BMEE302L

Metal Casting and Welding

Course objectives

- To provide an insight on the casting fundamentals and processes.
- To impart knowledge on the welding processes for developing various joints.

Course outcomes

At the end of the course, the student will be able to

1. Interpret the solidification characteristics for designing gating system.
2. Demonstrate working principle of various casting processes.
3. Use various melting practices and explore casting defects.
4. Apply suitable welding process for different functional requirements.
5. Examine weld defects and suggest suitable methods to assess weld quality.

Metal Casting

Module 1 : Casting Fundamentals

Module 2 : Expendable Mould casting

Module 3 : Permanent Mould casting

Module 4: Melting Technology and casting defects

Welding

Module 5: Joining Processes

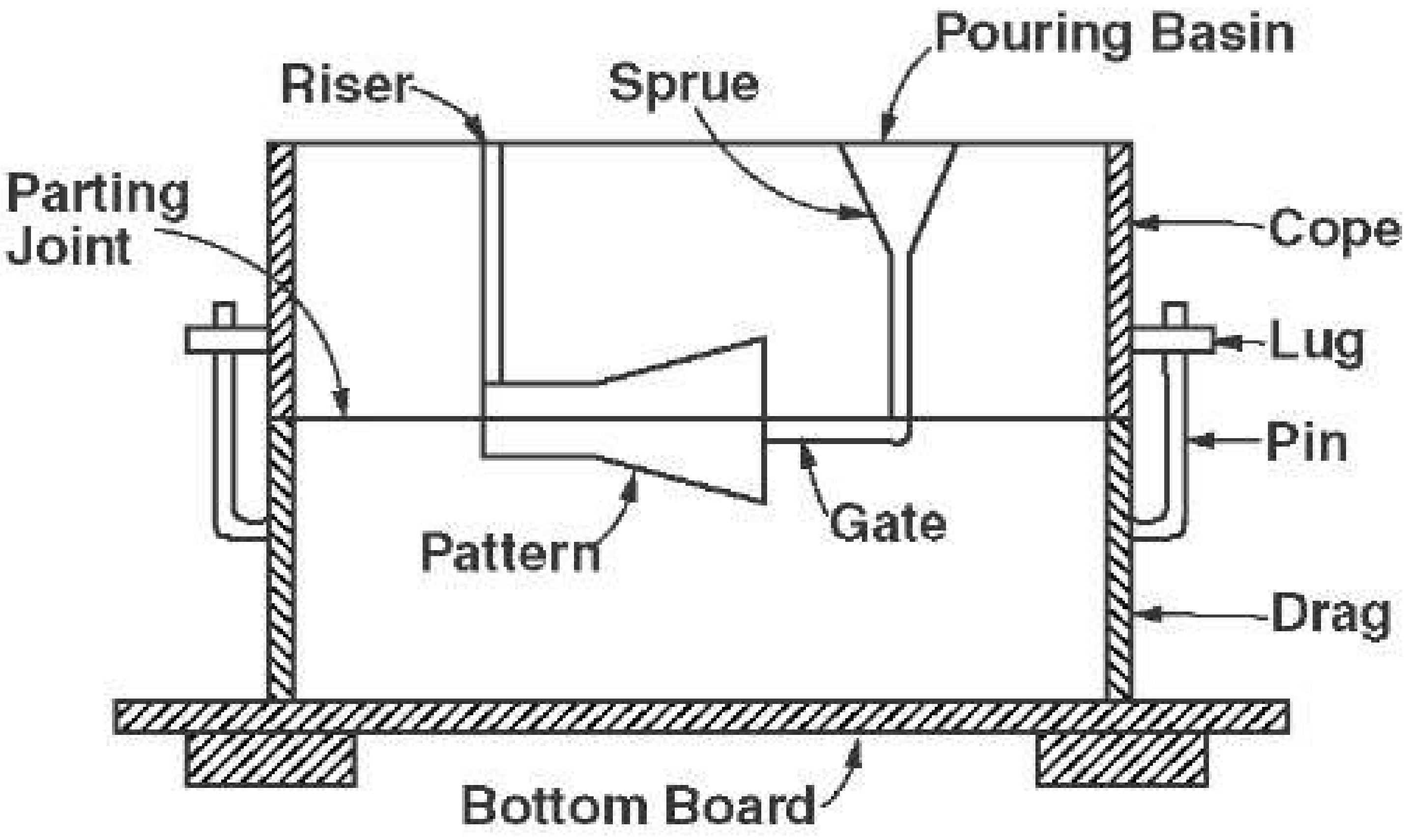
Module 6: Fundamentals of Welding

Module 7: Welding defects and testing

Module 8: Contemporary issues

Module:2	Expendable Mould Casting	6 hours
Sand casting – Types and properties of sand – Types, features and steps involved in sand mould – Pattern making, pattern allowances – Mould and Core materials – Core making, chaplets – Sand-moulding machines – Procedural steps and applications of Shell mould casting, Plaster and Ceramic mould casting, Lost-foam Casting, Investment mould casting.		

Sand Casting



How casting is made

https://www.youtube.com/watch?v=Qnw4TnZYRVA

Types of sand moulds

[(26) Green Sand Mould, Dry Sand Mould & Skin Dried Mould (3D Animation) - YouTube]

