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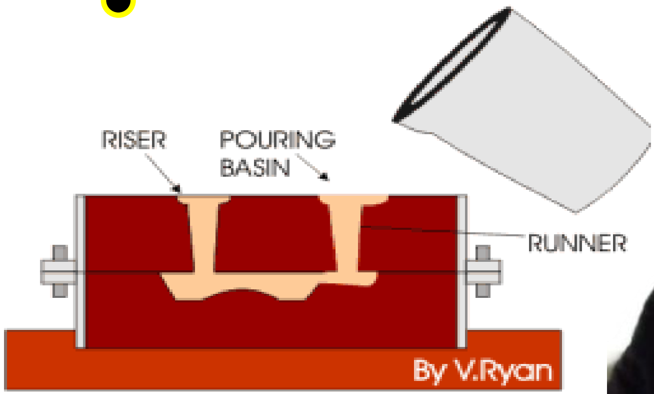
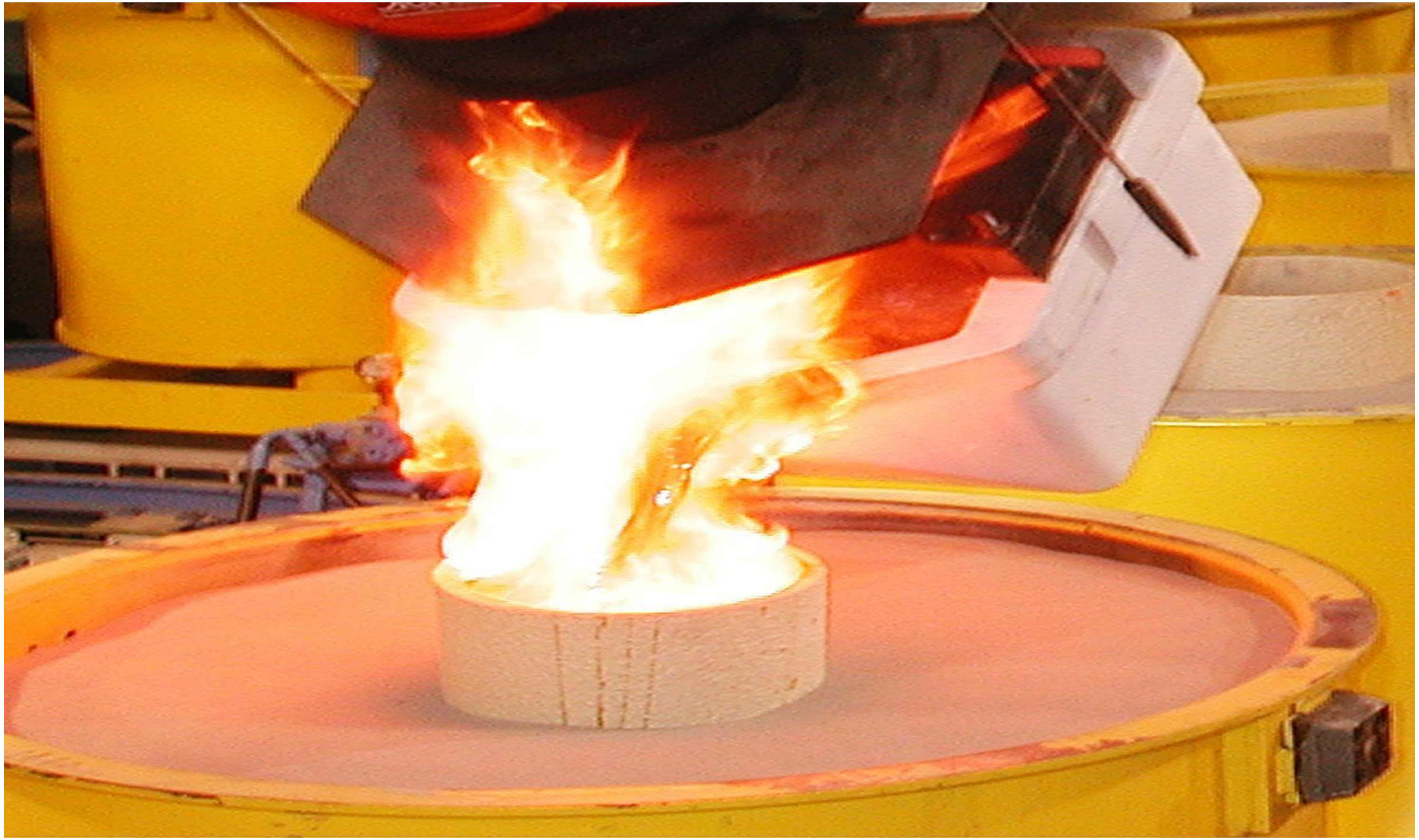
Ch-2 Foundry Technology

Casting Products-Pattern – Types of Pattern



Subject:MT Code:-3151912	Prepared by: Asst.Prof.Harin Prajapati (Mechanical Department,ACET)	AMIRAJ COLLEGE OF ENGINEERING & TECHNOLOGY

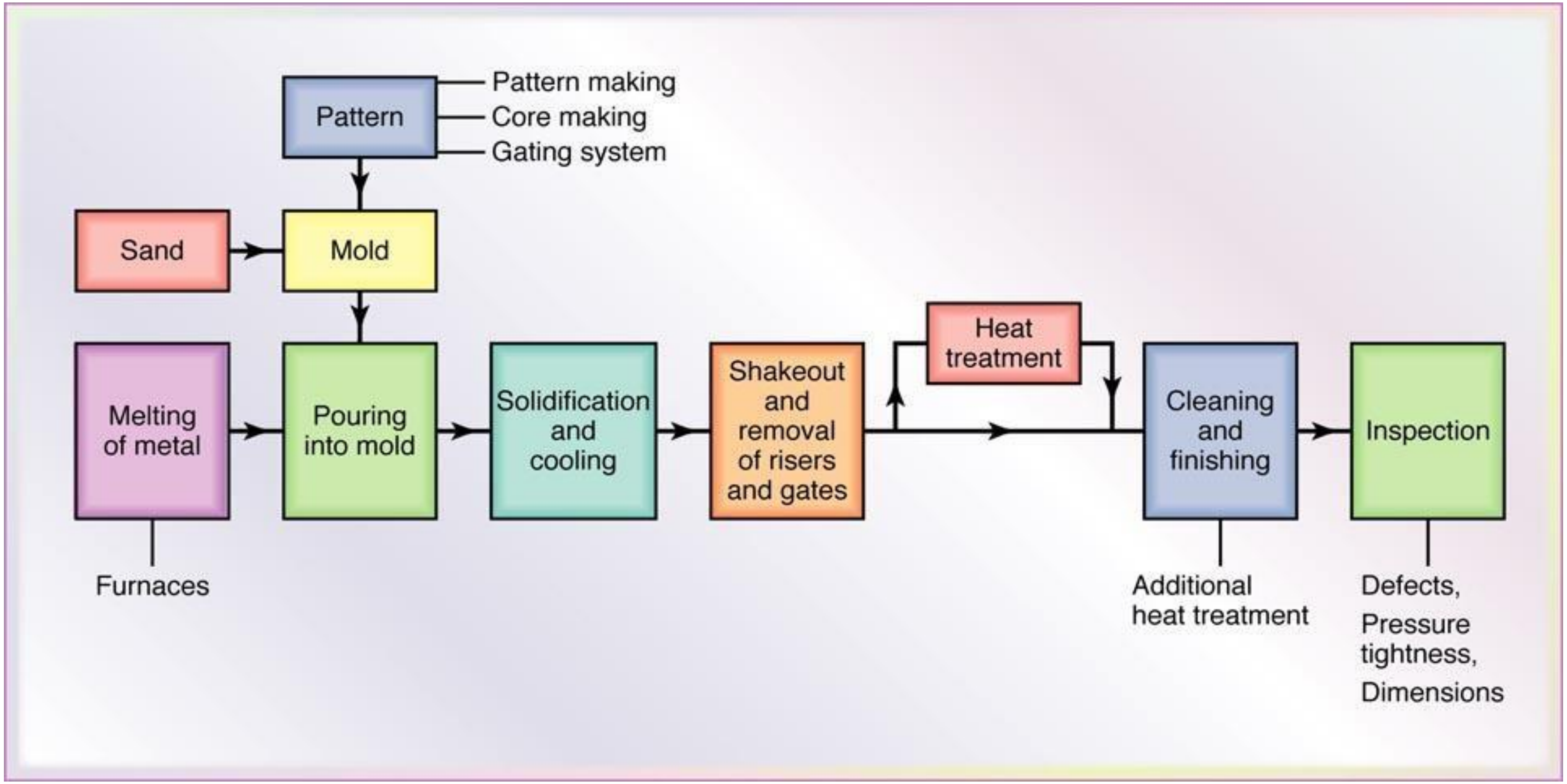
Metal-Casting Processes



Casting

- Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify.
- The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process.

Production Steps in Sand-Casting



Applications

- Transport : Automobile, aerospace, railways and shipping
- Heavy Equipment : Construction, farming and mining
- Machine Tools : Machining, casting, plastics molding, forging, extrusion and forming
- Plant Machinery : Chemical, petroleum, paper, sugar, textile, steel and thermal plants
- Defense : Vehicles, artillery, munitions, storage and supporting equipment
- Electrical Equipment Machines : Motors, generators, pumps and compressors
- Household : Appliances, kitchen and gardening equipment, furniture and fittings

Examples of Cast Parts

Crank handle formed by casting; some areas were machined and assembled after casting

C-clamps formed by casting (left) and machining (right)

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Casting Products

Die Casting

Metal toy cars

Iron pans

High end Cameras

Engine parts

Handles

Casting Products

Ornamental railing ends

One-off Sculptures / ornaments

PLUS anything else that *could* be die cast but could also be sand cast if you only wanted a small number.

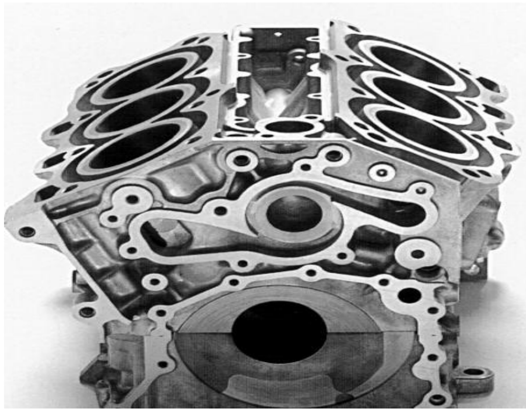
Engine parts (pipes)

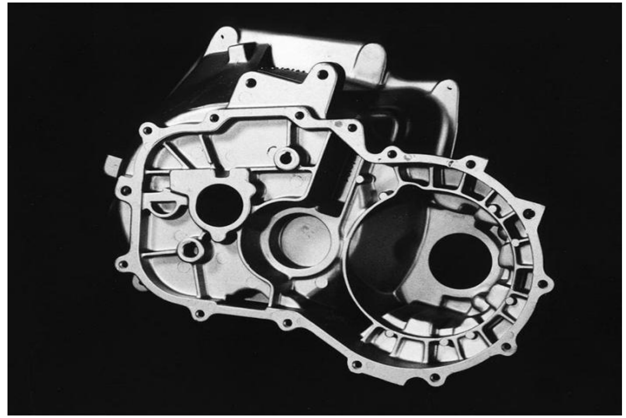
Casting Products

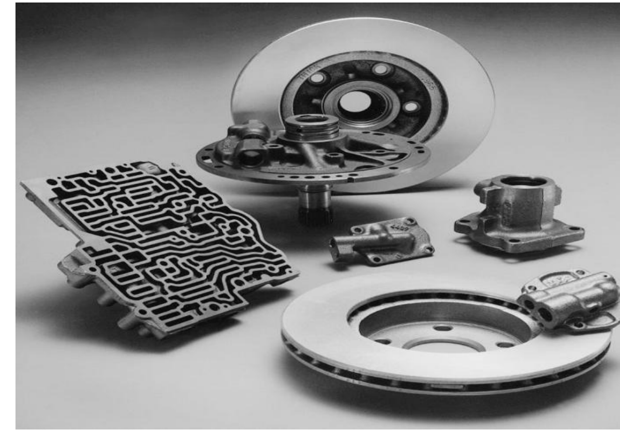
Investment Casting

- ***Basically anything that needs to be CAST but is a very complicated shape that could never be removed from a normal Die (mould)***

Casting Products







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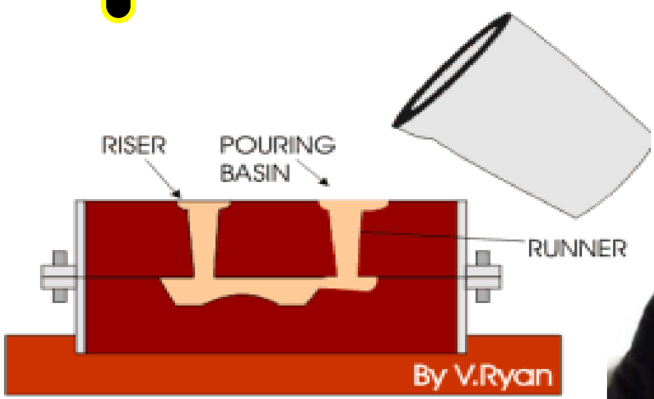
Casting Products-Pattern – Types of Pattern



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Pattern

“Pattern is defined as a model or replica of an object to be cast"

- The type of pattern to be used for a particular casting depends upon many factors like design of casting, complexity of shape, number of casting required [bulk of casting], mould process, surface finish and accuracy.
- **Functions of the Pattern**

1)A pattern prepares a mold cavity for the purpose of making a casting.

2)A pattern may contain projections known as core prints if the casting requires a core and need to be made hollow.

3)Runner, gates, and risers used for feeding molten metal in the mold cavity may form a part of the pattern.

4)Patterns properly made and having finished and smooth surfaces reduce casting defects.

5)A properly constructed pattern minimizes the overall cost of the castings.

Types Of Patterns

1. Single p tern.
2. Split pie pattern.
3. Loose p

Q. Classify the types of pattern. Explain the any two in details.

Q. What is pattern? List different type of pattern and explain any two with neat sketch.

7. Skeleton pattern
8. Follow board pattern.
9. Cope and Drag pattern.

1. Split pattern
2. Follow-board
3. Match Plate
4. Loose-piece
5. Sweep
6. Skeleton pattern

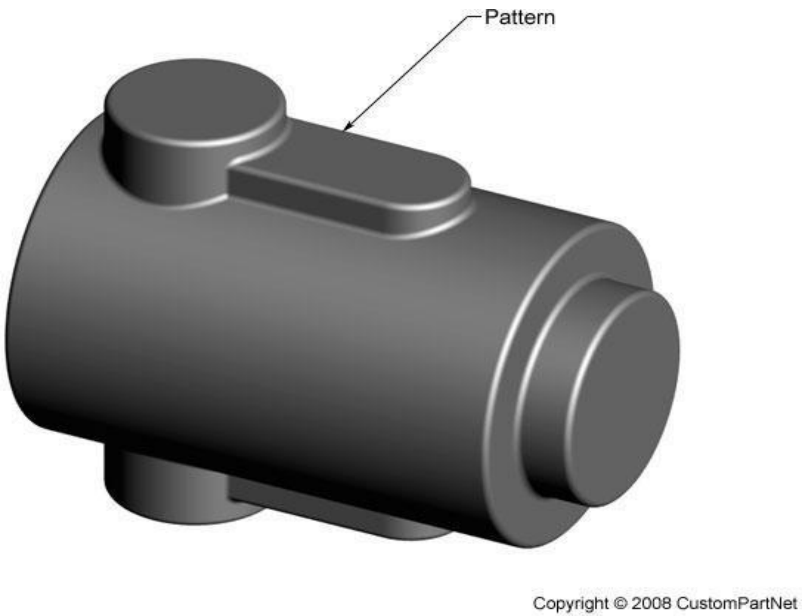
1. Single Piece (Solid) Pattern

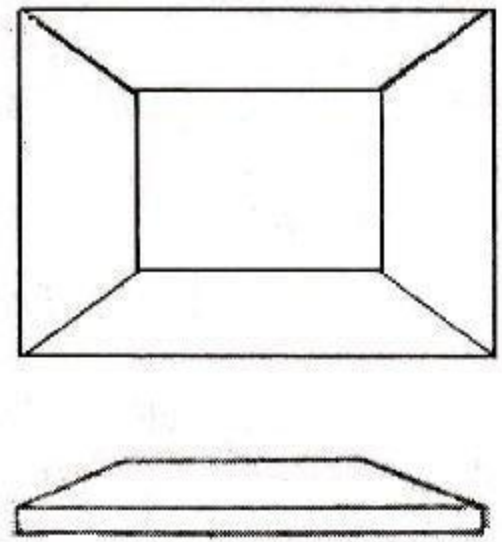
- Made from one piece and does not contain loose pieces or joints.
- Inexpensive.
- Used for large size simple castings.
- Pattern is accommodated either in the cope or in the drag.

Examples:

1. Bodies of regular shapes.
2. Stuffling box of steam engine.

1. Single Piece (Solid) Pattern





2. Split Piece Pattern

- Patterns of intric gs cannot be made in one piece because of iculties associated with the molding operatio ng pattern from mould).

Q. What is the benefit of a Split pattern over a one piece or solid pattern? (3 marks)

are accommodated in the cope and drag portions of the mold respectively.

- Parting line of the pattern forms the parting line of the mould.

2. Split Piece Pattern

- Dowel pins are used for keeping the alignment between the two parts of the pattern.
- Examples:
    - Hollow cylinder
    - Taps and water, stop cocks etc.,

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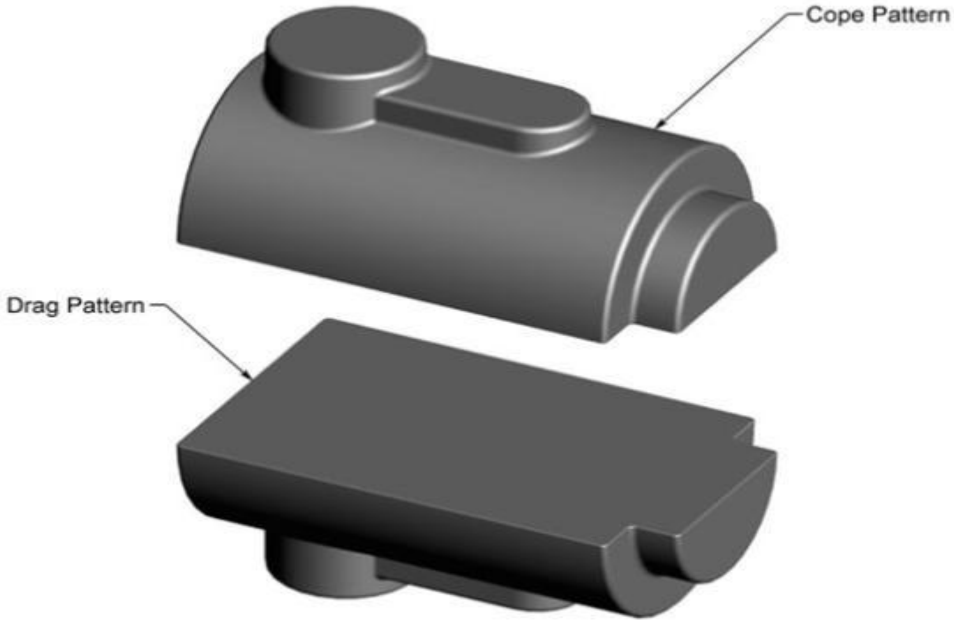
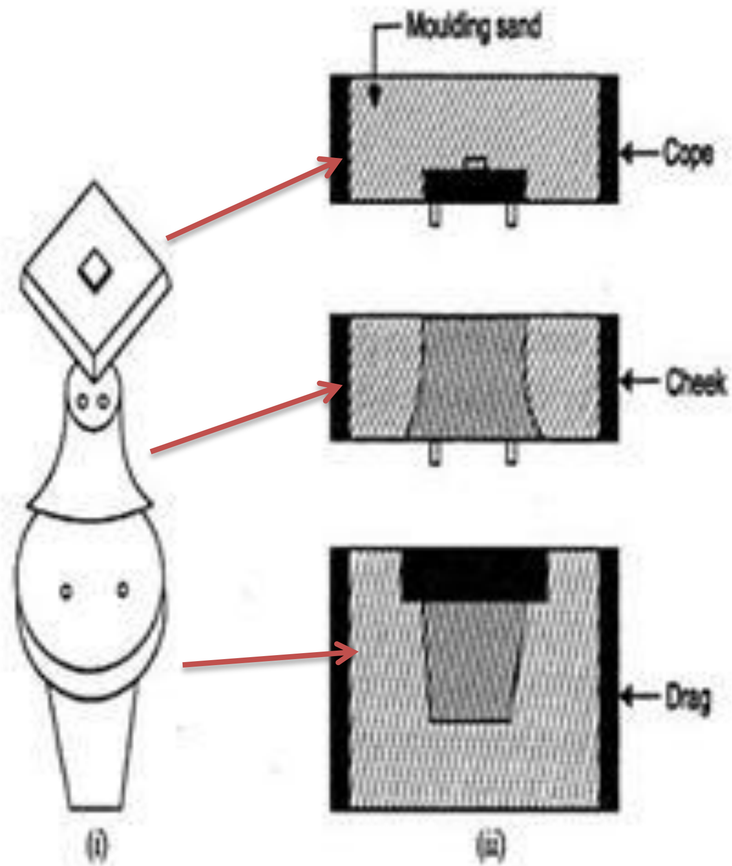
2. Split Piece Pattern





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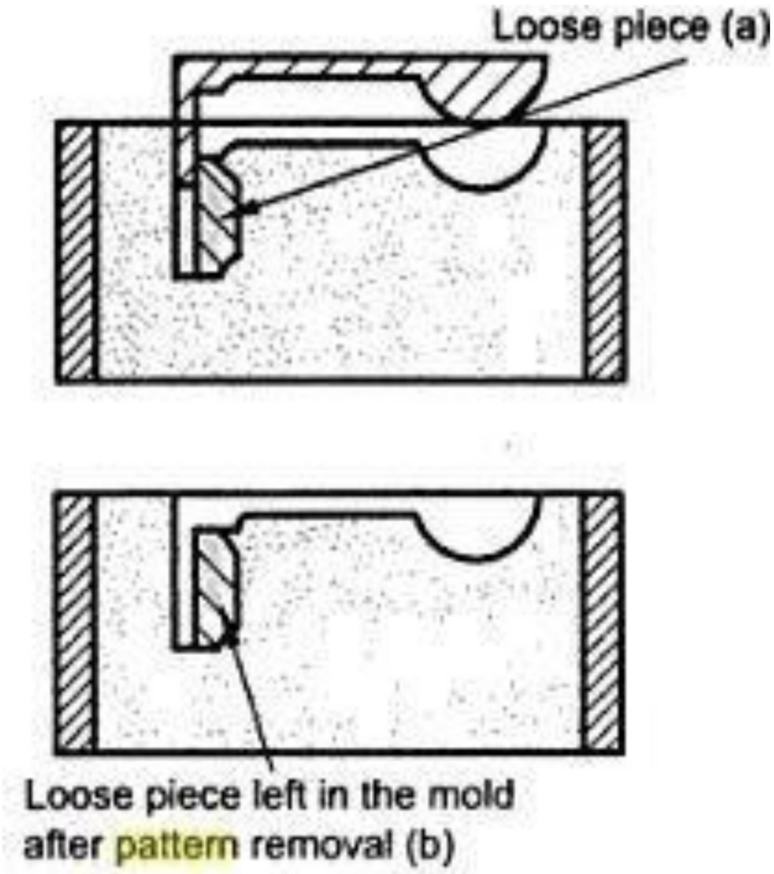
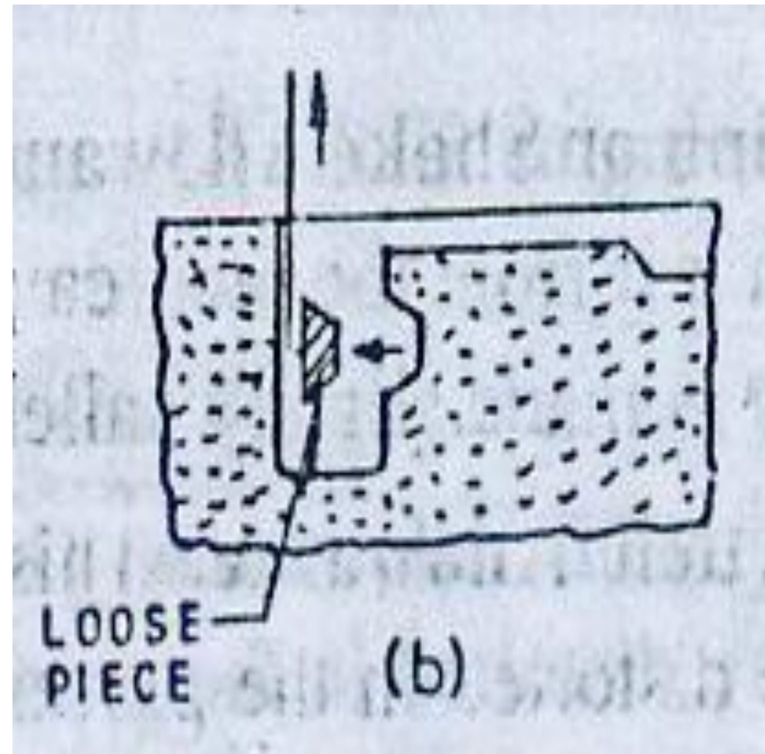
3.Loose Piece Pattern

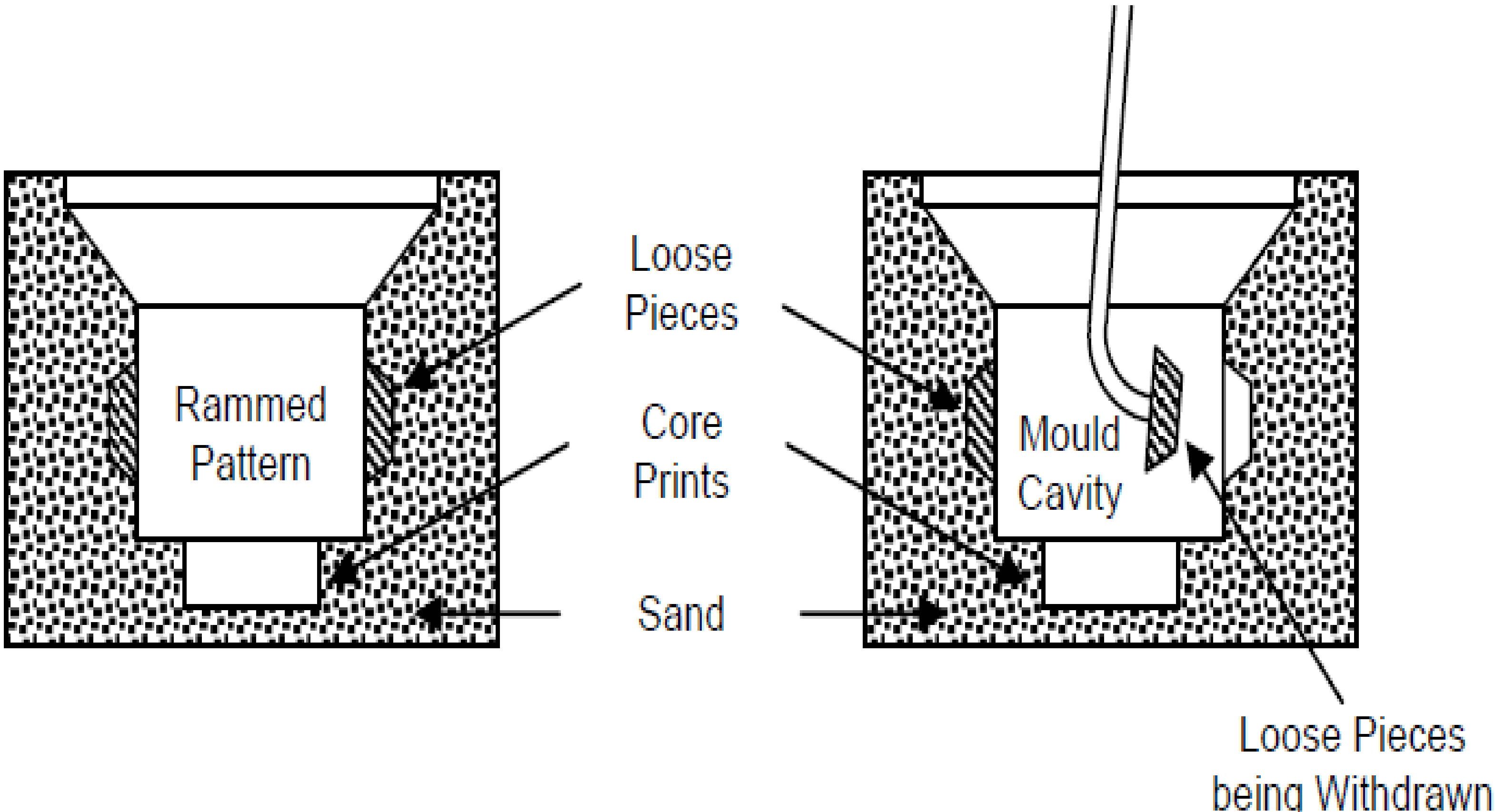
- Certain patterns cannot be withdrawn once they are embedded in the molding sand. Such patterns are usually made with one or more loose pieces for facilitating from the molding box and are known as loose piece patterns.
- Loose parts or pieces remain attached with the main body of the pattern, with the help of dowel pins.
- The main body of the pattern is drawn first from the molding box and thereafter as soon as the loose parts are removed, the result is

3.Loose Piece Pattern





3.Loose Piece Pattern



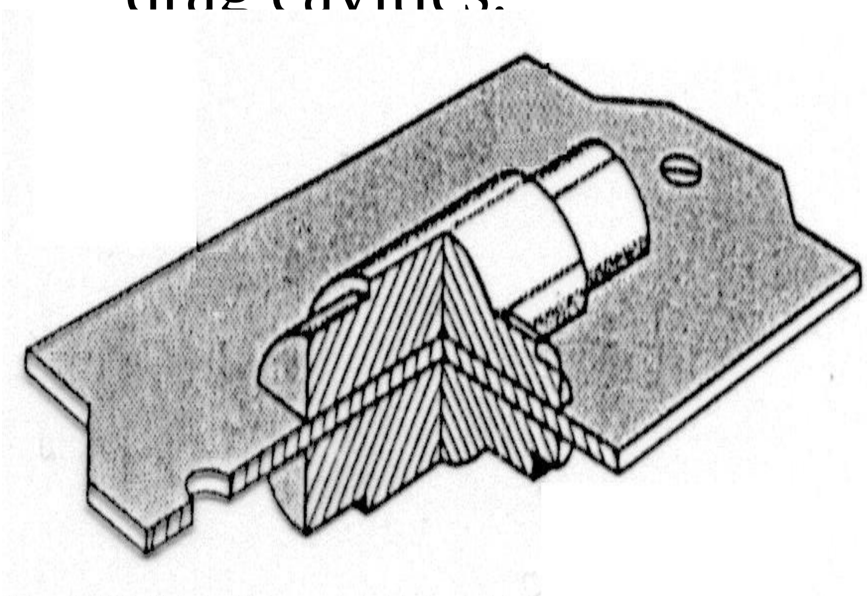
Loose Piece Pattern

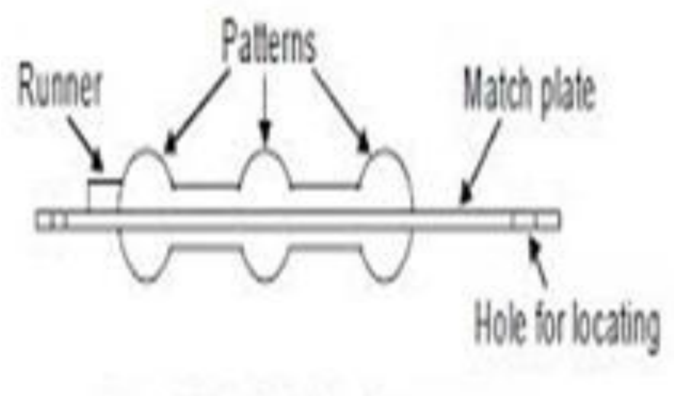
4. Match Plate Pattern

- It consists of a match plate, on either side of which each half of split patterns is fastened.
- A no. of different sized and shaped patterns may be mounted on one match plate.
- The match plate with the help of locator holes can be clamped with the drag.
- After the cope and drag have been rammed with the molding sand, the match plate pattern is removed

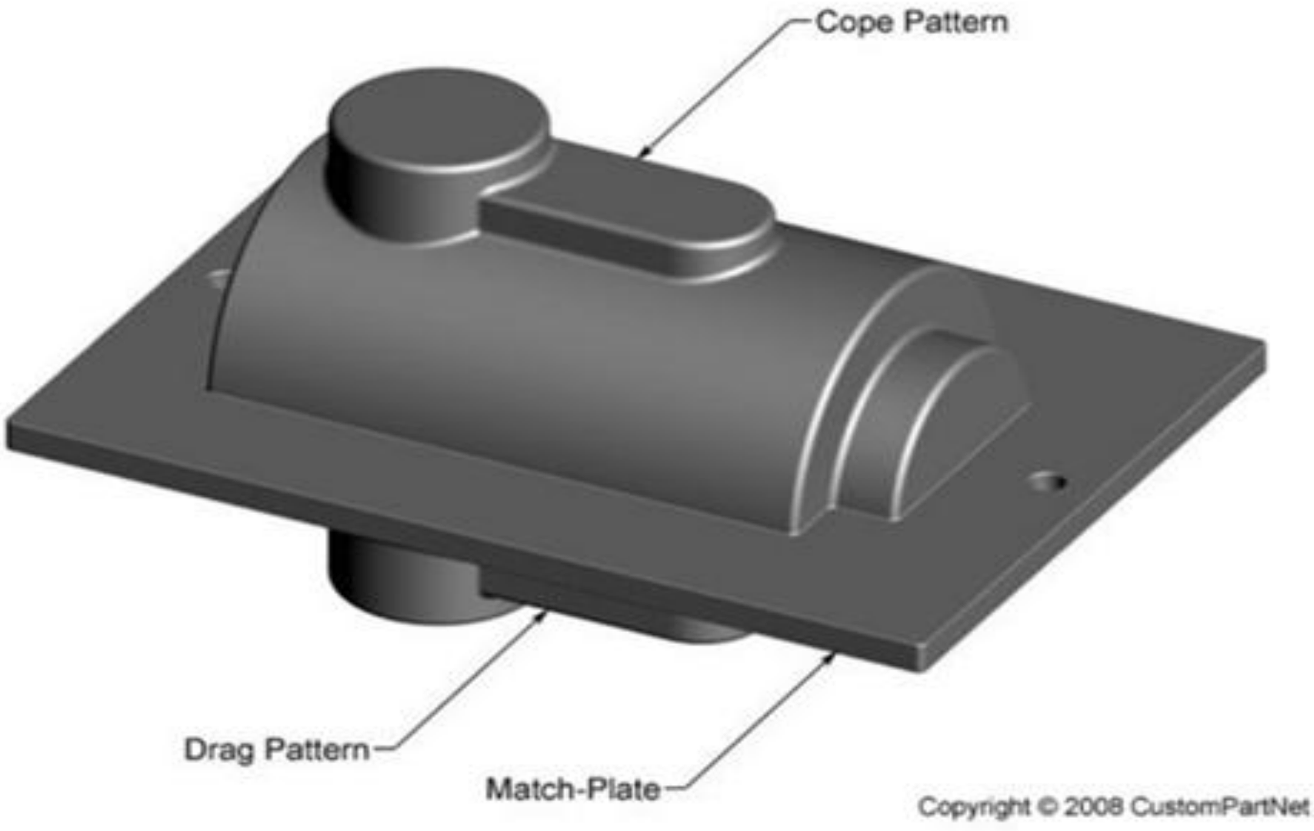
4. Match Plate Pattern

- Match plate patterns are normally used in machine molding.
- By using this we can eliminate mismatch of cope and drag cavities.





