Metal Casting

Casting

Process in which molten metal flows by gravity or other force into a mold where it solidifies in the shape of the mold cavity

- The term *casting* also applies to the part made in the process
- Steps in casting seem simple:
  1. Melt the metal
  2. Pour it into a mold
  3. Let it freeze

Capabilities and Advantages of Casting

- Can create complex part geometries that can not be made by any other process
- Some casting processes are *net shape*; others are *near net shape*
- Can produce very large parts (with weight more than 100 tons), like m/c bed
- Casting can be applied to shape any metal that can melt
- Some casting methods are suited to mass production
- Can also be applied on polymers and ceramics

Disadvantages of Casting

- Different disadvantages for different casting processes:
  - Limitations on mechanical properties
  - Poor dimensional accuracy and surface finish for some processes; e.g., sand casting
  - Safety hazards to workers due to hot molten metals
  - Environmental problems

Parts Made by Casting

- Big parts
  - Engine blocks and heads for automotive vehicles, wood burning stoves, machine frames, railway wheels, pipes, bells, pump housings
- Small parts
  - Dental crowns, jewelry, small statues, frying pans
- All varieties of metals can be cast - ferrous and nonferrous

Molding material

Choice of molding materials is based on their processing properties.

- Sand: Green sand (mixture of sand, clay, water, and some organic additives) is the **most commonly used**.
- Metals and alloys: Are used in multiple-use mold casting processes.
- Plaster: Plaster of Paris (or calcium sulfate or gypsum), with various additions to improve green strength, dry strength, permeability etc.
- Ceramic: Ceramic molds are similar to plaster molds, except that the mold can **withstand the higher melting point metals**.
- Graphite: Powdered graphite can be combined with cement, starch, and water and compacted around a pattern.
- Rubber: Several types of artificial elastomers can be compounded in liquid form and poured over a pattern to form a Semi-rigid mold. Rubber molds **are flexible** and used for **intricate pattern or shapes** small castings of low melting point materials.

COMPOSITION OF MOLDING SAND

Material used for making green sand moulds consists following:

1. **Sand (70-85%): to provide refractoriness**
2. **Clay (10-20%): to act as binder, along with water, impart tensile and shear strength to the molding sand**
3. **Water (3-6%): to activate the clay and provide p**lasticity
4. **Organic additives (1-6%): to enhance desired sand properties**

CONSITUTENT OF MOULDING SAND

Clay

Clay is generally used **as binding agent** in the molding sand **to provide the strength**, because of its low cost and wider utility.

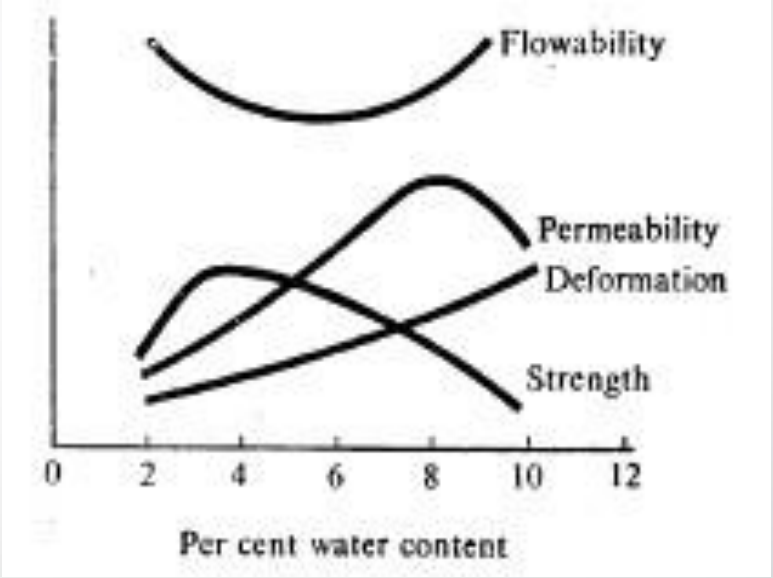
The most popular types of clay used are:

1. **Kaolinite or fire clay** (melting point: range of 1750 to 1787°c)
2. **Bentonite** (melting point: range of 1250 to 1300 0c)

Kaolinite and Bentonite rocks

Water

- Water **activates clay** so that it **develops** the necessary plasticity and strength.
- Amount of water used should be properly controlled.
- A part of the water absorbed by clay helps in bonding while the **remainder** up to a limit helps in improving the plasticity.
- Excessive water **decreases** the strength and formability.
- Normal percentages of water used are from 2 to 8%.