Moulding essentials

Moulding box

Trowel

Rammer

Runner/Sprue/Riser

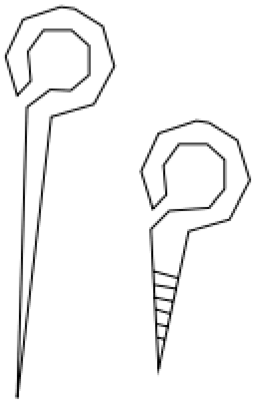
Moulding sand

Strike off bar

Vent wire

Pattern

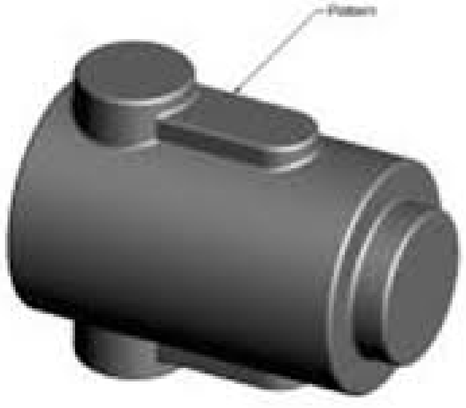
Gate cutter/Lifter



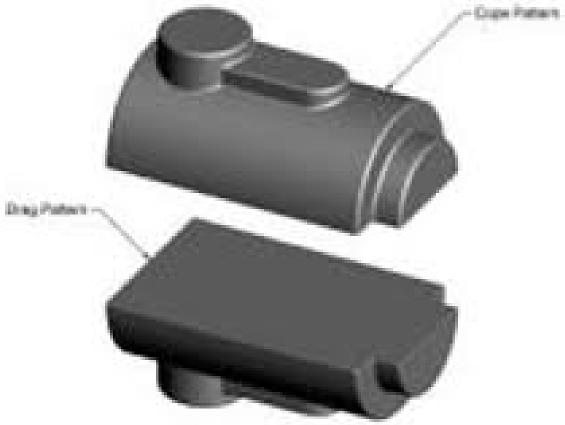
Draw spike

Bellows

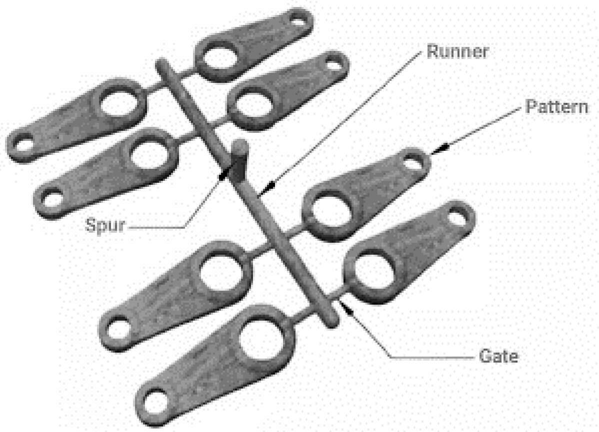
Types of Patterns used in Casting



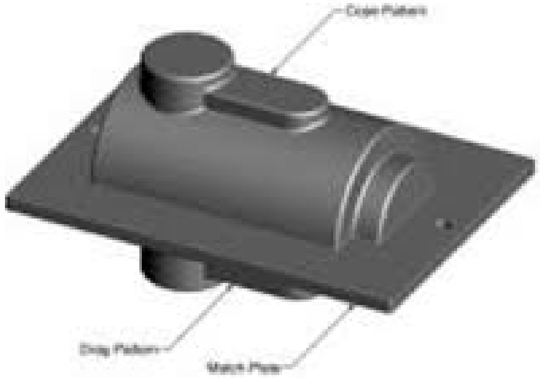
One piece or Solid Pattern



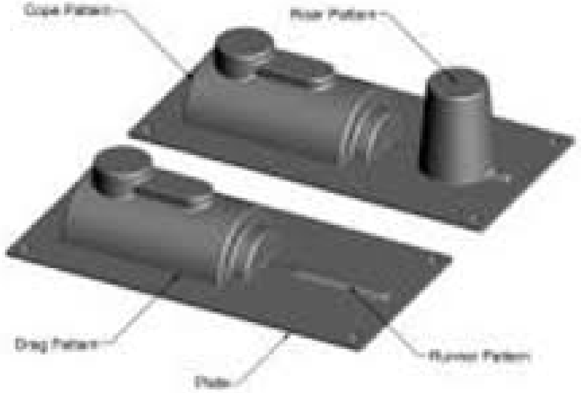
Split Pattern



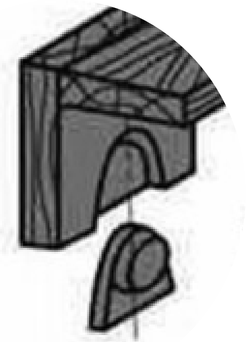
Gated Pattern



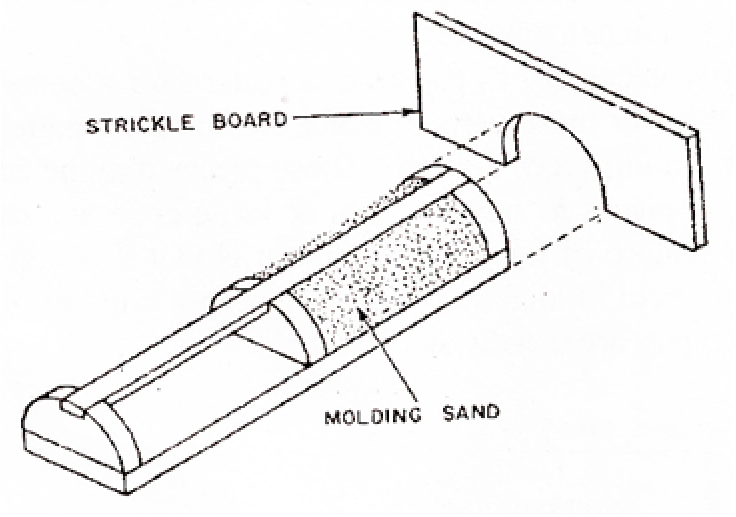
Match Plate Pattern



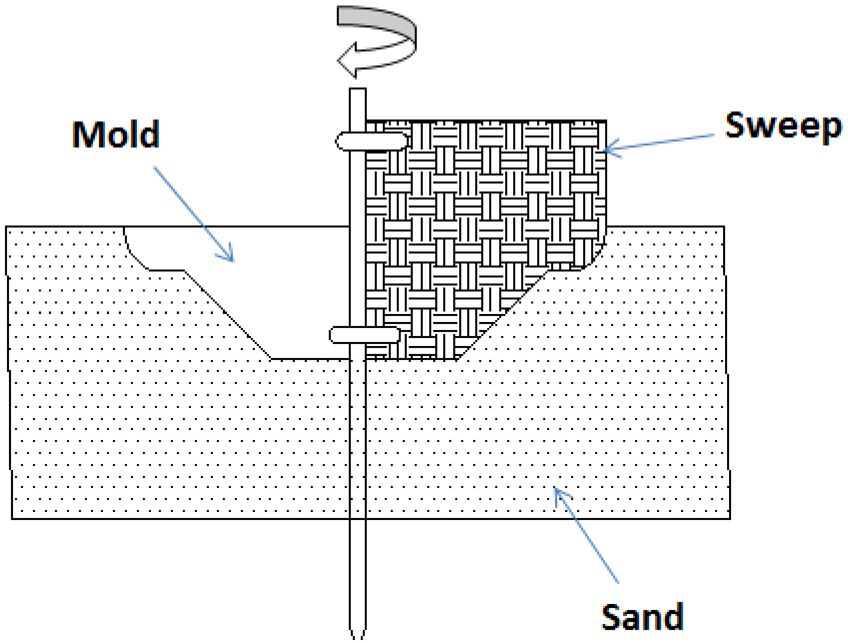
Cope & Drag Pattern



Loose piece pattern



Skeleton pattern



Sweep pattern

[(26) Types of Pattern in Sand Casting (3D Animation) - YouTube]

Pattern Allowances

1. Shrinkage allowance
2. Machining allowance
3. Draft or Taper allowance
4. Shaking allowance
5. Distortion allowance

Various Metals and Their Shrinkage Allowances

#	Material	Pattern Dimensions mm	Shrinkage Allowance mm/m
1	Grey Cast Iron	up to 600 600 to 1200 over 1200	10.5 8.5 7.0
2	Plain Carbon Steel	up to 600 600 to 1800 over 1800	21.0 16.0 13.0
3	Chromium Steel	-	20.0
3	Manganese Steel	-	25.0 to 38.0

Machining Allowances on patterns for sand castings

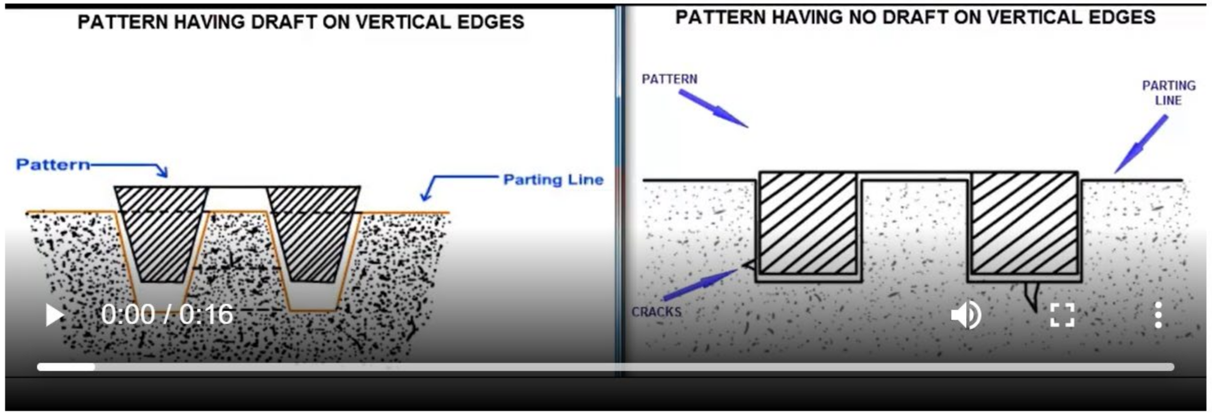
Dimension, mm	Allowance, mm		
	Bore	Surface	Cope Side
Cast Iron			
up to 300	3.0	3.0	3.0
301 to 500	5.0	4.0	6.0
501 to 900	6.0	5.0	6.0
Cast Steel			
up to 150	3.0	3.0	6.0
151 to 500	6.0	5.5	7.0
501 to 900	7.0	6.0	9.0
Non-ferrous			
up to 200	2.0	1.5	2.0
201 to 300	2.5	1.5	3.0
301 to 900	3.0	2.5	3.0