4. Match Plate Pattern



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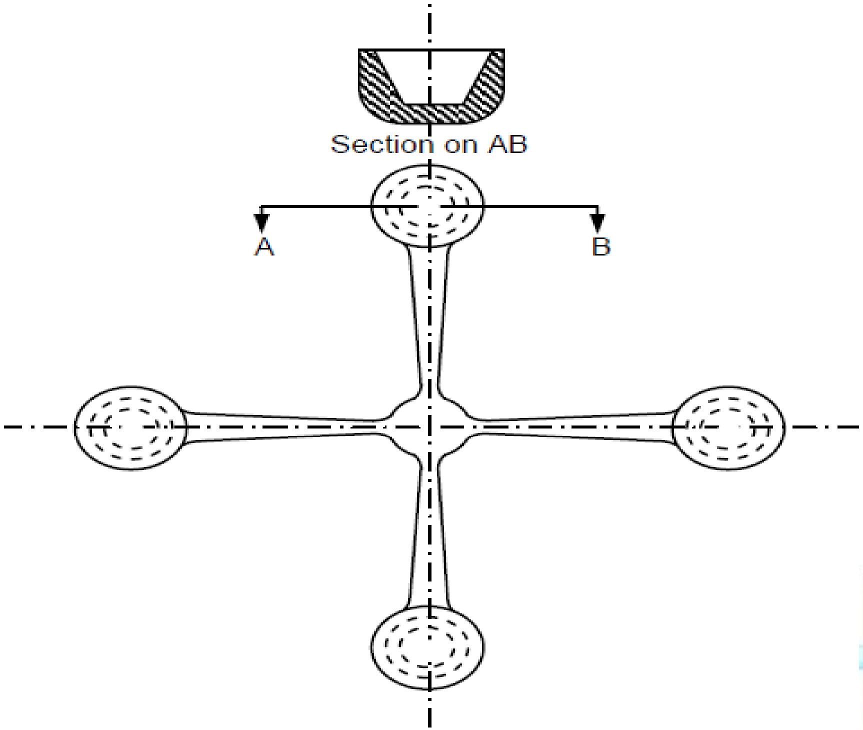
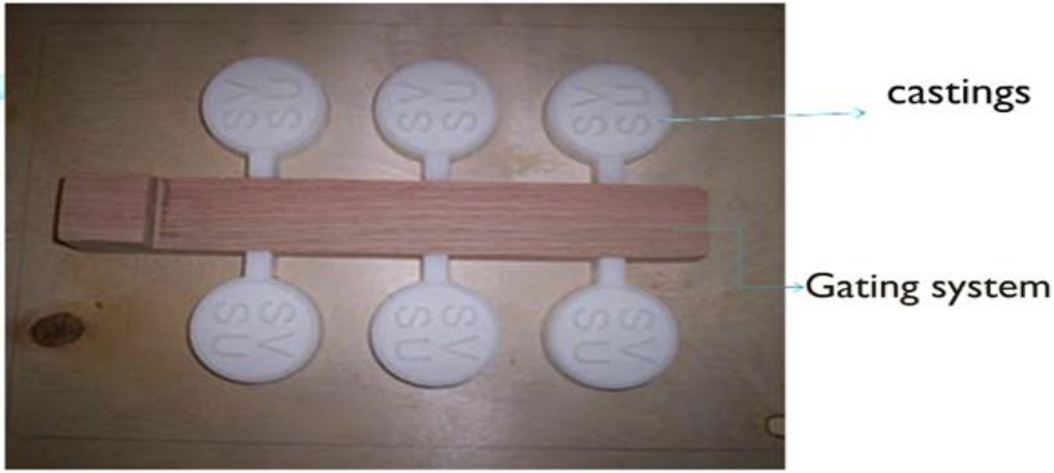
5.Gated Pattern

- The sections connecting different patterns serve as runner and gates.
- This facilitates filling of the mould with molten metal in a better manner and at the same time eliminates the time and labour otherwise consumed in cutting runners and gates.
- A gated pattern can manufacture many casting at one time and thus it is used in mass production systems.
- Gated patterns are employed for producing small castings

5.Gated Pattern





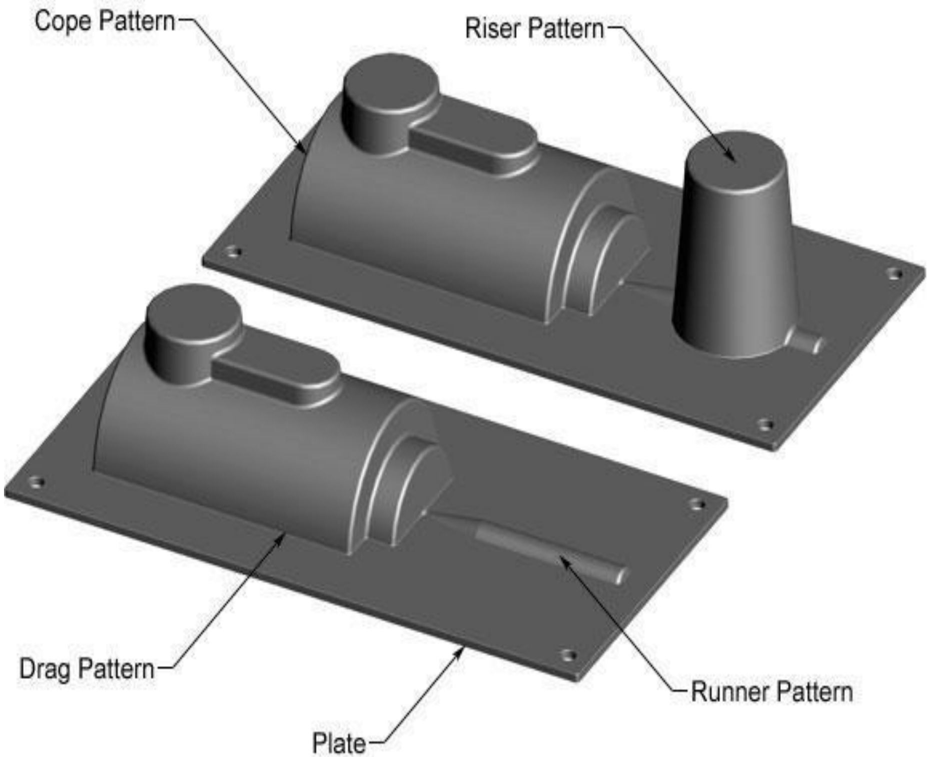
6.Cope and Drag patterns

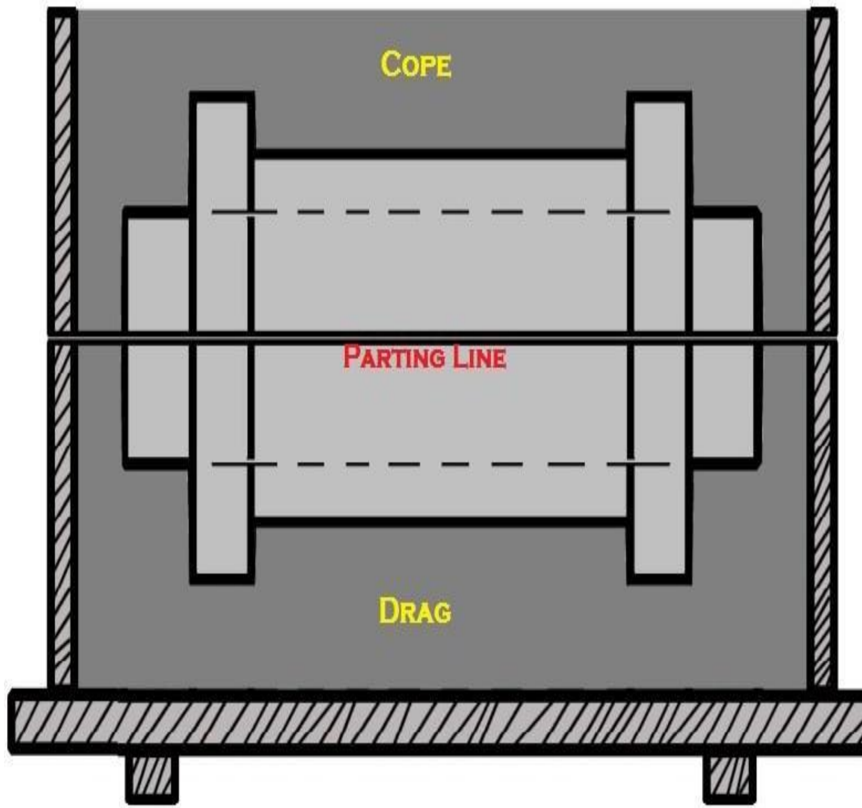
- A cope and drag pattern is another form of split pattern.
- Each half of the pattern is fixed to a separate metal/wood plate.
- Each half of the pattern(along the plate) is molded separately in a separate molding box by an independent molder or moulders.

6.Cope and Drag patterns

- The two moulds of each half of the pattern are finally assembled and the mould is ready for pouring.
- Cope and drag patterns are used for producing big castings which as a whole cannot be conveniently handled by one moulder alone.

6.Cope and Drag patterns





7.Sweep pattern

- A sweep pattern is just a form made on a wooden board which sweeps the shape of the casting into the sand all around the circumference. The sweep pattern rotates about the post.
- Once the mold is ready, Sweep pattern and the post can be removed.
- Sweep pattern avoids the necessity of making a full, large circular and costly three dimensional pattern

7.Sweep pattern

- Making a sweep pattern saves a lot of time and labor as compared to making a full pattern.
- A sweep pattern is preferred for producing large casting of circular sections and symmetrical shapes.

7.Sweep pattern

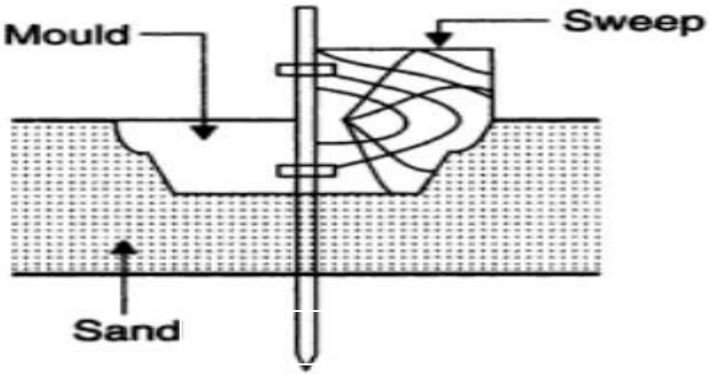
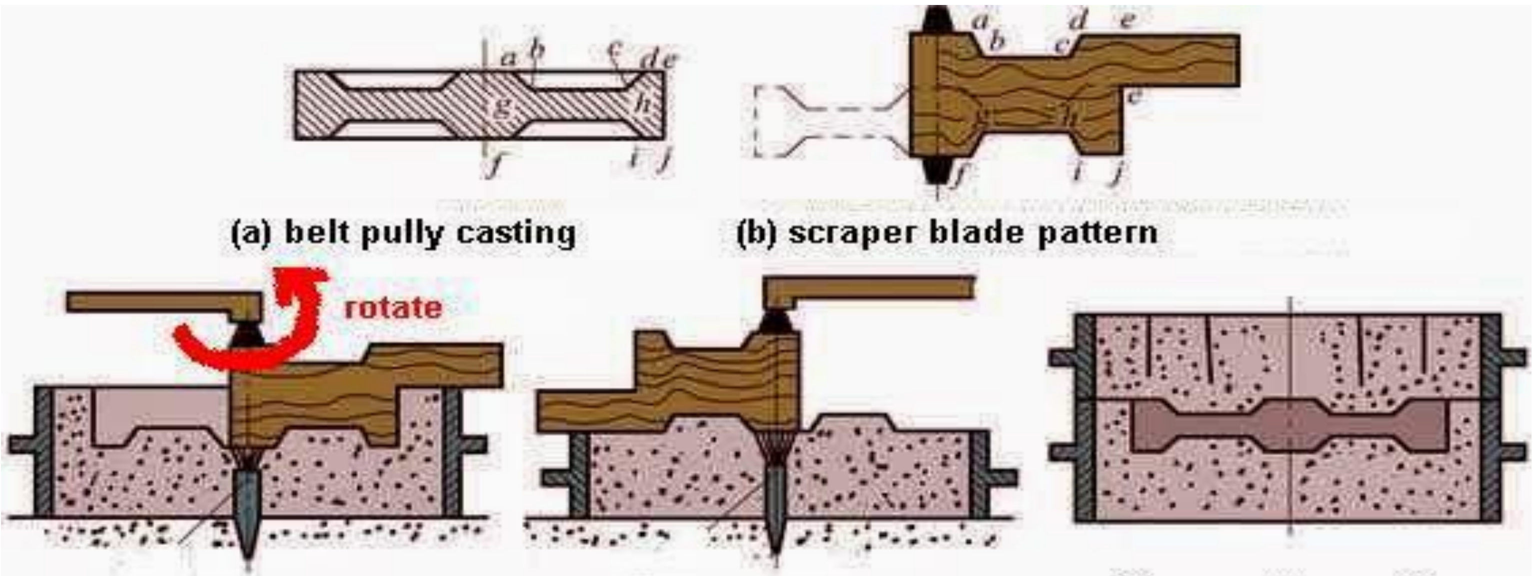


Fig. 2.8. Sweep pattern.



(a) belt pully casting

(b) scraper blade pattern

(c) make top mold

(d) make bottom mold

(e) assembly sand boxes

8. Skeleton pattern

- A skeleton pattern is the skeleton of a desired shape which may be S-bend pipe or something else. The skeleton frame is mounted on a metal base
- The skeleton is made from wooden strips, and is thus a wooden work.
- The skeleton pattern is filled with sand and is rammed.

8. Skeleton pattern

- A strickle (board) assists in giving the desired shape to the sand and removes extra sand.
- When the size of the casting is very large, but easy to shape and only a few numbers are to be made
- A skeleton pattern is very economical, because it involves l

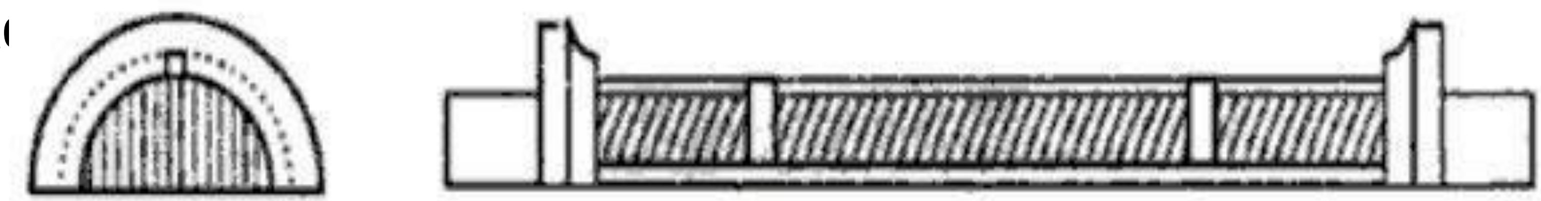


Fig. 1.78. A skeleton pattern for a flanged pipe.

9. Follow Board Pattern

- A follow board is a wooden board and is used for supporting a pattern which is very thin and fragile and which may give way and collapse under pressure when the sand above the pattern is being rammed.
- With the follow board support under the weak pattern, the drag is rammed, and then the fallow board is with drawn, The rammed drag is inverted,

9. Follow Board Pattern

- During this operation pattern remains over the inverted drag and get support from the rammed sand of the drag under it.
- Follow boards are also used for casting master patterns for many applications.

9. Follow Board Pattern

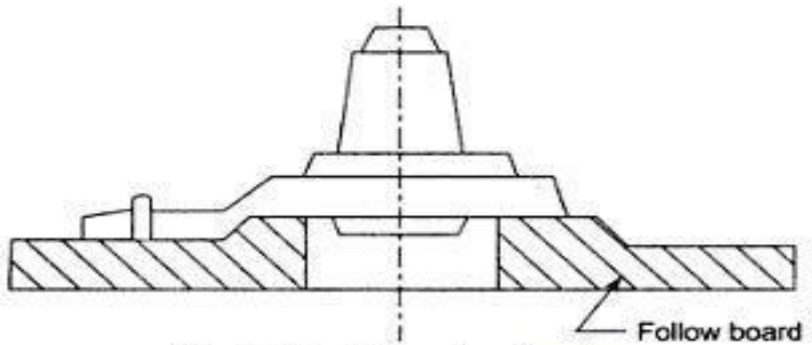


Fig. 3.14 *Follow board pattern*

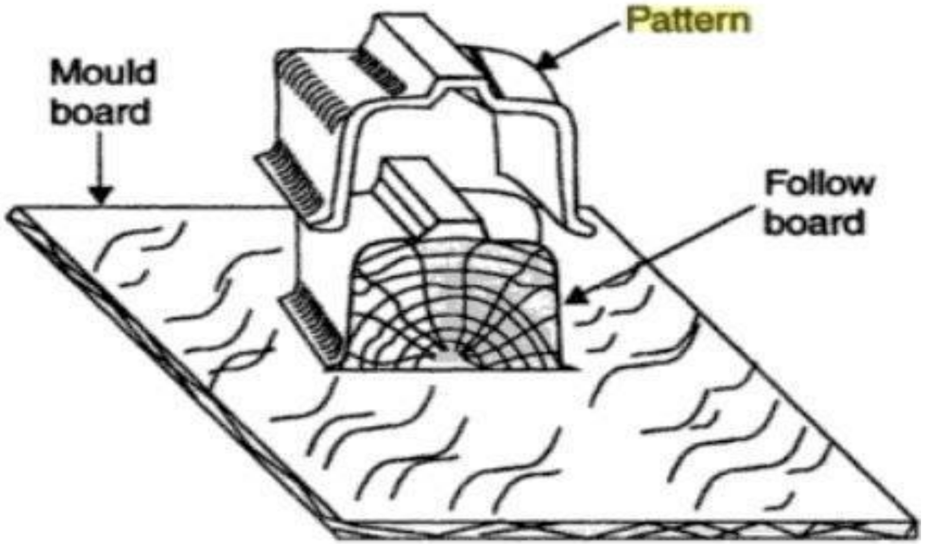


Fig. 1.80. A follow board pattern.

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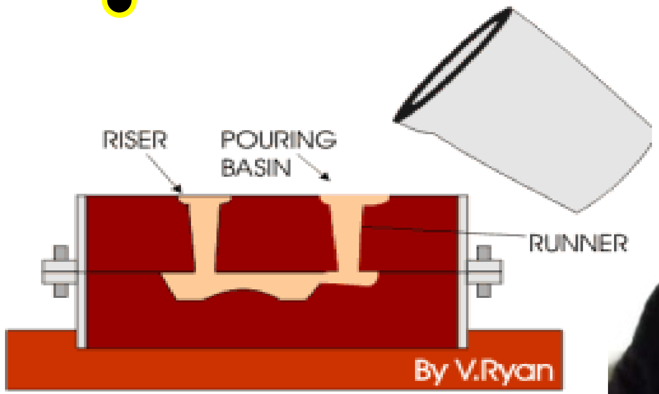
Ch-2 Foundry Technology

Pattern Material – Allowances-Colors



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Pattern material

- Wood
- Metal
- Plastic
- Plaster
- W

Q. List various material used for pattern and describe its materials demerits.

Q. List out pattern material. Explain any two along with their advantage and limitations.

Pattern material

- Easily worked, shaped and joined
- Light in weight
- Strong, hard and durable
- Resistant to wear and abrasion
- Resistant to corrosion, and to chemical reactions
- Dimensionally stable and unaffected by variations in temperature and humidity
- Available at low cost

1.Wood

- Advantages

➢ Cheap, easily available, light, easiness in surfacing, preserving (by shellac coating), workable, ease in joining, fabrication

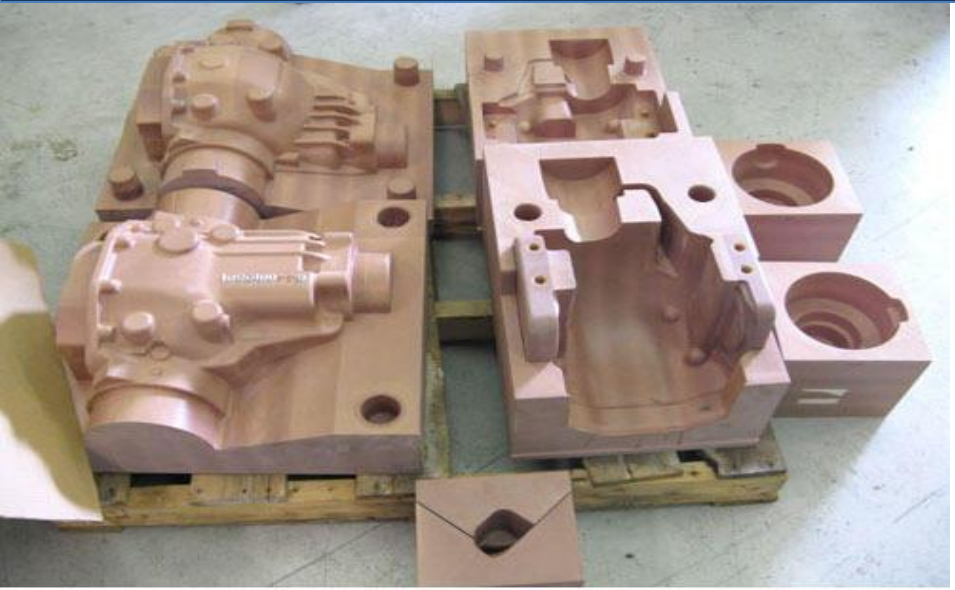
- Disadvantages

➢ Moisture effects, wear by sand abrasion, warp during forming, not for rough use.

Must be properly dried/ seasoned, free from knots, straight grained

Egs. Burma teak, pine wood, mahogany, Sal, Deodar, Shisham, Walnut, Apple tree

1.Wood



2.Metals

- Used for mass production
- For maintaining closer dimensional tolerances on casting.
- More life when compared to wooden patterns
- Few of the material used include CI, Al, Fe, Brass etc. Al is widely used.
- More expensive
- Cannot be repair

- **Egs: Al alloys, Brass, Mg alloys, Steel, cast Iron for mass production**

2.Metal Patterns

- These are employed where large no. of castings have to be produced from same patterns.
- Commonly used metals for making patterns:
    - Cast iron
    - Aluminium and its alloys
    - Steel
    - White metal
    - Brass etc..

Advantages

- Do not absorb moisture
- More stronger
- Possess much longer life
- Do not wrap, retain their shape
- Greater resistance to abrasion
- Accurate and smooth surface finish
- Good machinability

2.Metal Patterns




3.Plastics

- Low weight
- Easier formability
- Do not absorb moisture
- Good corrosion resistance

- The most generally used plastics are
  - Epoxy resins with fillers
  - PU foam

3.Plastics

- Plaster of Paris or gypsum cement is used as a pattern material
- Complicated shapes can be easily cast
- Has high compressive strength
- Used for making small and intricate pattern and core boxes

3.Plastics

4.Wax

- Wax is used in specialized applications such as investment casting process etc
- Wax provide good surface finish
- Provide high accuracy to the casting


Pattern Allowances

- Pattern is alway[...] than the final casting because[...]ain allowances due to metallurgica[...]l reasons
- **Types**

> **Q. Define pattern allowances. List various pattern allowances. State purpose of each allowance.**
>
> **Q. What type of allowance is generally incorporated into a casting pattern explain.**

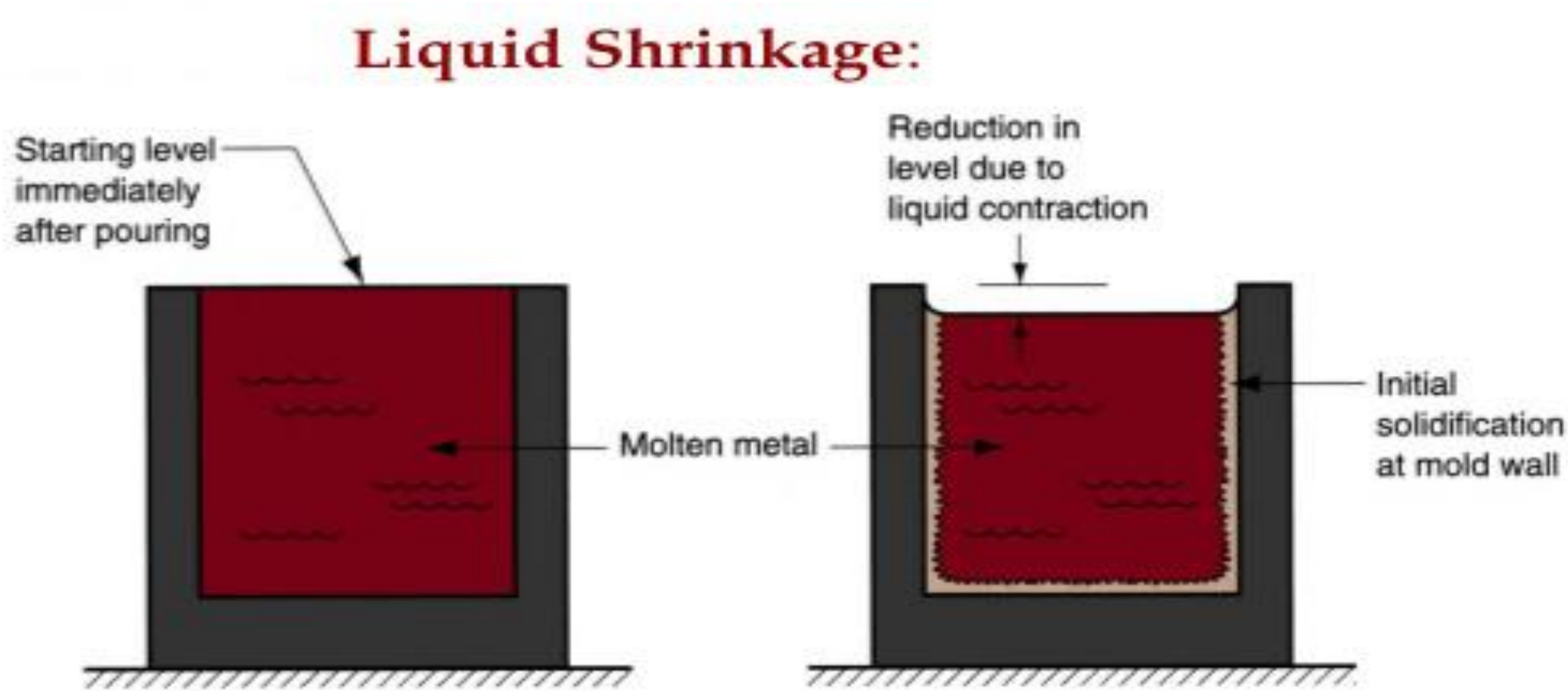
D. Distortion or camber allowance

E. Rapping allowance

A. Shrinkage or contraction allowance

- Almost all cast metals shrink or contract volumetrically on cooling.
- shrinkage allowance gives to the pattern to compensate for the contraction of the liquid metal on cooling.
- For this, the dimensions of the pattern is made slightly oversize.
- The shrinkage allowance will be different for different metals.
- The shrinkage allowance is greater for cast steel than that of other alloys.
- The shrinkage allowance is always added along the length than along the diameter

A. Shrinkage or contraction allowance



Rate of Contraction of Various Metals

Material	Dimension	Shrinkage allowance (inch/ft)
Grey Cast Iron	Up to 2 feet 2 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

B. Machining or finish allowance

- This allowance is provided on the pattern if the casting is to be machined.
- This allowance is given in addition to shrinkage allowance.
- The amount of this allowance varies from 1.6 to 12.5 mm which depends upon the type of the casting metal, size and the shape of the casting.
- The ferrous metals require more machining allowance than non ferrous metals.

B. Machining or finish allowance

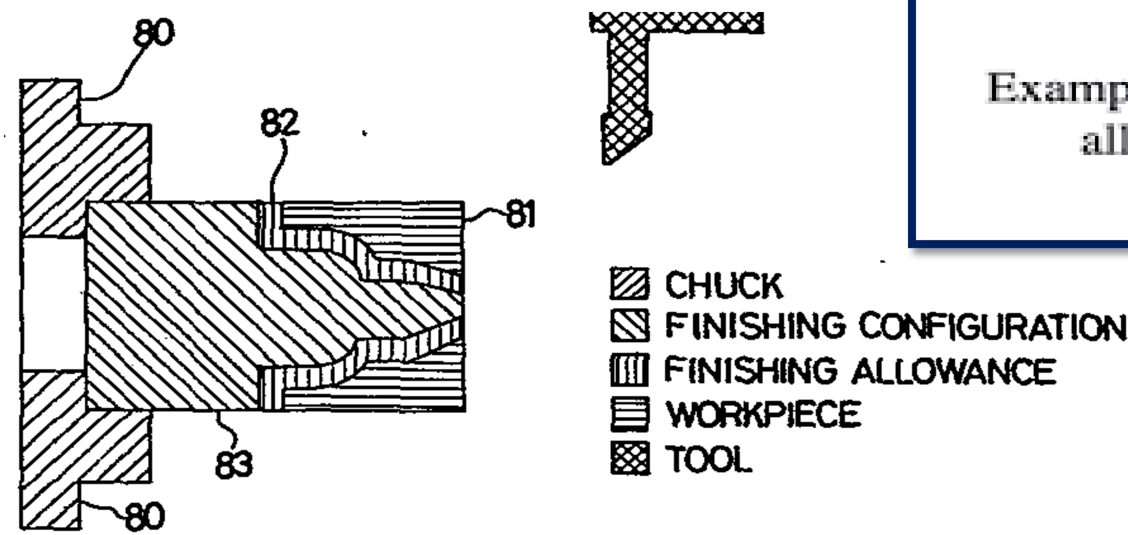
Is given due to the following reasons:

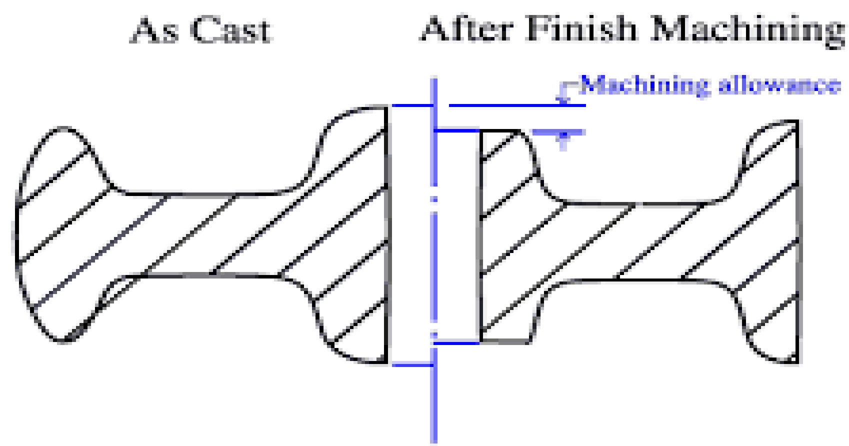
1. For removing surface roughness, Scale, slag, dirt and other imperfections from the casting.
2. For obtaining exact dimensions on the casting.
3. To achieve desired surface finish on the casting.

The dimension of the pattern to be increased depends upon the following factors:

1. Method of machining used (turning, grinding, boring, etc.).
2. Characteristics of metal
3. Method of casting used.
4. Size and shape of the casting.
5. Degree of finish required.

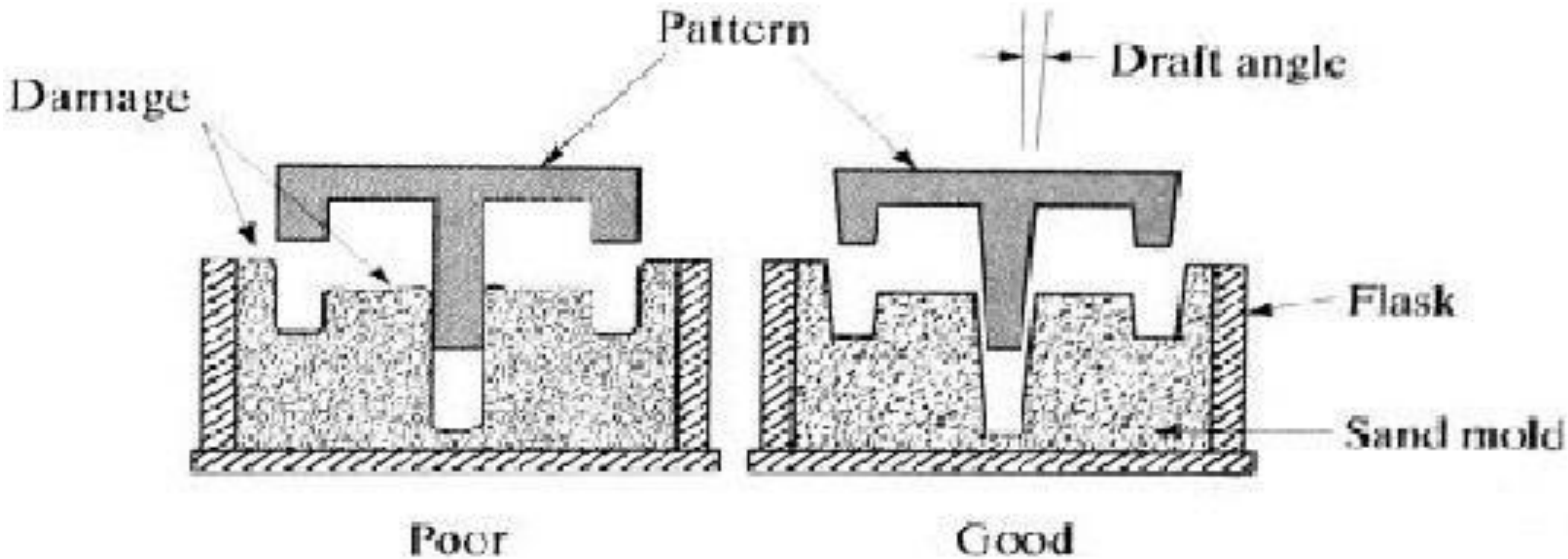
B. Machining or finish allowance





Example of machining or "cleanup" allowance on hub face of a wheel casting

C. Draft or taper allowance



- Provided to facilitate easy withdrawal of the pattern.
- Typically it ranges from 1 degree to 3 degree for wooden patterns.
- The amount of draft required depends upon the shape and size of the casting, moulding method, the method of production, intricacy of pattern, and whether moulded by hand or machine.

C. Draft or taper allowance

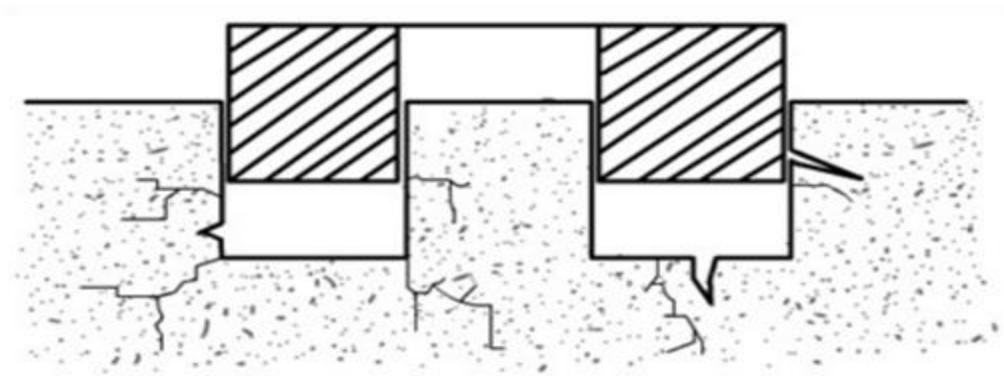
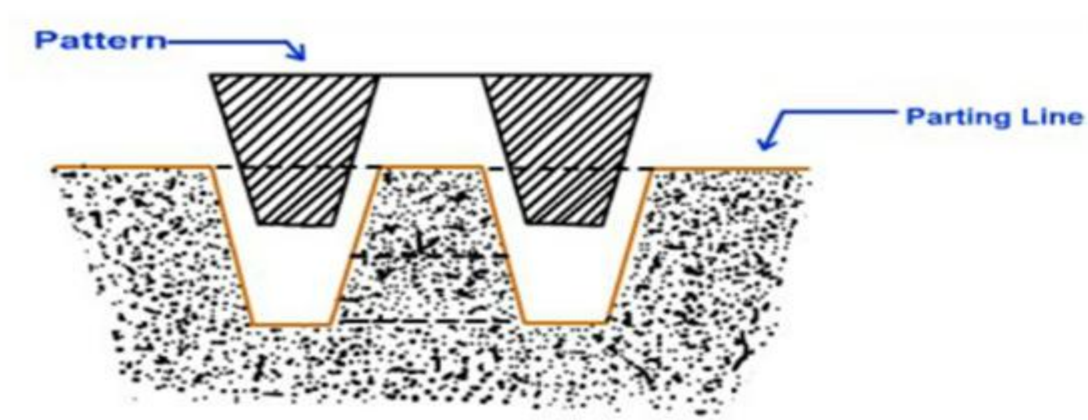


Figure 3 (a) Pattern Having No Draft on Vertical Edges



Draft Allowances of Various Metals

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

D. Distortion or Camber Allowance

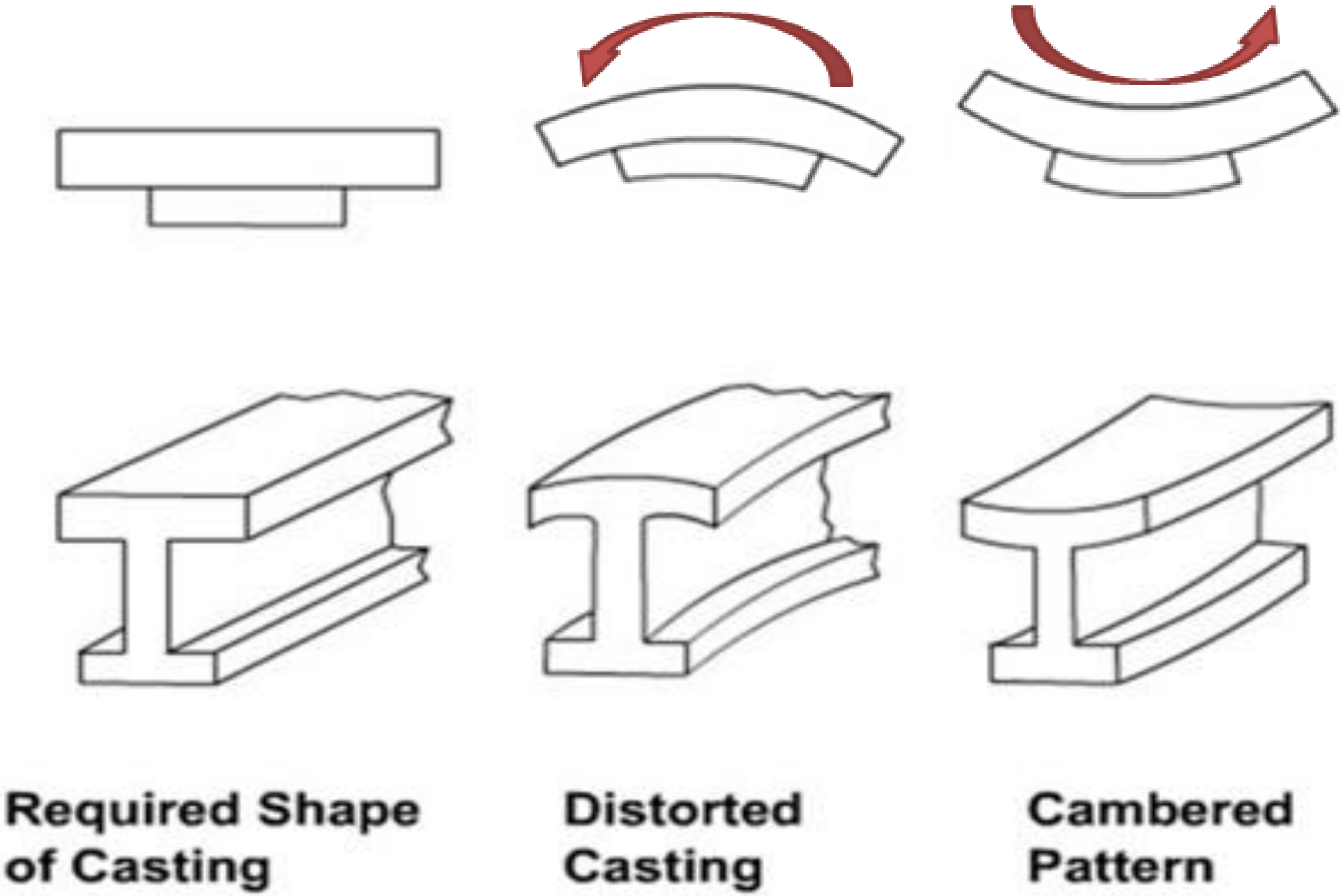
- Sometimes castings, because of their size, shape and type of metal, tend to warp or distort during the cooling period depending on the cooling speed.
- Expecting the amount of warpage, a pattern may be made with allowance of warpage. It is called camber.
- For example, a U-shaped casting will be distorted during cooling with the legs diverging, instead of parallel as shown in fig. For compensating this warpage, the pattern is made with the legs converged but, as the casting cools, the legs straighten and remain parallel.