ADDITIVES

Additives are added to sand to **enhance the specific properties**.

Sea coal (Added upto 8%)

- **It is finely ground soft coal**
- **Obtain smoother and cleaner surface of casting**
- **Reduce adherence of sand particles to casting**

Cereals (Added upto 0.25% to 2%)

- **It is finely ground corn starch**
- **Increase green and dry strength of moulding sand**

PROPERTIES OF MOLDING SAND

Properties:

1. **Refractoriness**
2. **Cohesiveness**
3. **Permeability**
4. **Plasticity**
5. **Adhesiveness**

REFRACTORINESS

- **Refractoriness** is the ability of moulding sand to withstand the high temperatures of melt so that it does not fuse with melt.
- Presence of *sand imparts* this property to the moulding sand.
- Higher the pouring temperature higher will be the required refractoriness and vice versa.

PERMEABILITY

- Permeability is the ability to permit gases to escape through it.

- Permeability is the property of the moulding sand due to which it allows the gases inside the mold (during solidification of casting) to escape to the surroundings.
- The mould must be enough porous to permit the gases to escape and avoid defects due to entrapped gases.

PLASTICITY

- Plasticity is also known as Flowability.
- Plasticity is the property of moulding sand due to which it flow around and over the pattern to **acquire the desired shape during** molding.
- Moulding sand should be plastic so that it flows and acquire the desired shape under the pressure.
- *Flowability* of moulding sand **increases as clay and water content increase**.

COHESIVENESS

- **Cohesiveness** is defined as the *ability to retain a given shape.*
- Thus due to cohesiveness, rammed moulding sand particles are bonded together once the pattern is withdrawn from mould.
- Cohesiveness is obtained by *coating the sand grains with clays* that become cohesive when moistened.

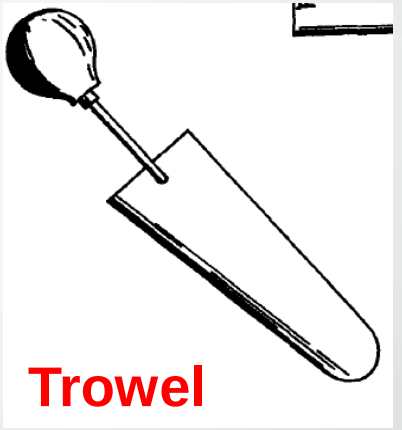
ADHESIVENESS

- Adhesiveness is the property of the molding sand by which it is **capable to adhere** to the surface of the molding flask.
- Adhesiveness renders sand particles capable of sticking to the surface of moulding box of flask.
- Because of Adhesiveness moulding sand mass is **held in the moulding box** and can be **manipulated** as desired without any **chance of its falling out**.

TOOLS AND EQUIPMENT

Trowels:

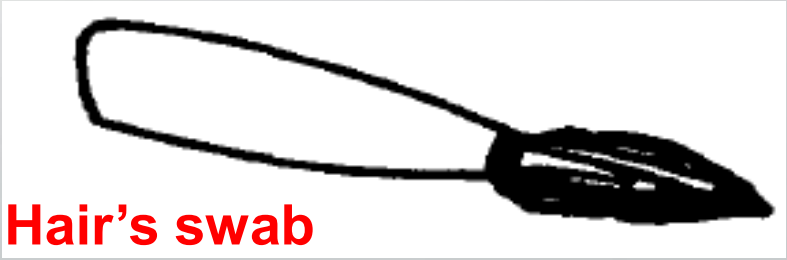
- To sleek down the surface, to strike-off and cut away the surface



Hair swab:

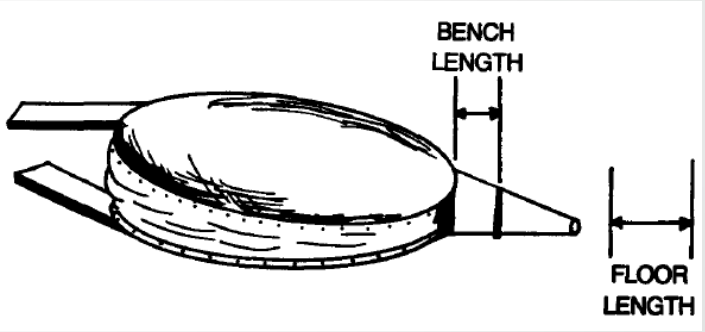
- Used to apply wet mold wash and core wash prior to drying