Draft Allowance 1 deg to 3 deg

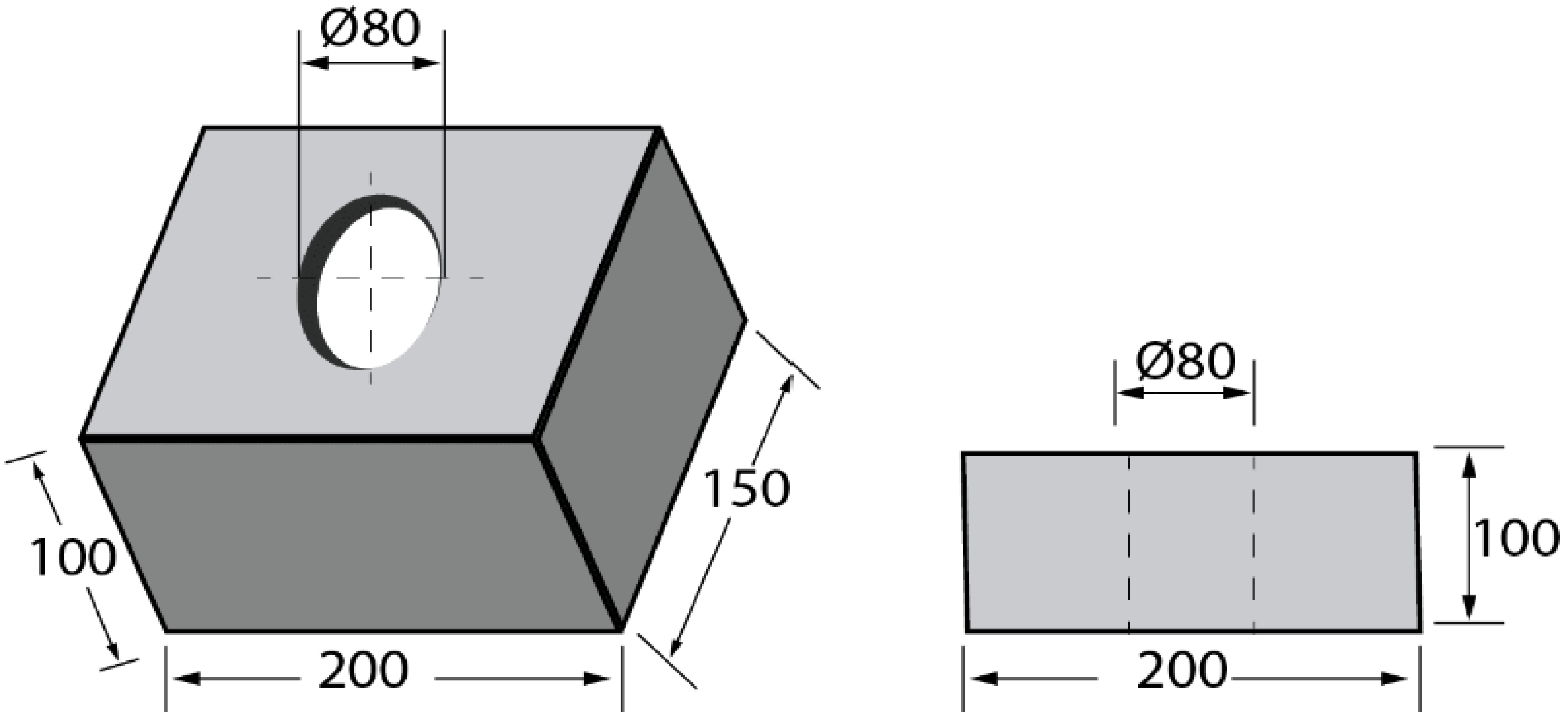
(a) Pattern with zero (no) draft

(b) Pattern with draft

(Not to scale)



Design a pattern to cast a steel of the given dimensions by considering the shrinkage allowance, machining allowance and shaking allowance.



The casting shown in the above figure is to be made in plain carbon steel using a wooden pattern. Assuming only shrinkage allowance, calculate the dimensions of the pattern

From the shrinkage allowance table above, the shrinkage allowance for steel is 21.0 mm/m

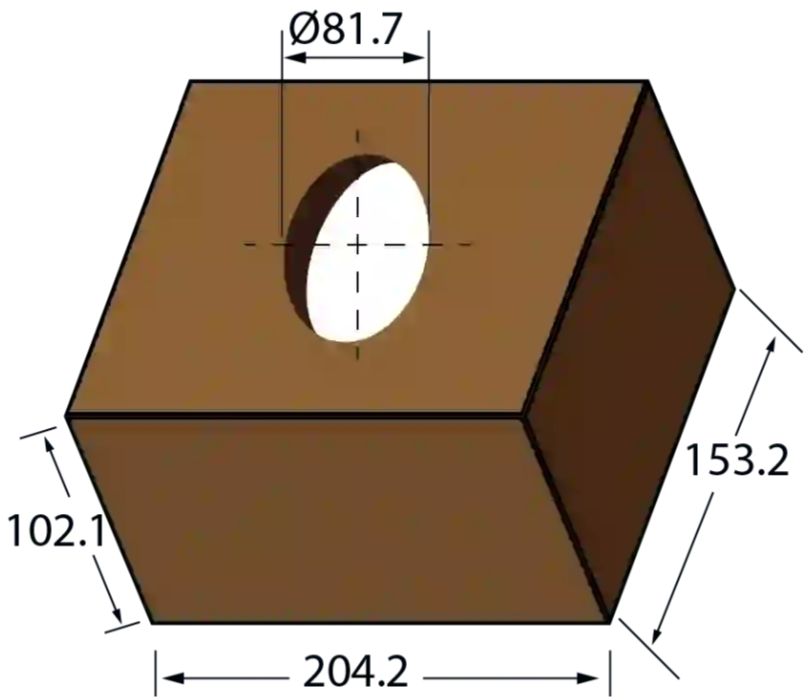
For dimension 200, allowance is 200 * 21.0/1000 = 4.20 mm

For dimension 150, allowance is 150 * 21.0/1000 = 3.15 = 3.20 mm (approximately)

For dimension 100, allowance is 100 * 21.0/1000 = 2.10 mm

For dimension 80, allowance is 80 * 21.0/1000 = 1.68 = 1.70 mm (approximately)

Therefore, the pattern with required dimensions taking shrinkage into account is shown below



What is Double shrinkage allowance, why it is allowed in pattern?

A double shrinkage allowance is provided for the dimension of pattern that is used to make a metal pattern for another product. Double shrinkage allowance takes care the shrinkage of the final product (product material) as well as shrinkage of the pattern (pattern material). For example, if a pattern for an object (metal A) is made of metal (metal B), then you have to cast the pattern (metal B) by using another pattern (say wooden pattern). Then the double shrinkage allowance is provided to wooden pattern to compensate shrinkage of metal A and metal B.

Why shrinkage allowance of outer surface is higher than inner surface?

The **shrinkage allowance** always adds to the linear dimension, even in the case of internal dimension. The material has a tendency to contract towards the center during cooling. Usually, shrinking occurs uniformly unless restraints are provided. For example, the core centers in casting can restrain the metal from contracting at the inner surface. However, there is no restriction to contracting at outer surface or edges. So it is desired to give higher shrinkage allowance at outer dimension when compared to the inner surface.