Casting without camber

Actual Casting

Pattern with camber allowance

D. Distortion or Camber Allowance



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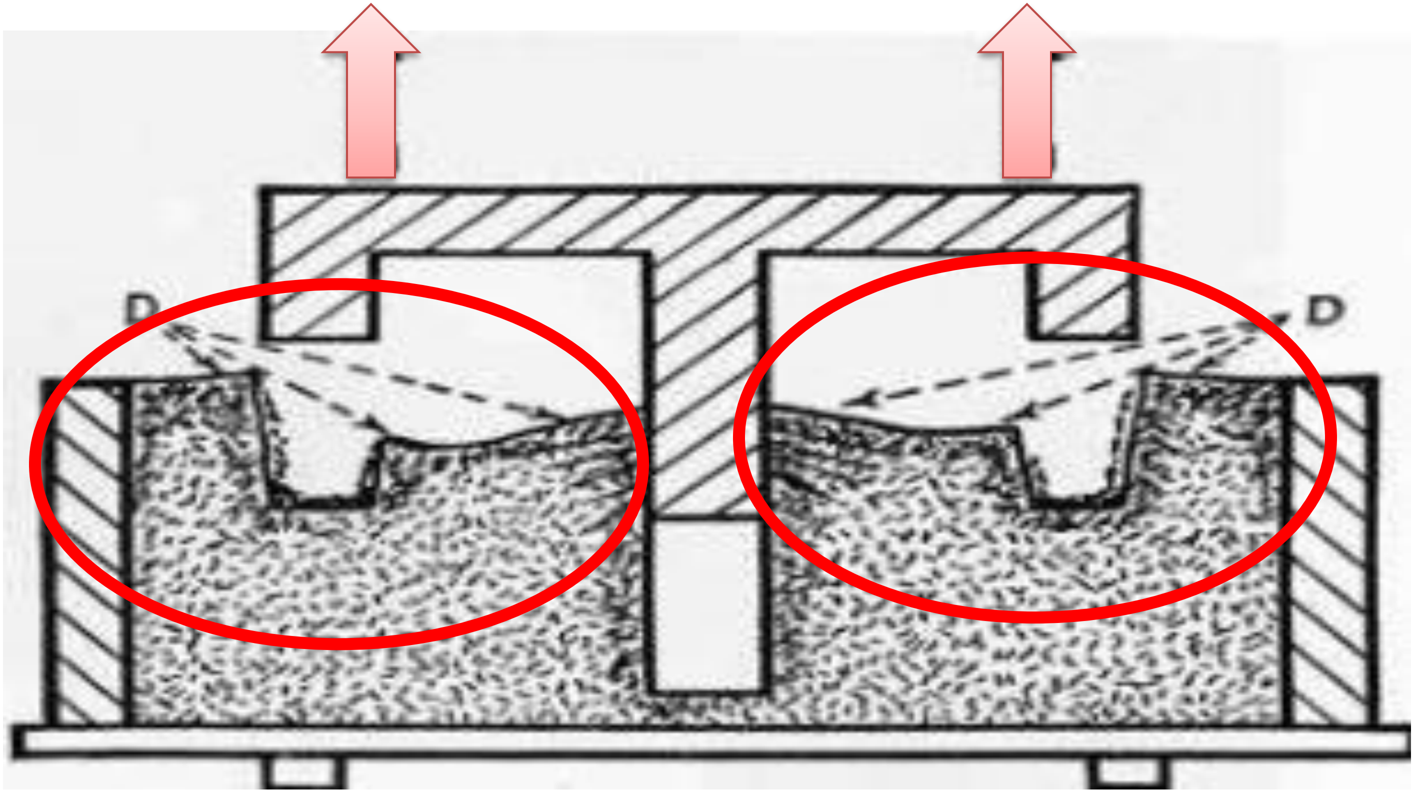
E. Rapping or Shaking Allowance

- When the pattern is shaken for easy withdrawal, the mould cavity, hence the casting is slightly increased in size. In order to compensate for this increase, the pattern should be initially made slightly smaller.
- For small and medium sized castings, this allowance can be ignored.
- Large sized and precision castings, however, shaking allowance is to be considered.
- The amount of this allowance is given based on previous experience.

E. Rapping or Shaking Allowance



Pattern Colors

- There is no universal method of colouring but following method is followed as a practice for colouring the patterns and core boxes.
- Red for machining surface.
- **Black** for un-machined surface.
- Yellow for core print.
- **Red strip on yellow base** for seat for loose pieces
- Without colour for parting surface.

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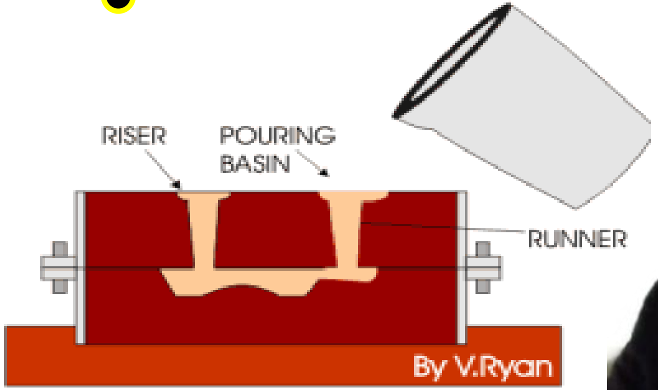
Core-Hand Molding Equipments



Subject:MT
Code:-3151912

Prepared by: Asst.Prof.Harin Prajapati
(Mechanical Department,ACET)

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Core

- Full-scale mode ... faces of part used to produce hollow ...
- It is inserted int ... ty prior to pouring
- The molten met ... idifies between the mold cavity and the core to form the casting's

Q. Explain with neat sketch any two types of cores.

Q. Describe core making and core material briefly .

Q. What is Core-Print and what is its purpose?

- Castings are often required to have holes, recesses, etc. of various sizes and shapes. These impressions can be obtained by using cores.

Core

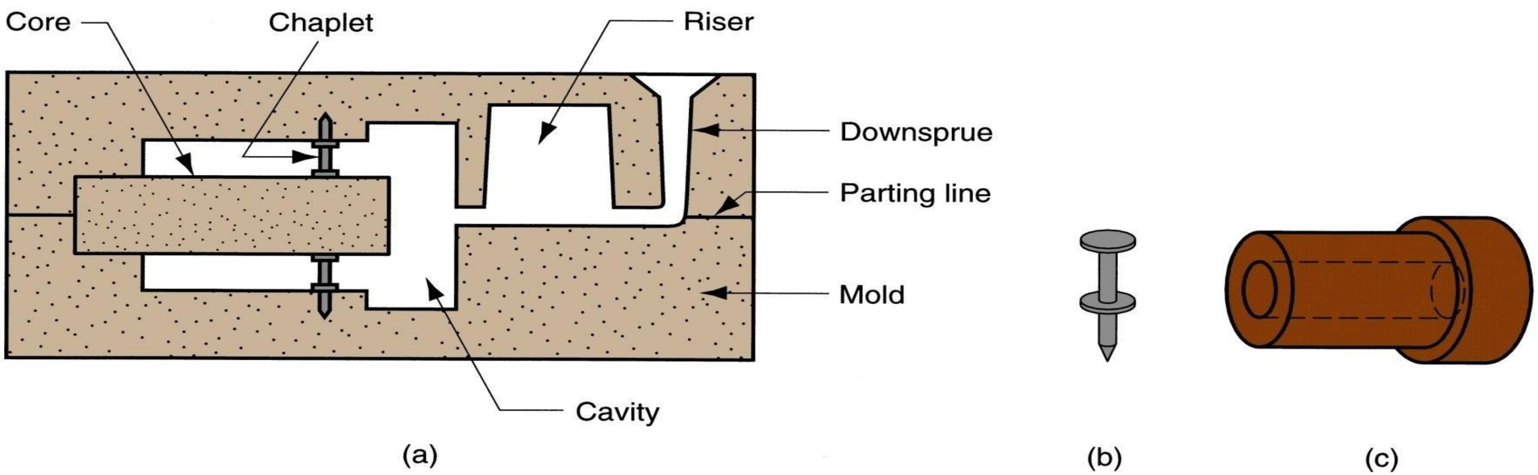

Figure- Core held in place in the mold cavity by chaplets

(b) possible chaplet design

(c) casting with internal cavity

Core Properties

- It must be strong to retain the shape while handling,
- It must resist erosion by molten metal,
- It must be permeable to gases,
- It must have high refractoriness, and
- It must have good surface finish to replicate it on to the casting.

Steps In Core Making

1. Core sand preparation.
2. Core making.(Jolt machine, sand slinger, core blower)
3. Core baking.(to remove moisture)
4. Core finishing (coating of refractory or protective materials)
5. Setting the core

Core Making

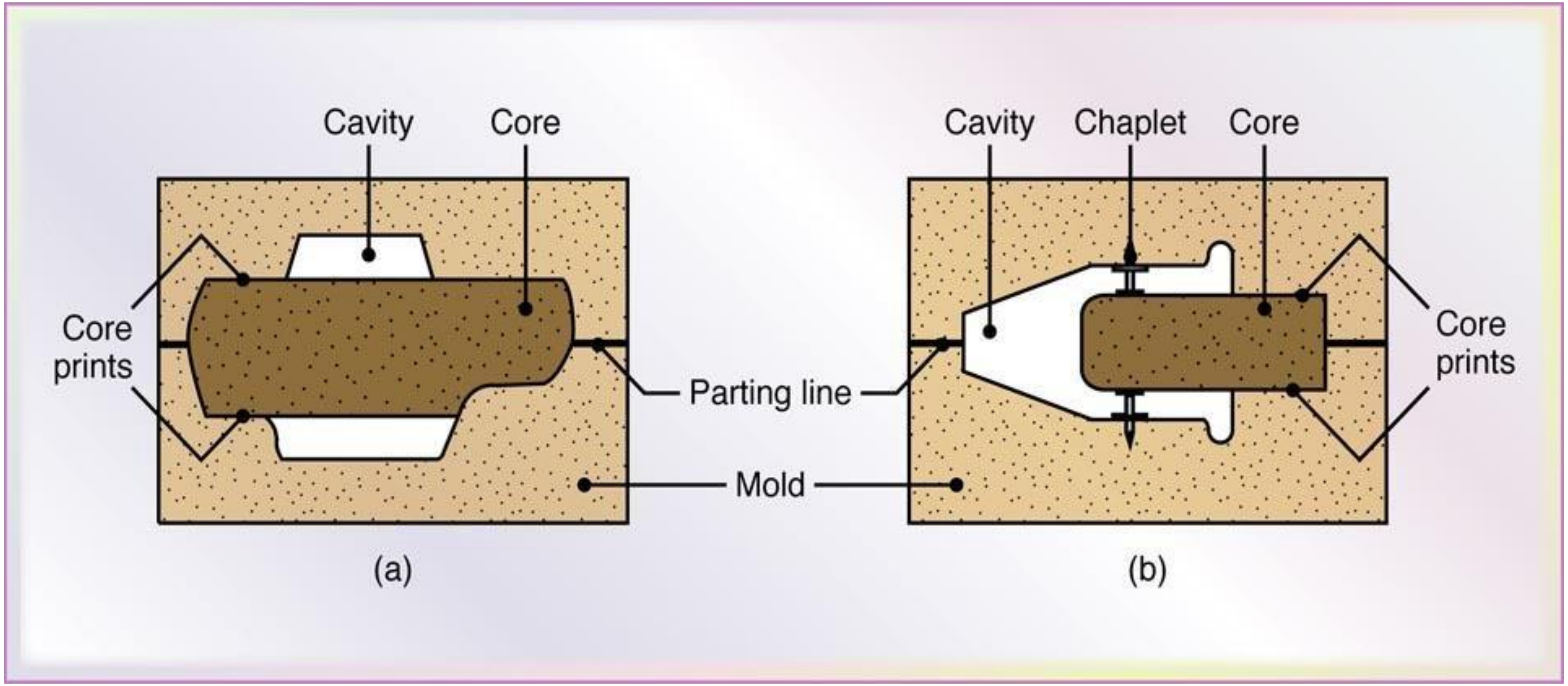

Figure-- Examples of sand cores showing core prints and chaplets to support cores.

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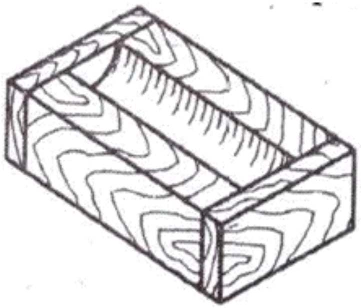
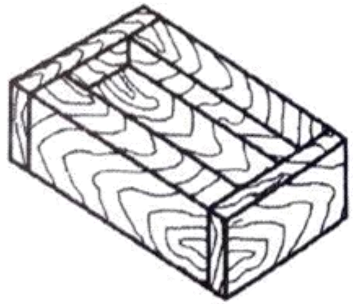
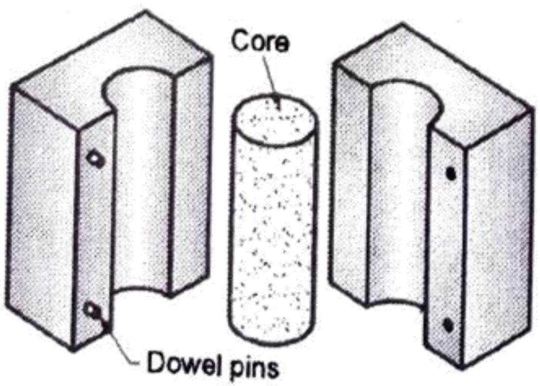
Core Making



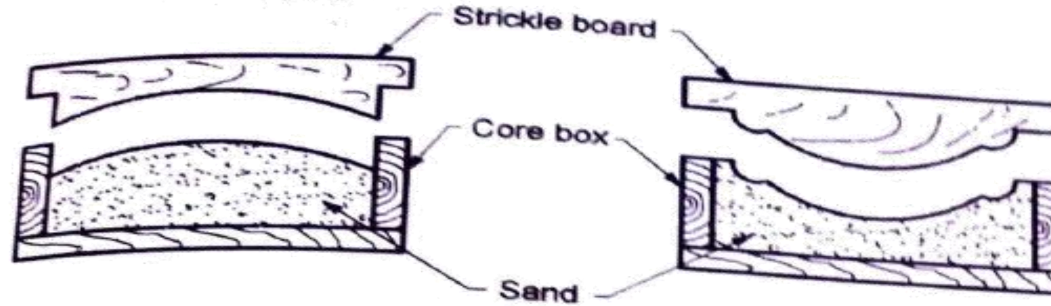
(a) Half core box



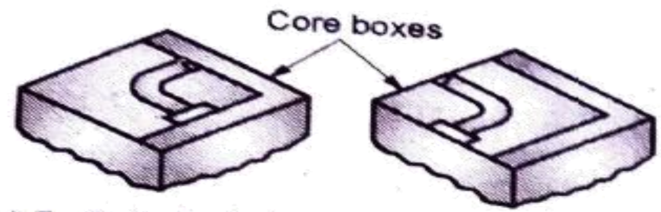
(b) Dump box



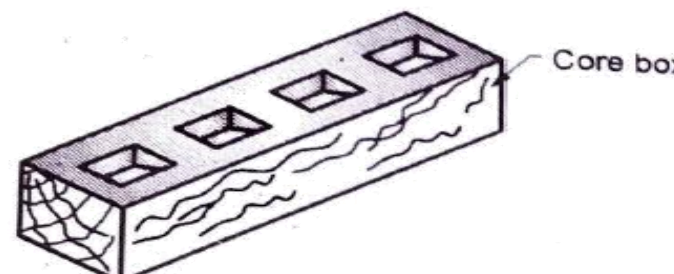
(c) Split core box



(d) Strickle boxes



(e) Left and right hand core boxes



(f) Gang core boxes

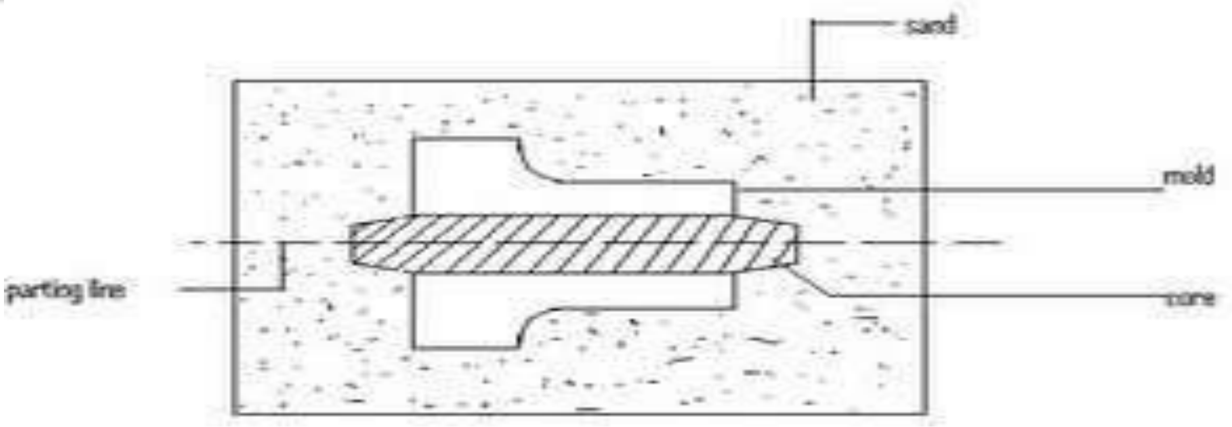
Types Of Cores

According to the Shape and Position of the Core

1) Horizontal core
2) Vertical core
3) Hanging core
4) Balanced core
5) Kiss core
6) Ram up core
7) Drop core

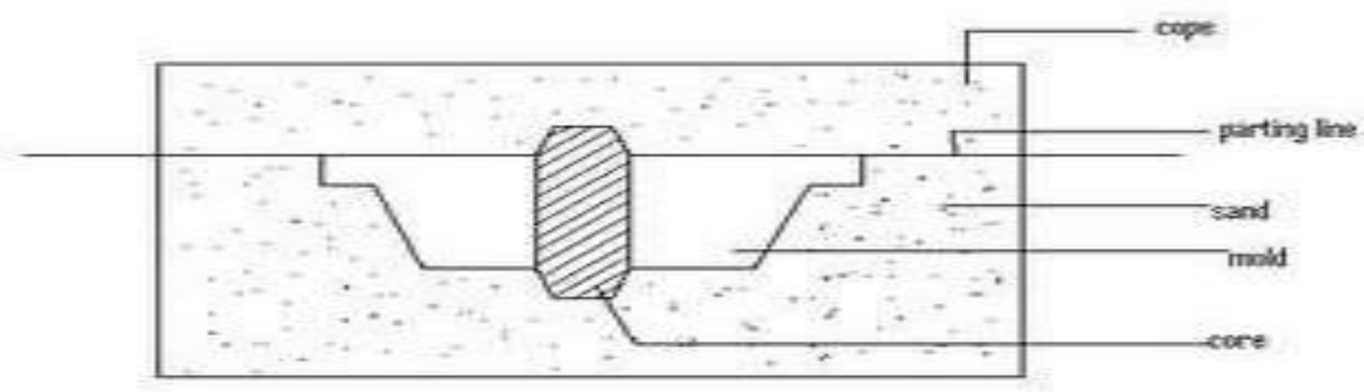
1. Horizontal Core

- Positioned horizontally in the mould
- Can have any shape according to cavity and casting required



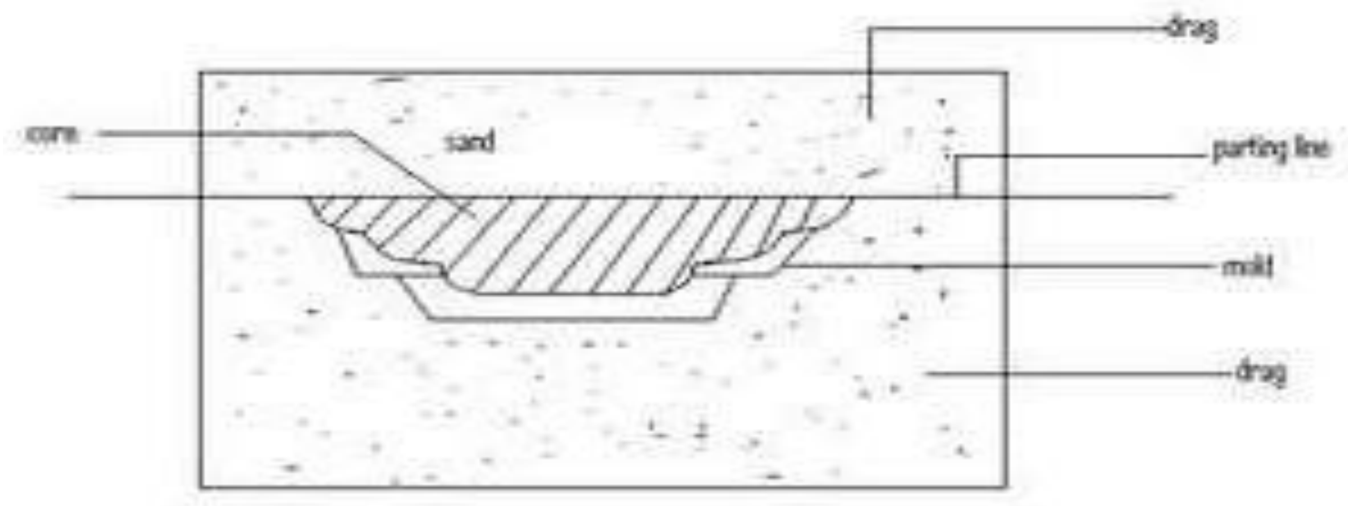
2. Vertical Core

- Fitted in mould with its axis vertical.
- Taper is provided at top end for smooth fitting of core in cope portion.
- Major portion remains in the drag portion.



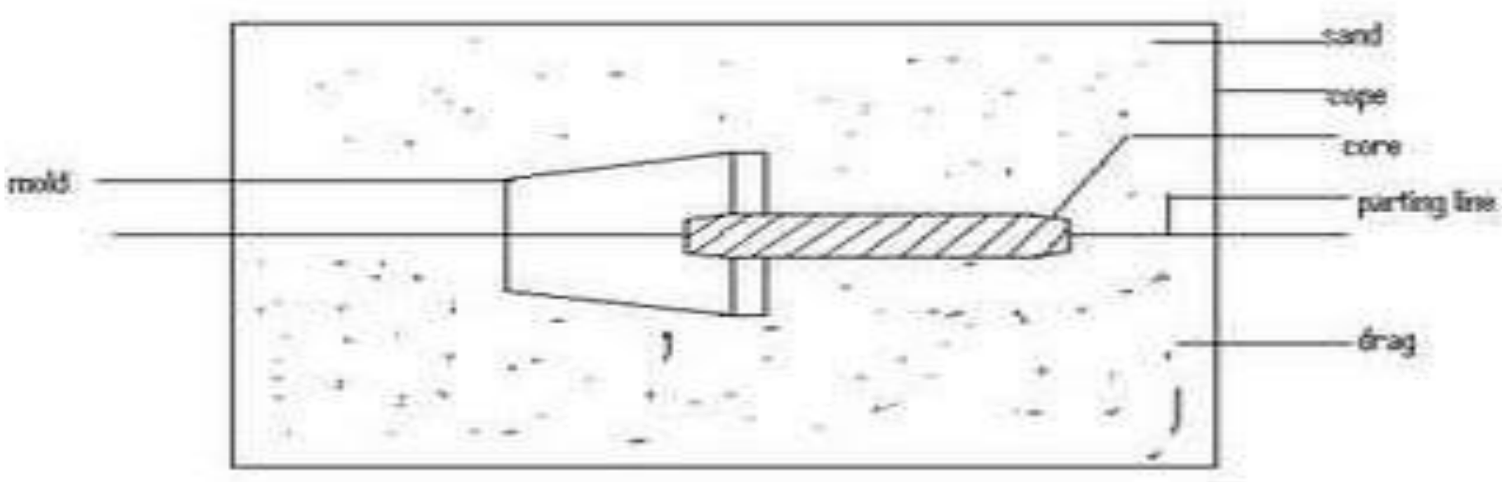
3. Hanging or Cover Core

- It is supported from above and hangs vertically in the mould cavity
- No support from bottom



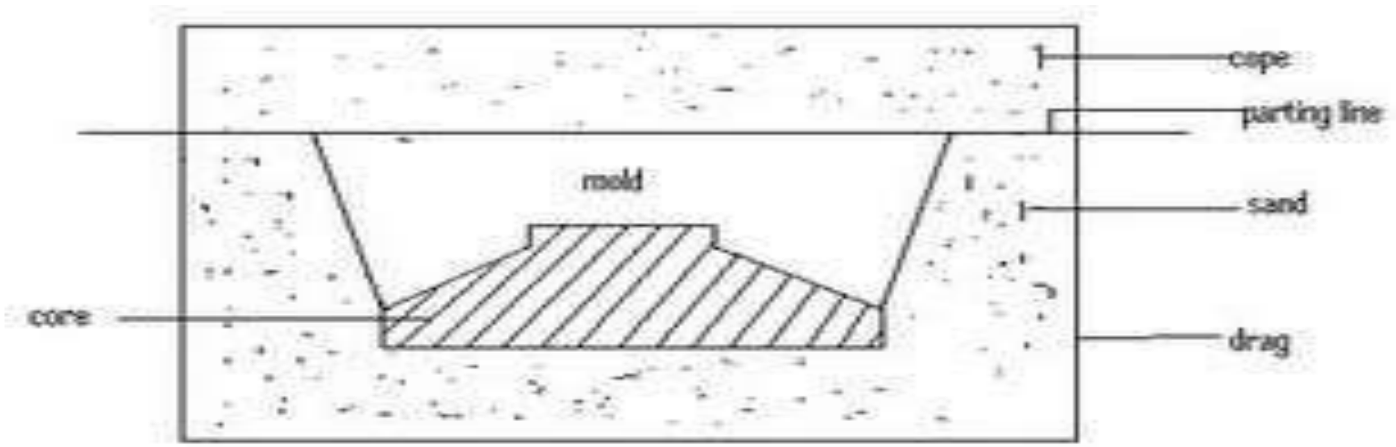
4. Balanced Core

- Supported and balanced from its one end only
- Required long core seat.



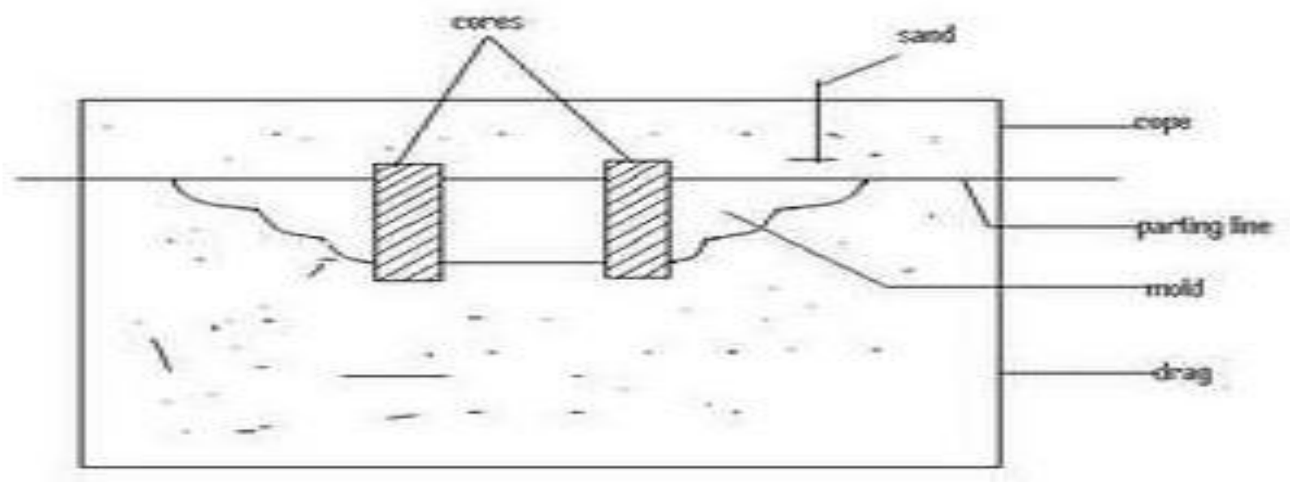
5.Ram Up Core

- It is placed in the sand along with pattern before ramming the mould
- Used to make external or internal details of a casting



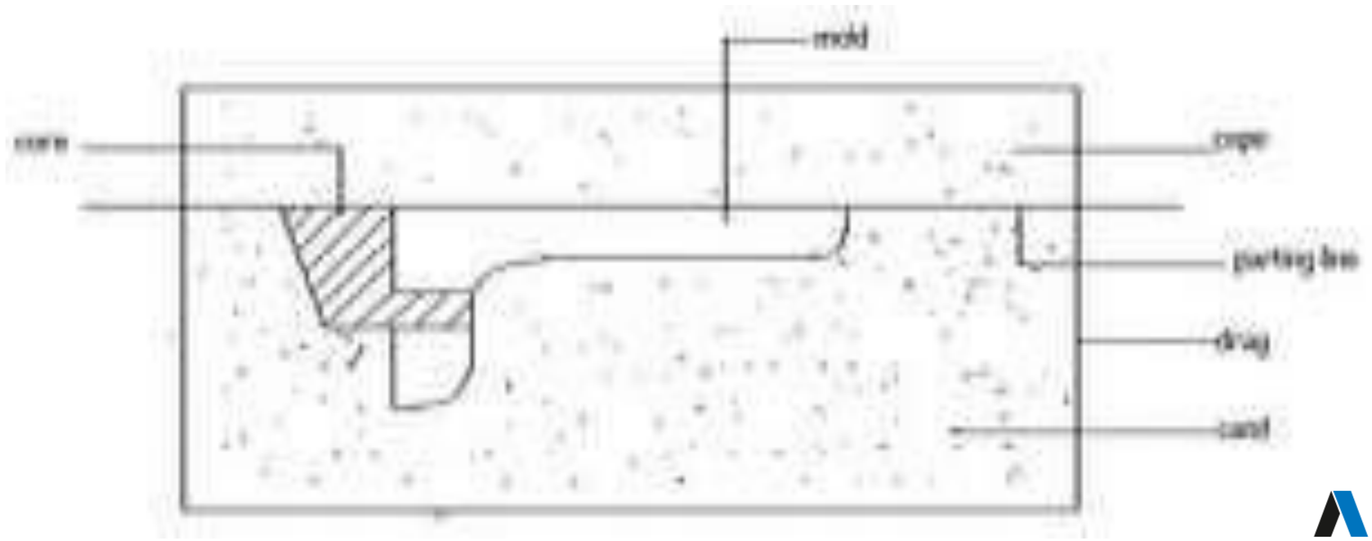
6. Kiss core

- It doesn't required core seats for support
- It is held in position between drag and core due to pressure exerted by cope on the drag
- To obtain a number of holes in a casting, a number of kiss cores can be placed.



7.Drop Or Stop Off Core

- Used to make a cavity which cannot be made with other type of cores.
- Used when a hole, recess or cavity required in a casting is not in line with parting surfaces



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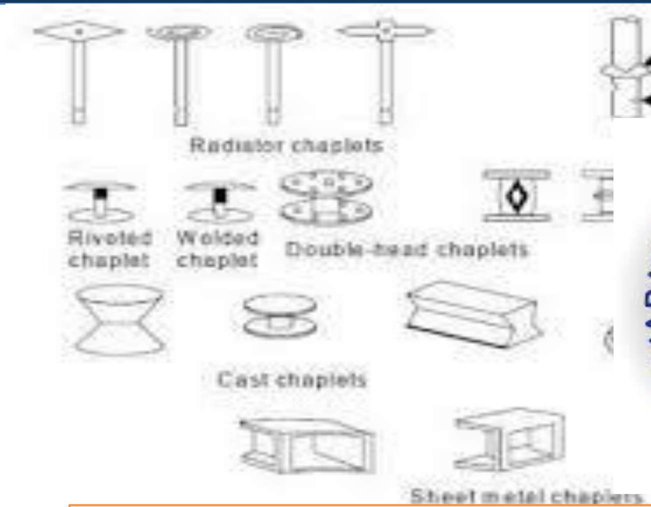
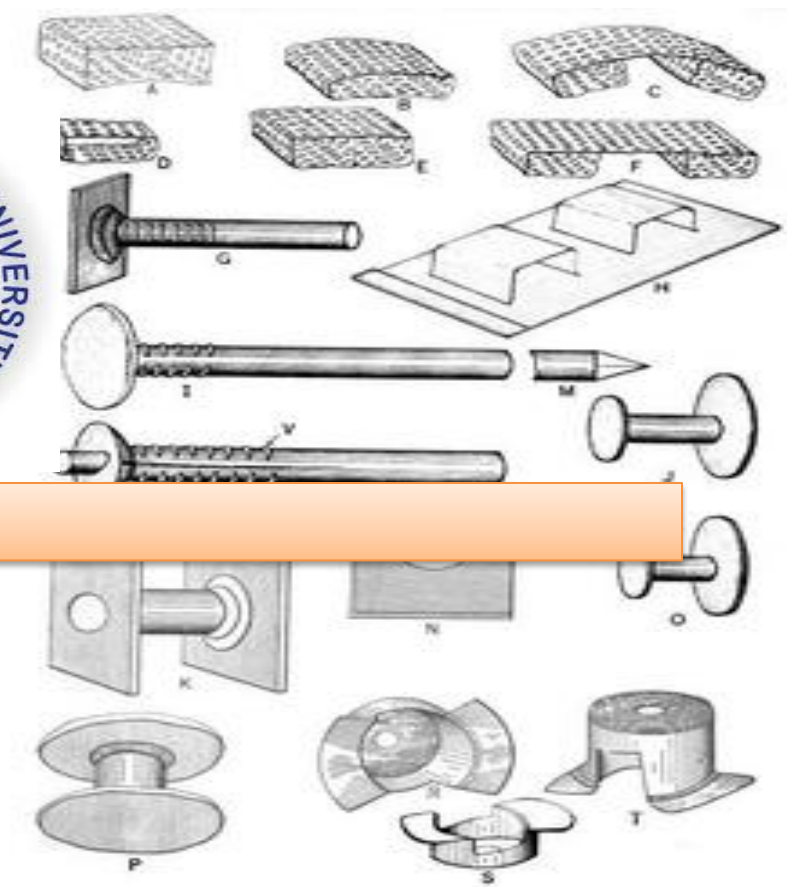
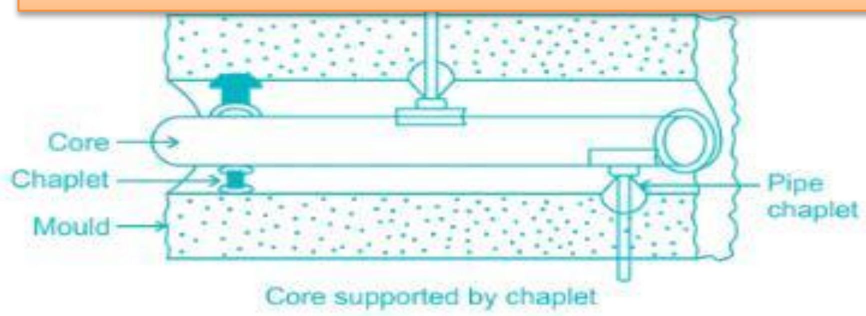
Chaplets





Q. Explain use of Chaplets in core making?



Hand Molding Equipments

1.Shovel

- It is just like rectangular pan fitted with a handle. It is used for mixing the moulding sand and for moving it from one place to the other.

2. Riddle:

- It is used for removing foreign materials like nails, shot metal splinters of wood etc from the moulding sand.

3. Rammer:

- It is a wooden tool used for ramming or packing the sand in the mould. Rammers are made in different shapes.

Hand Molding Equipments

4. Strike-off bar:

- It is a cast iron or wrought iron bar with a true straight edge. It is used to remove the surplus sand from the mould after the ramming has been completed.

5. Vent wire:

- It is a mild steel wire used for making vents or openings in the mould.

6. Lifter:

- It is a metal piece used for patching deep section of the mould and removing loose sand from pockets of the mould.

Hand Molding Equipments

7. Slick:

- Different types of slicks are used for repairing and finishing moulds.

8. Trowel:

- It contains of a flat and thick metal sheet with upwards projected handle at one end. It is used for making joints and finishing flat surface of a mould.

9. Swab:

- It is made of flax or hemp. It is used for applying water to the mould around the edge of the pattern.

10. Draw spike:

- It is a metal rod with a pointed or screwed end. It is used for removing the pattern from the mould.