It is applied around the edge before pattern is withdrawn



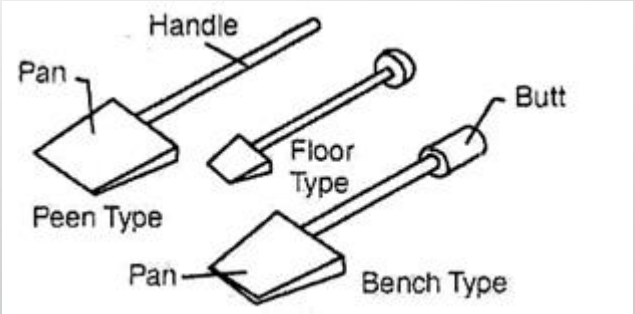
Bellows:

- For blowing out the sand at the cast cavity after removing pattern



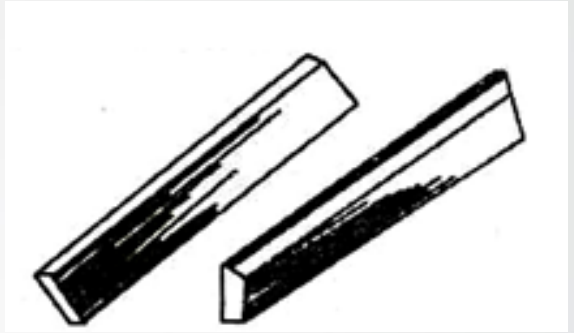
Rammers:

- Used to spread and hardened the loose sand by ramming action such that sand particles are packed and binded properly
- Three types of rammer: peen rammer, floor rammer and bench rammer



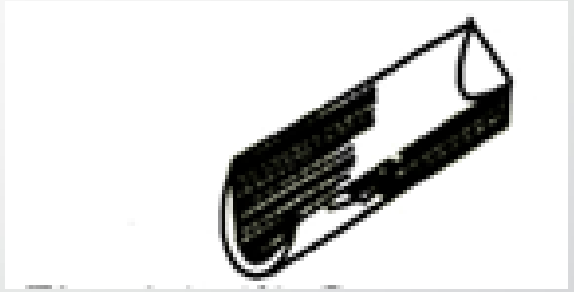
Strike-off bar:

- To strike-off excess sand from the mold box to provide smooth surface



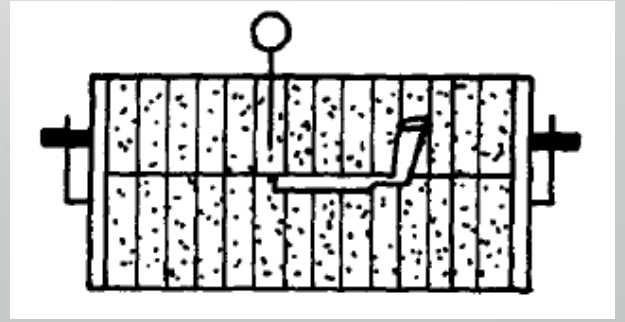
Gate cutter:

- Used to cut the gate in the mold which acts as passage for hot metal



Vent wire:

- It is used to make hole into the cope and drag of sand mold to allow easy access of gases to the outside, during the pouring of the casting

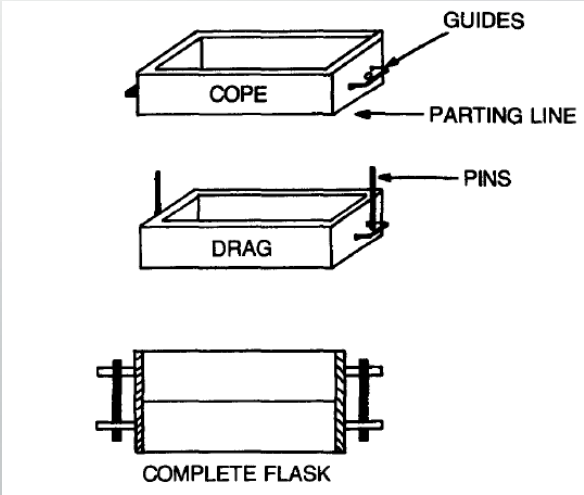


Sprue cutter:

- It is used to make the passage of molten metal to the gate

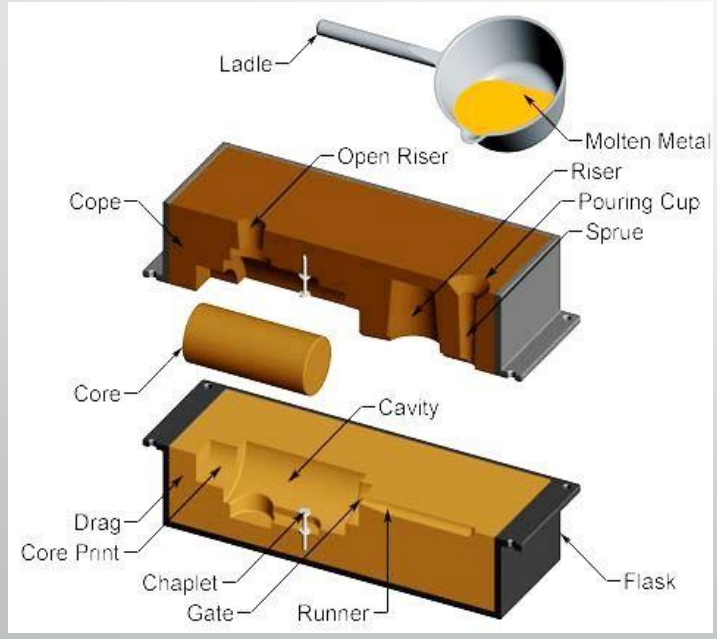
Molding box:

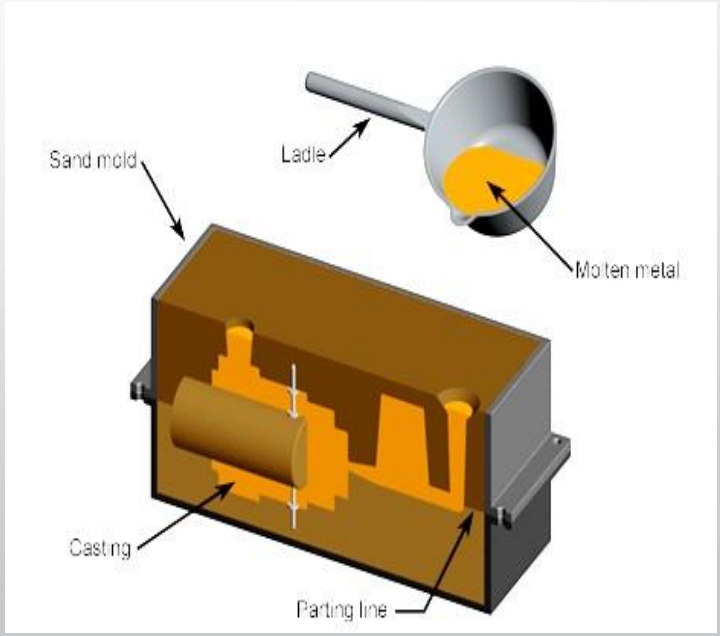
- These are used to pack the green sand, to form mold and carry out casting
- Consist of upper part (cope) and bottom part (drag) and locating pins to align properly



Moulds

- Mould or Mould cavity contains molten metal and is essentially a negative of the final product.
- Mould is obtained by pattern in moulding material (sand).
- Mould material should posses refractory characteristics and withstand the pouring temperature.