Machining allowance for steel

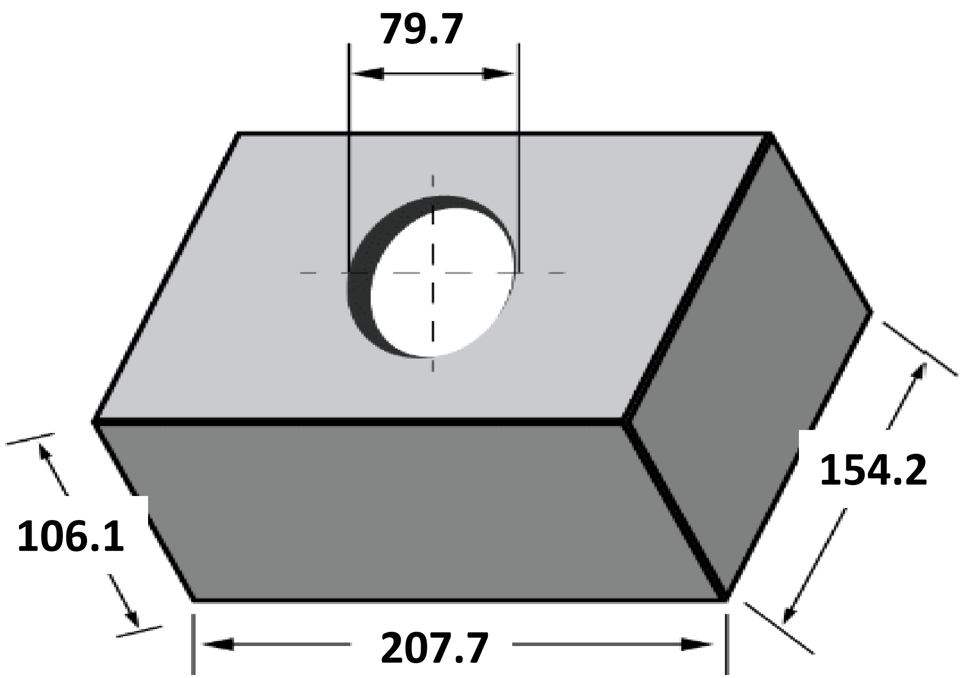
Up to 150 mm
surface
allowance = 3mm

151-500 mm
surface
allowance = 5.5 mm

For bore (up to 150 mm)
Allowance = 3mm

l = 204.2+5.5 = 209.7 mm
w= 153.2 +3 = 156.2 mm
h= 102.1+6 = 108.1 mm

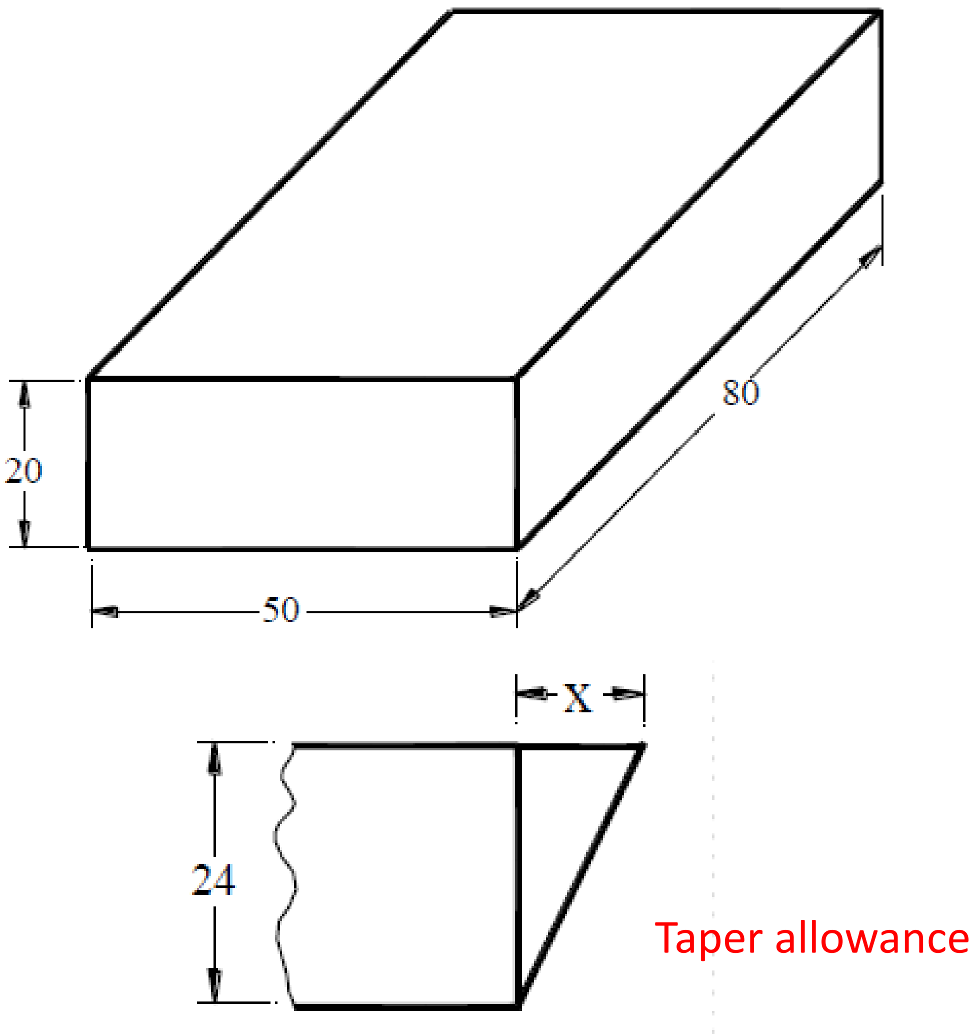
d= 81.7+3 = 84 mm



Shaking allowance = 2mm

l = 209.7 -2 = 207.7 mm
w= 156.2-2=154.2 mm
h= 108.1-2=106.1 mm

d= 81.7-2=79.7 mm

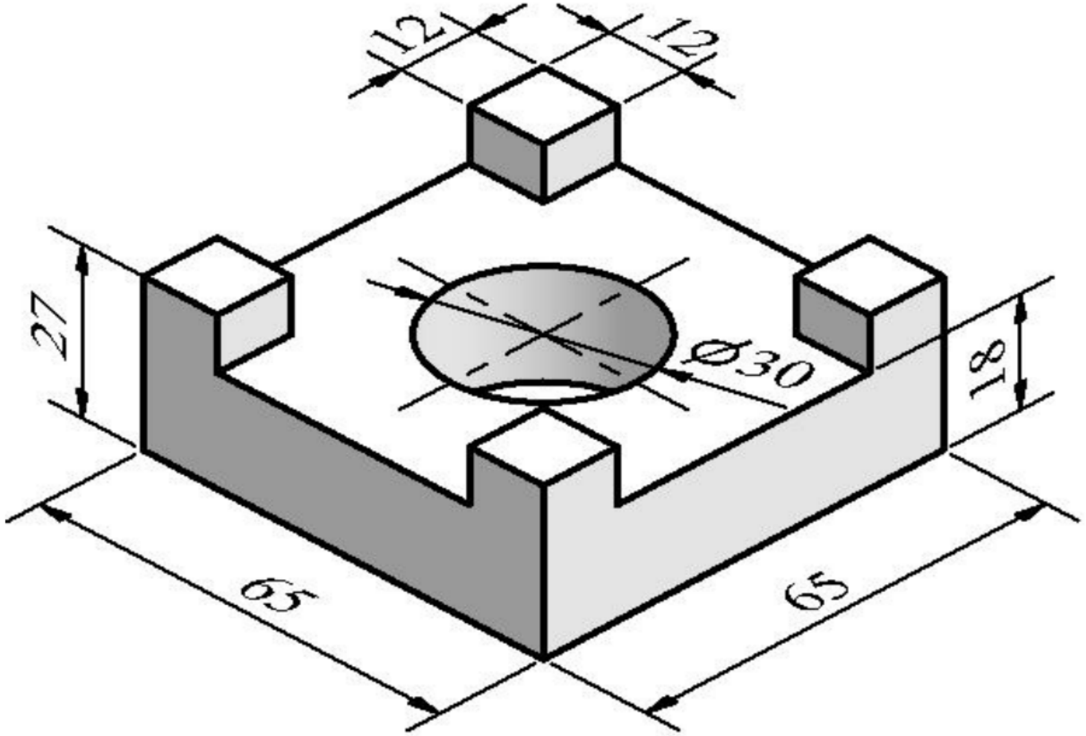


Design a wooden pattern for making a steel cast of the given dimensions by considering the allowances given below:

Machining allowance – 2mm on each side
Shrinkage allowance – 2%
Taper allowance – 1 degree
Shaking allowance – 1 mm

Problem

The figure shows a steel part is to be obtained by sand casting. Design the requisite pattern.



