and at the parting line. Further away from pattern, the density keeps on decreasing. Since the moulding sand is firmly packed around the pattern, the mould is very strong and there is very less possibility of swells, scabs or run-outs.

Jolt Machine



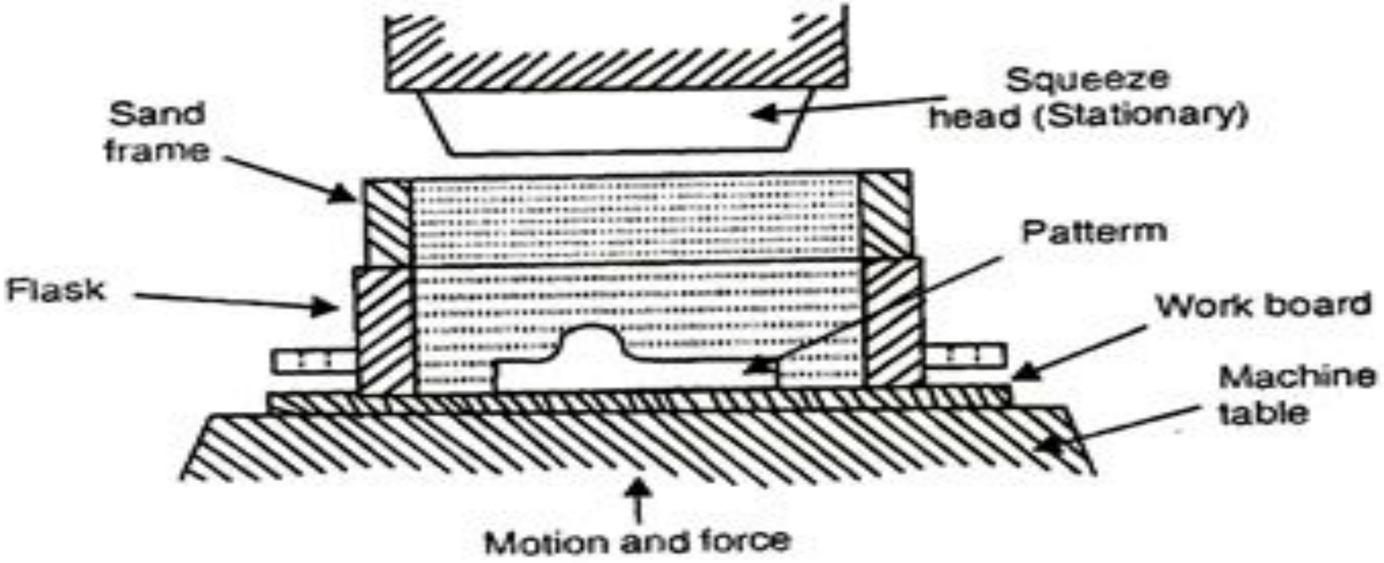
Types of Moulding Machines

2. Squeezing Machine

In this machine sand is compressed through the application of compressed air or other suitable force transmitted through a piston-table arrangement which squeezes the sand against a platen.

The ramming is best at the sand platen interface from where pressure is applied and not near the pattern, whereas in Jolt machine the ramming is best around pattern. Therefore, combination of jolting and squeezing gives best results and both the operations can be carried out in a single machine called Jolt-squeeze moulding machine (Fig. 3.59). In pure squeezing, both the parts of the mould could be formed at the same time if the depth is not too great. It is generally limited to rather shallow work.