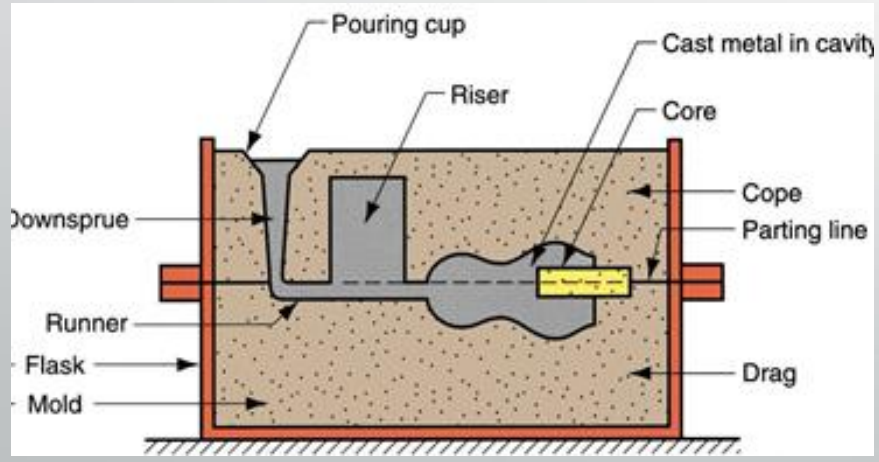


Two Categories of Casting Processes

1. **Expendable mold processes** – 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 Casting Mold Terms

- Mold consists of two halves:
  - ***Cope*** = upper half of mold
  - ***Drag*** = bottom half
- Mold halves are contained in a box, called a ***flask***
- The two halves separate at the ***parting line***



Forming the Mold Cavity

- ***Cavity*** *is inverse of final shape with shrinkage allowance*

Pattern *is model of final shape with shrinkage allowance*

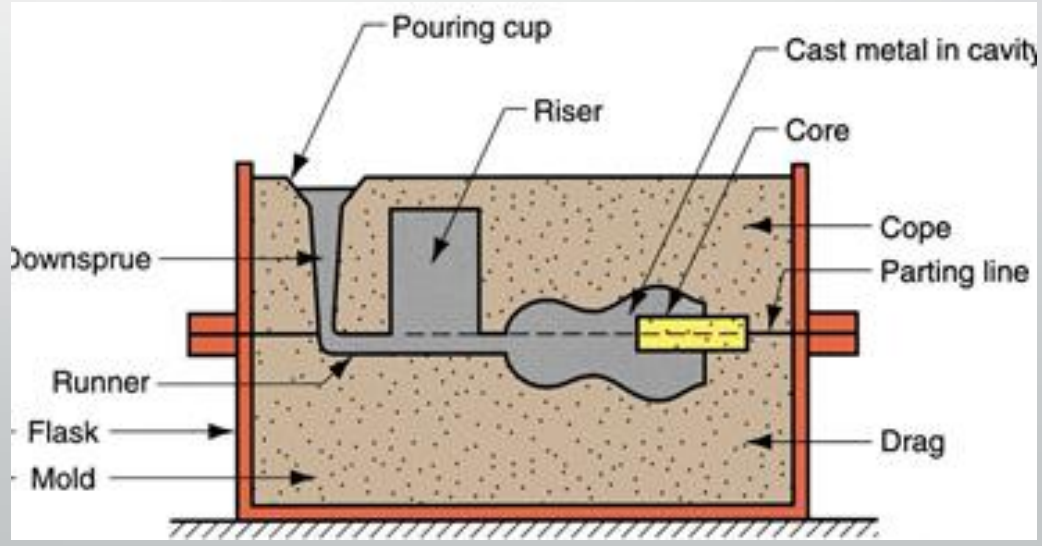
Wet sand *is made by adding binder in the sand*

- Mold cavity is formed by packing sand around a ***pattern***

When the ***pattern*** is removed, the remaining cavity of the packed sand has desired shape of cast part

- The pattern is usually oversized to allow for shrinkage of metal during solidification and cooling

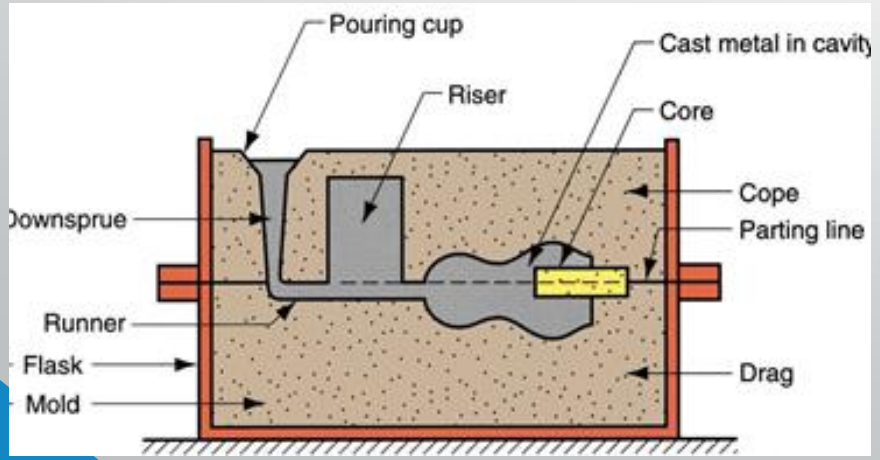
Difference among pattern, cavity & part ?