Types of Moulding sand

1. Green sand
2. Facing sand
3. Parting sand
4. Loam sand

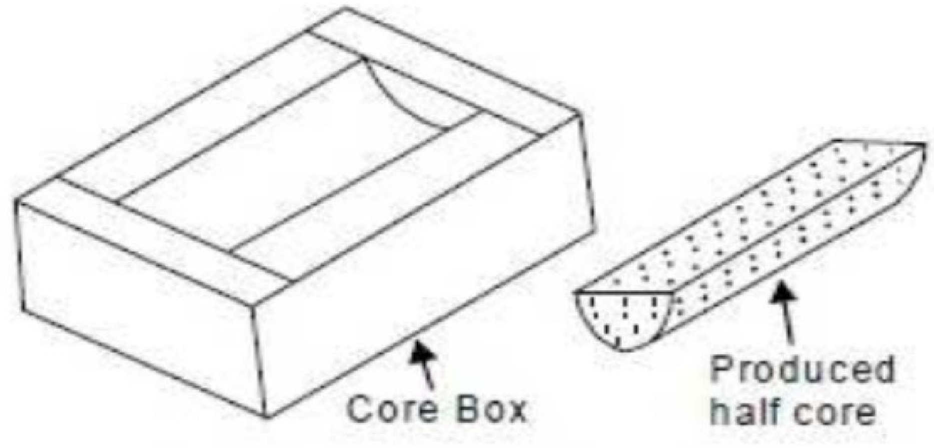
Properties of Moulding sand

1. Permeability/Porosity
2. Collapsibility
3. Grain size
4. Flowability
5. Refractoriness
6. Strength

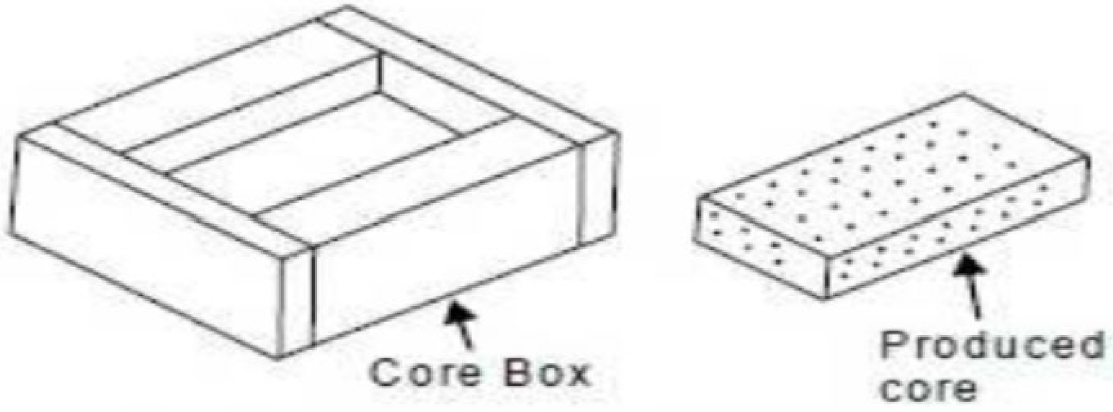
Preparation of Sand Cores

Cores are made of sand, clay (binder) and moisture. The mixture of sand, clay and moisture is thoroughly mixed and then it is compacted in the core box.

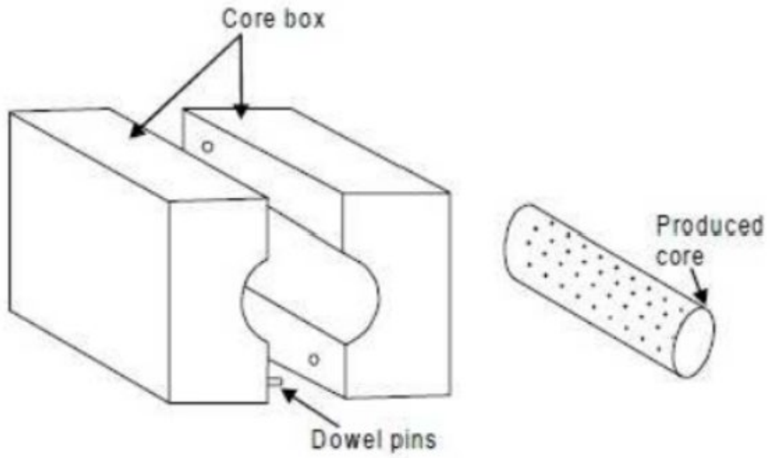
- On compaction, the sand mixture attains the shape of the cavity in the core box.
- In order to prevent the core from breaking/ crumbling (during handling) reinforcement of cores is done by inserting metallic wires in them.
- The core is next placed in an oven and heated to 154˚C for about 2 hours to drive out the moisture in the core sand.
- On drying the core attains strength.



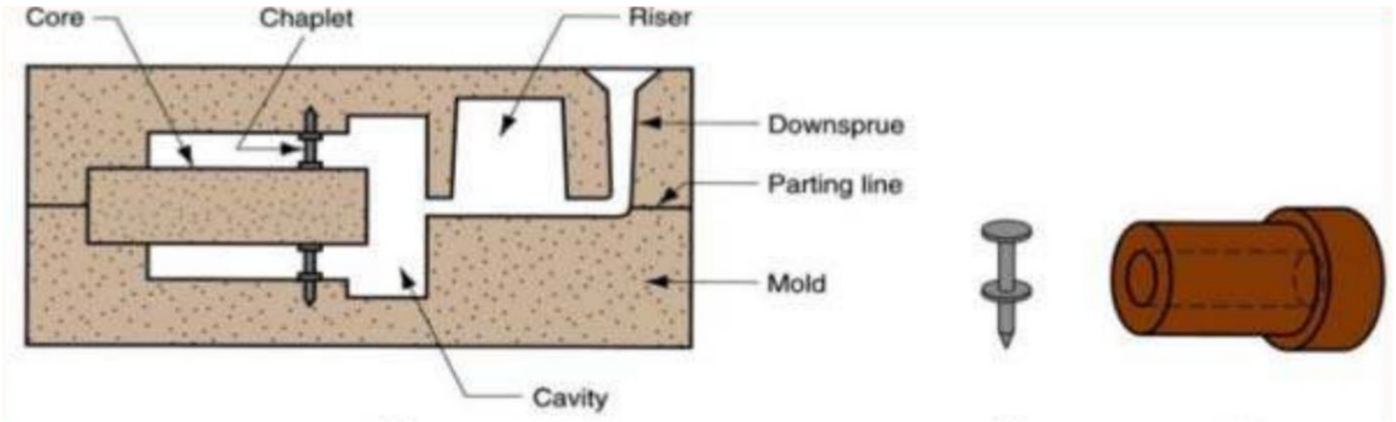
Half core box



Dump core box



Split core box



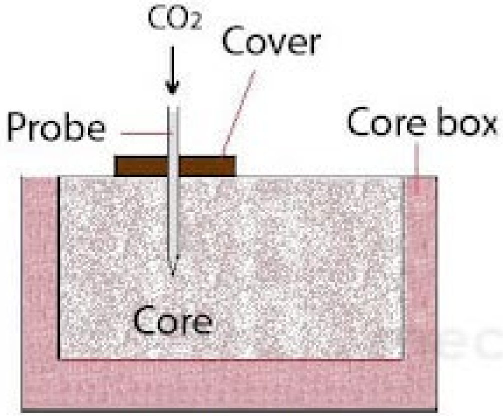
Types of sand moulding

Green sand moulds
Green sand mould is the most common type of sand mould. Green moulding sand is a mixture of sand, pulverized coal, bentonite, water, and other material. It is called “green” because of the presence of water content. They are used for making grills, weights, moulding boxes etc.