Hand Molding Equipments

Hand Molding Equipments

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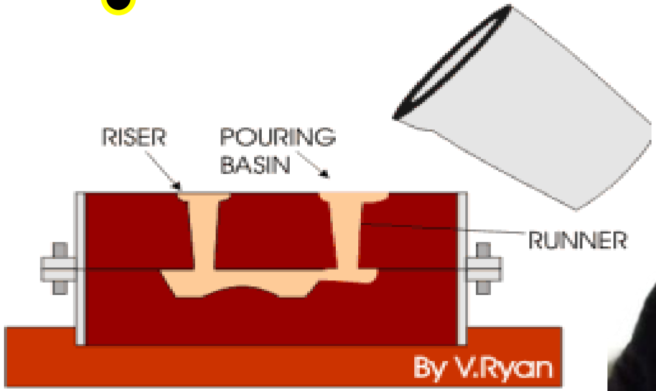
Ch-2 Foundry Technology

Furnaces in Casting



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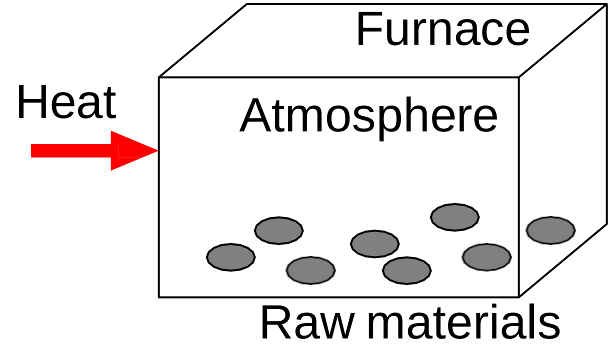
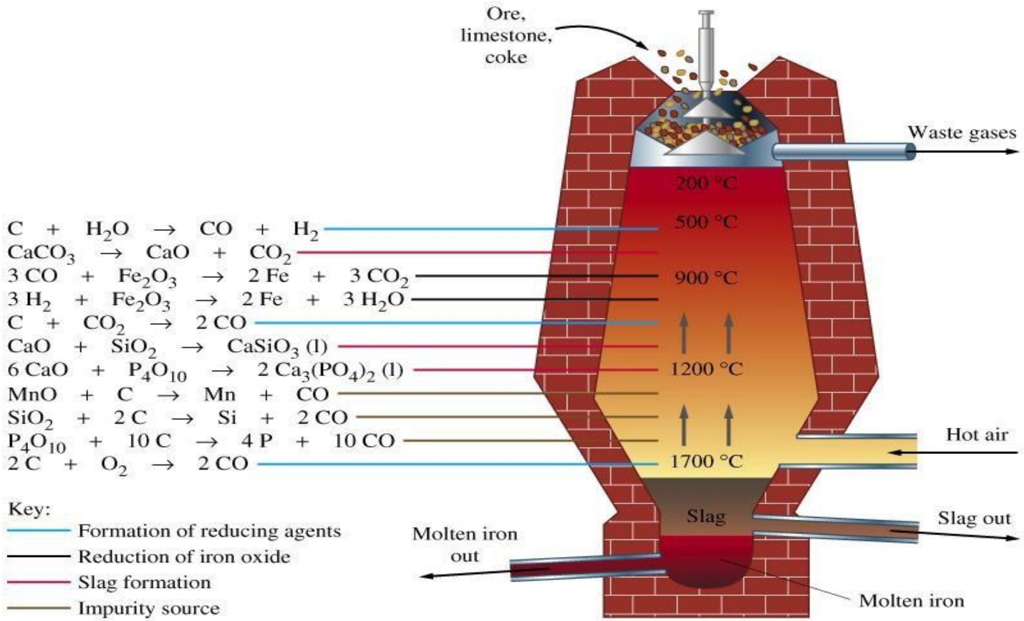
Melting

- Raw material (charge)
- – scrap, alloying materials
- Atmosphere
  - – Air (oxygen), vacuum, inert gas (argon)

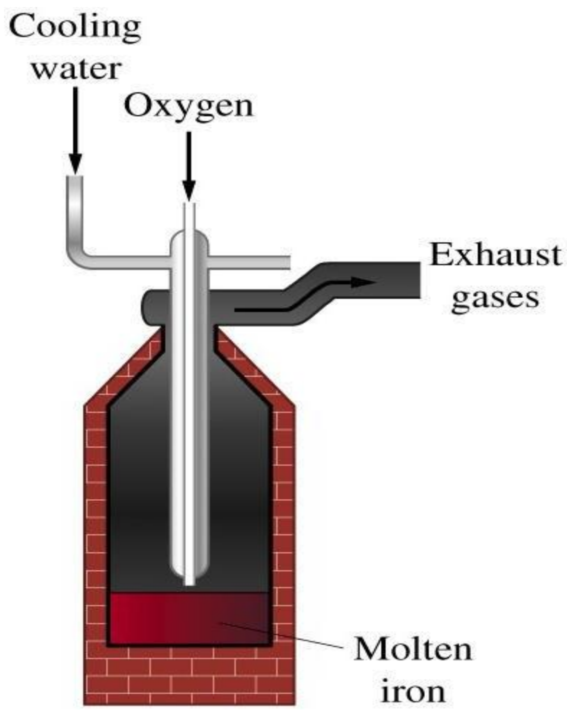


- Heating
  - – External - electric, gas, oil
  - – Internal - induction, mix fuel with charge
    - steel making in blast furnace -mix coke with iron
- Furnace material
  - – refractory ceramics

Furnaces

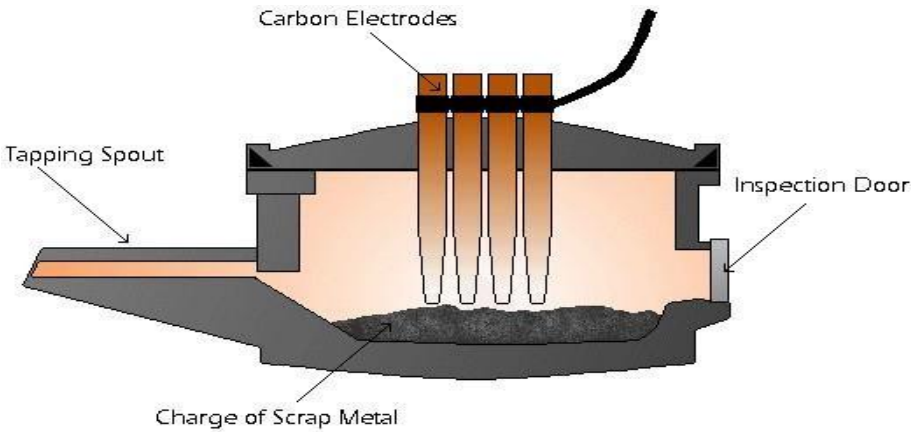


Blast furnace

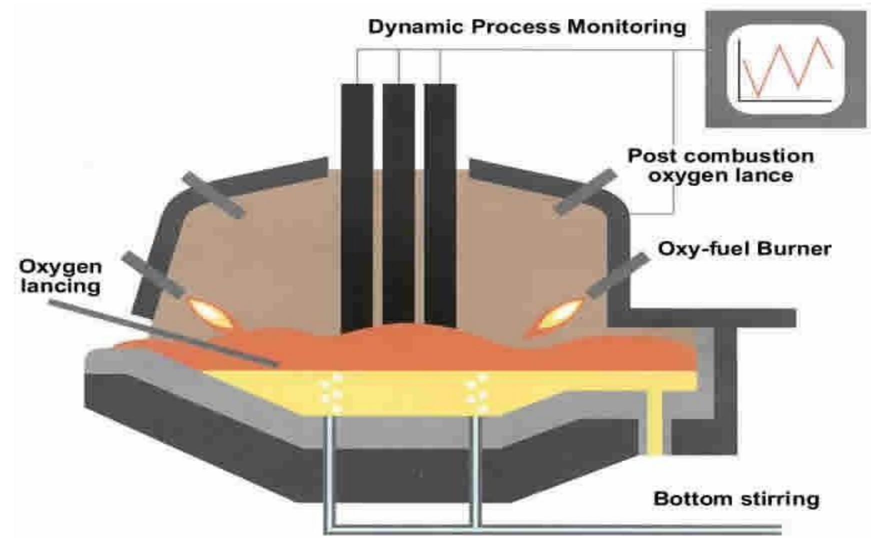


Basic Oxygen Furnace

Furnaces

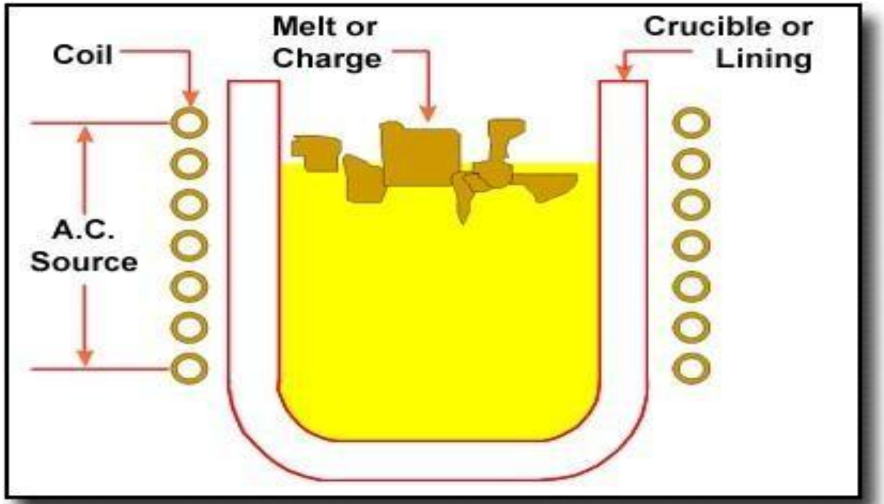


Electric Arc Furnace

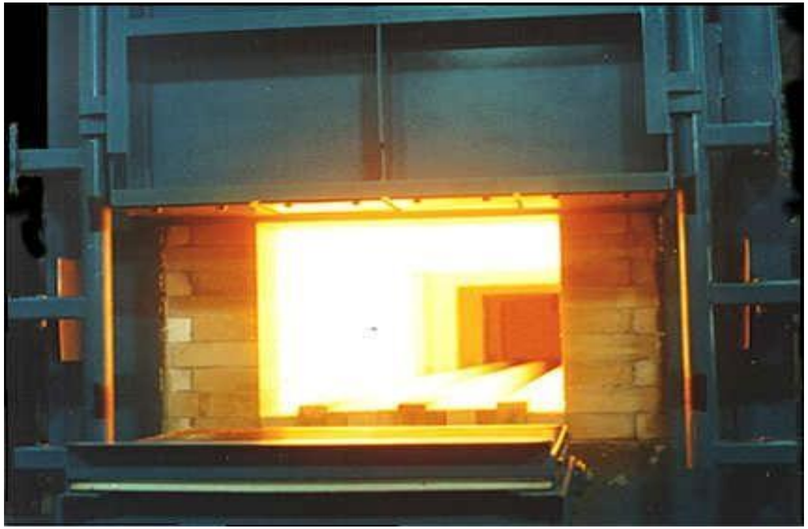


Oxygen-Fuel,
Oxygen Lance Furnace

Furnaces



Induction Furnace



Electric Furnace

Types of Furnaces

- Cupola
- Direct Fuel- Fired
- Crucible
- Electric-Arc
- Induction

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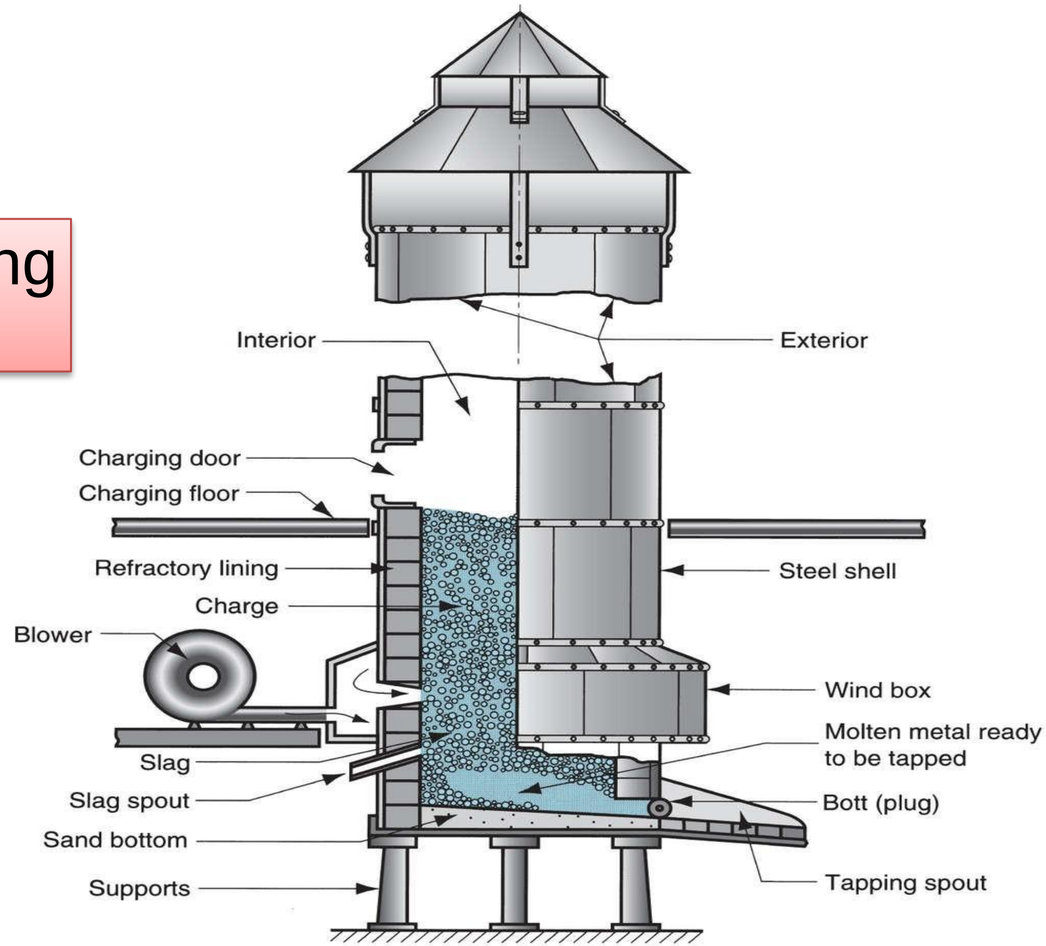
Coupola

Vertical cylindrical furnace equipped with tapping spout near base

- Used only for cast irons
  - Although other furnaces are also used, the largest tonnage of cast iron is melted in cupolas
- The "charge," consisting of iron, coke, flux, and any alloying elements, is loaded through a charging door located less than halfway up height of cupola

Coupola

- Cupola for melting cast iron



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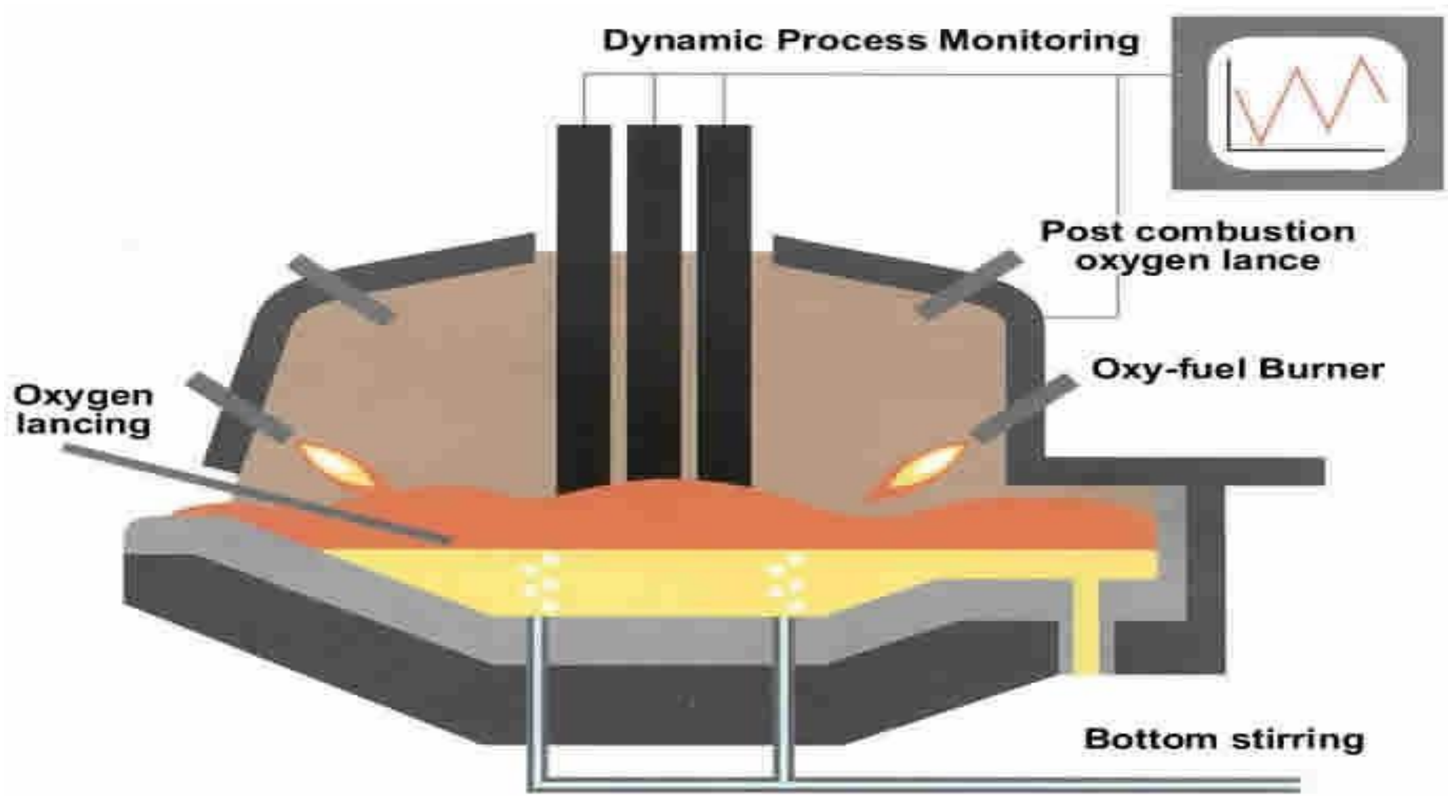
Direct Fuel- Fired Furnaces

Small open-hearth in which charge is heated by natural gas fuel burners located on side of furnace

- Furnace roof assists heating action by reflecting flame down against charge
- At bottom of hearth is a tap hole to release molten metal
- Generally used for nonferrous metals such as copper-base alloys and aluminum

Direct Fuel- Fired Furnaces



Oxygen-Fuel,
Oxygen Lance Furnace

Crucible Furnaces

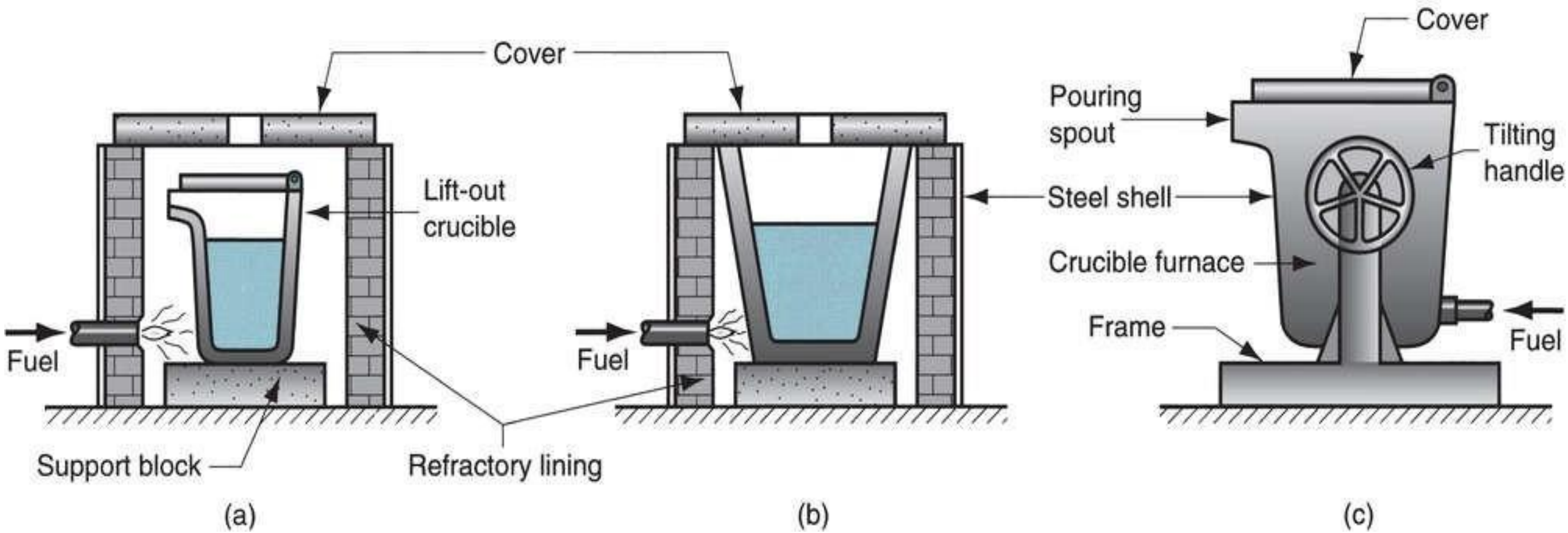
Metal is melted without direct contact with burning fuel mixture

- Sometimes called *indirect fuel-fired furnaces*
- Container (crucible) is made of refractory material or high-temperature steel alloy
- Used for nonferrous metals such as bronze, brass, and alloys of zinc and aluminum
- Three types used in foundries: (a) lift-out type, (b) stationary, (c) tilting

Crucible Furnaces

Three Types of Crucible Furnaces

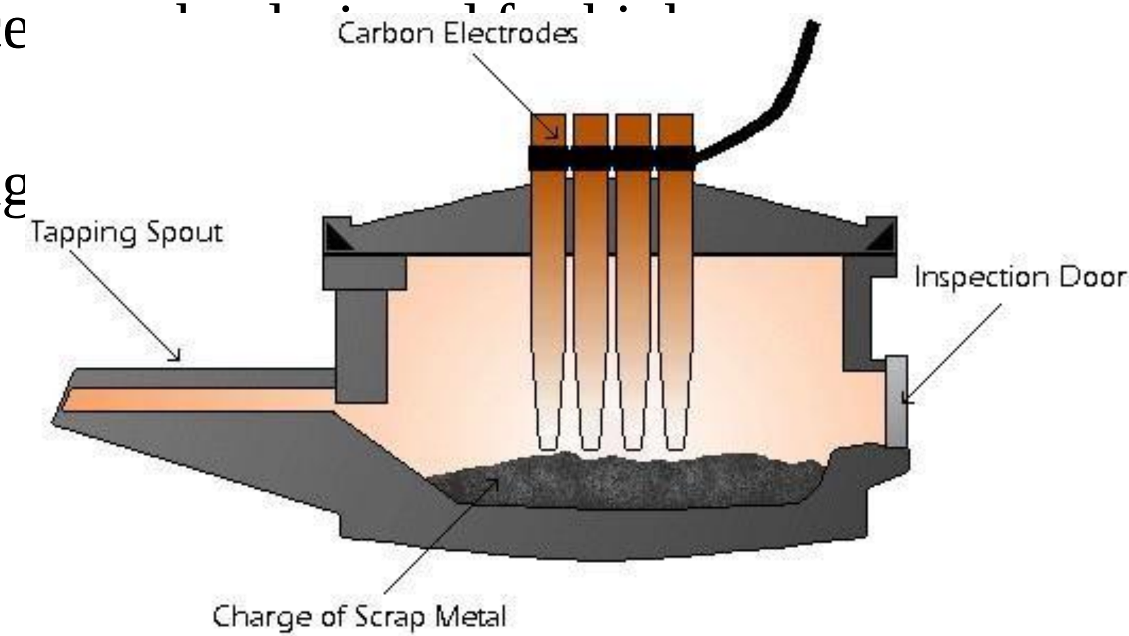
- (a) Lift–out crucible, (b) stationary pot - molten



Electric-Arc Furnaces

Charge is melted by heat generated from an electric arc

- High power consumption
  - But electric-arc furnace
    melting capacity
- Used primarily for melting

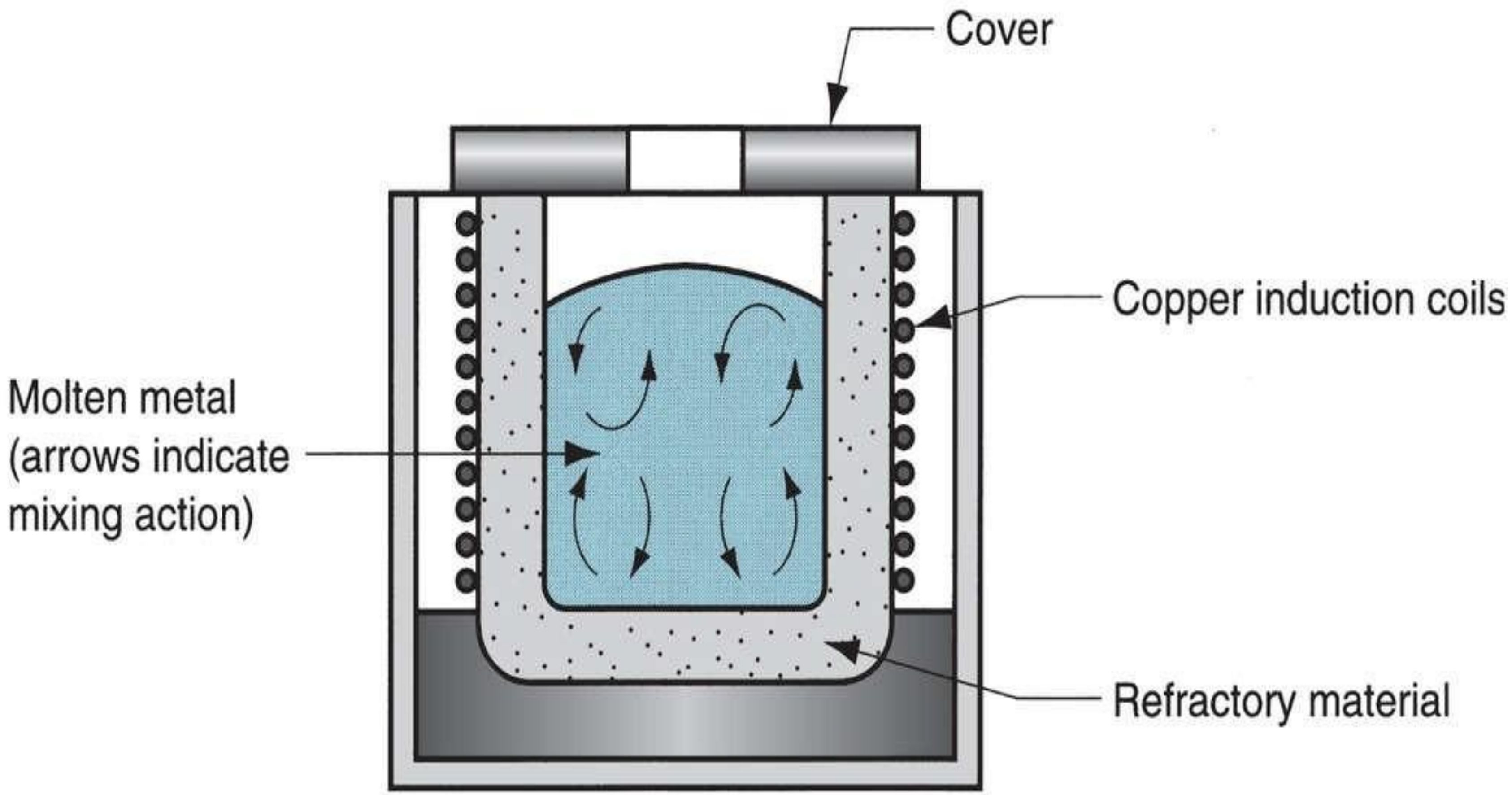


Electric Arc Furnace

Induction Furnaces

- Uses alternating current passing through a coil to develop magnetic field in metal
  - Induced current causes rapid heating and melting
  - Electromagnetic force field also causes mixing action
- Since metal does not contact heating elements, environment can be closely controlled to produce molten metals of high quality and purity
- Common alloys: steel, cast iron, and aluminum

Induction Furnaces



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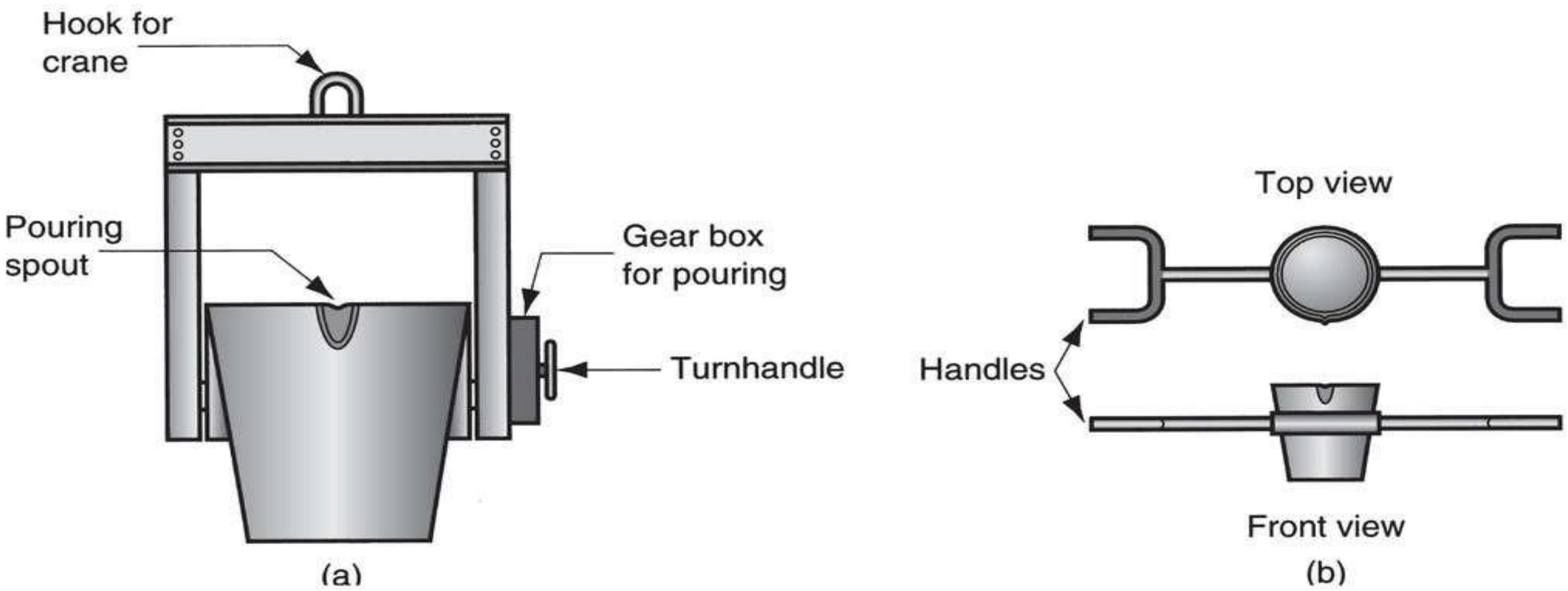
Ladles for Purring Metal

- Two common types of ladles to transfer molten metals to molds: (a) crane ladle, and (b) two−man ladle



Ignite Your Mind

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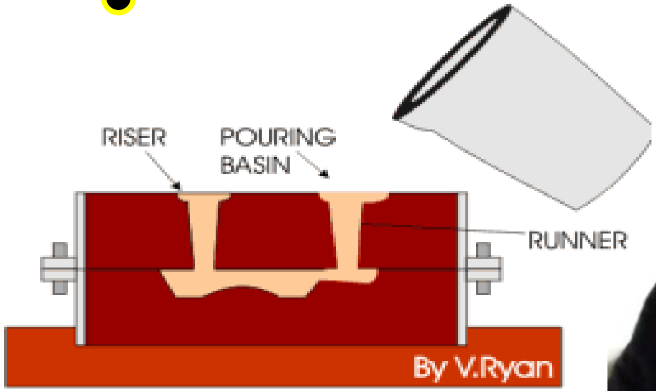
Ch-2 Foundry Technology

Mould-Send Mould



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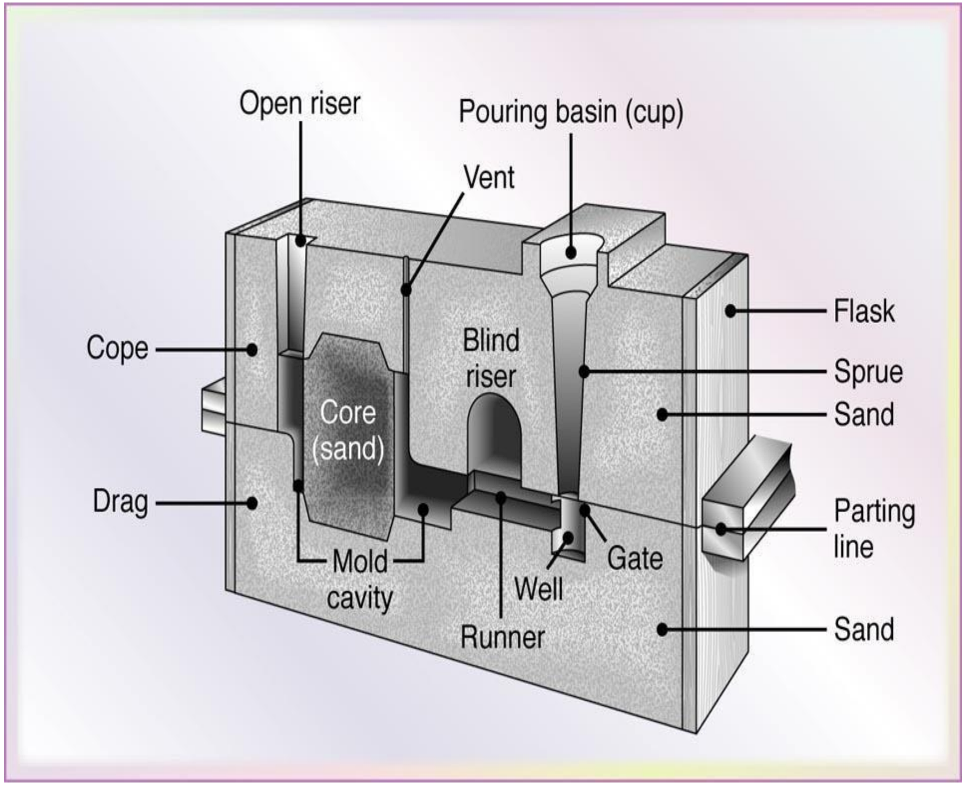
Mould



Schematic illustration of a sand mold, showing various features.

- Mould is a container having a cavity of the shape to be cast, whereas core is a body which is employed to produce a cavity in the casting and is generally made of sand

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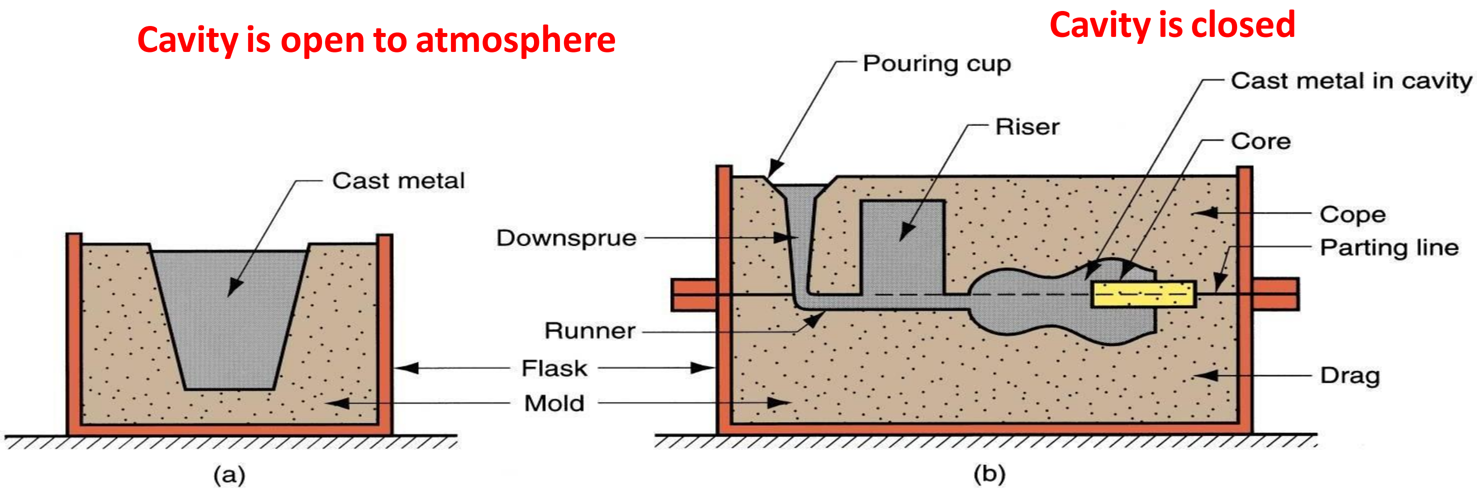
Making The Sand Mold

- The cavity in the sand mold is formed by packing sand around a pattern, then separating the mold into two halves and removing the pattern
- The mold must also contain gating and riser system
- If casting is to have internal surfaces, a core must be included in mold
- A new sand mold must be made for each part produced

Open Molds and Closed Molds



Two forms of mold:

(a) open mold, simply a container in the shape of the desired part;

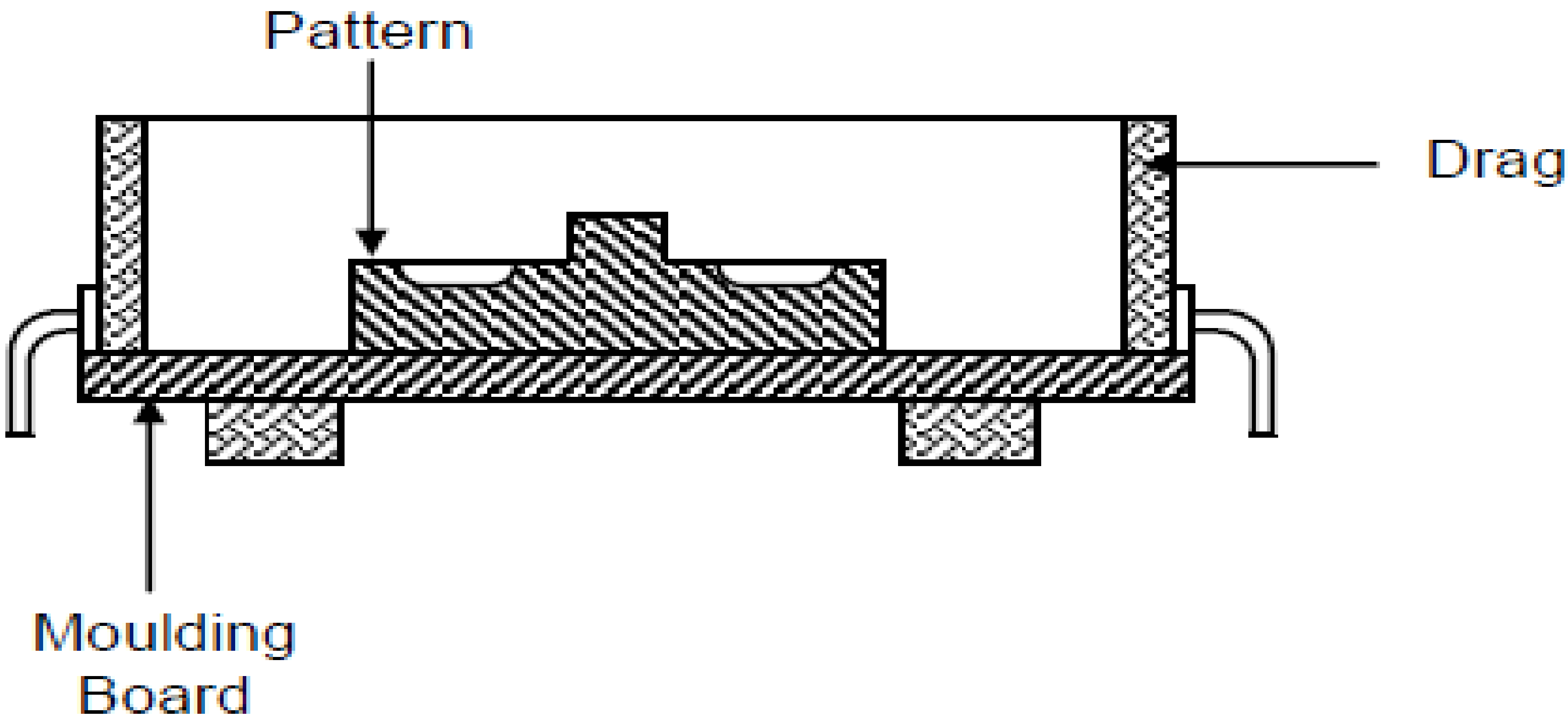
(b)closed mold, in which the mold geometry is more complex and requires a gating system (passageway) leading into the cavity.