Squeezing Machine

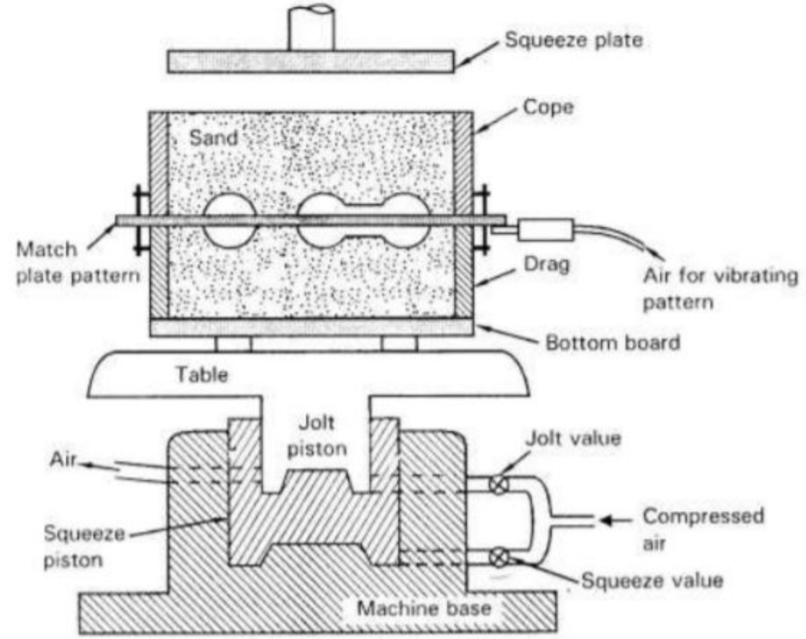


(a) Squeezer.

Types of Moulding Machines

3. jolt-squeeze machines

- jolt-squeeze machines, that employ a combination of the working principles of two of the main types. No matter what type of moulding machine is used, special machines are used to draw the pattern out of the mould.
- Basically, these machines achieve this by turning the flask (together with the pattern) upside, down and then lifting the pattern out of the mould. Roll-over moulding machines and rock-over pattern-draw machines, are some examples of this category