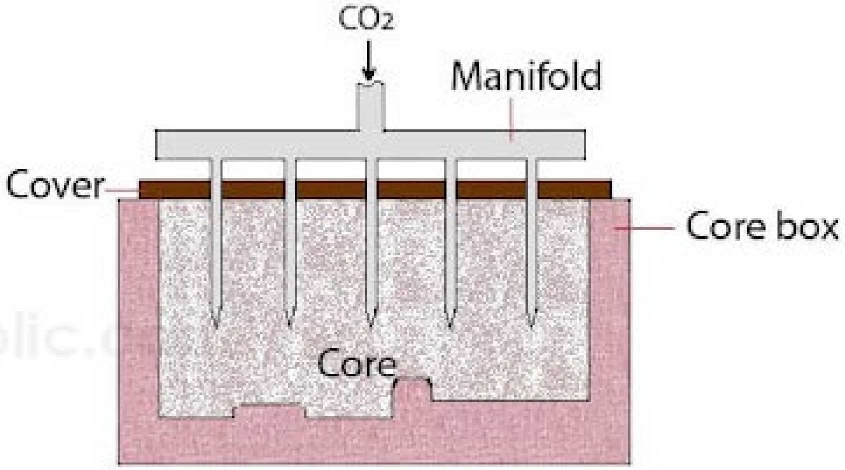
Dry-sand moulds
Dry sand moulds are made of drying raw sand; it does not require moisture to develop the strength. Some binding resins are used for strength. These types of molds are usually used in steel casting. Used for making parts like larger rolls, gear housing etc.

Skin-dried moulds
As the name suggests, the skin layer of this mould is dry by heating the sample to the required surface.These are the mould with dry sand facing and green sand backing. Since it has green backing, it is less expensive when compared to dry sand mould. But it is not strong as a dry sand mould. Skin-dried mould is the most commonly used type of mould for large casting. This type of mould is used to cast both ferrous and nonferrous alloys.

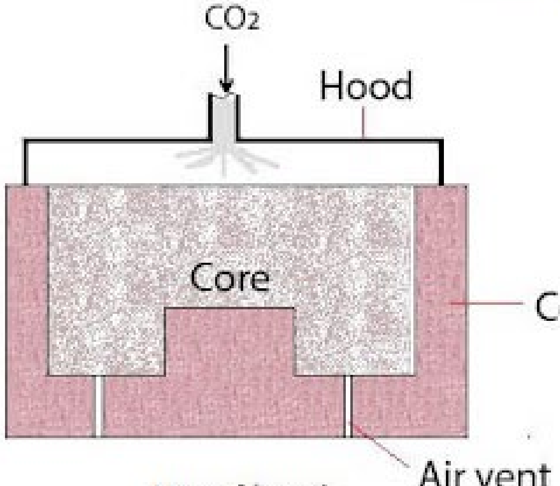
Carbon dioxide Moulding



Use of single probe



Use of manifold



Use of hood

- **CO_2 moulding (Carbon dioxide moulding) is a unique moulding process.**
- **Here liquid sodium silicate is used as a binder instead of clay in the conventional sand moulding.**
- **When CO_2 passes through a sand mix containing liquid sodium silicates binder for two-three minutes, it immediately gets hardened by silica gel formation.**
- **The silica gel ($SiO_2.x.H_2O$) is formed by the chemical reaction between sodium silicate and carbon dioxide. This silica gel gives the strength sufficient to eliminate baking/ drying of mould.**

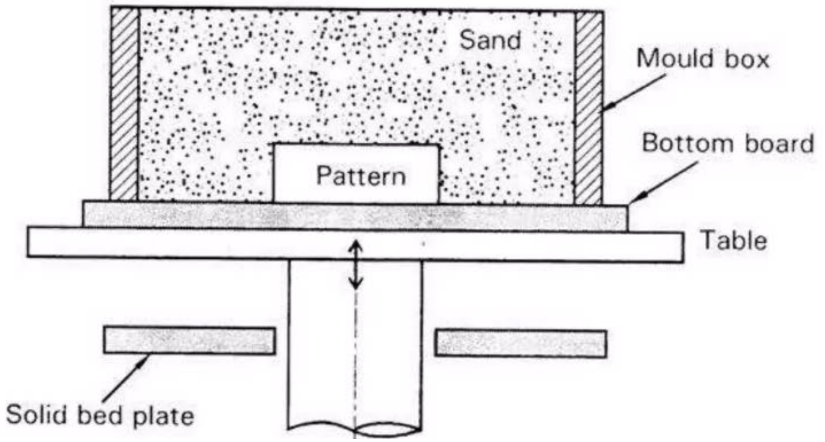
Usage time = with in 12 hours
Gassing time = 2 to 3 mins
Machining allowance can be reduced

Moulding Machines

1. Jolt machine
2. Squeeze machine
3. Sand slinger

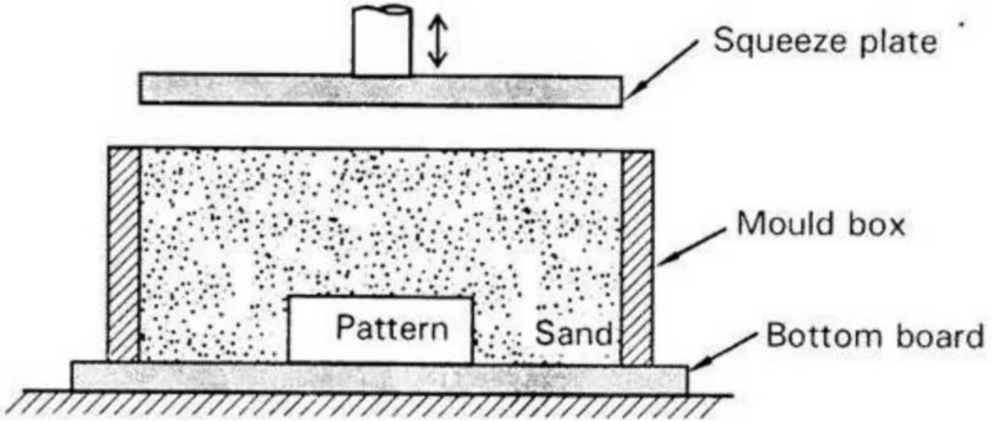
1. Jolt Machine

- A jolt machine consists of *a flat table mounted on a piston-cylinder arrangement and can be raised* or lowered by means of compressed air.
- In operation, the mould box with the pattern and sand is placed on the table. The table is raised to a short distance and then dropped down unde the influence of gravity against a solid bed plate. The action of raising and dropping (lowering) is called 'Jolting'.
- Jolting causes the sand particles to get packed tightly above and around the pattern. The number of 'jolts' may vary depending on the size and hardness of the mould required. Usually, less than 20 jolts are sufficient for a good moulding.
- The disadvantage of this type is that, the density and hardness of the rammed sand at the top of the mould box is less when compared to its bottom portions.