Two Categories of Casting Processes

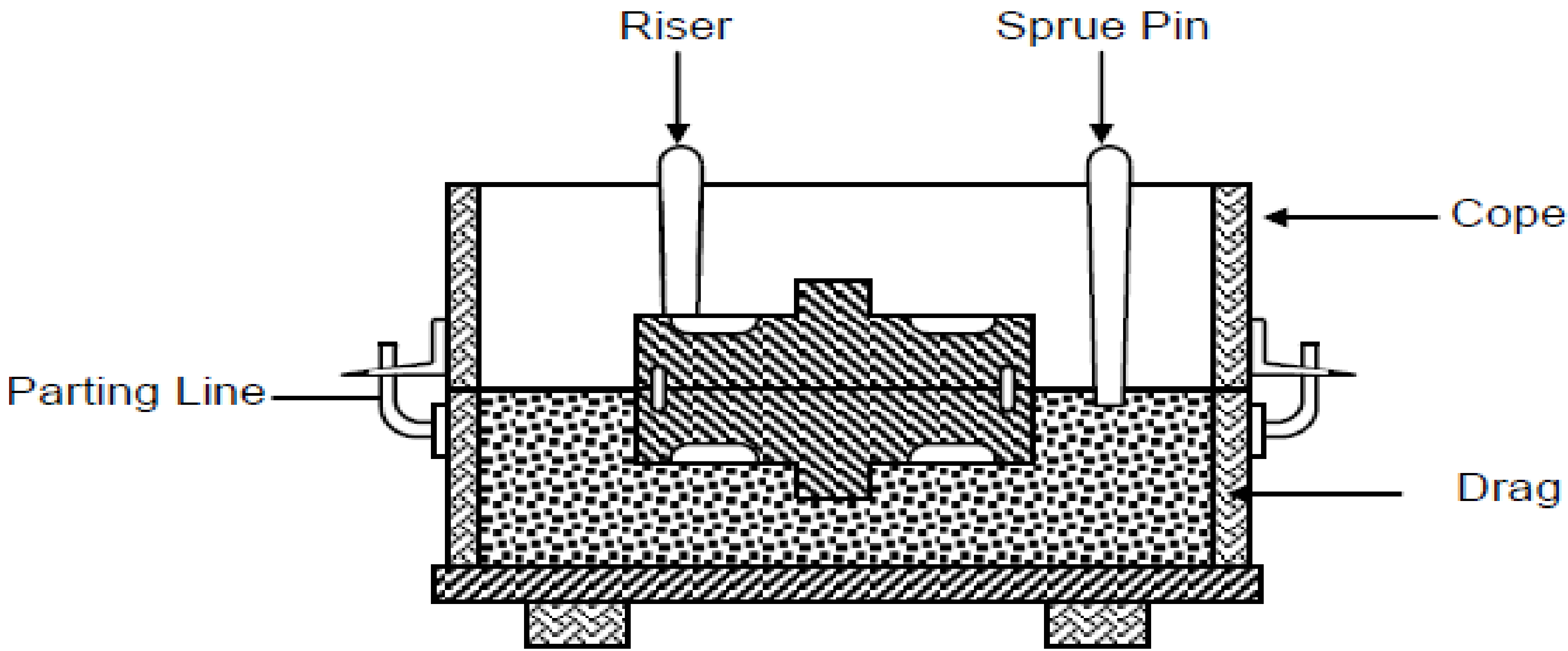
1. **Expendable mold processes (Temporary refractory mould)** – uses an expendable mold which must be destroyed to remove casting
   – **Mold materials**: sand, plaster, and similar materials, plus binders
2. **Permanent mold processes** – uses a permanent mold which can be used over and over to produce many castings
   – Made of metal (or, less commonly, a ceramic refractory material)

SAND MOULDING

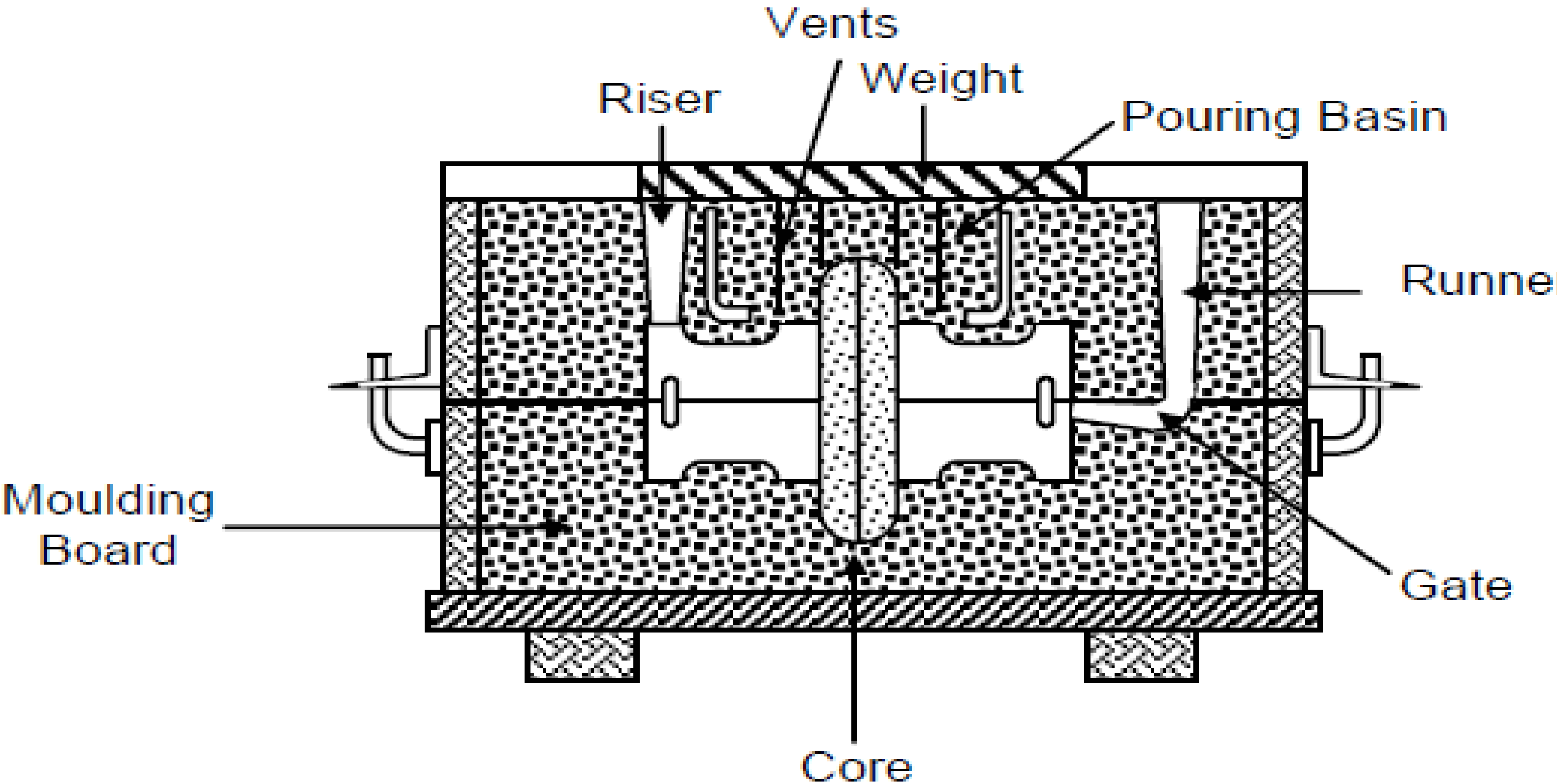
PROCESS



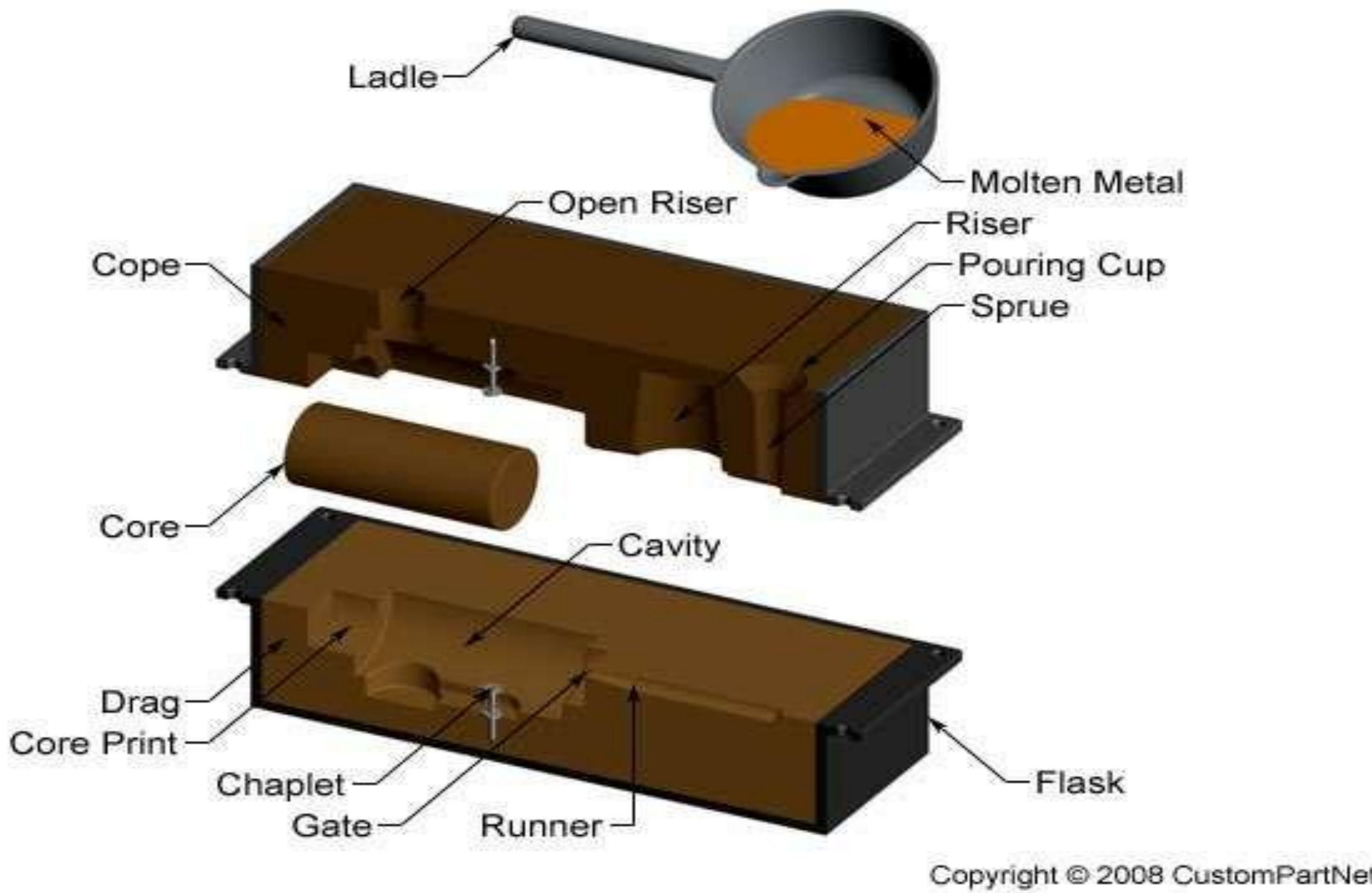
(First Step)



(Second Step)



(Third Step)
(Completed-Mould)



Sand mold - opened

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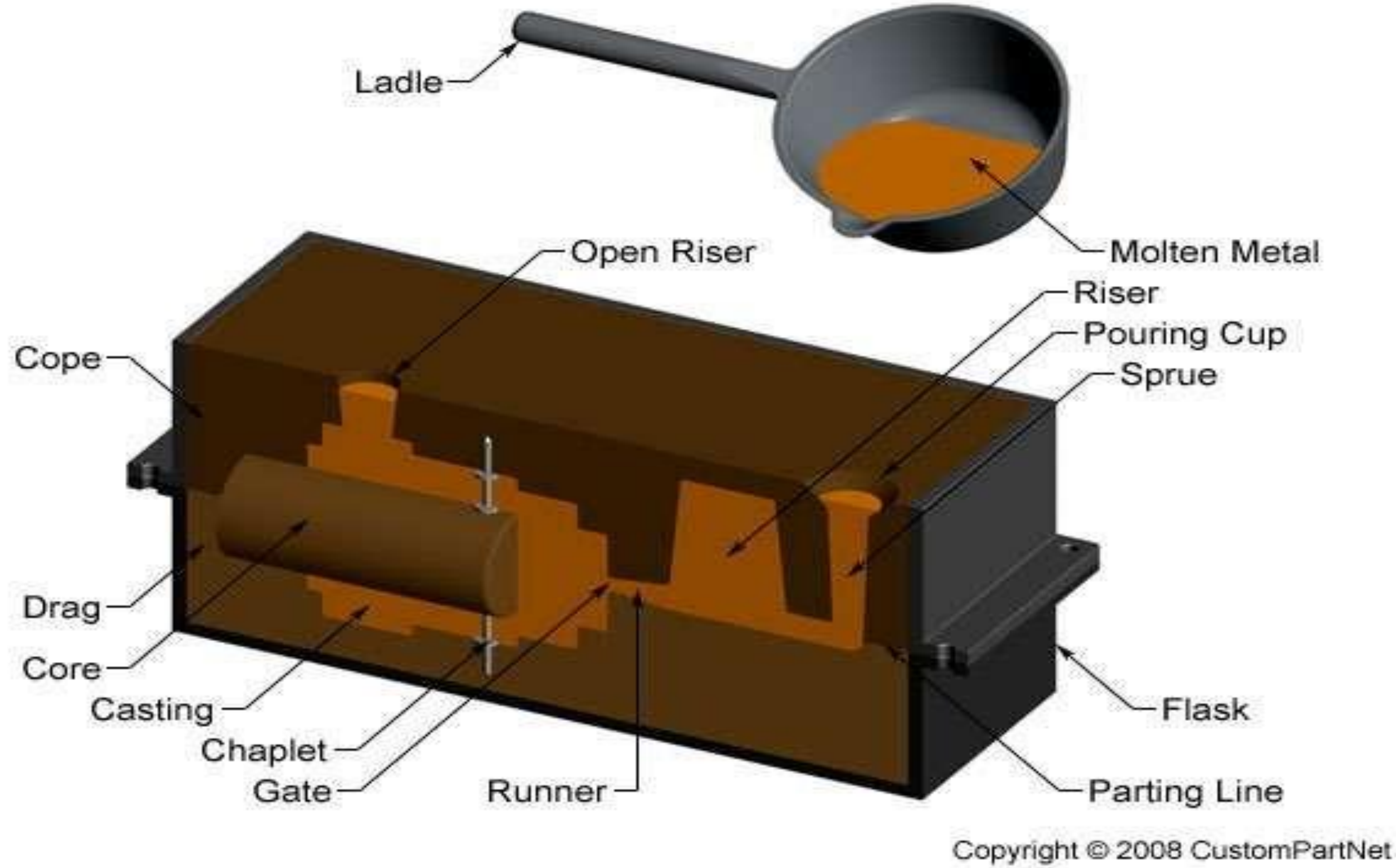

Sand mold - closed

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Mixing moulding sand with binders & adhesives

Filling sand in moulding flasks

Melting furnace

Pouring molten liquid

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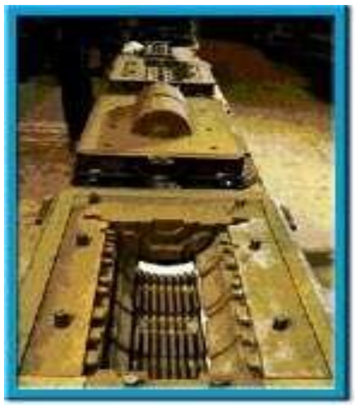
Knock out

Heat treatment

Machining

final products of casting

Casting Methods



- Sand Casting

High Temperature Alloy,
Complex Geometry,
Rough Surface Finish

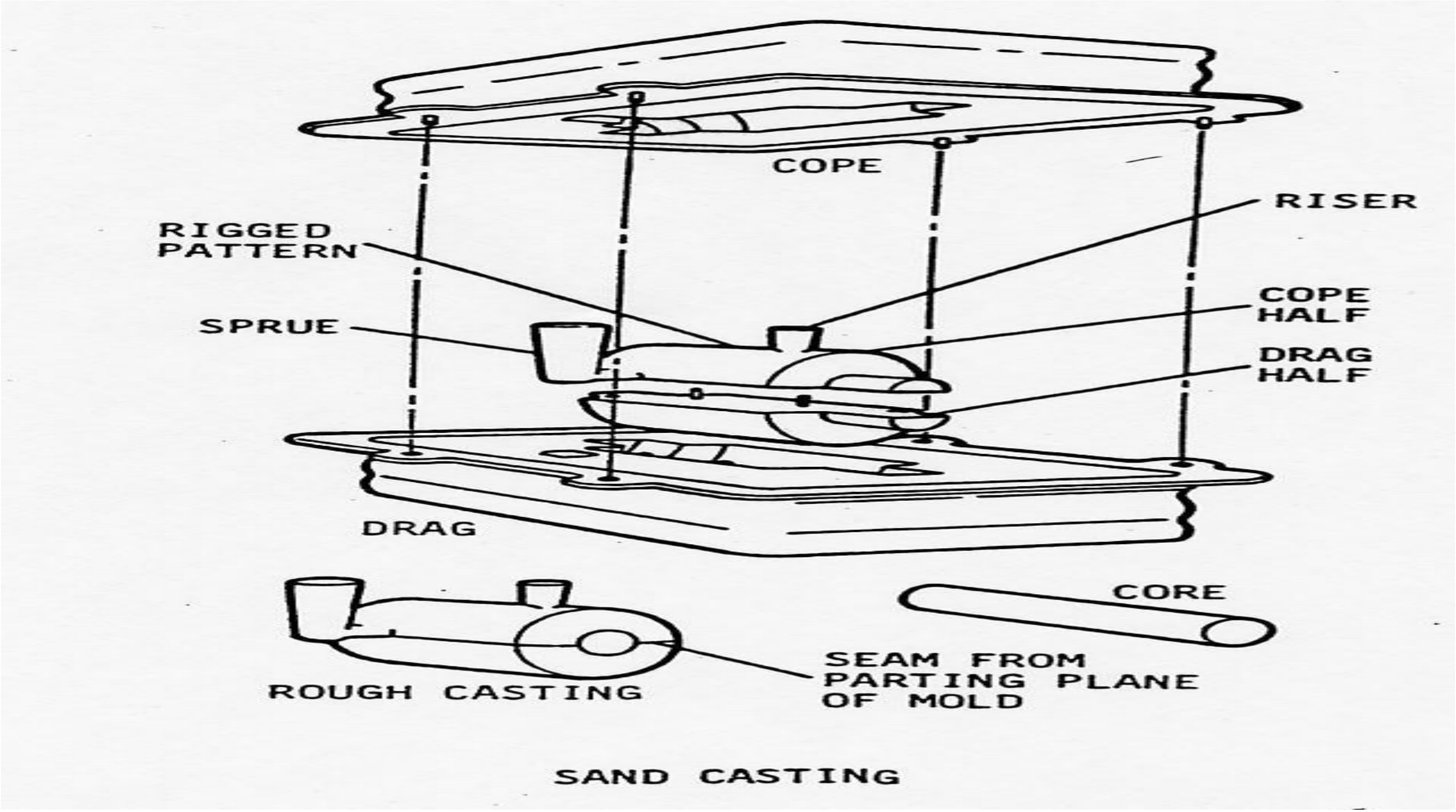
- Investment Casting

High Temperature Alloy,
Complex Geometry,
Moderately Smooth Surface Finish

- Die Casting

High Temperature Alloy,
Moderate Geometry,
Smooth Surface

Sand Casting



Moulding Sand

- Depending upon the purity and other constituents present, sand is classified into

(i) Natural sand.

(ii)Synthetic sand,

(iii)Special sand or loam sand.

1.Natural sand

- Natural sand is directly used for molding and contains 5-20% of clay as binding material.
- It needs 5-8% water for mixing before making the mold. Many natural sands possess a wide working range of moisture and are capable of retaining moisture content for a long time.
- Its main drawback is that it is less refractory as compared to synthetic sand.
- Many natural sands have weak molding properties.
- These sands are reconditioned by mixing small amounts of binding materials like bentonite to improve their properties and are known as semi-synthetic sand.

2.Synthetic Sands

- Synthetic sand consists of silica sand with or without clay, binder or moisture.
- It is a formulated sand i.e. sand formed by adding different ingredients. Sand formulations are done to get certain desired properties not possessed by natural sand.
- These sands have better casting properties like permeability and refractoriness and are suitable for casting ferrous and non-ferrous materials.
- These properties can be controlled by mixing different ingredients.
- Synthetic sands are used for making heavy castings.

3.Loam Sand

- Loam sand contains many ingredients, like fine sand particles, finely ground refractories, clay, graphite and fiber reinforcements.
- In many cases, the clay content may be of the order of 50% or more.
- When mixed with water, the materials mix to a consistency resembling mortar and become hard after drying.
- Big molds for casting are made of brick framework lined with loam sand and dried.
- Sweeps etc are used for making big castings like big bells by using loam sand.

Characteristics Of Molding Sand

1) Green strength

- The green sand after water has been mixed into it, must have sufficient strength and toughness to permit the making and handling of the mold.
- The green strength also depends upon the grain shape and size, amount and type of clay and the moisture content.
- It is the strength of sand in the green or moist condition.

Characteristics Of Molding Sand

2) Dry strength

- As soon as the molten metal is poured into the mold, the moisture in the sand layer adjacent to the hot metal gets evaporated and this dry sand layer must have sufficient strength to its shape in order to avoid erosion of mold wall during the flow of molten metal.

3) Flowability or plasticity

- It is the ability of the sand to get compacted and behave like a fluid.

Characteristics Of Molding Sand

4) Permeability or porosity

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

Characteristics Of Molding Sand

5) Refractoriness

- Refractoriness is defined as the ability of molding sand to withstand high temperatures without breaking down or fusing thus facilitating to get sound casting. It is a highly important characteristic of molding sands. Refractoriness can only be increased to a limited extent.
- Molding sand with poor refractoriness may burn on to the casting surface and no smooth casting surface can be obtained.

Characteristics Of Molding Sand

6) Adhesiveness

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

7) Cohesiveness

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

Characteristics Of Molding Sand

8)Thermal stability

- Heat from the casting causes rapid expansion of the sand surface at the mold- metal interface.
- The mold surface may then crack, buckle, or flake off (scab) unless the molding sand is relatively stable dimensionally under rapid heating.

Constituents Of Molding Sand

- The main constituents of molding sand involve silica sand, binder, moisture content and additives.

1)Silica sand

- Silica sand in form of granular quarts is the main constituent of molding sand having enough refractoriness which can impart strength, stability and permeability to molding and core sand.
- Along with silica small amounts of iron oxide, alumina, lime stone, magnesia, soda and potash are present as impurities.

Constituents Of Molding Sand

- The silica sand can be specified according to the size (small, medium and large silica sand grain) and the shape (angular, sub-angular and rounded).

2) Additives

- Additives are the materials generally added to the molding and core sand mixture to develop some special property in the sand. Some common used additives for enhancing the properties of molding and core sands are

(i) Coal dust

Coal dust is added mainly for producing a reducing atmosphere during casting. This reducing atmosphere results in any oxygen in the poles becoming chemically bound so that it cannot oxidize the metal.

Constituents Of Molding Sand

(ii) Dextrin

- Dextrin belongs to starch family of carbohydrates. It increases dry strength of the molds.

(iii) Pitch

- It is distilled form of soft coal. It can be added from 0.02 % to 2% in mold and core sand.
- It enhances hot strengths, surface finish on mold surfaces.

Constituents Of Molding Sand

(iii) Binders

- Binders are added to give cohesion to molding sands.
- Binders provide strength to the molding sand and enable it to retain its shape as mold cavity.
- Binders should be added in optimum quantity as they reduce refractoriness and permeability.
- An optimal quantity of binders is needed, as further increases have no effect on properties of foundry sand.
- The following binders are available

(i) Fireclay (ii) Illite (iii) **Bentonite(clay binders)**

iv) Limonite (iv) Kaolinite

Constituents Of Molding Sand

(iv) Moisture(Water)

- The amount of moisture content in the molding sand varies generally between 2 to 8 percent.
- This amount is added to the mixture of clay and silica sand for developing bonds.
- This is the amount of water required to fill the pores between the particles of clay without separating them.
- This amount of water is held rigidly by the clay and is mainly responsible for developing the strength in the sand.
- The effect of clay and water decreases permeability with increasing clay and moisture content.

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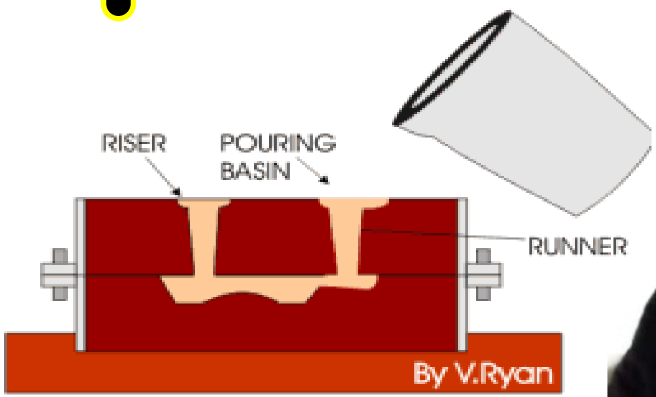
Ch-2 Foundry Technology

Send Testing -Types Of Sand Test's



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SAND TESTING

- Molding sand and core sand depend upon shape, size composition and distribution of sand grains, amount of clay, moisture and additives.
- The increase in demand for good surface finish and higher accuracy in castings necessitates certainty in the quality of mold and core sands.
- Sand testing often allows the use of less expensive local sands. It also ensures reliable sand mixing and enables a utilization of the inherent properties of molding sand.

Types Of Sand Test's

1. Moisture content Test
2. Clay content Test
3. Permeability Test
4. Grain fitness Test
5. Mould hardness Test
6. Refractoriness Test
7. Compression Strength Test

1.Moisture Content Test

- The moisture content of the molding sand mixture may determine by drying a weighed amount of 20 to 50 grams of molding sand to a constant temperature up to 100°C in a oven for about one hour.
- It is then cooled to a room temperature and then reweighing the molding sand.
- The moisture content in molding sand is thus evaporated.
- The loss in weight of molding sand due to loss of moisture, gives the amount of moisture which can be expressed as a percentage of the original sand sample.
- The percentage of moisture content in the molding sand can also be determined in fact more speedily by an instrument known as a speedy moisture teller.

1.Moisture Content Test

Moisture content tester

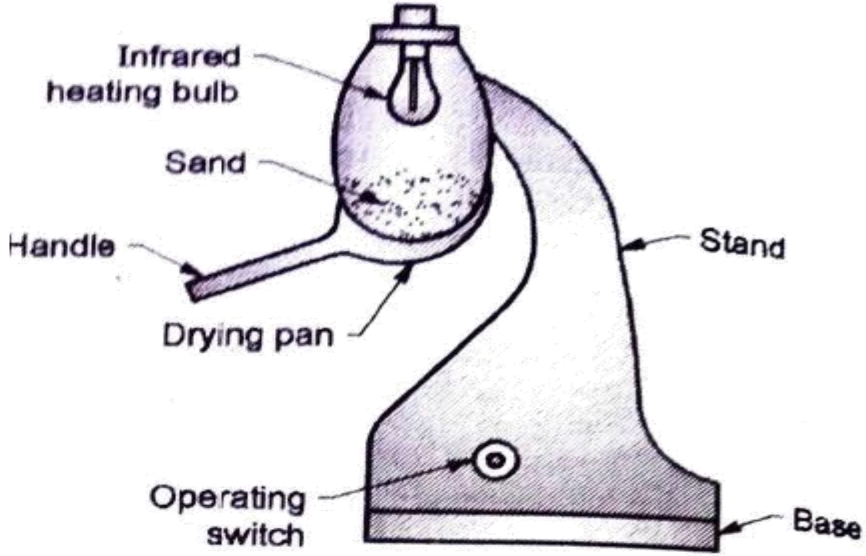

Fig. 2.4.1 : Moisture test apparatus

2. Permeability Test

- Permeability is determined by measuring the rate of flow of air(around 2000cc) through a compacted specimen under standard conditions.
- A cylinder sand sample is prepared by using rammer and die. This specimen (usually 2 inch diameter & 2 inch height) is used for testing the permeability or porosity of molding and the core sand.
- The test is performed in a permeability meter consisting of the balanced tank, water tank, nozzle, adjusting lever, nose piece for fixing sand specimen and a manometer. The permeability is directly measured.

2. Permeability Test

- Permeability number P is volume of air (in cm3) passing through a sand specimen of 1 cm2 cross- sectional area and 1 cm height, at a pressure difference of 1 gm/cm2 in one minute.

$$P = V*h / a*t*p$$

Where,

P = permeability

v = volume of air passing through the specimen in c.c.

h = height of specimen in cm p

= pressure of air in gm/cm2

a = cross-sectional area of the specimen in cm2 t =

time in minutes.

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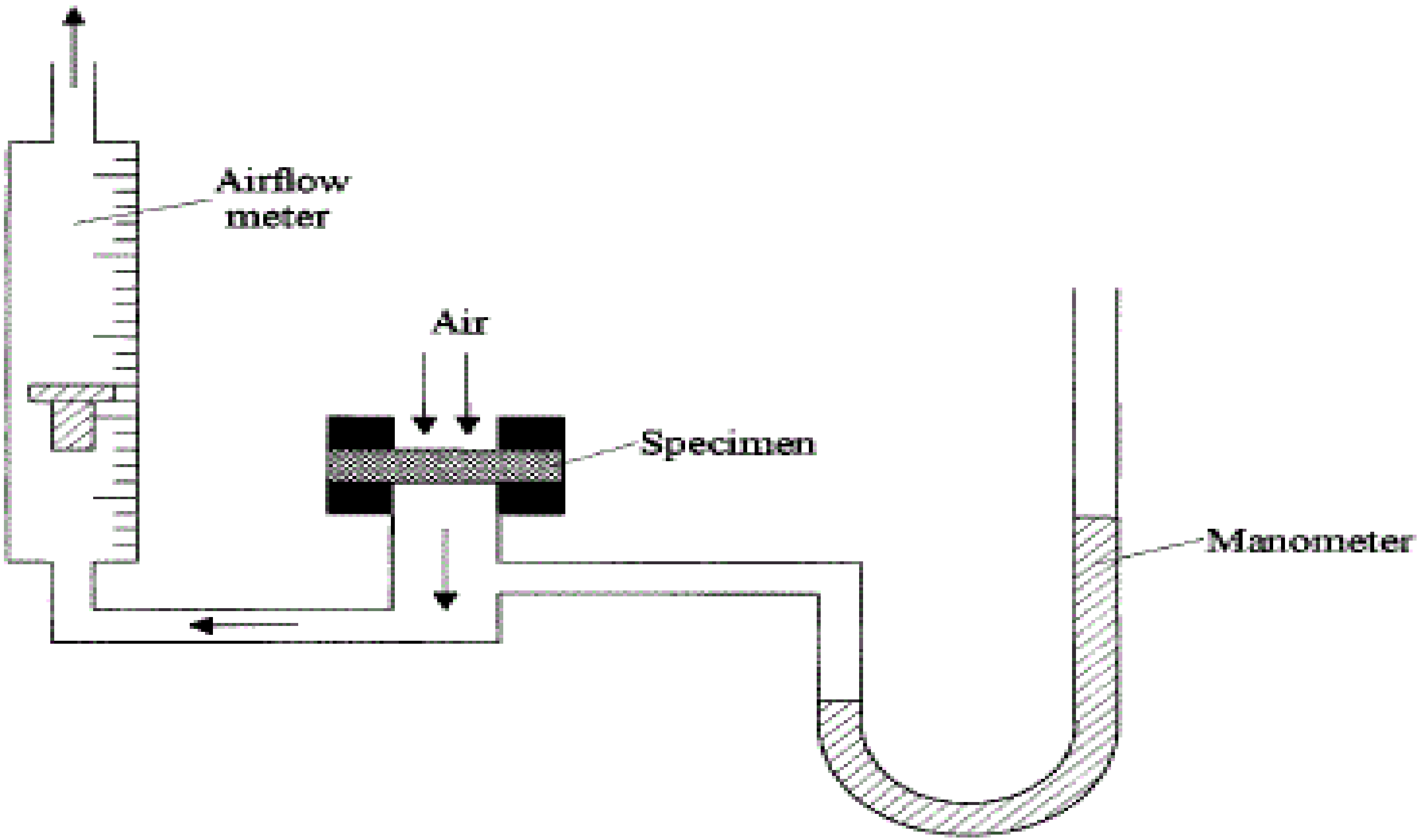
2. Permeability Test



Permeability Tester

2. Permeability Test

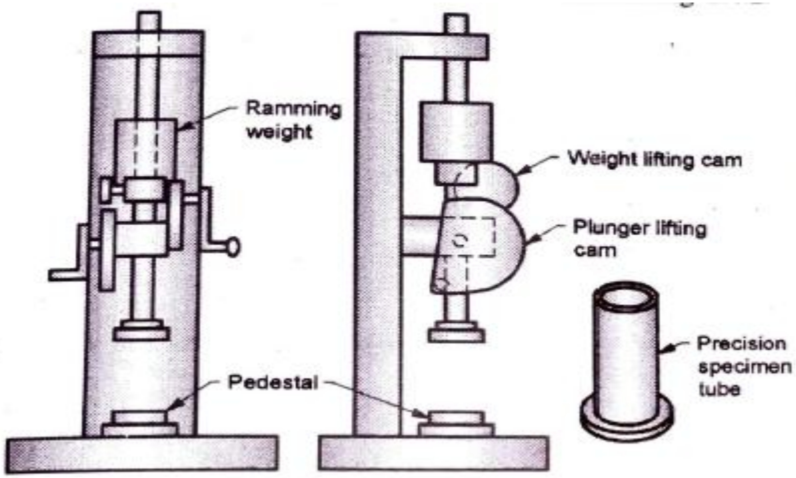
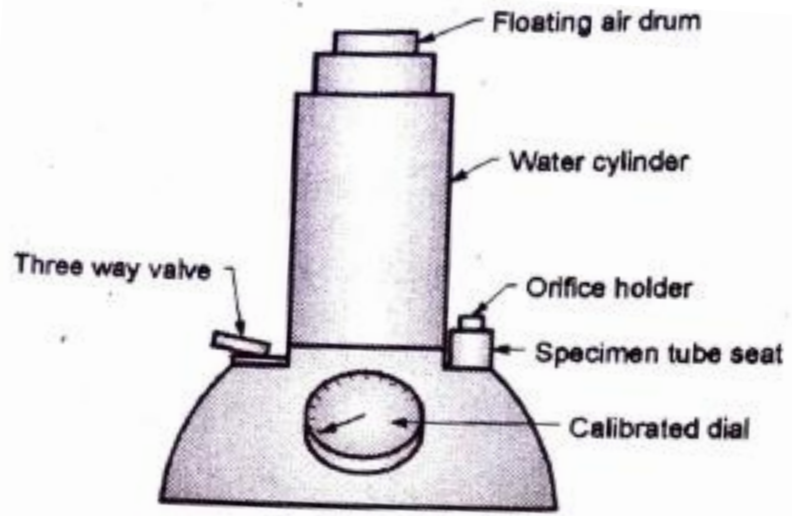
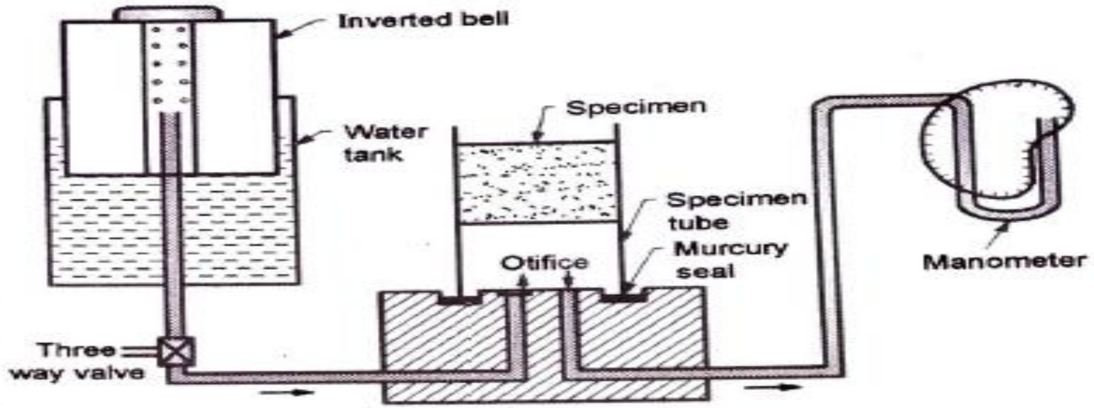


Fig. 2.4.2 : Specimen rammer



Outside details of a permeability meter



Principle of operation

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2. Permeability Test

Table 2.4.2 : Recommended sand permeability Numbers

Application	Permeability number
Green sand brass and bronze castings	5 to 30
Dry sand brass and bronze castings	15 to 20
Green sand gray iron castings	15 to 30
Dry sand castings for machine members	40 to 50
Green sand aluminum castings	20 to 40
Green sand steel castings	Greater than 50
Core sands depending on size of cores	50 to 200

3.Grain Fitness Test

- The Grain Fineness Number (GFN) is one means of measuring the grain fineness of a sand system.
- GFN is a measure of the average size of the particles (or grains) in a sand sample.
- The grain fineness of molding sand is measured using a test called sieve analysis.
- The test is carried out in power-driven shaker consisting of number of sieves fitted one over the other.

3.Grain Fitness Test

1) A representative sample of the sand is dried and weighed, then passed through a series of progressively finer sieves (screens) while they are agitated and tapped for a 15-minute test cycle. The series are placed in order of fineness from top to bottom.
2) The sand retained on each sieve (grains that are too large to pass through) is then weighed and recorded.
3) The weight retained on each sieve is carried out through calculations to get the GFN.