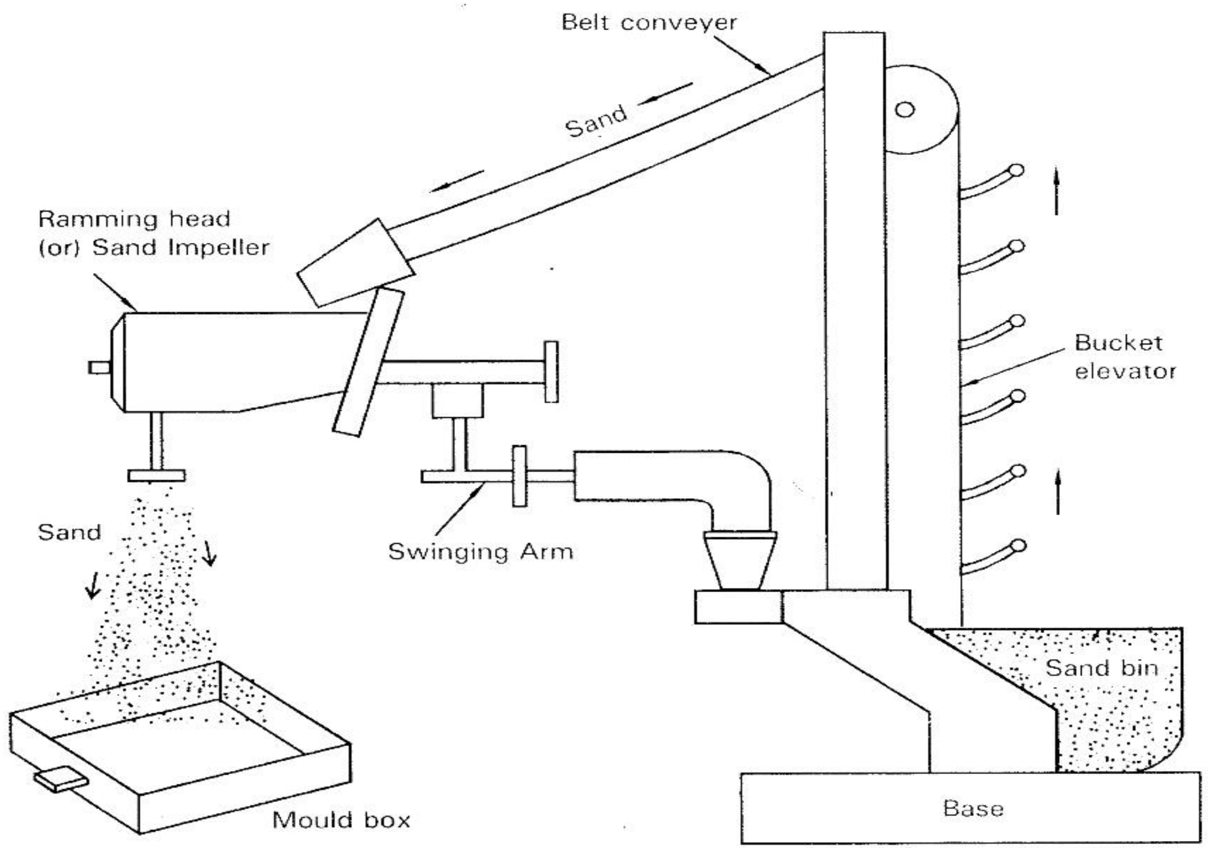


Types of Moulding Machines

4. Sand Slingers:

- The working principle of a sand slinger machine is shown in Fig. 4.11 (c). As can be seen, moulding sand is fed into a housing containing an impeller that rotates rapidly around a horizontal axis.
- Sand particles are picked up by the rotating blades and thrown at a high speed through an opening onto the pattern, which is positioned in the flask. This type of machine is employed in moulding sand in flasks of any size, whether for mass production of moulds or individual mould.

Sand Slingers



Casting defects

Following are the casting defects arises during faulty processes in casting.

1. Blow holes.
2. Pin holes.
3. Shift.
4. Short runs.
5. Hot tears.
6. cold shuts.

Casting defects

1. Blow Holes

Blow holes are spherical, flattened or elongated cavities present in the casting .They are formed due to following reasons.

- Reasons.

a) Rapid evolution of gas from mould.
b) Lack of porosity in mould box.
c) Excess moisture in sand.
d) Hard ramming of sand.

- Remedies

a) Moulds and cores are properly vanted.
b) Avoid hard ramming.
c) Proper amount of moisture in sand.
d) Proper grain size of sand.

Casting defects

2. Pinholes

Pin holes are small holes of less than 2mm diameter which are on surface or bellow the surface of casting.

Causes.

a) High pouring temperature.
b) Gas dissolved in molted metal.
c) gases are not removed properly from molted metal.
d) Sand with higher moisture content.

Remedies.

a) Maintain pouring temperature.
b) increase flux proportion.
c) reducing moisture content in sand.
d) Effective regarding.

Casting defects

3. Shift

It is external defect arises due to mis allotment parts of casting.

Causes.

a) Core displacement.
b) Misalignment of cope and drag.
c) warn out or burn out of clamping pins.
d) Misalignment of two halves of pattern.

Remedies.

a) Repair or replacement of dowel pins.
b) Proper alignment of pattern.
c) Proper alignment of cope and drag.
d) Repair clamping pins.

Casting defects

4. Short run

- It is also called as Morin. When cavity in mould is filled incompletely then short run introduces.

Causes.

a) Insufficient metal supply.
b) lack of fluidity in molten Merkel.
c) Molten metal temp is low.
d) faulty gating system.

Remedies.

a) Adjust pouring temp.
b) Adjust rate of pouring.
c) Modifications in gating system.

Casting defects

5. Hot tears

- It is also called as pulls or hot crack.
- They may be internal or external.
- They having dark blue in appearance on surface.

Causes.

a) Lack of compatibility of core.
b) high temp of casting metal.
c) incorrect design of gating system.
d) Lack of fillets and corner redii.

Remedies.

a) Improved design of casting.
b) Improved compatibility.
c) Proper solidification.
d) correct pouring temp.