2. Squeeze Machine

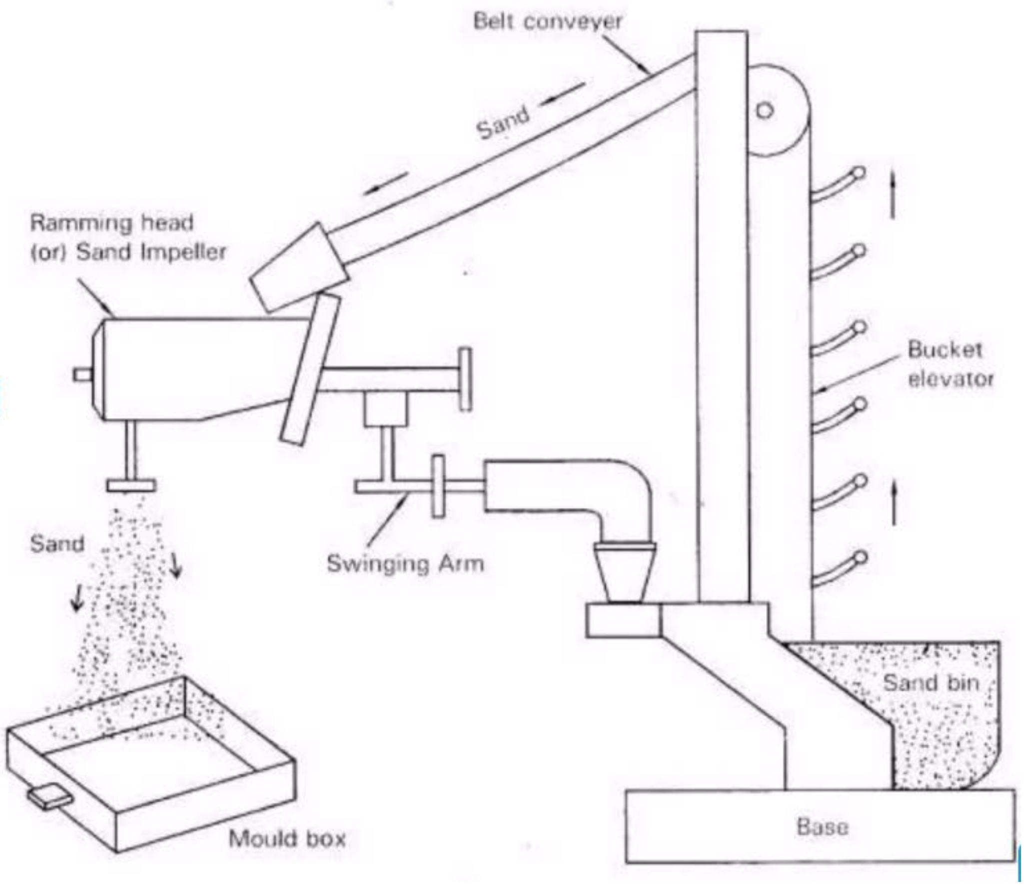
- In squeeze machine, the mould box with pattern and sand in it is placed on a fixed table as shown in figure
- A flat plate or a rubber diaphragm is brought in contact with the upper surface of the loose sand and pressure is applied by a pneumatically operated piston.
- The squeezing action of the plate causes the sand particles to get packed tightly above and around the pattern.
- Squeezing is continued until the mould attains the desired density.
- In some machines, the squeeze plate may be stationary with the mould box moving upward.
- The disadvantage of squeeze machine is that, the density and hardness of the rammed sand at the bottom of the mould box is less when compared to its top portions.



4. Sand slinger

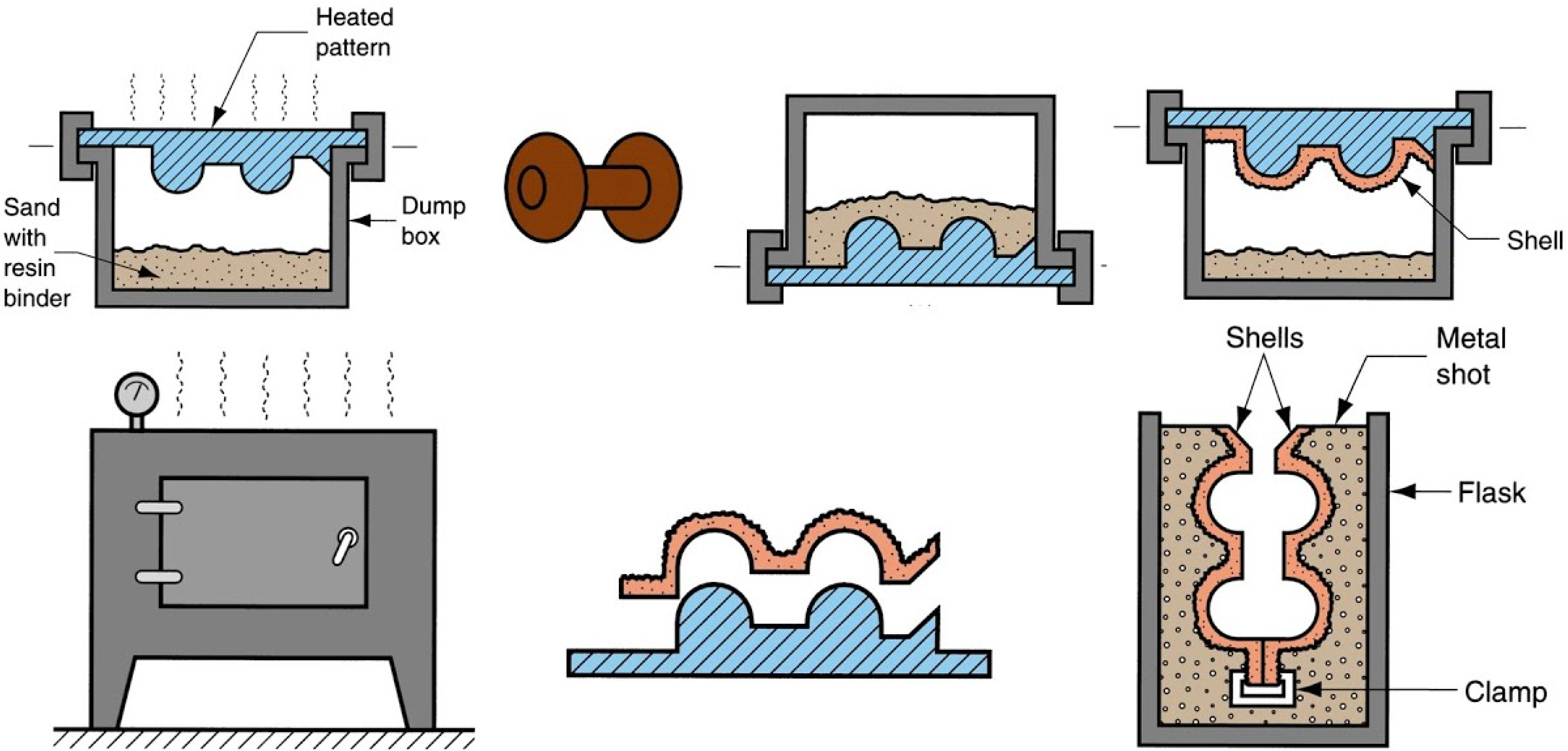
- A sand slinger is an automatic machine equipped with a unit that throws sand rapidly and with great force into the mould box. Figure shows a sand slinger. Sand slinger consists of a rigid base, sand bin, bucket elevator, belt conveyor, ramming head (sand impeller) and a swinging arm.

- In operation, the pre-mixed sand mixture from the sand bin is picked by the bucket elevator and is dropped on to the belt conveyor.
- The conveyor carries the sand to the ramming head, inside which there is a rotating impeller having cup shaped blades rotating at high speeds (around 1800 rpm).