3.Grain Fitness Test

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4. Compression Tests

- Sand molds are subjected to compressive, tensile, shearing, and transverse stresses.
- The green compressive strength test and dry compressive strength is the most used test in the foundry
- A rammed specimen of tempered molding sand is produced that is 2 inches in diameter and 2 inches in height.
- The rammed sample is then subjected to a load which is gradually increased until the sample breaks.
- The point where the sample breaks is taken as the compression strength.

4. Compression Tests

4. Compression Tests

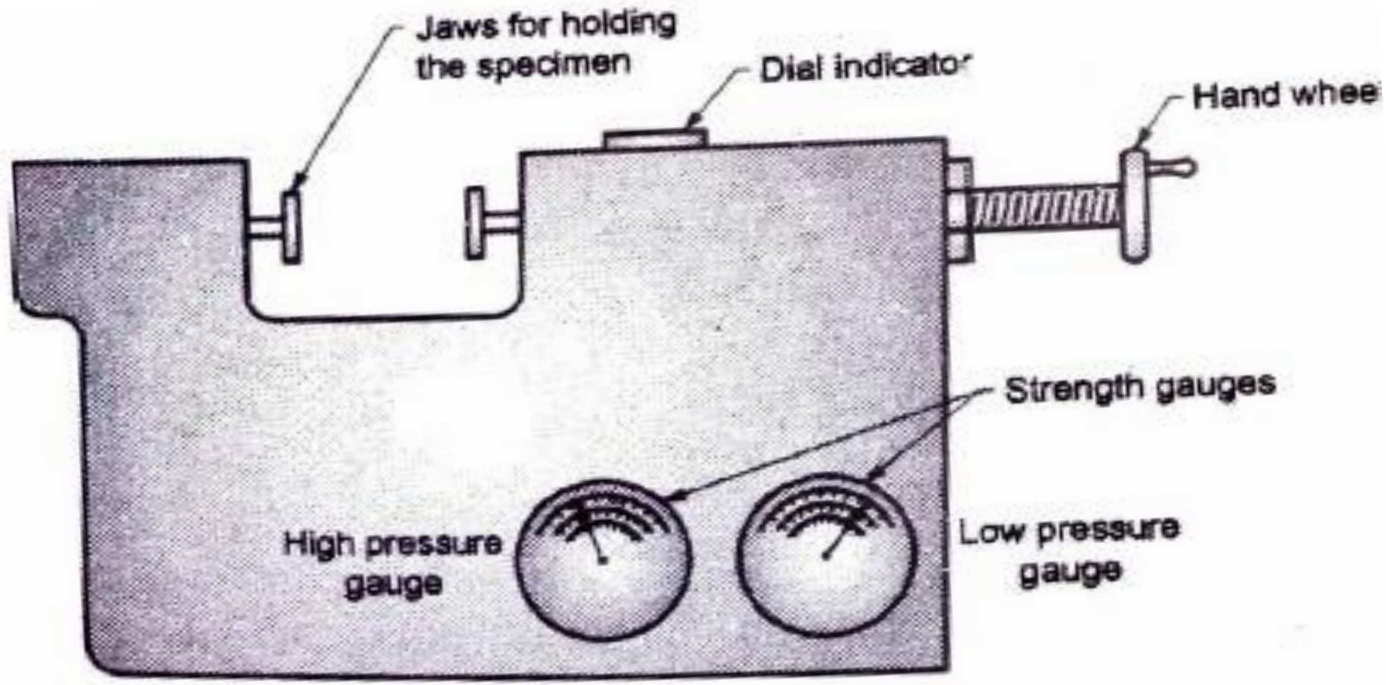

Fig. 2.4.5 : Schematic diagram of standard strength testing

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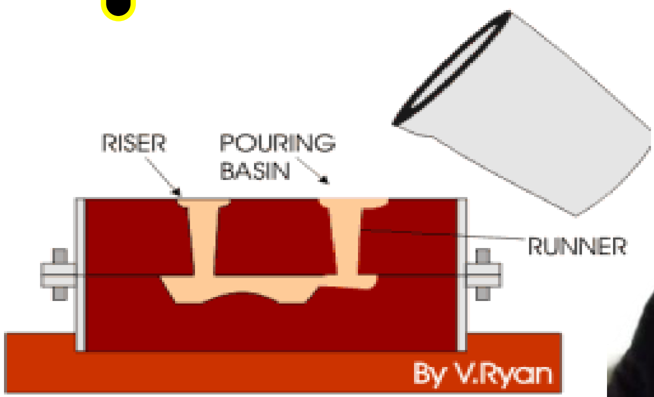
Ch-2 Foundry Technology

Classification Of Molding Processes



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Classification Of Molding Processes

- Broadly they are classified either on
- the basis of the method used or on the basis of the mold material used.

(i) Classification based on the mold material used:

(a) Sand molding:

1. Green sand mold
2. Dry sand mold
3. Cement bonded sand mold
4. Carbon-dioxide mold.
5. Shell mold.

(b) Plaster molding,

(c) Metallic molding.

Classification Of Molding Processes

(ii) Classification based on the method used

(a) Bench molding.

(b) Floor molding.

(c) Pit molding.

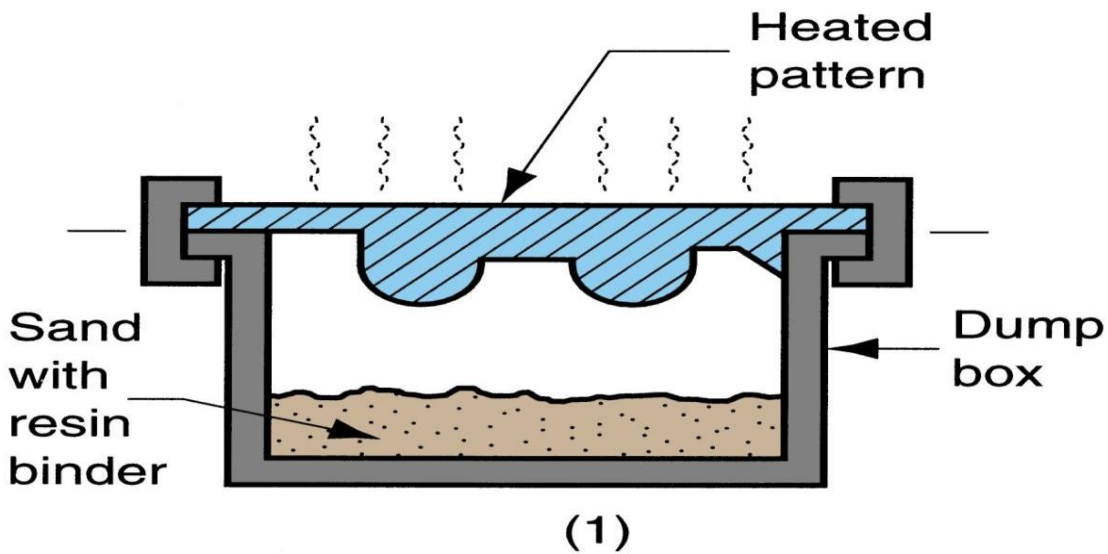
(d) Machine molding.

Shell Molding

- It is a moulding process in which the mold is a thin shell of sand held together by thermosetting resin binder
- Developed in Germany during early 1940s
- Used for mass production and smooth finish
- Shell mold casting is particularly suitable for steel castings under 10 kg; however almost any metal that can be cast in sand can be cast with shell molding process.
- Also much larger parts have been manufactured with shell molding.
- Typical parts manufactured in industry using the shell mold casting process include cylinder heads, gears, bushings, connecting rods, camshafts and valve bodies.

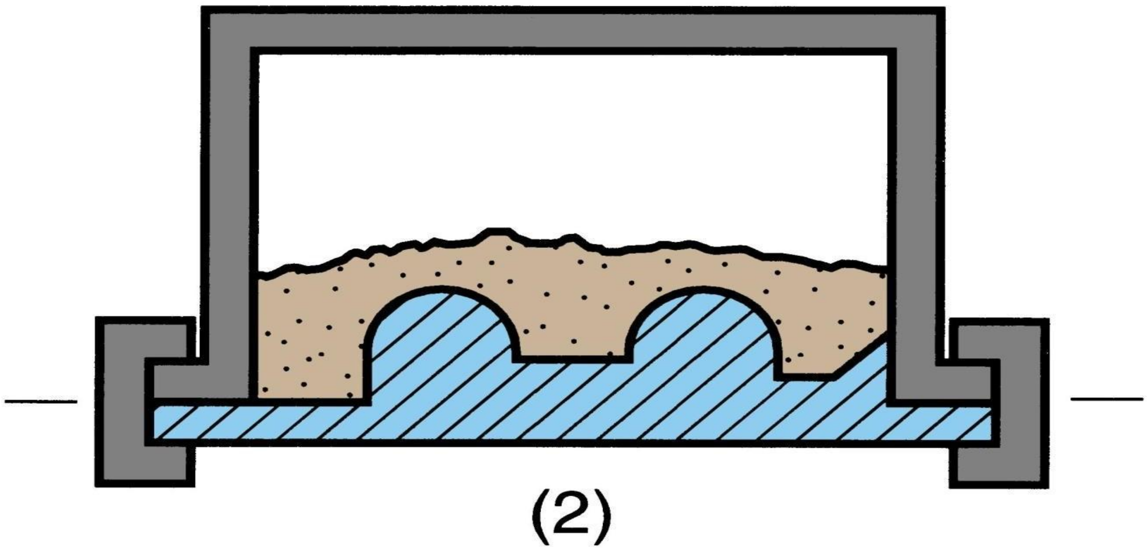
Steps In Shell-molding:

(1) A match-plate or cope-and-drag metal pattern is heated and placed over a box containing sand mixed with thermosetting resin



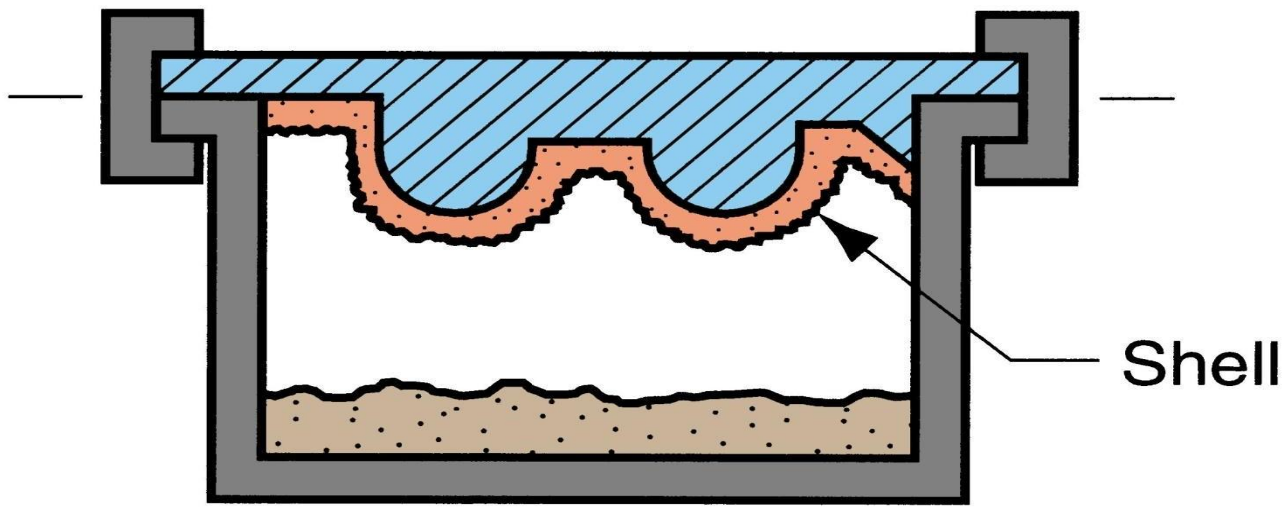
Step (2)

box is inverted so that sand and resin fall onto the hot pattern, causing a layer of the mixture to partially cure on the surface to form a hard shell



Steps -3

box is repositioned so that loose uncured particles drop away



(3)

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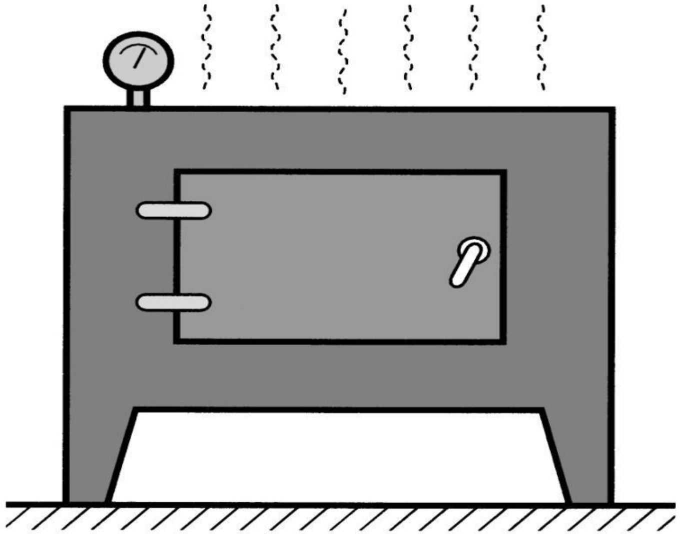

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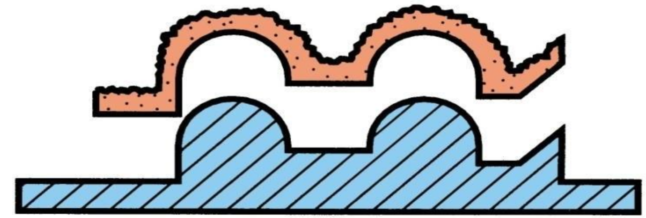
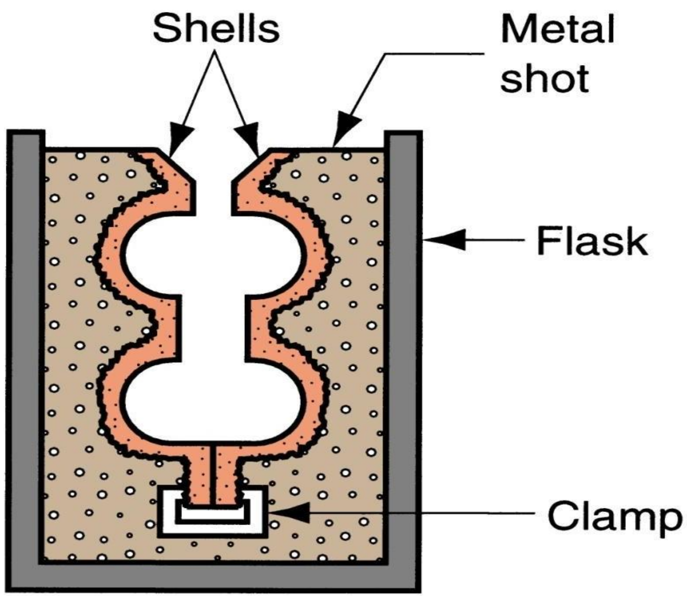


(5)

(4)sand shell is heated in oven for several minutes to complete curing

(5) shell mold is stripped from the pattern



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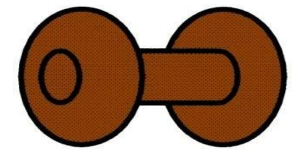

(7)

(6)two halves of the shell mold are assembled, supported by sand or metal shot in a box, and pouring is accomplished

(7) the finished casting with sprue removed

Advantages and Disadvantages of Shell Molding

- Advantages:
  - Smoother cavity surface permits easier flow of molten metal and better surface finish on casting
  - Good dimensional accuracy
  - Machining often not required
  - Mold collapsibility usually avoids cracks in casting
  - Can be mechanized for mass production
- Disadvantages:
  - More expensive metal pattern
  - Difficult to justify for small quantities

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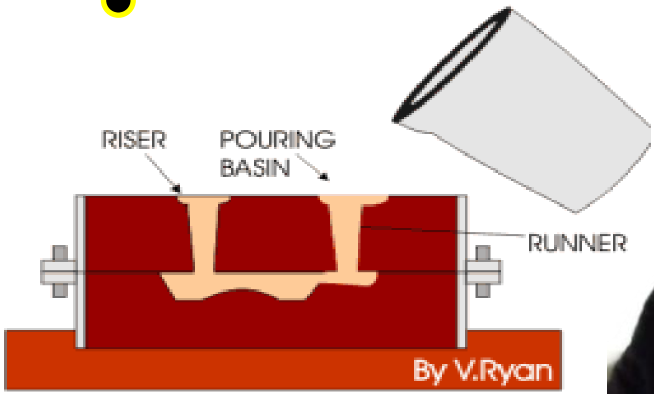
Ch-2 Foundry Technology

GATING SYSTEM



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GATING SYSTEM

- The term gating system refers to all passageways through which the molten metal passes to enter the mould cavity.
- The gating system is composed of

✓ Pouring basin

✓ Sprue

✓ Runner

✓ Gates

✓ Risers

- Any gating system designed should aim at providing a defect free casting. This can be achieved by considering following requirements.
- A gating system should avoid sudden or right angle changes in direction.
- A gating system should fill the mould cavity before freezing.
- The metal should flow smoothly into the mould without any turbulence. A turbulence metal flow tends to form dross in the mould.
- Unwanted materials such as slag, dross and other mould materials should not be allowed to enter the mould cavity.
- The metal entry into the mould cavity should be properly controlled in such a way that aspiration of the atmospheric air is prevented.

- A proper thermal gradient should be maintained so that the casting is cooled without any shrinkage cavities or distortions.

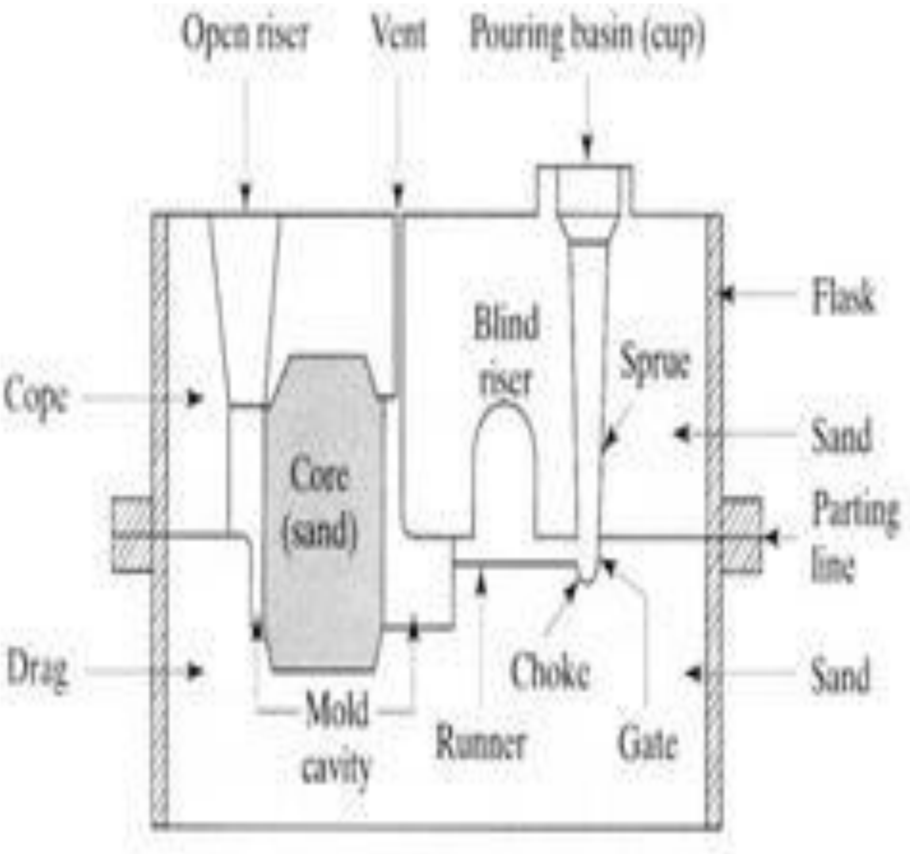
- Metal flow should be maintained in such a way that no gating or mould erosion takes place.

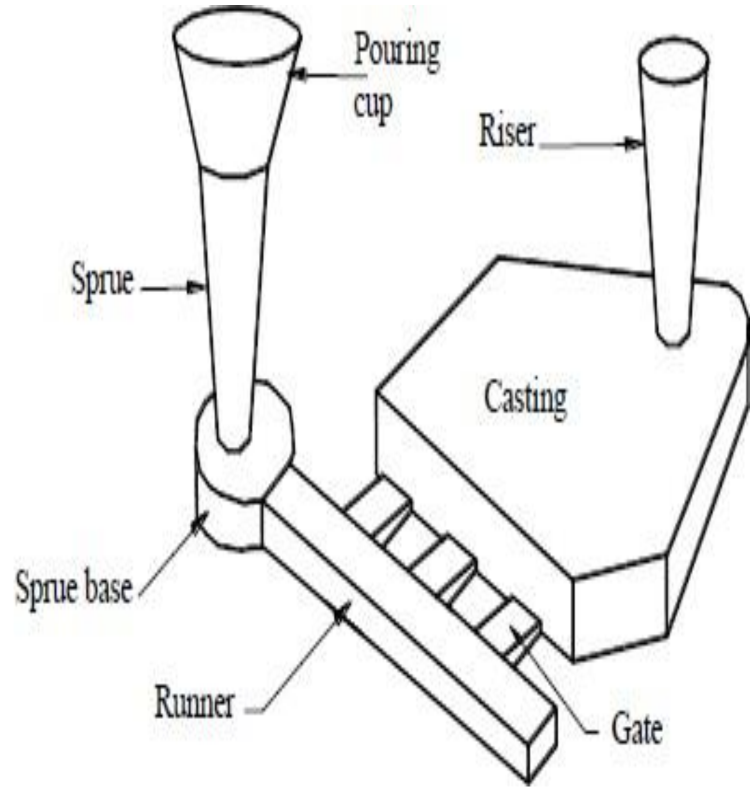
- The gating system should ensure that enough molten metal reaches the mould cavity.

- It should be economical and easy to implement and remove after casting solidification.

- For proper functioning of the gating system, the following factors need to be controlled.
- Type of pouring equipment, such as ladles, pouring basin etc.
- Temperature/ Fluidity of molten metal.
- Rate of liquid metal pouring.
- Type and size of sprue.
- Type and size of runner.
- Size, number and location of gates connecting runner and casting.
- Position of mould during pouring and solidification.

Gating System





Pouring Basin

- **A pouring basin** makes it easier for the ladle or crucible operator to direct the flow of metal from crucible to sprue.

- Helps maintaining the required rate of liquid metal flow.

- Reduces turbulence at the sprue entrance.
- Helps separating dross, slag etc., from metal before it enters the sprue.

SPRUE

- The vertical passage that passes through the cope and connects the pouring basin with the runner or gate is called the sprue.
- A sprue feeds metal to runner which in turn reaches the casting through gates.
- A sprue is tapered with its bigger end at top to receive the liquid metal. The smaller end is connected to runner.
- As the metal flows down the sprue, its velocity increases. Hence the section of the sprue should decreases, otherwise the sprue will not remain full of metal with the metal leaving the walls of the spure.

Gates

- A gate is a channel which connects runner with the mould cavity and through which molten metal flows to fill the mould cavity.
- A small gate is used for a casting which solidifies slowly and vice versa.
- A gate should not have sharp edges as they may break during pouring and sand pieces thus may be carried with the molten metal in the mould cavity.
- **Ingate** is the End of gate where it joins the mould cavity and through which, molten metal is introduced into the mould cavity.

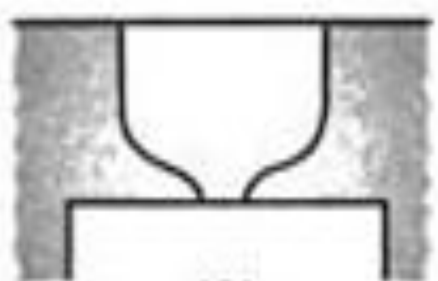
Gates

- **Choke** is part of the gating system which has smallest cross sectional area. its function is to control the flow rate of metal and to hold back slag ,foreign particles etc.

- **Types**
- Top gate
- Bottom gate
- Parting line side gate

Top Gate

- A top gate is sometimes also called as Drop gate because the molten metal just drops on the sand in the bottom of the mould.
- Generation of favourable temperature gradients to enable directional solidification from the casting towards the gate which serves as a riser too.



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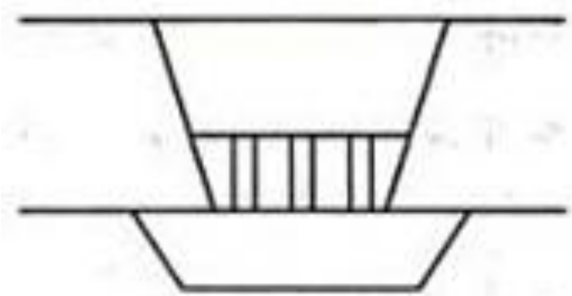


(E)

Disadvantages

Disadvantages

•The dropping liquid metal stream erodes the mould surface.

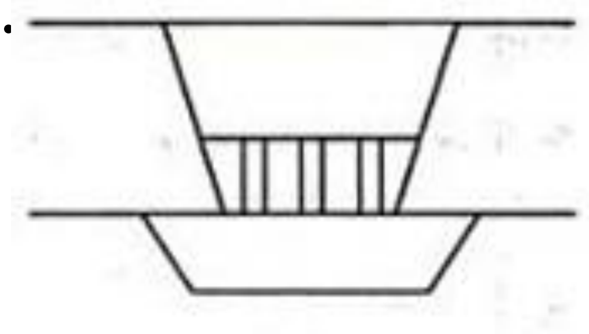
•There is a lot of turbulence.

Bottom Gates

- A bottom gate is made in the drag portion of the mould.
- In a bottom gate the liquid metal fills rapidly the bottom portion of the mould cavity and rises steadily and gently up the mould walls.
- As comparison to top gate, bottom gate involves little turbulence and sand erosion.
- Bottom gate produces good casting surfaces.

Disadvantages

- In bottom gates, liquid metal enters the mould cavity at the bottom. If freezing takes place at the bottom, it could choke off the metal flow before the mould is full.
- A bottom gate creates an unfavourable temperature gradient and [illegible] achieve directional solidification.



(E)

PARTING LINE SIDE GATE

- Middle or side or parting gating systems combine the characteristics of top and bottom gating systems.
- In this technique gate is provided along the parting line such that some portion of the mould cavity will be below the parting line and some portion will be above the parting line.
- The cavity below the parting line will be filled by assuming top gating and the cavity above the parting line will be filled by assuming bottom gating.

Types Of GATE

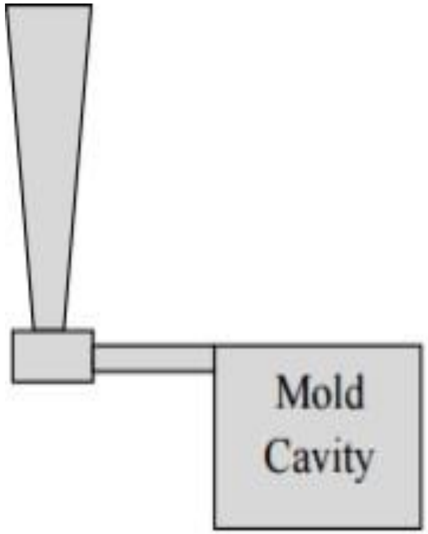


Fig: Top Gating

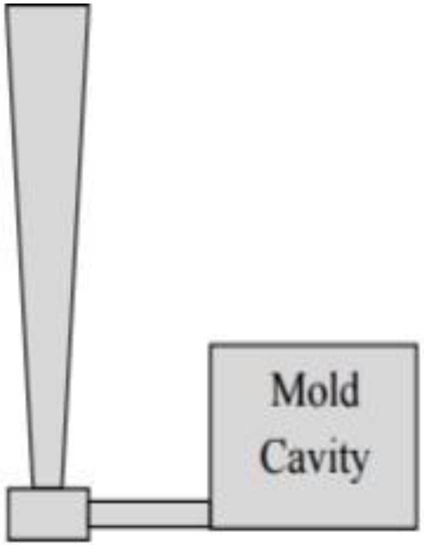


Fig: Bottom Gating

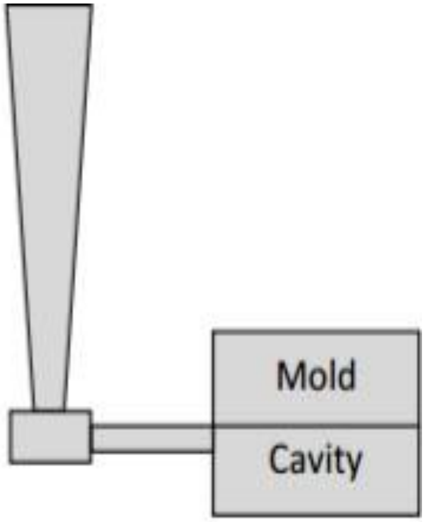


Fig: Parting line Gating

Runner

- In large castings the molten metal carried from sprue to gates around the cavity through a passage way called runner is generally preferred in drag, same times in cope depends on shape of casting .
- The Runners are of large cross-section and often streamlined to slow down and smooth out the flow, and are designed to provide approximately uniform flow rates to the various parts of the mould cavity.
- Runners are commonly made trapezoidal in cross-section.

Riser

- The function of a riser is to supply addition molten metal to a casting to ensure a shrinkage porosity free casting
- It provides the direction solidification of molten metal It escapes the gases in cavity during casting.
- It also indicates the filling of cavity. The rate at which the pouring metal is stop or not.
- The riser is placed top most portion of the mould cavity.

Riser

- To be effective a riser must solidify after the casting and contain sufficient metal to feed the casting or portion of a casting.
- Casting solidification time can be predicted using Chvorinov's Rule.

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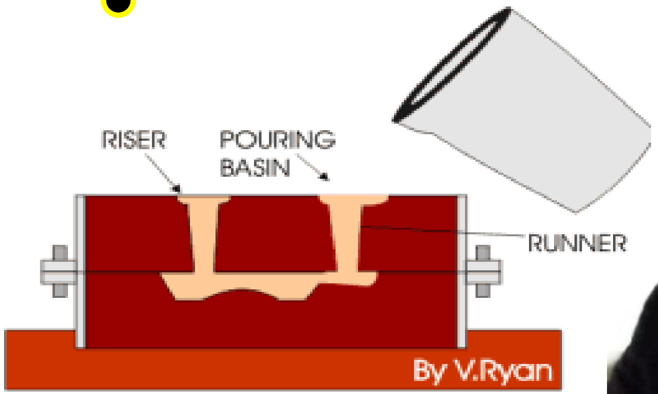
Ch-2 Foundry Technology

Moulding Machine



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Moulding Machine

- A ‘MOULDING MACHINE’ may be defined as a device which have a large number of correlated parts and mechanisms ,transmits and directs various forces and motions in required directions so as to help the preparation of a sand mould

FUNCTIONS OF MOULDING MACHINE

- RAMMING OF MOULDING SAND
- ROLLING OVER OR INVERTING THE MOULD
- RAPPING THE PATTERN
- WITHDRAWING THE PATTERN FROM THE MOULD

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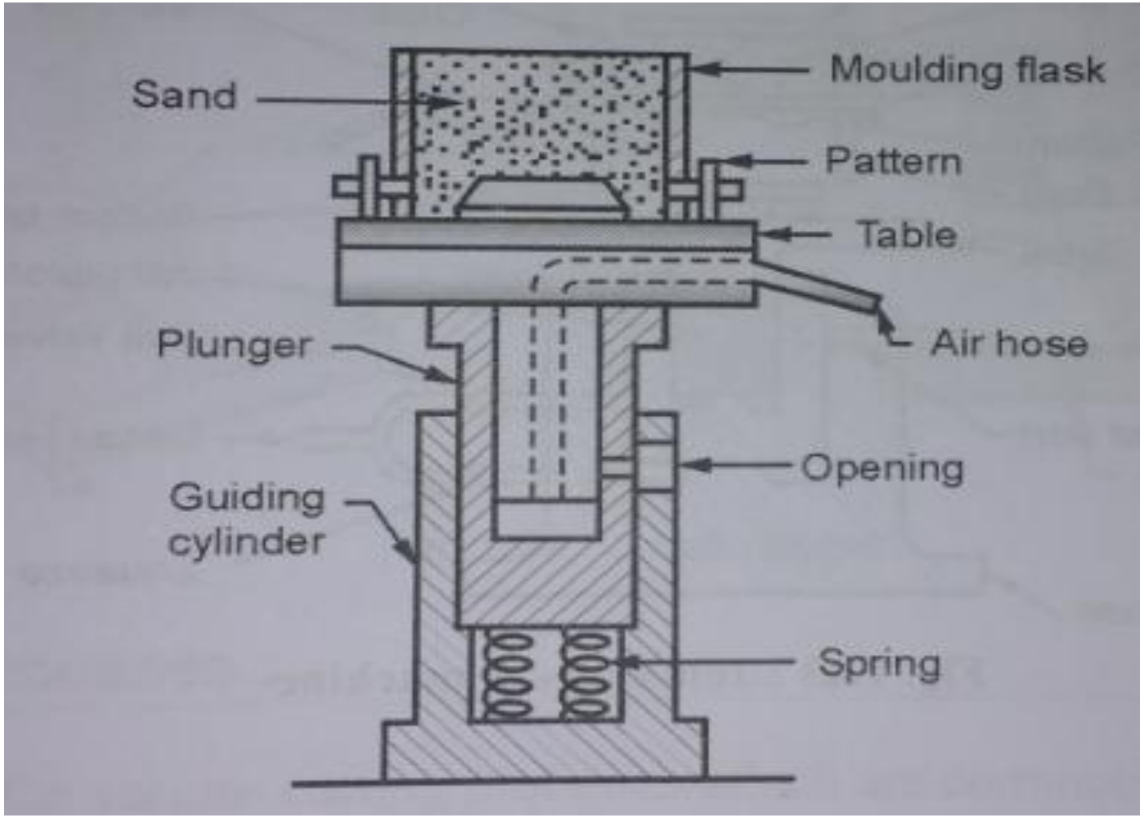
TYPES OF 'MOULDING MACHINE'

1. Jar Or Jolt Moulding Machine
2. Squeezer Moulding Machine
3. Jolt - Squeezer Moulding Machine
4. Sand Slinger (Slinging Machines)

1. Jar or Jolt Moulding Machine

- This machine consists of an air operated piston and cylinder.
- piston is suddenly released, resulting in an even packing of sand around the pattern in the flask
- It is known as 'JOLTING'
- Jolting is accomplished by opening the valve which admits air to raise the jolt piston

1.Jar or Jolt Moulding Machine

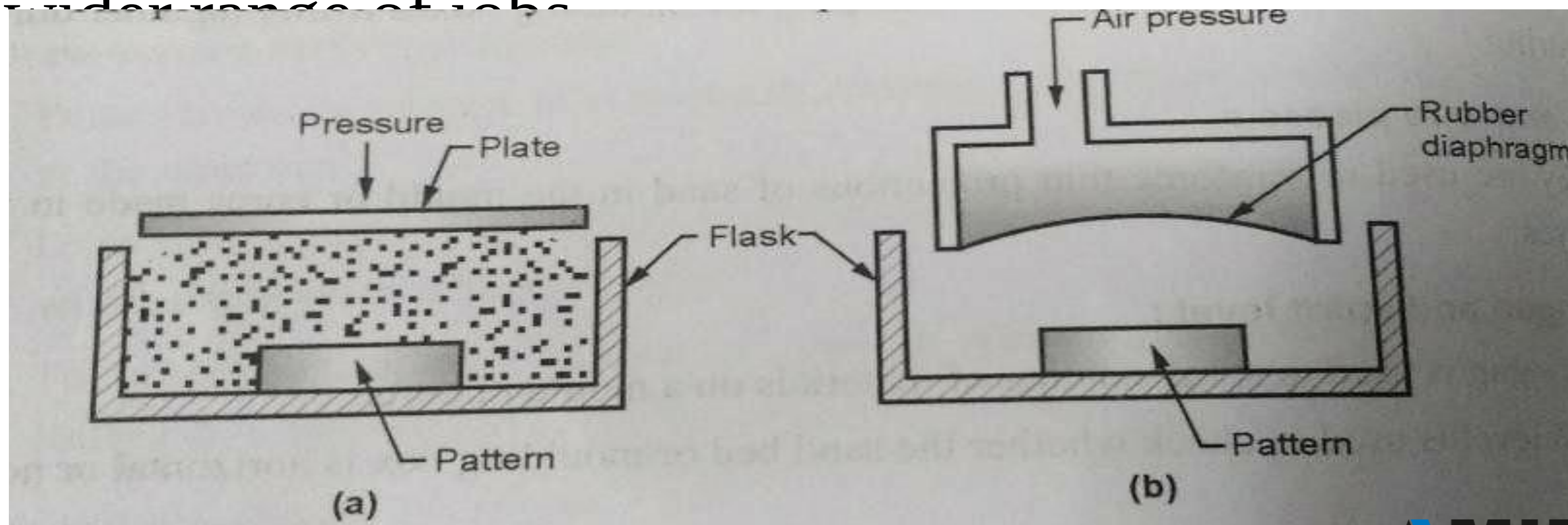


2. SQUEEZER MACHINE

- The pattern is placed over the machine table , followed by the moulding flask .
- In hand-operation machines the machine plate is lifted by a hand-operated mechanism whereas in power machines it is lifted by a action of air pressure on a piston in the cylinder in the same way as in jolt machine. The difference is that the table is not dropped from height but it raised gradually .
- On the top of machine column is provided an overhead plate and the sand in the flask is squeezed between this plate and upward rising table.

2. SQUEEZER MACHINE

- . This enables a uniform pressing of sand in the flask.
- A specific advantage of power operated machines over hand operated ones is that more pressure can be applied in the former, which facilities handling of a wider range of jobs.