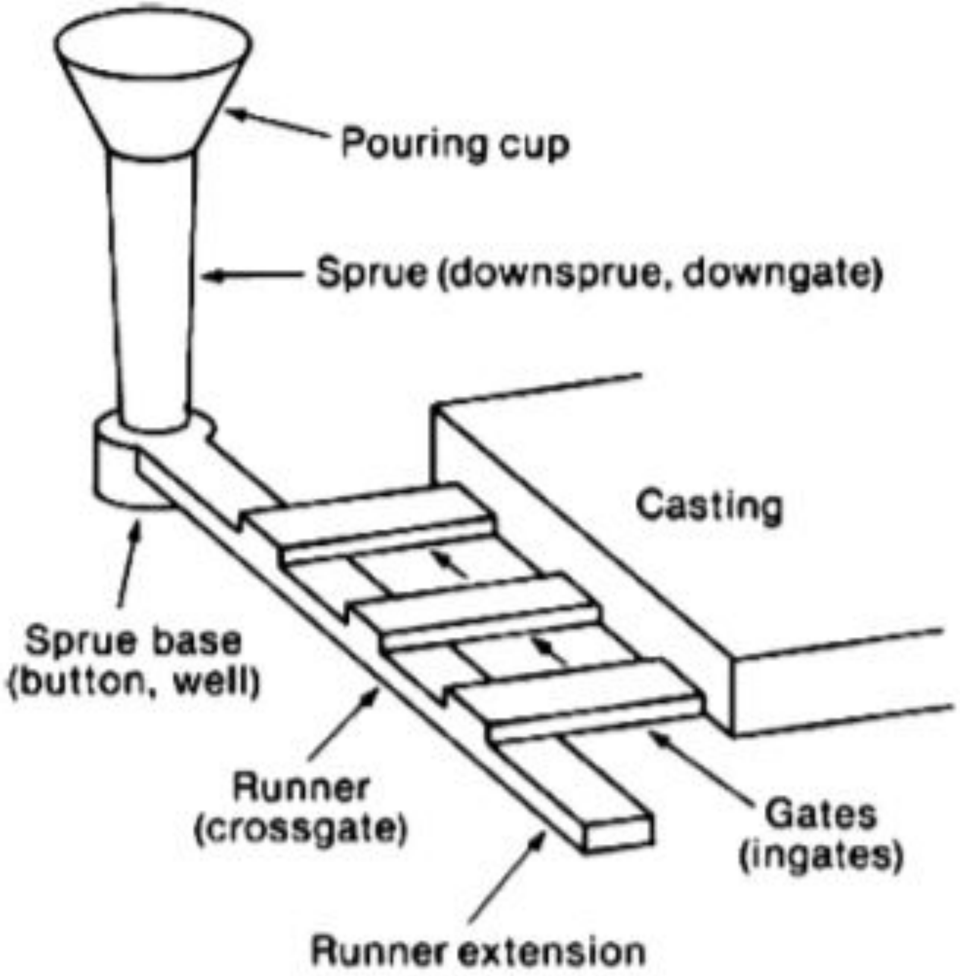
Gating System For Casting

Gating system:- It refers to all those elements connected with the flow of molten metal from ladle to mould cavity.

Various elements:-

- pouring basin
- sprue
- sprue base well
- Runner extension
- Ingate
- Riser

Gating System For Casting



Gating System For Casting

- Pouring Basin

It is the funnel-shaped opening, made at the top of the mold. The main purpose of the pouring basin is to direct the flow of molten metal from ladle to the sprue. It should be made substantially large and is kept near the edge of the mold box.

Pouring basin must be deep enough to reduce the vortex formation and is kept full during entire pouring operation.

Gating System For Casting

Sprue

- It is a passage which connects the pouring basin to the runner or ingate. It is generally made tapered downward to avoid aspiration of air. The cross section of the sprue may be square, rectangular, or circular. The round sprue has a minimal surface area exposed to cooling and offers the lowest resistance to the flow of metal. The square or rectangular sprue minimizes the air aspiration and turbulence.

- Sprue well It is located at the base of the sprue. It arrests the free fall of molten metal through the sprue and turns it by a right angle towards the runner.