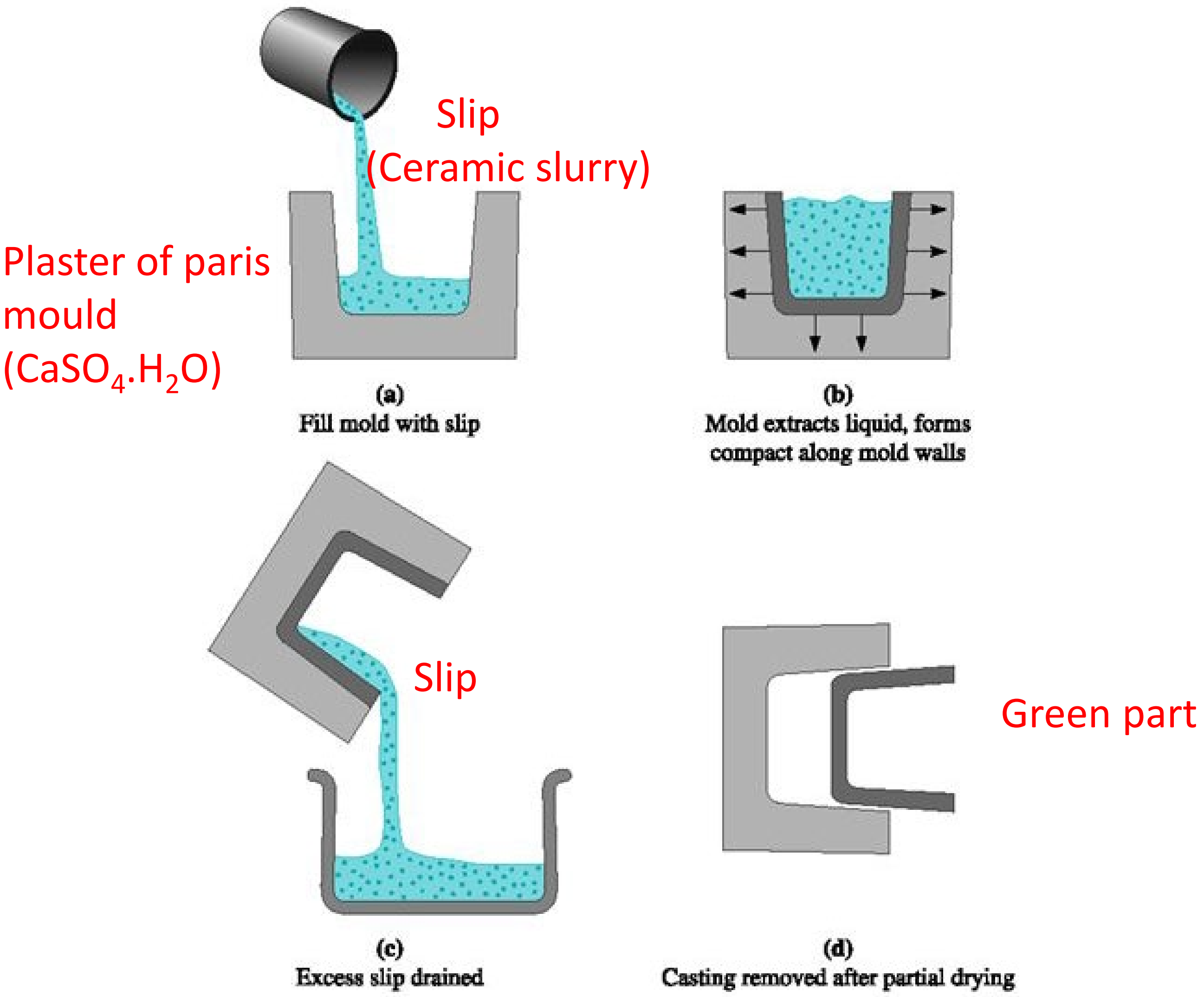


- The force of the rotor blades imparts velocity to the sand particles and as a result the sand is thrown with very high velocity into the mould box thereby filling and ramming the sand at the same time.

Shell Moulding



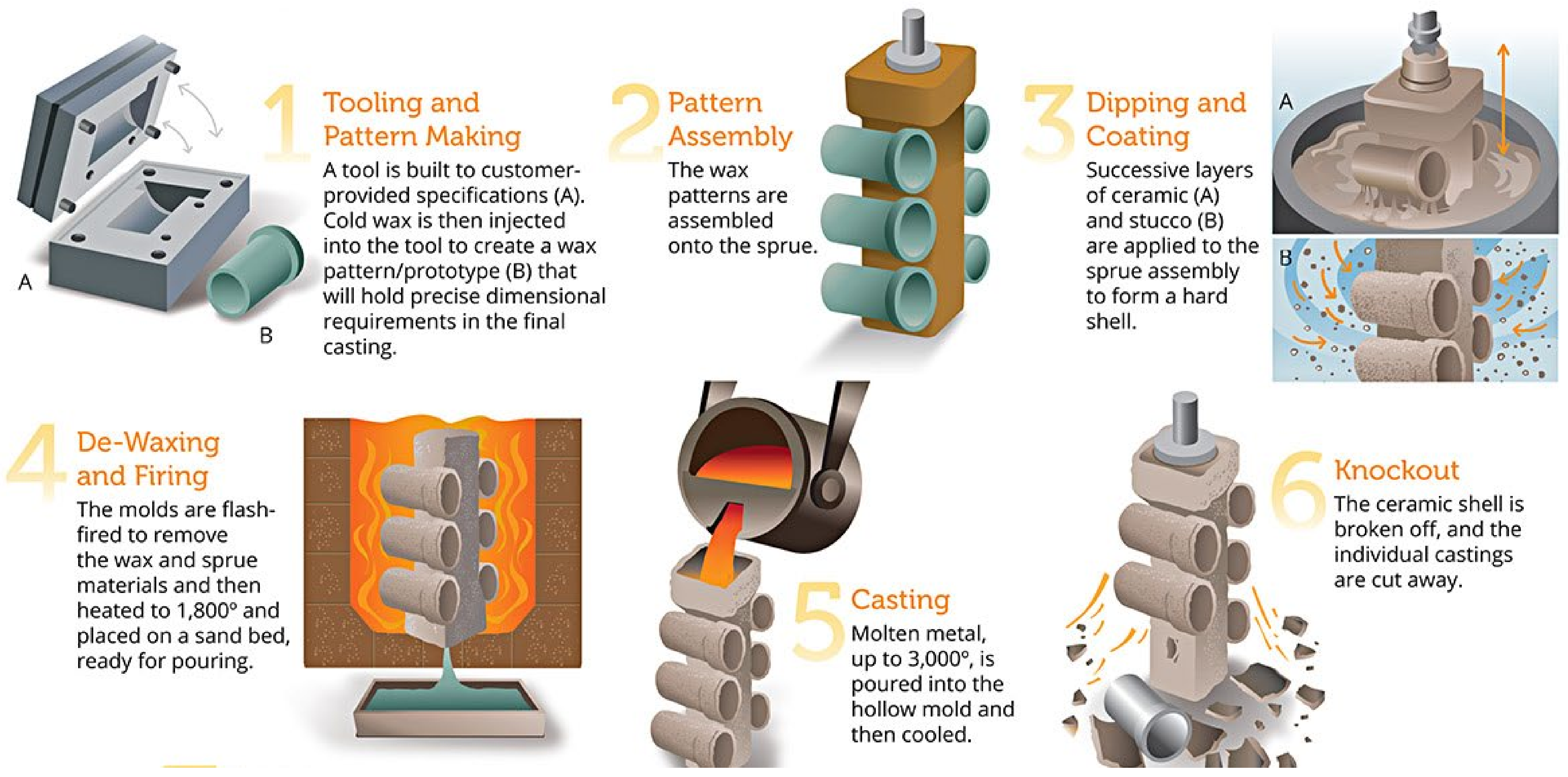
Plaster/Ceramic mould Casting (Slip Casting)



How Does Slip Casting Work?

- The precise method of slip casting involves a simple porous mould that is typically made from plaster. This enclosure is used to consolidate small to medium volumes of an aqueous slip and form green bodies with near net shapes to reduce or eliminate the need for surface finishing and machining.
- An aqueous slip is a slurry comprised of water, an organic dispersant, and a blend of ceramic powder materials. These components are milled together to create a heterogenous mixture with highly-uniform solid particle dispersion throughout the water. The dispersing agent ensures that the ceramic particles do not flocculate.
- The slip is then poured into the plaster mould at room temperature. Water is drawn from the slurry through the capillary action of the plaster's porous structure, which causes deposition of ceramic particles on the inside of the mould. Manufacturers monitor the gradual swelling of the cast to assess the levels of slip moisture loss and particle deposition. When the cast has grown to a required thickness, the slip is drained from a valve or opening in the mould and the ceramic component is removed from the plaster cast.

Investment Casting (Lost wax casting)



Lost Foam Casting

Polystyrene pattern

Polystyrene pattern coated with ceramic