2. SQUEEZER MACHINE

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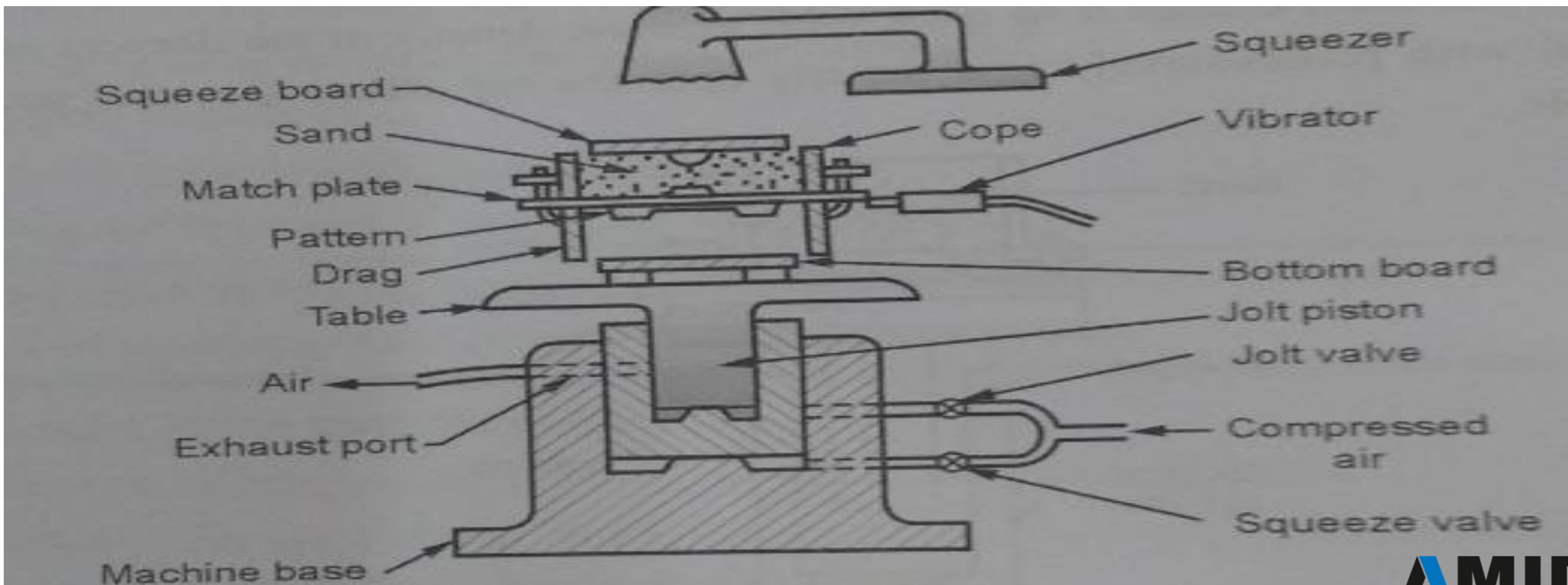
3. JOLT-SQUEEZER MOULDING MACHINE

- Mostly used for match plate moulding
- This machine, as is clear from its name, combines the principle of both jolt and squeezer machines. The complete mould is prepared on this machine
- First the drag is filled with sand and then rammed by the jolting action of the table.
- Then the cope is filled up with sand and the latter rammed by squeezing between the overhead plate and the machine table

3. JOLT-SQUEEZER MOULDING MACHINE

- The overhead plate is then swung aside and sand on the top levelled off, cope removed and the drag vibrated by air vibrator.
- This is followed by removal of match plate and closing



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Jolt Squeezer Machine

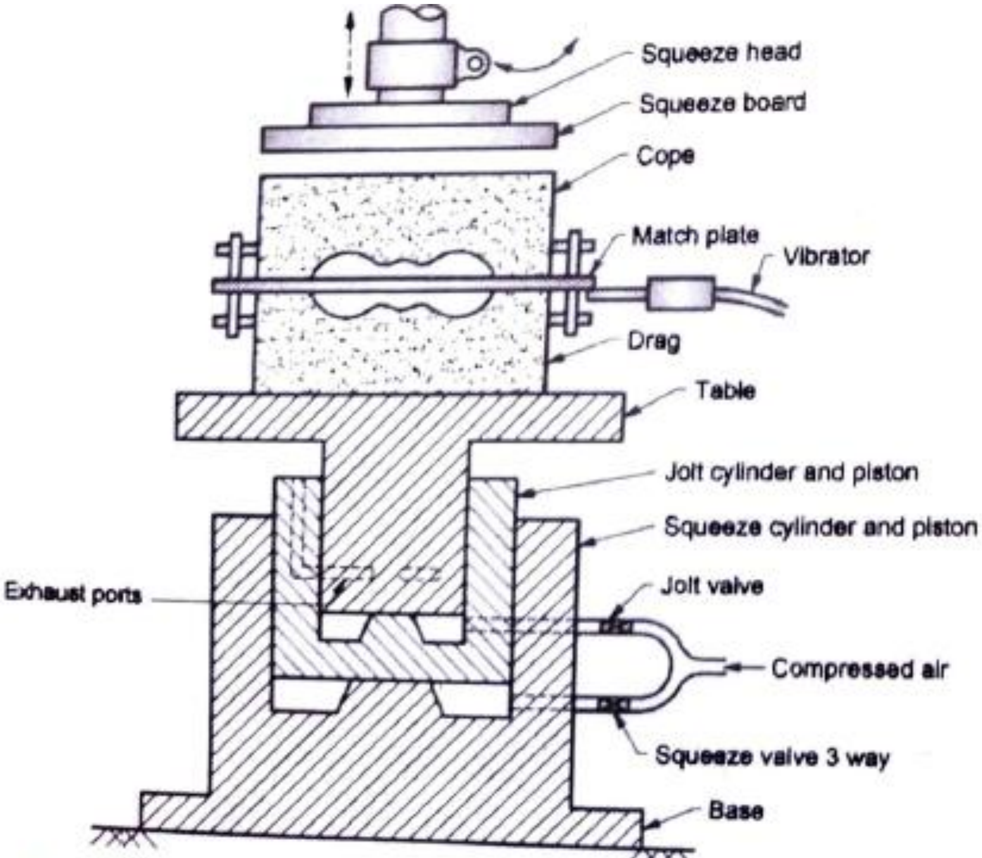
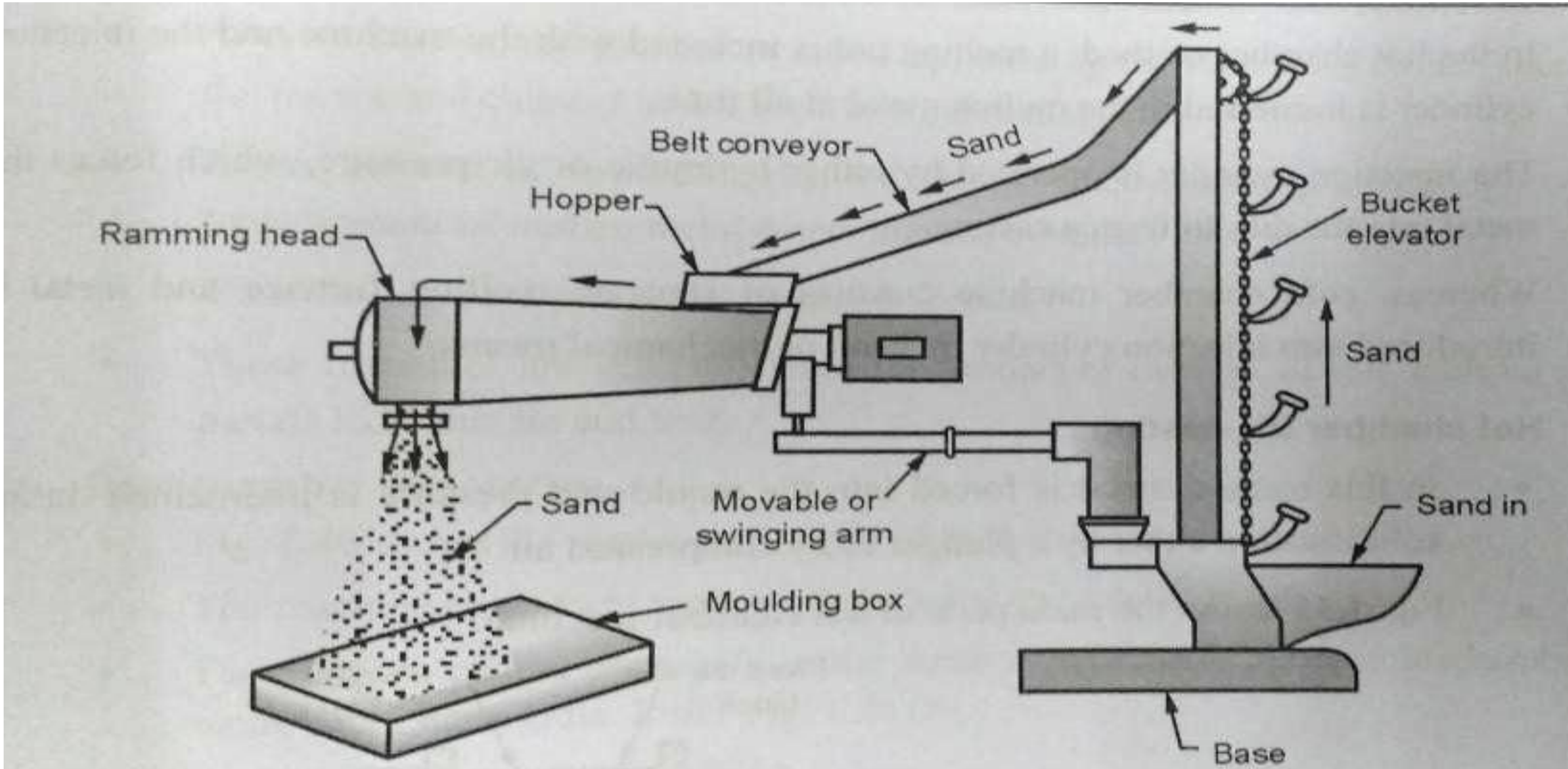


Fig. 2.7.3 : Schematic diagram for air operated jolt squeeze machine

4.SLINGING MACHINES OR SAND SLINGERS

- These machines are used for filling and uniform amount of sand in moulds and are particularly adopted with advantage for large moulds.
- They can also be used in conjunction with other moulding devices, like rollover machines and pattern draw machines, so as to eliminate more manual operations.

4.SLINGING MACHINES OR SAND SLINGERS



4.SLINGING MACHINES OR SAND SLINGERS

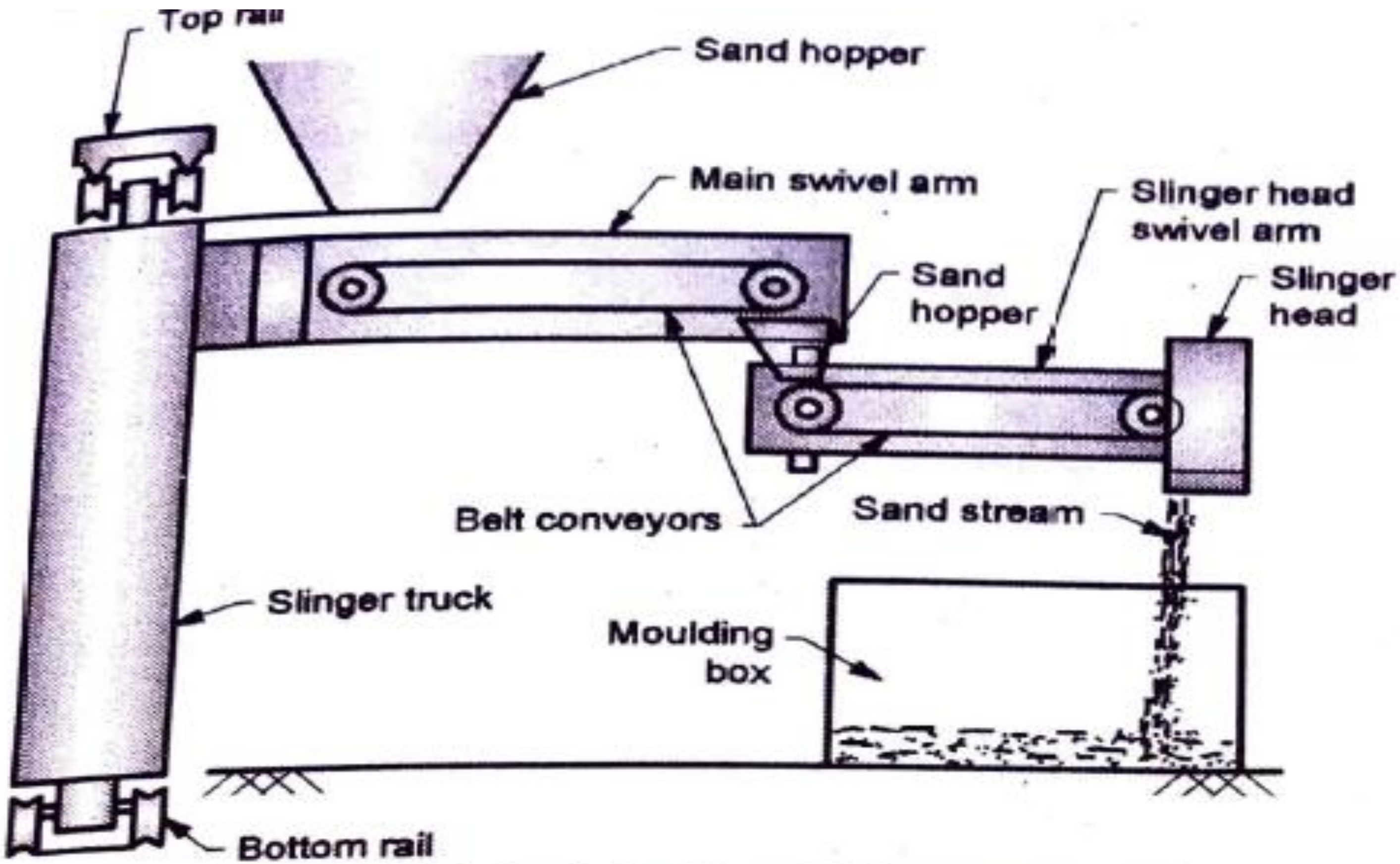


Fig. 2.7.4 : Principle of sand slinger machine

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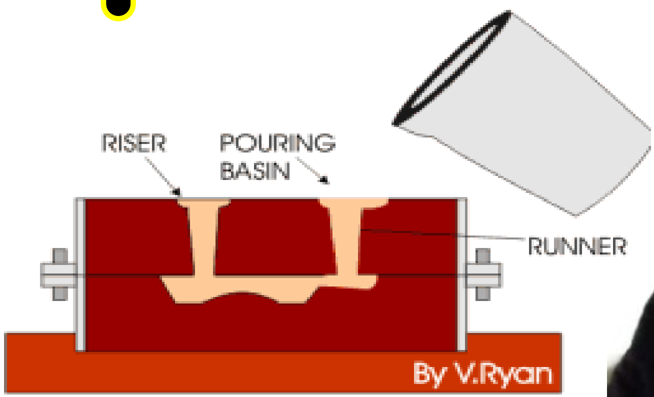
Ch-2 Foundry Technology

Moulding Machine



Subject:MT Code:-3151912	Prepared by: Asst.Prof.Harin Prajapati (Mechanical Department,ACET)	COLLEGE OF ENGINEERING & TECHNOLOGY

Types of Casting Processes

1.Pressure die casting

2.Investment casting

3.Centrifugal casting

4.Continuous casting

1.Pressure Die casting

- Die casting is a moulding process in which the molten metal is injected under high pressure and velocity into a split mould die. It is also called pressure die casting.
- The split mould used under this type of casting is reusable. Die casting is categorized two types namely- ***Hot Chamber And Cold Chamber***
- It is type of permanent mold casting
- Common uses: components for rice cookers, stoves, fans, washing-, drying machines, fridges, motors, toys, hand-tools, car wheels, …

1.1 Hot-Chamber Die-Casting

- HOT CHAMBER: (low mp e.g. Zn, Pb; non-alloying)

(i) die is closed, gooseneck cylinder is filled with molten metal

(ii) plunger pushes molten metal through gooseneck into cavity

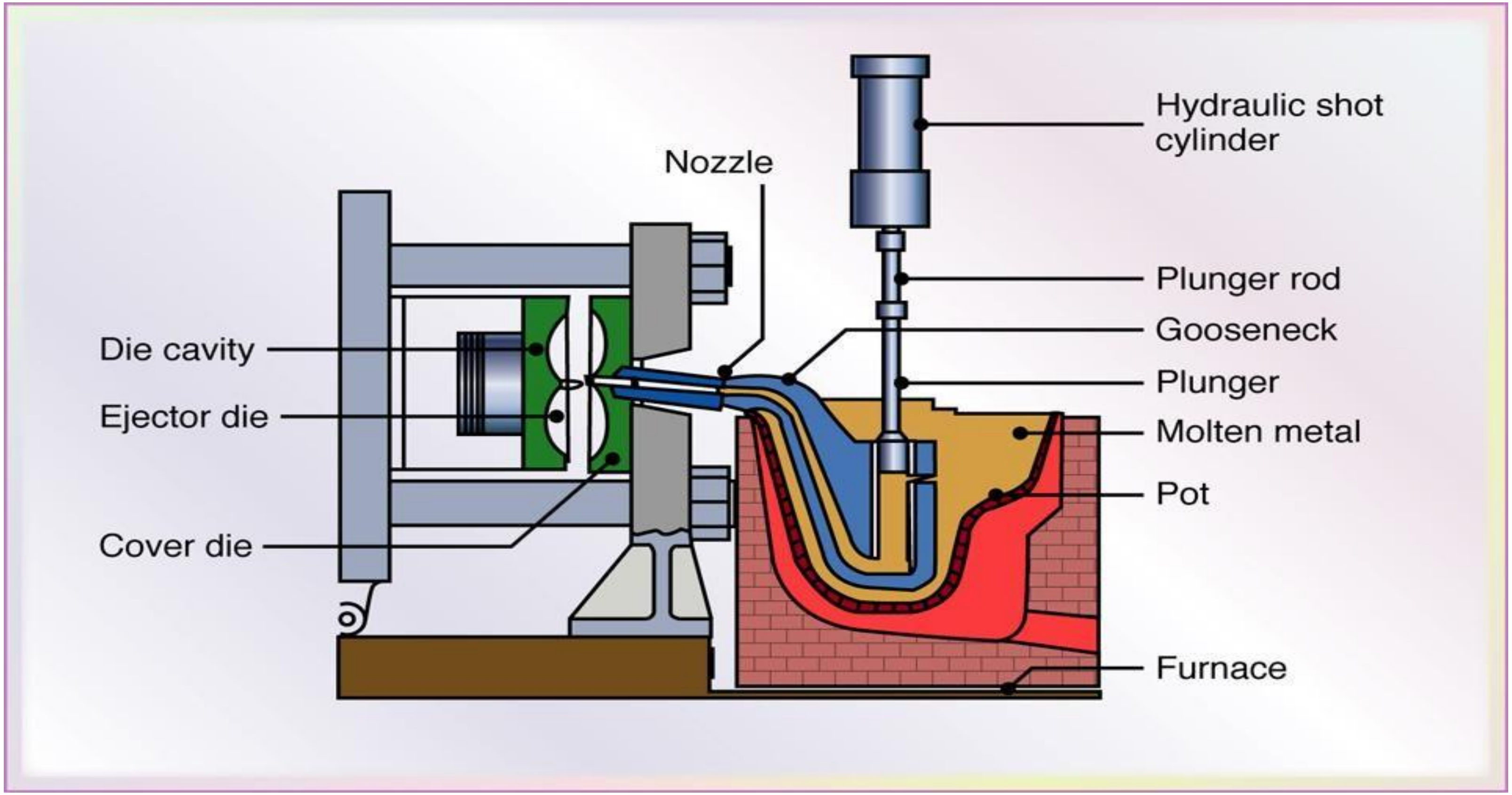
(iii) metal is held under pressure until it solidifies

(iv) die opens, cores retracted; plunger returns

(v) ejector pins push casting out of ejector die

- Applications limited to low melting-point metals that do not chemically attack plunger and other mechanical components

1.1 Hot-Chamber Die-Casting



1.2 Cold-Chamber Die-Casting

- COLD CHAMBER: (high melting point metals e.g. Cu, Al)

(i) die closed, molten metal is ladled into cylinder

(ii) plunger pushes molten metal into die cavity

(iii) metal is held under high pressure until it solidifies

(iv)die opens, plunger pushes solidified slug from the cylinder

(v) cores retracted

(iv) ejector pins push casting off ejector die

1.2 Cold-Chamber Die-Casting

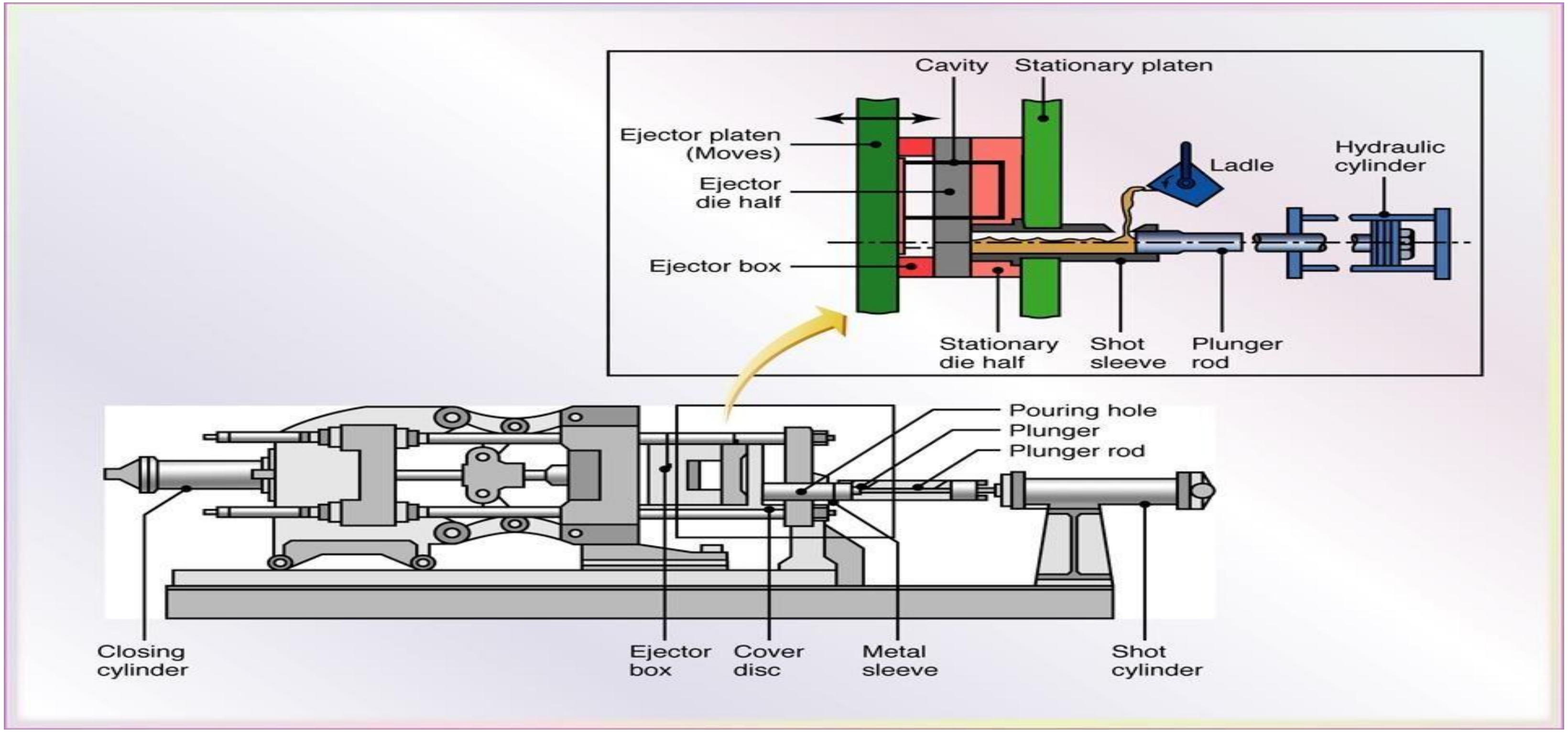


Figure - Schematic illustration of the cold-chamber die-casting process. These machines are large compared to the size of the casting, because high forces are required to keep the two halves of the dies closed under pressure.

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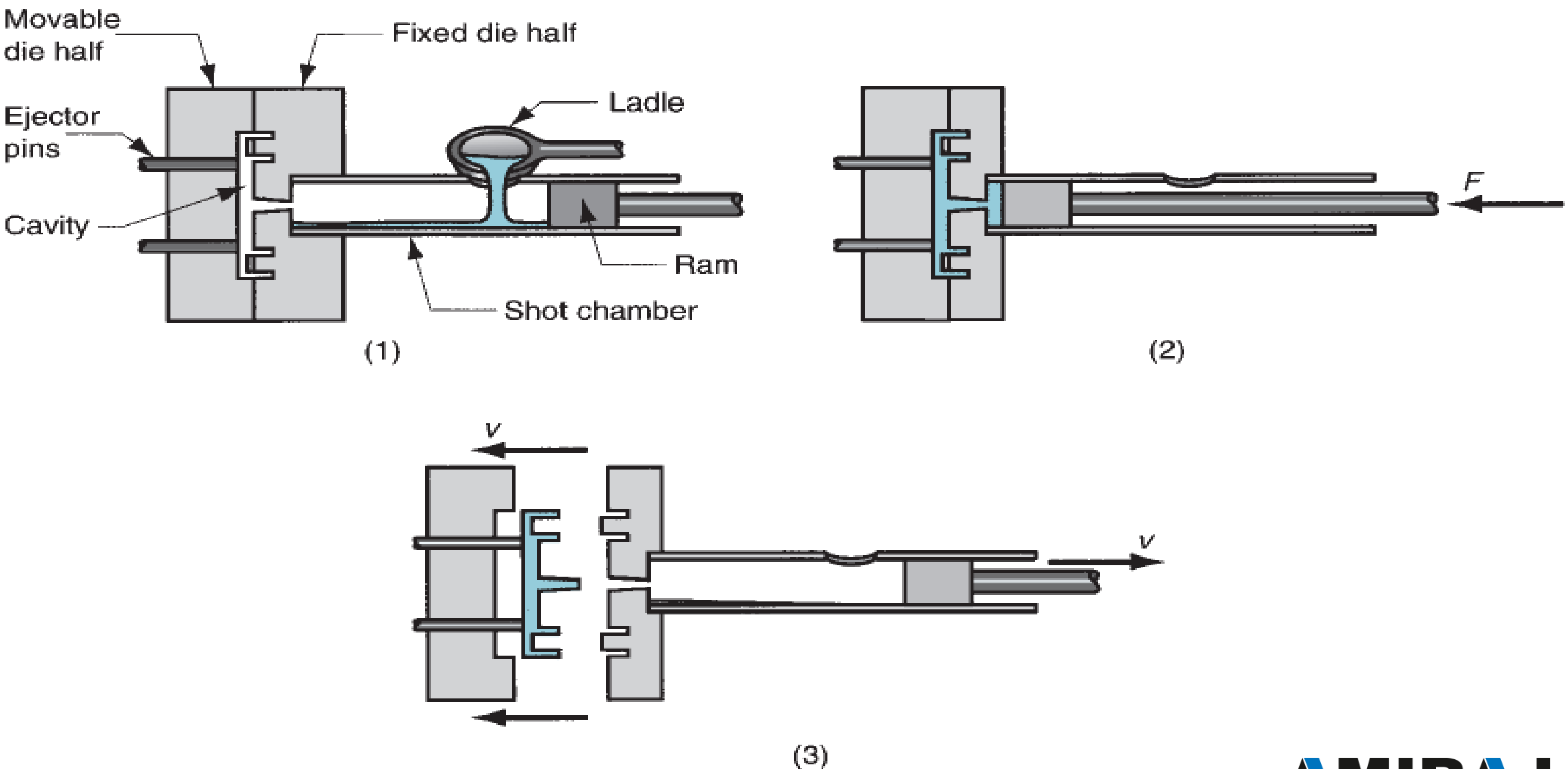
1.2 Cold-Chamber Die-Casting



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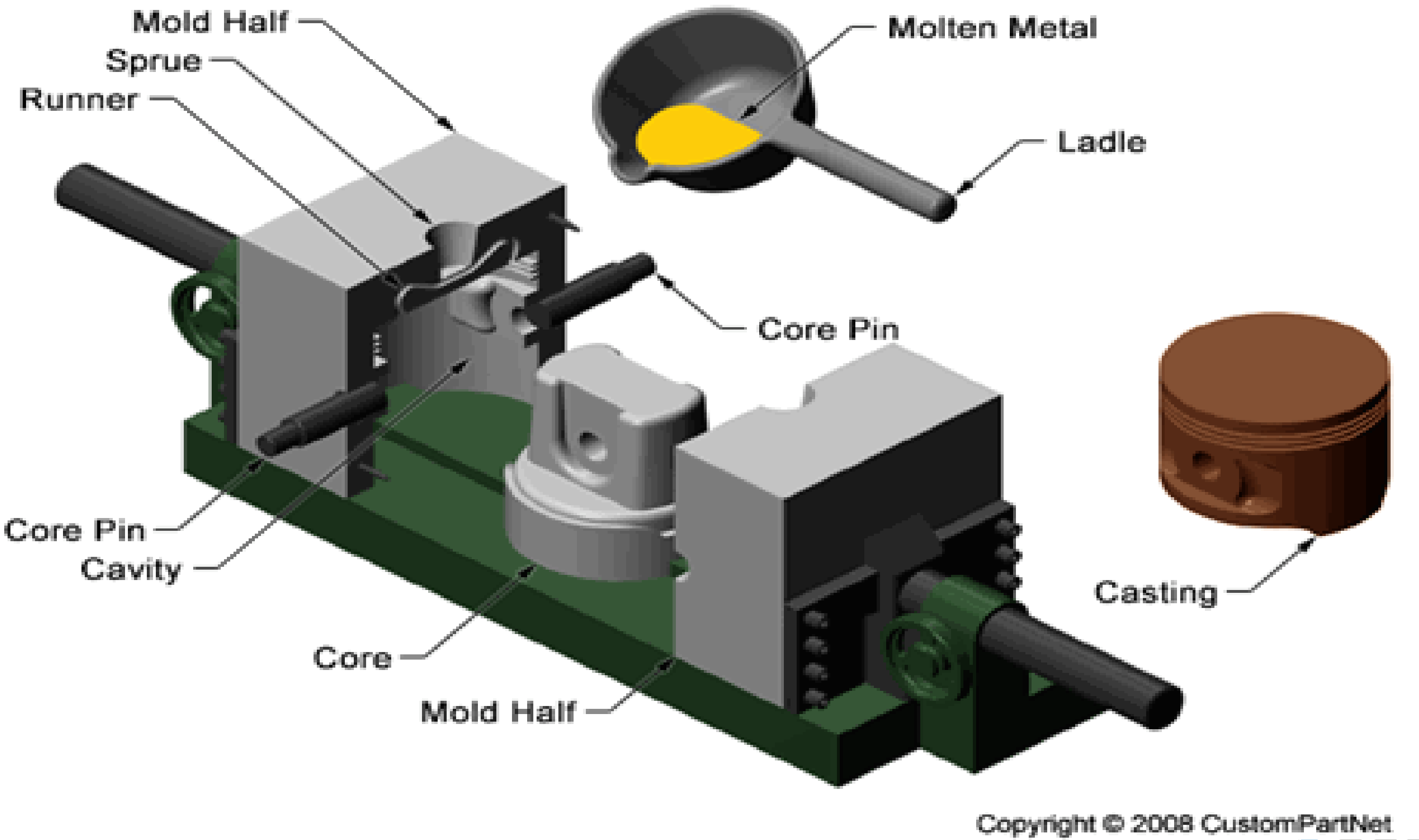
1.2 Cold-Chamber Die-Casting



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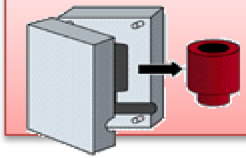
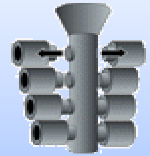
2.Investment Casting (Lost Wax Process)

- A pattern made of wax is coated with a refractory material to make mold, after which wax is melted away prior to pouring molten metal
- "Investment" comes from one of the less familiar definitions of "invest" - "to cover completely," which refers to coating of refractory material around wax pattern
- It is a precision casting process - capable of castings of high accuracy and intricate detail

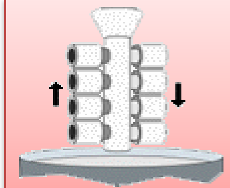
2.Investment Casting (Lost Wax Process)



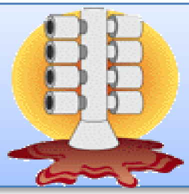
(a) Wax pattern
(injection molding)



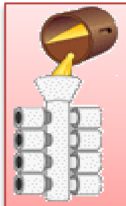
(b) Multiple patterns
assembled to wax sprue



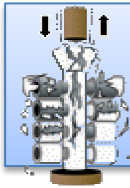
(c) Shell built →
immerse into ceramic slurry
→ immerse into fine sand
(few layers)



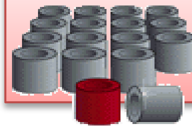
(d) dry ceramic
melt out the wax
fire ceramic (burn wax)



(e) Pour molten metal (gravity)
→ cool, solidify
[Hollow casting:
pouring excess metal before solidification

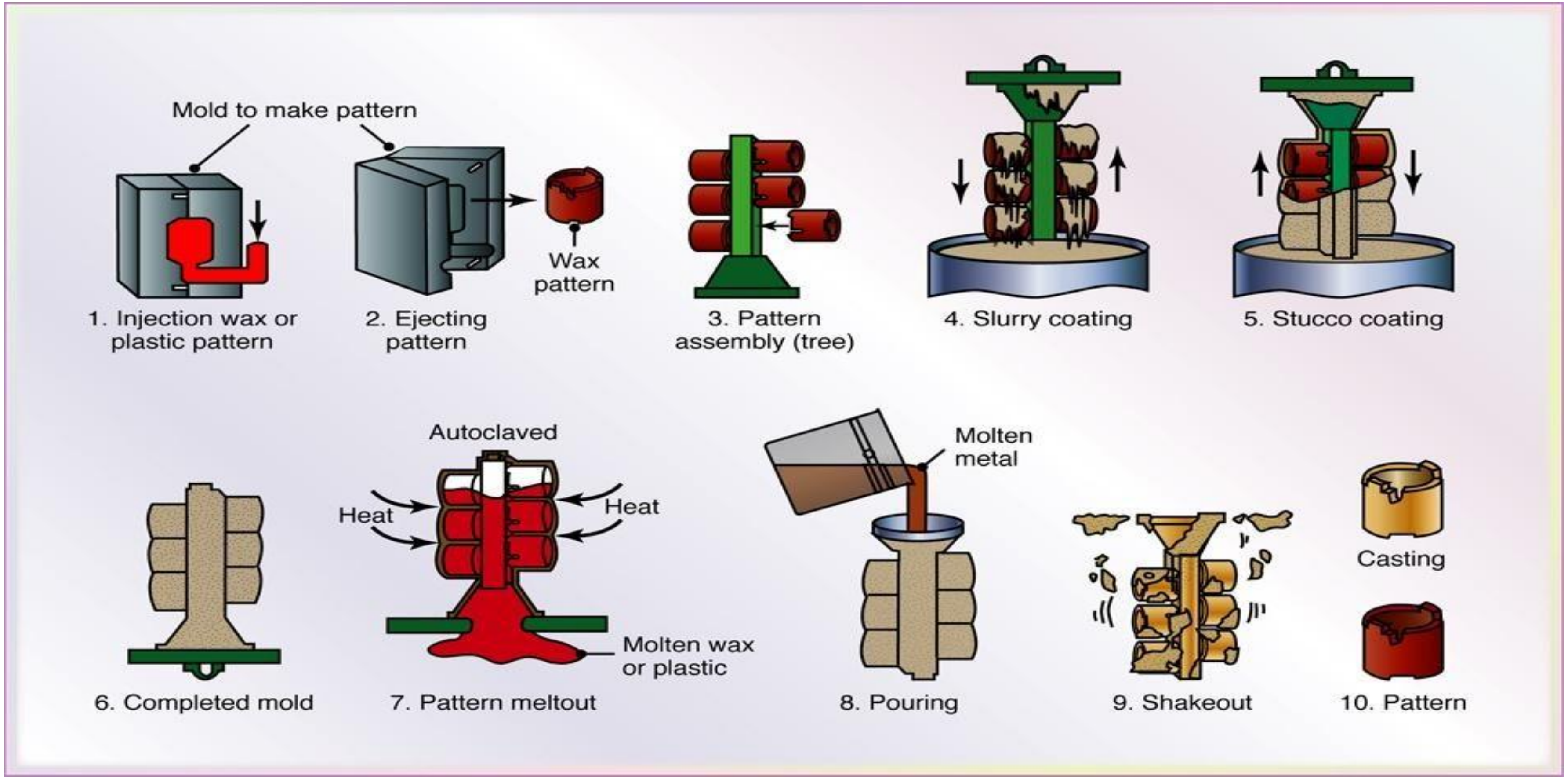


(f) Break ceramic shell
(vibration or water blasting)



(g) Cut off parts
(high-speed friction saw)

2.Investment Casting (Lost Wax Process)



Steps in investment casting:

(1) Wax patterns are produced

(2) Several patterns are attached to a sprue to form a pattern tree

(3) The pattern tree is coated with a thin layer of refractory material

(4) The full mold is formed by covering the coated tree with sufficient refractory material to make it rigid

(5) The mold is held in an inverted position and heated to melt the wax and permit it to drip out of the cavity

(6) The mold is preheated to a high temperature, which ensures that all contaminants are eliminated from the mold; it also permits the liquid metal to flow more easily into the detailed cavity; the molten metal is poured; it solidifies

(7) The mold is broken away from the finished casting - parts are separated from the sprue

Advantages and Disadvantages of Investment Casting

- *Advantages:*
  - Parts of great complexity and intricacy can be cast
  - Close dimensional control and good surface finish
  - Wax can usually be recovered for reuse
  - Additional machining is not normally required - this is a net shape process
- *Disadvantages:*
  - Many processing steps are required
  - Relatively expensive process

3. Centrifugal Casting

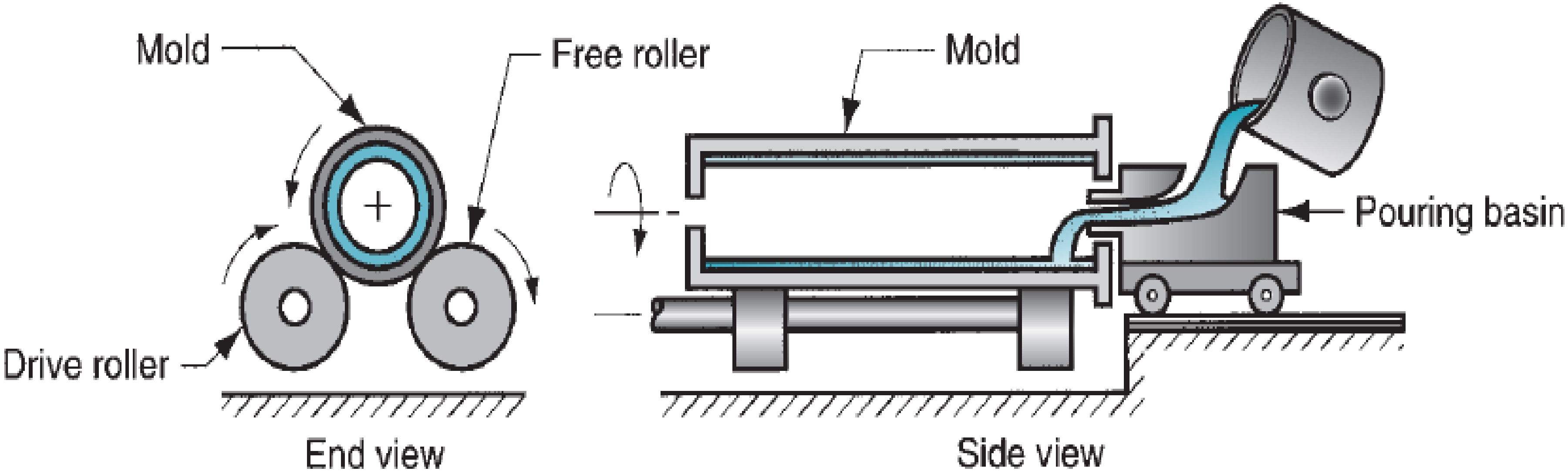
A group of casting processes in which the mold is rotated at high speed so centrifugal force distributes molten metal to outer regions of die cavity

- The group includes:
  - True centrifugal casting
  - Semi centrifugal casting
  - Centrifuge casting

3. Centrifugal Casting

- A permanent mold made of metal or ceramic is rotated at high speed(300 to 3000 rpm). The molten metal is then poured into the mold cavity and due to centrifugal action the molten metal conform to the cavity provided in the mould.
- Castings are known for their higher densities in the outer most regions.
- The process gives good surface finish
- Applications: pipes, bushings, gears, flywheels etc.