Gating System For Casting

- Cross-gate or Runner

In case of large casting, the fluidity length of the molten metal is less than the maximum distance required to be travelled by the molten metal along the flow path. So it is necessary to provide the multiple ingates to reduce the maximum flow distance needed to be travelled by the molten metal. Moreover, in a multi-cavity mould also each cavity must have at least one ingate, therefore it is necessary to connect all the ingate to a common passageway which is finally linked with the sprue to complete the flow path. This passage way is called runner. The cross section of the runner is usually rectangular to get a streamlined flow with less turbulence.

- Ingate or Gate

It is a small passage which connects the runner to the mould cavity. The cross section is square, rectangular and trapezoidal.

Gating System For Casting

- RISER

Most alloys shrink during solidification. As a result of this volumetric shrinkage, voids are formed which are known as hot spots. So a reservoir of molten metal is maintained from which the metal can flow steadily into the casting. These reservoirs are known as risers. Design considerations:- The metal in riser should solidify at the end and the riser volume should be sufficient for compensating the shrinkage in the casting. To solve this problem, the riser should have higher volume.

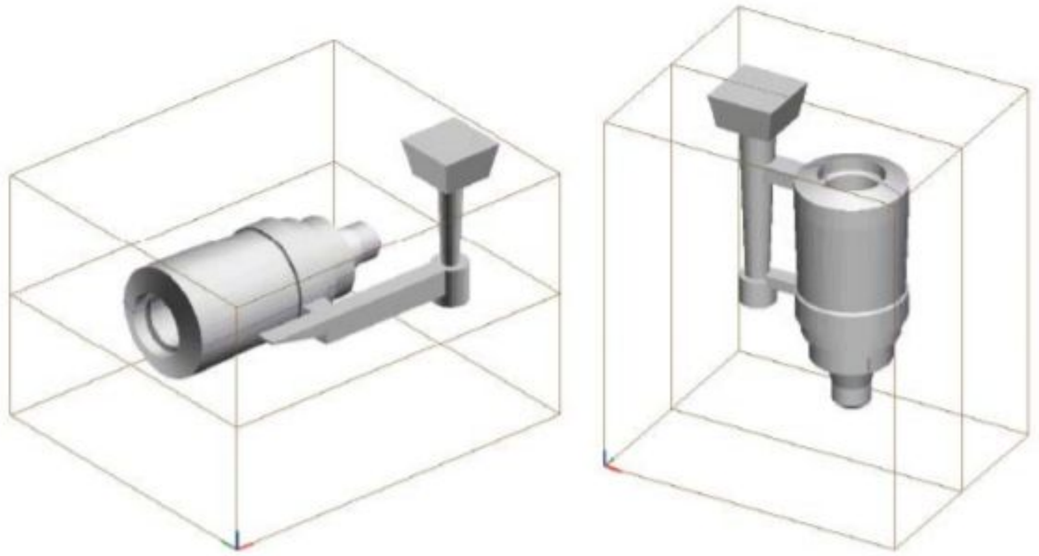
Gating System and Types

a) Depending upon the orientation of the parting plane, the gating system can be classified as horizontal and vertical gating systems

- Horizontal Gating System In horizontal gating systems, parting plane is horizontal and contains runners and ingates. The sprue is vertical, perpendicular to the parting plane. These are suitable for flat castings filled under gravity, such as in green sand casting and gravity die casting.

Gating System and Types

- Vertical Gating System In the vertical gating system, parting plane is vertical and contains runners and ingates. For gravity filling processes (high pressure sand molding, shell molding and gravity die casting) the sprue is vertical and for pressure die casting sprue is along the parting plane. It is suitable for tall castings.



(a) Horizontal gating system (b) Vertical gating system

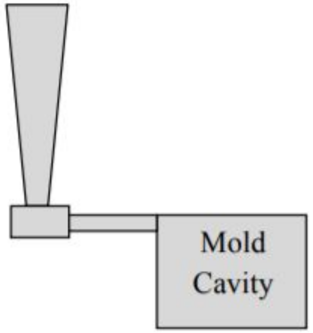
Gating System and Types

b) Depending upon the position of ingate(s), horizontal gating systems can be classified as

- Top line gating system
- bottom line gating system
- parting line gating system

Gating System and Types

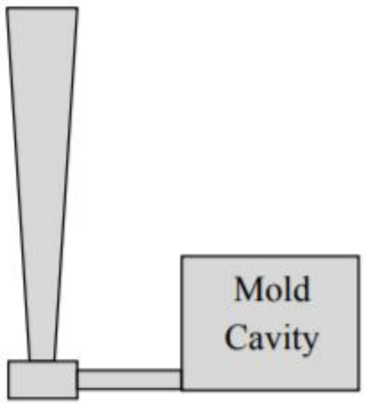
- Top Gating System In top gating molten metal from the pouring basin flows to the mold cavity directly from the top of the mold cavity. The advantage of the top gating is that it promotes directional solidification from bottom to the top of the casting cavity. The disadvantage is that the free fall of the hot molten metal causes mold erosion. It is suitable only for flat casting. The velocity of molten metal remains constants at the ingate from start to the end of filling, so top gating gives fastest filling rate as compared to the bottom and parting line gate.



(a) Top gating

Gating System and Types

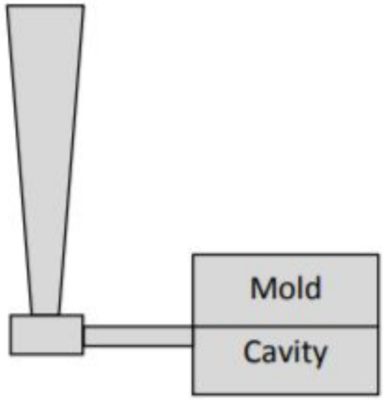
- Bottom Gating System In bottom gating molten metal enters from the bottom of the casting cavity. It is recommended for tall casting where free fall of molten metal has to be avoided. The advantage of the bottom gating is that molten metal enters the bottom of the cavity gradually with minimal disturbances. The only disadvantage is that casting cavity is filled with variable filling rate, having high velocity of molten metal at the start of filling and gradually decreasing velocity as the molten metal fills the ca



(b) Bottom gating

Gating System and Types

- Parting-line Gating System In a parting-line gating system the gating channel are located at the parting plane, usually at the middle. It combines the advantages of both top and bottom gating system by reducing the free fall height of the metal to almost half of the mold height and allowing high filling rate as compared to the bottom gating system. Turbulence effect is also minimized as compared to top gating system. The most commonly used gating system is horizontal gating system with ingates at the parting plane.



(c) Parting line gating

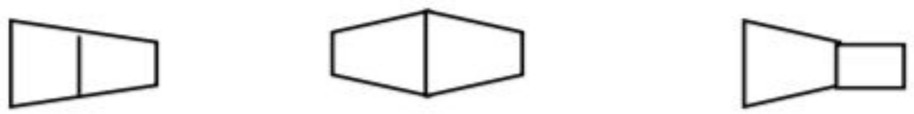
Gating System and Types

c) Depending on the ratio of total cross sectional area of sprue exit, runner and ingate ($A_s : A_r : A_g$), gating system is divided into pressurized system and non pressurized system.

Gating System and Types

- Pressurized System

In this system pressure is maintained at the ingates by the fluid. In order to achieve this total gate area should be less than the sprue exit area (A g < As). In other words choke is located at the ingate. This system keeps gating channels full of metal. Due to pressurization the flow separation is absent in the system also air aspiration is minimized. The filling rate and yield increase. However, high metal velocity will cause turbulence.



1:0.75:0.5　　1:2:0.75　　2:1:1

Gating System and Types

- Non Pressurized System

In this system choke is located at the sprue exit. Hence the sprue exit area is less than the total gate area (As < A g), for example 1:2:2, 1:4:4. Due to lower velocity, filling rate will be less.

The process yield increases but it suffers from the disadvantage of flow separation.