3. Centrifugal Casting



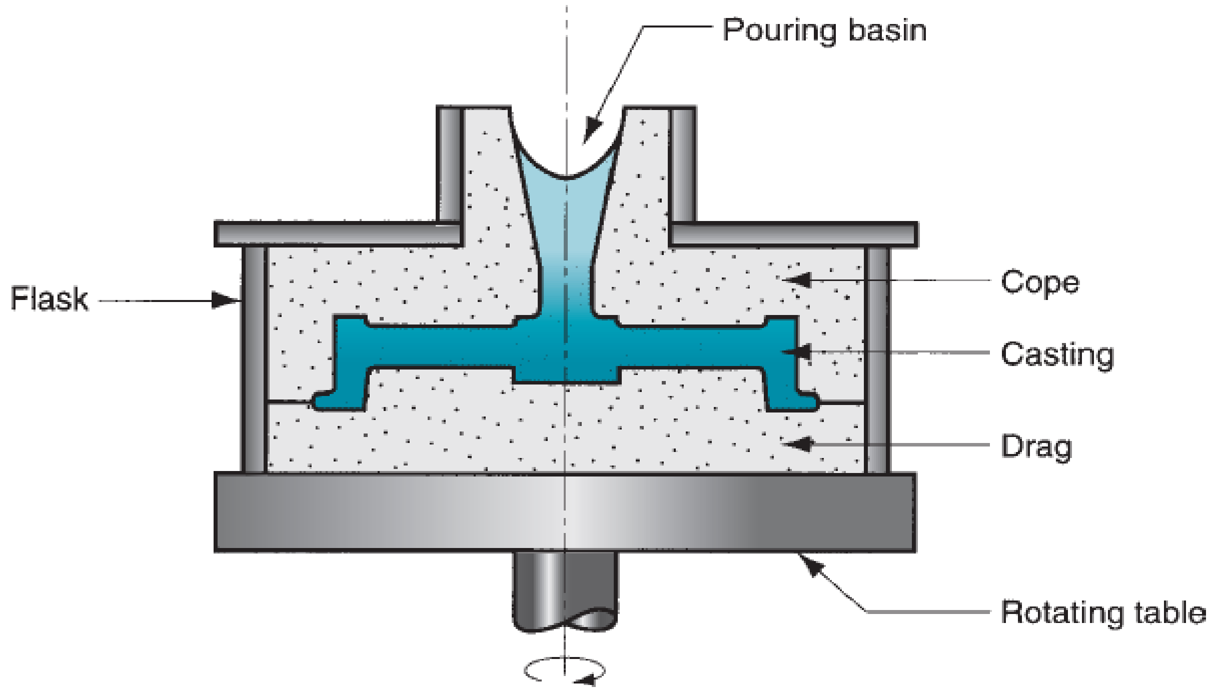
True Centrifugal Casting

- Molten metal is poured into rotating mold to produce a tubular part
- In some operations, mold rotation commences after pouring rather than before
- Parts: pipes, tubes, bushings, and rings
- Outside shape of casting can be round, octagonal, hexagonal, etc , but inside shape is (theoretically) perfectly round, due to radially symmetric forces

Semi Centrifugal Casting

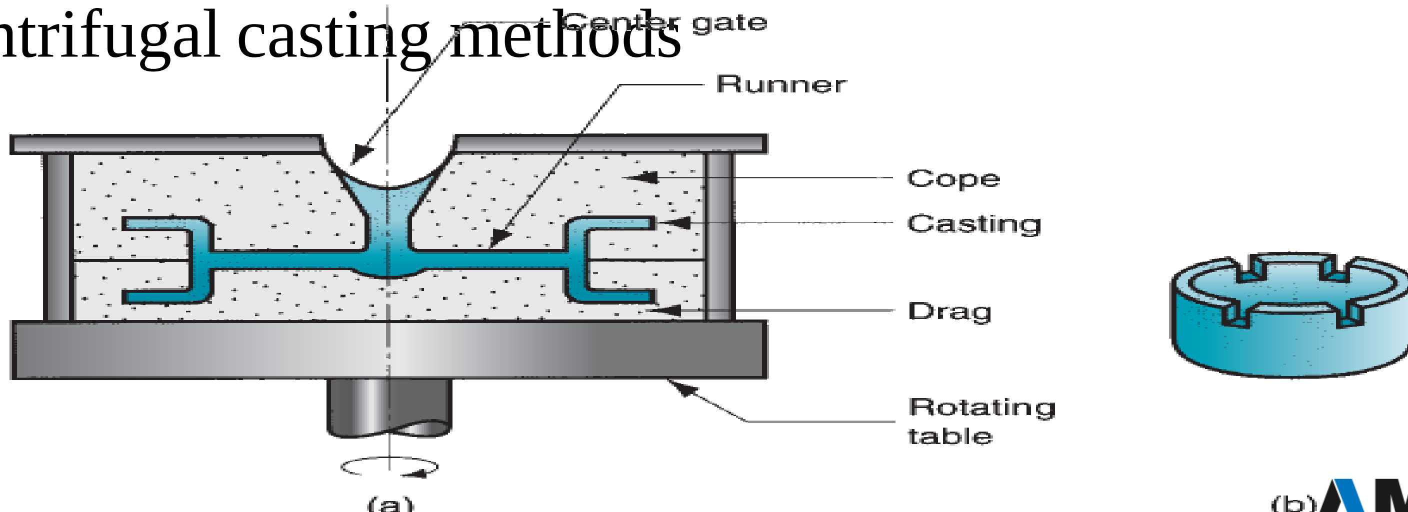
- Centrifugal force is used to produce solid castings rather than tubular parts
- Molds are designed with risers at center to supply feed metal
- Density of metal in final casting is greater in outer sections than at center of rotation
- Often used on parts in which center of casting is machined away, thus eliminating the portion where quality is lowest
- Examples: wheels and pulleys

Semi Centrifugal Casting

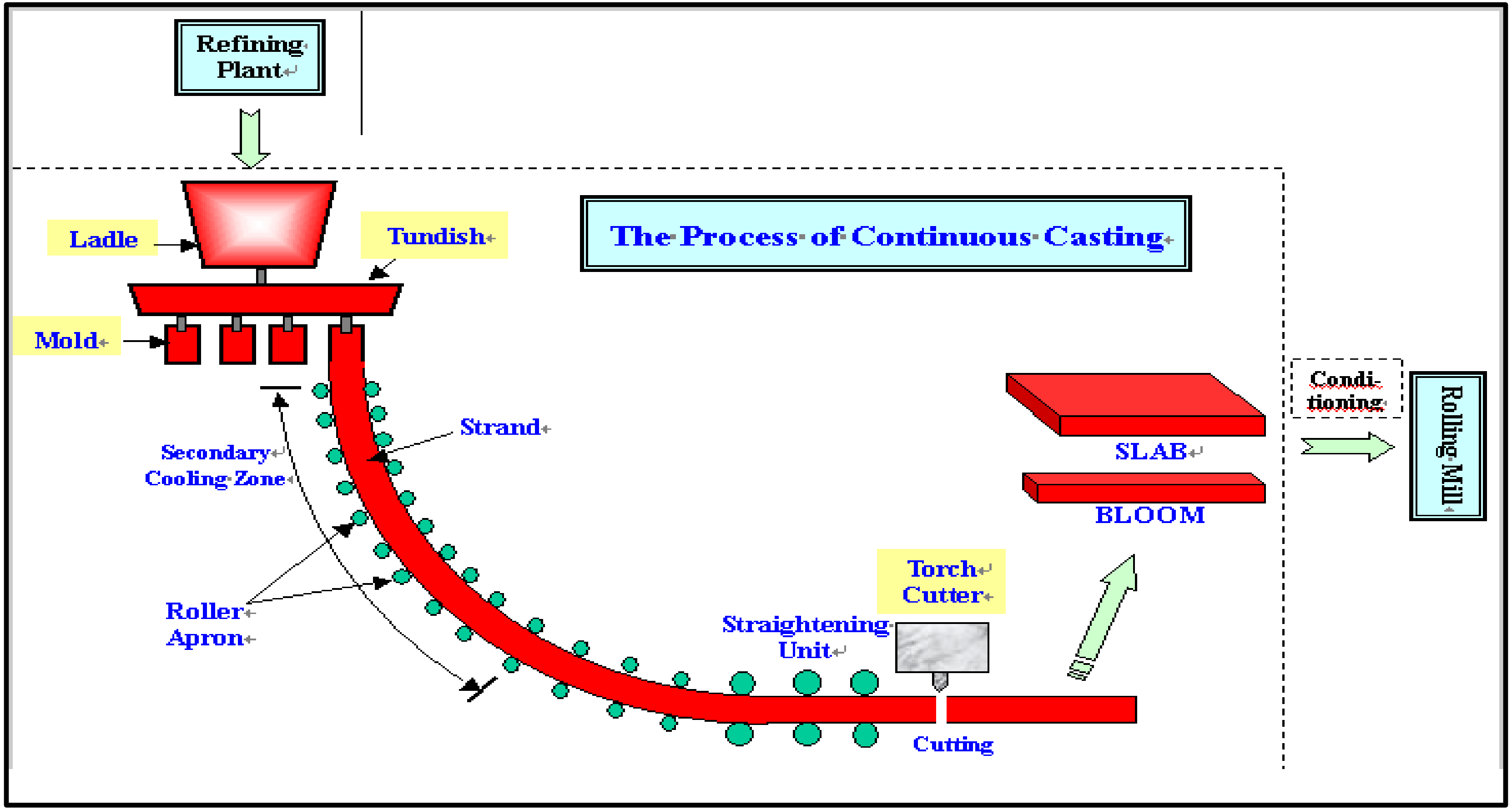


Centrifuge Casting

- Mold is designed with part cavities located away from axis of rotation, so that molten metal poured into mold is distributed to these cavities by centrifugal force
- Used for smaller parts
- Radial symmetry of part is not required as in other centrifugal casting methods



4. Continuous Casting



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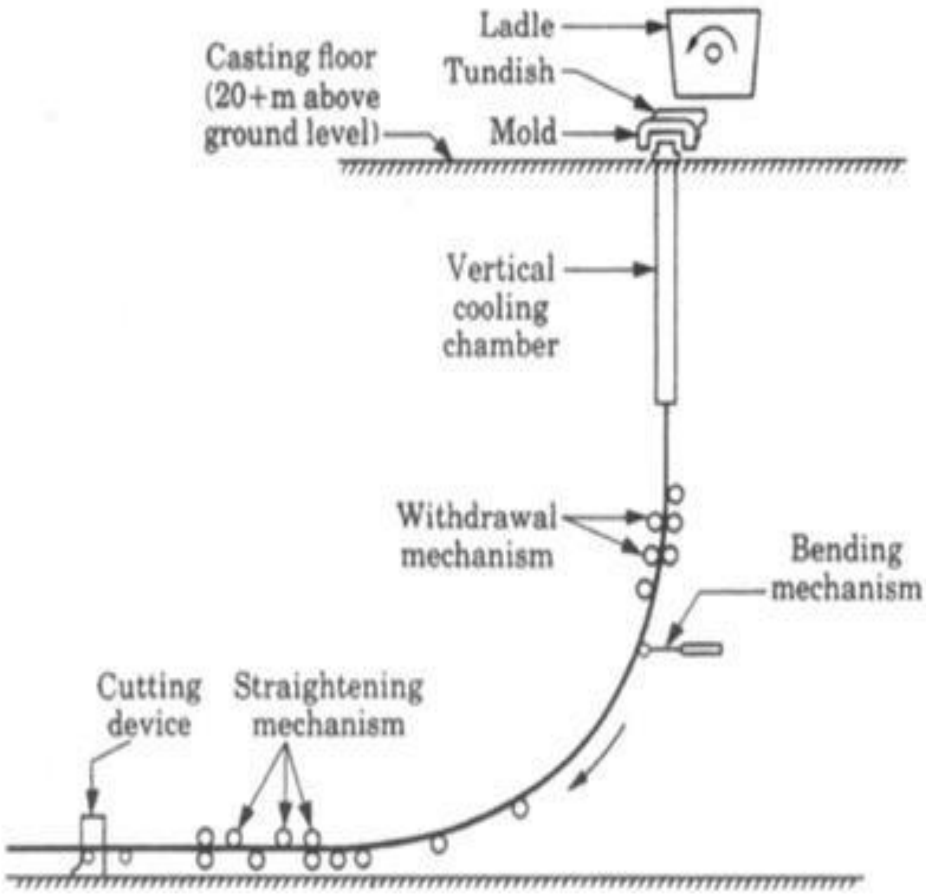
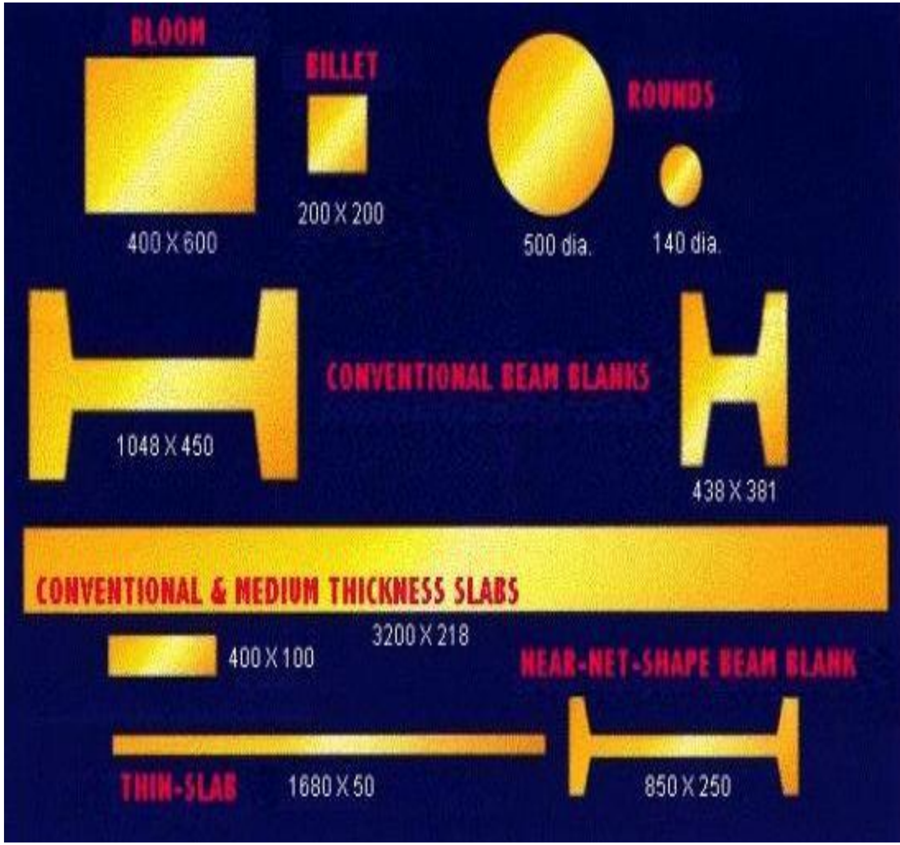
4. Continuous Castingc





4. Continuous Castingc

- major improvements in efficiency and productivity and significant reductions in cost
- the molten metal in the ladle is cleaned and equalized in temperature by blowing nitrogen gas through it for 5 to 10 min.
- The metal is then poured into a refractory lined intermediate pouring vessel (tundish) where impurities are skimmed off.
- The molten metal travels through water cooled copper molds and begins to solidify as it travels downward along a path supported by rollers (pinch rolls)
- A cut off station may be provided to cut the metal into required lengths by sawing or flame cutting
- Many common shapes like round, square, rectangular, hexagonal can be produced.

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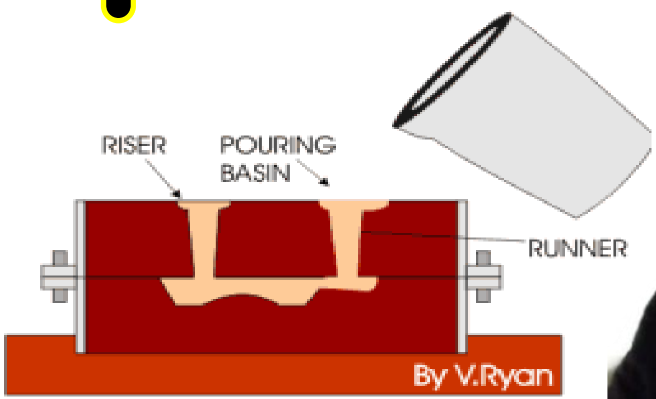
Ch-2 Foundry Technology

Casting Defects- Product Design Consideration



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Casting Defects

- Defects may occur due to one or more of the following reasons:

- Fault in design of casting pattern
- Fault in design on mold and core
- Fault in design of gating system and riser
- Improper choice of moulding sand
- Improper metal composition
- Inadequate melting temperature and rate of pouring

Casting Defects

SURFACE

METALLIC PROJECTION –

- Swell, Crush, Mould Drop, Fillet Vein

- **DEFECTIVE SURFACE –**
- Erosion Scab, Fusion, Expansion Scab, Rat tails, Buckle, Seams, Gas Runs, Fillet Scab, Rough Surface, Slag Inclusion, Elephant Skin
- **CHANGE IN DIMENSION-**
- Warped casting
- **INCOMPLETE CASTING-**
- Misrun, Run out
- **CAVITY-**
- Blow Holes, Shrinkage cavity, Pinholes
- **DISCONTINUITY-**
- Hot Cracking, Cold Shut, Cold Cracking

SUBSURFACE

SUBSURFACE CAVITY-

Blow Holes, Pin Holes, Shrinkage

Porosity, Internal Shrinkage, Severe

Roughness

INCLUSIONS-

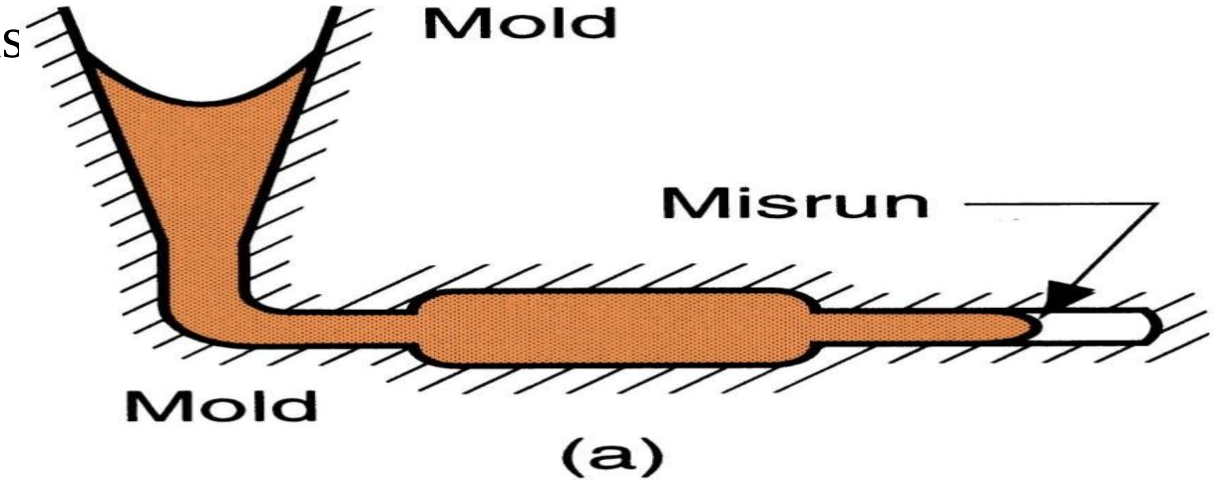
Gas Inclusions, Slag, Blow Holes

DISCONTINUITY-

Cold Shuts

Misrun

- A casting that has solidified before completely filling mold cavity
- Misrun defect is a kind of incomplete casting defect, which causes the casting uncompleted. The edge of defect is round and smooth.
- When the metal is unable to fill the mould cavity completely and thus



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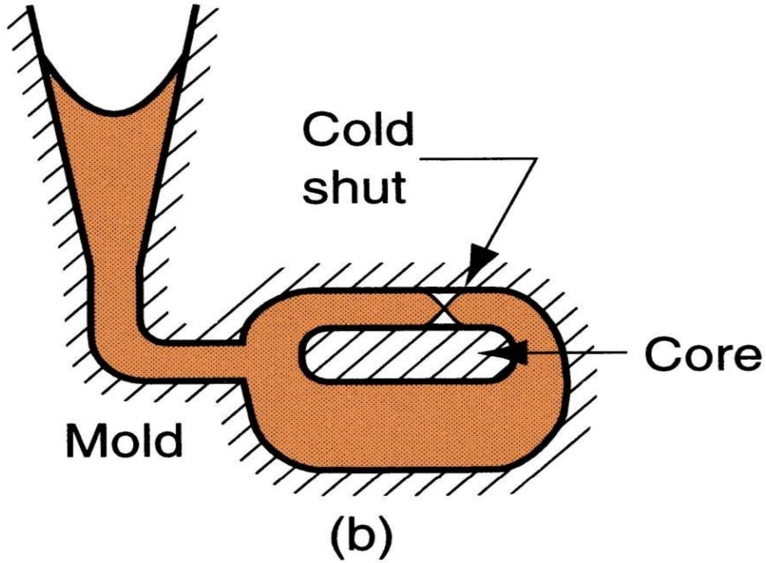
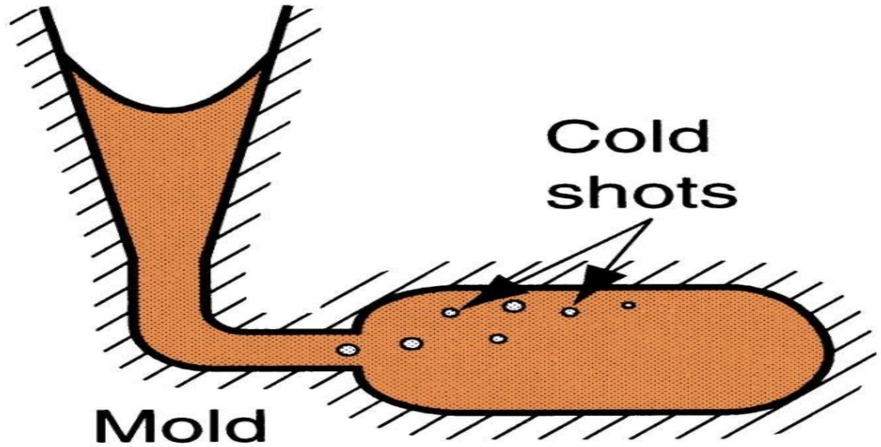
Cold Shut

Two portions of metal flow together but there is a lack of fusion due to premature(early) freezing



Cold Shot

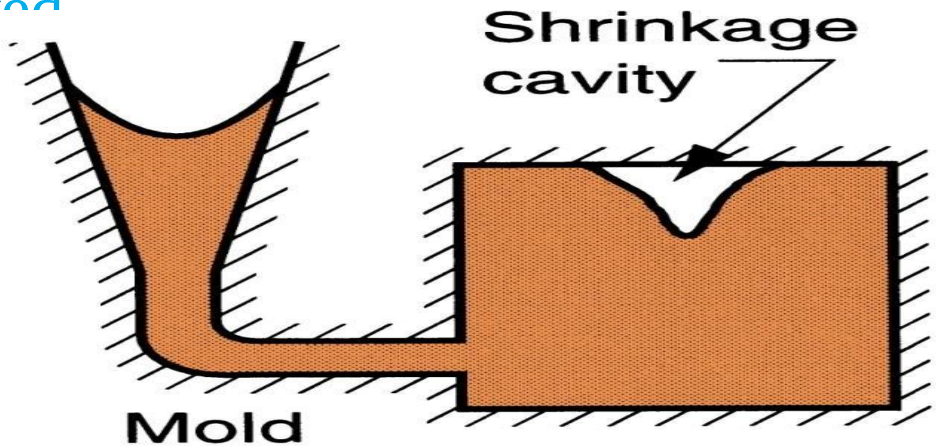
- Metal splatters during pouring and solid globules form and become entrapped in casting
- Gating system should be improved to avoid splashing



(c)

Shrinkage Cavity

- Depression in surface or internal void caused by solidification shrinkage that restricts amount of molten metal available in last region to freeze
- The collapsibility (ability to give way and allow molten metal to shrink during solidification) of mold should be improved



(d)

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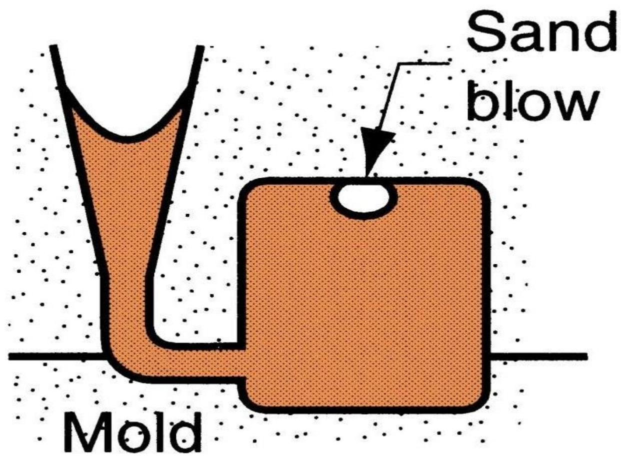
Sand Blow/Blow holes

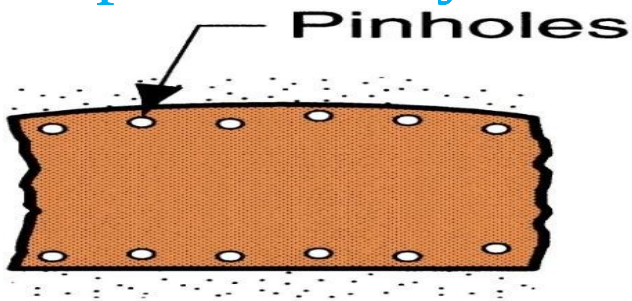
- Balloon-shaped gas cavity caused by release of mold gases during pouring
- Low permeability of mold, poor venting, high moisture content in sand are major reasons



(a)

Pin Holes

- Formation of many small gas cavities at or slightly below surface of casting
- Caused by release of gas during pouring of molten metal.
- To avoid, improve permeability & venting in mold



(b)

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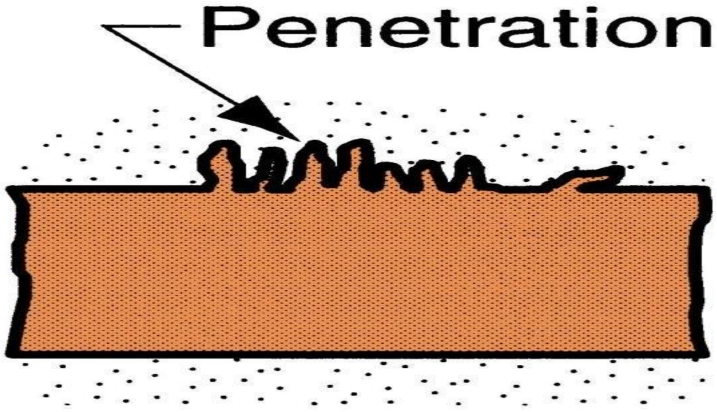
Penetration

- When fluidity of liquid metal is high, it may penetrate into sand mold or sand core, causing casting surface to consist of a mixture of sand grains and metal
- Harder packing of sand helps to alleviate this problem
- Reduce pouring temp if possible
- Use better sand binders



(e)

Mold Shift

A step in cast product at parting line caused by sidewise relative displacement of cope and drag

- It is caused by buoyancy force of molten metal.
- Cope an drag must be aligned accurately and fastened.
- Use match plate patterns

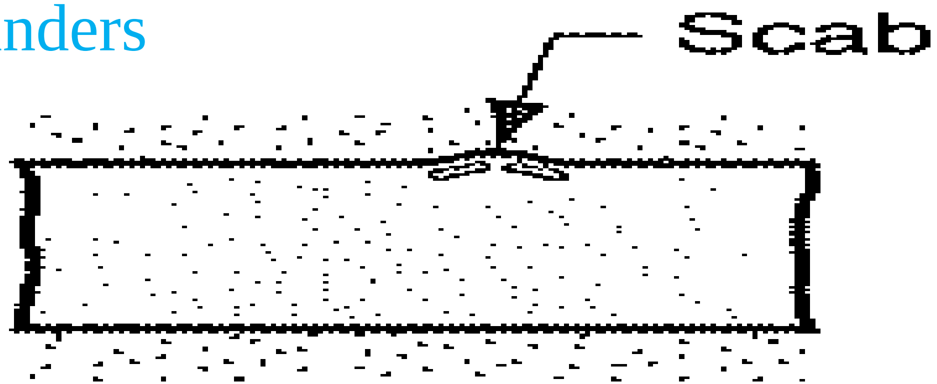
(f)

Scabs

- Scabs are rough areas on the surface of casting due to un-necessary deposit of sand and metal.

•It is caused by portions of the mold surface flaking off during solidification and becoming embedded in the casting surface

•Improve mold strength by reducing grain size and changing binders



- **Incomplete Filling**: cold shut, misrun.
- **Gaseous Entrapments**: blow hole, gas porosity.
- **Solid Inclusions**: sand inclusion, slag inclusion.

COLD SHUT

MISRUN

BLOW HOLE

GAS POROSITY

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Product Design Considerations

- Geometric simplicity
  - Although casting can be used to produce complex part geometries, simplifying the part design usually improves castability
  - Avoiding unnecessary complexities:
    - Simplifies mold-making
    - Reduces the need for cores
    - Improves the strength of the casting

Product Design Considerations

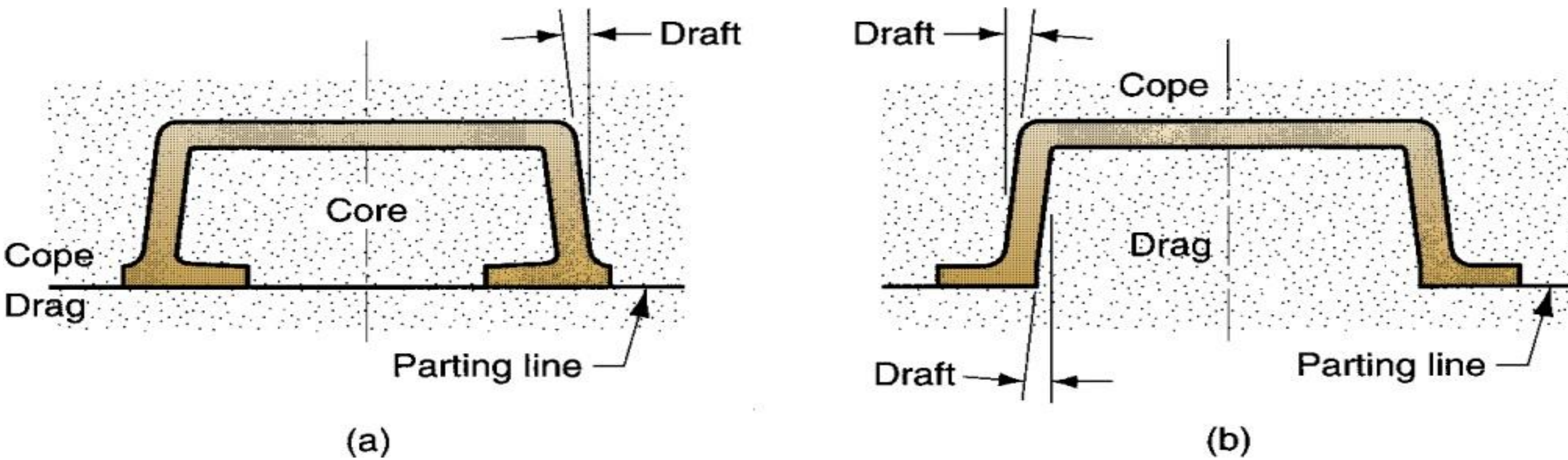
- Corners on the casting
  - Sharp corners and angles should be avoided, since they are sources of stress concentrations and may cause hot tearing and cracks
  - Generous fillets should be designed on inside corners and sharp edges should be blended

Product Design Considerations

- Draft Guidelines
  - In expendable mold casting, draft facilitates removal of pattern from mold
    - Draft = 1° for sand casting
  - In permanent mold casting, purpose is to aid in removal of the part from the mold
    - Draft = 2° to 3° for permanent mold processes
  - Similar tapers should be allowed for solid cores

Draft

- Design change to eliminate need for using a core: (a) original design, and (b) redesign



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Product Design Considerations

- Dimensional Tolerances and Surface Finish
  - Dimensional accuracy and finish vary significantly, depending on process
    - Poor dimensional accuracies and finish for sand casting
    - Good dimensional accuracies and finish for die casting and investment casting

Product Design Considerations

- Machining Allowances
  - Almost all sand castings must be machined to achieve the required dimensions and part features
  - Additional material, called the *machining allowance*, is left on the casting in those surfaces where machining is necessary
  - Typical machining allowances for sand castings are around 1.5 and 3 mm (1/16 and 1/4 in)

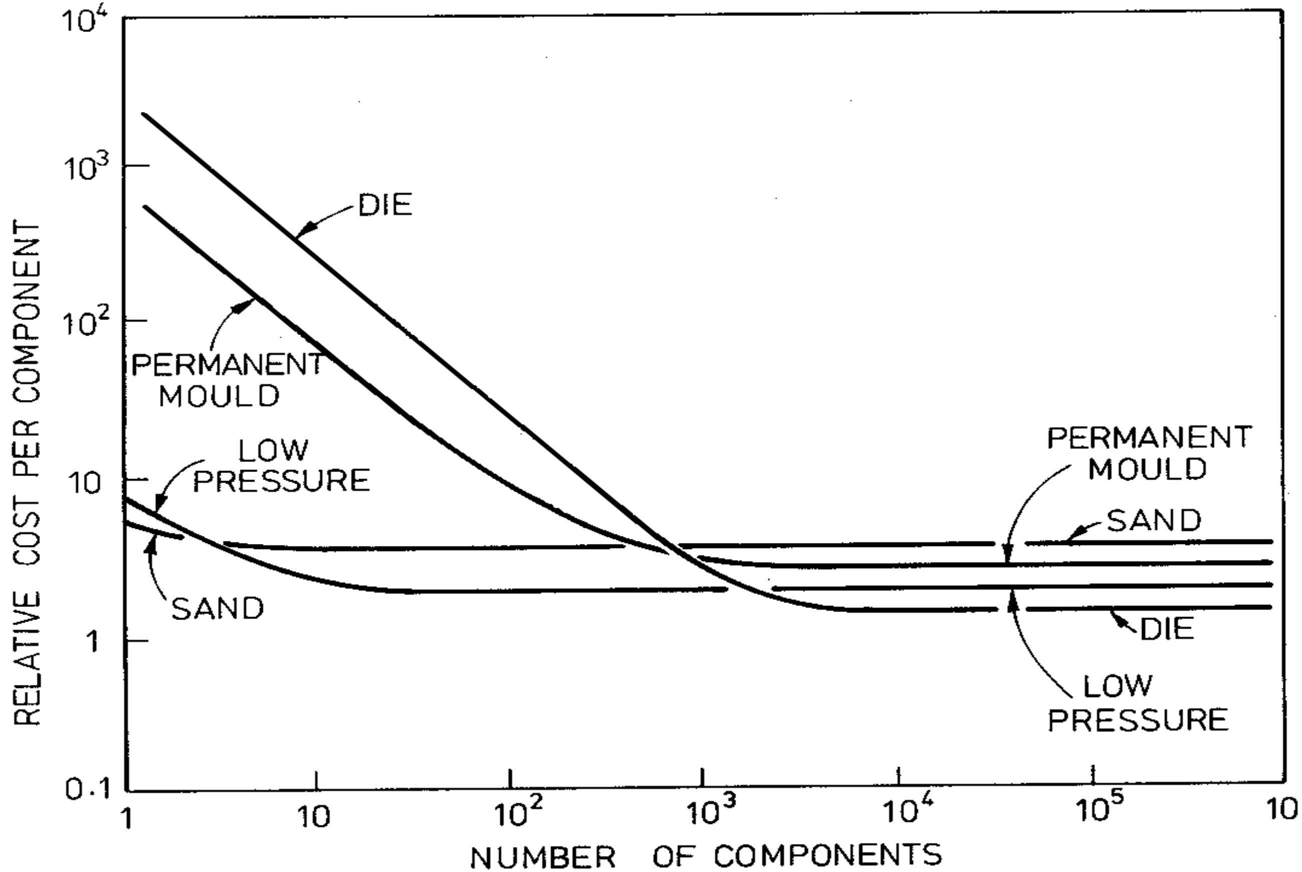
Casting Costs

TABLE 5.10

Process	Cost* Die	Cost* Equipment	Cost* Labor	Production rate (Pc/hr)
Sand	L	L	L–M	<20
Shell-mold	L–M	M-H	L–M	<50
Plaster	L–M	M	M–H	<10
Investment	M–H	L-M	H	<1000
Permanent mold	M	M	L–M	<60
Die	H	H	L–M	<200
Centrifugal	M	H	L–M	<50

* L, low; M, medium; H, high.

Processs Economics



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