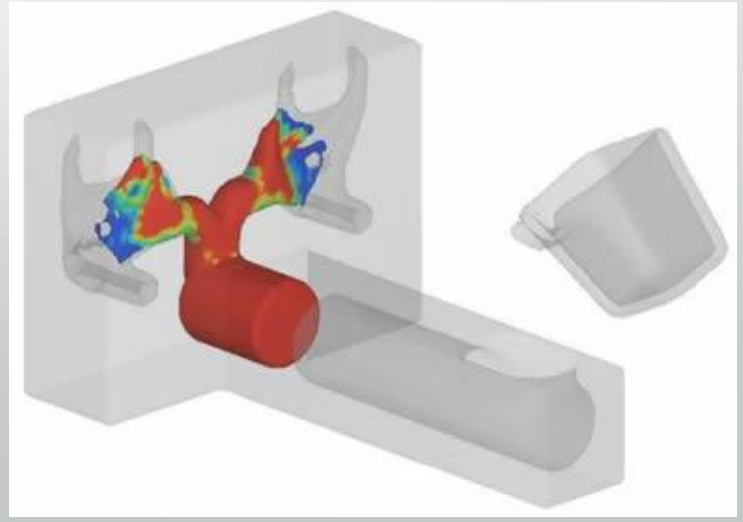


Gating System

It is channel through which molten metal flows into cavity from outside of mold

- Consists of a ***down-sprue***, through which metal enters a ***runner*** leading to the main cavity
- At the top of down-sprue, a ***pouring cup*** is often used to minimize splash and turbulence as the metal flows into down-sprue

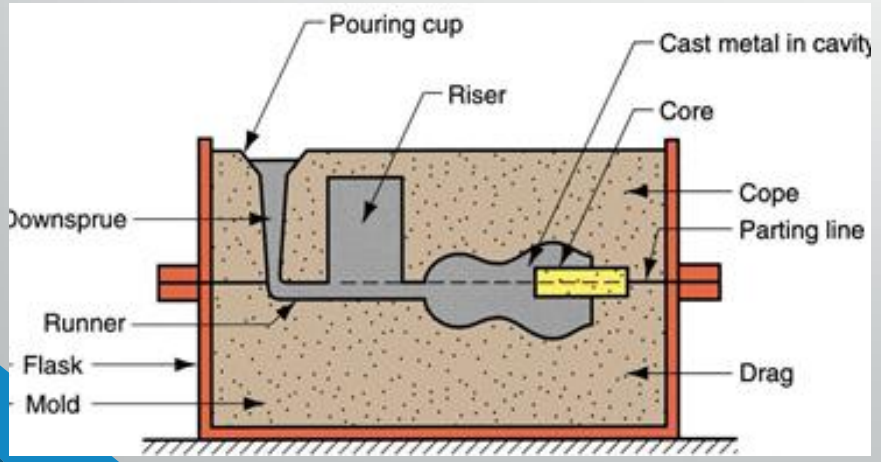




Riser

It is a reservoir in the mold which is a source of liquid metal to compensate for shrinkage of the part during solidification

Most metals are less dense as a liquid than as a solid so castings shrink upon cooling, which can leave a void at the last point to solidify. Risers prevent this by providing molten metal to the casting as it solidifies, so that the cavity forms in the riser and not in the casting



The Pattern

A full-sized model of the part, slightly enlarged to account for shrinkage and machining allowances in the casting

- Pattern materials:
  - **Wood** - common material because it is easy to work, but it warps
  - **Metal** - more expensive to make, but lasts much longer
  - **Plastic** - compromise between wood and metal

Types of Patterns

(a) solid pattern

(b) split pattern

(c) match-plate pattern

(d) cope and drag pattern

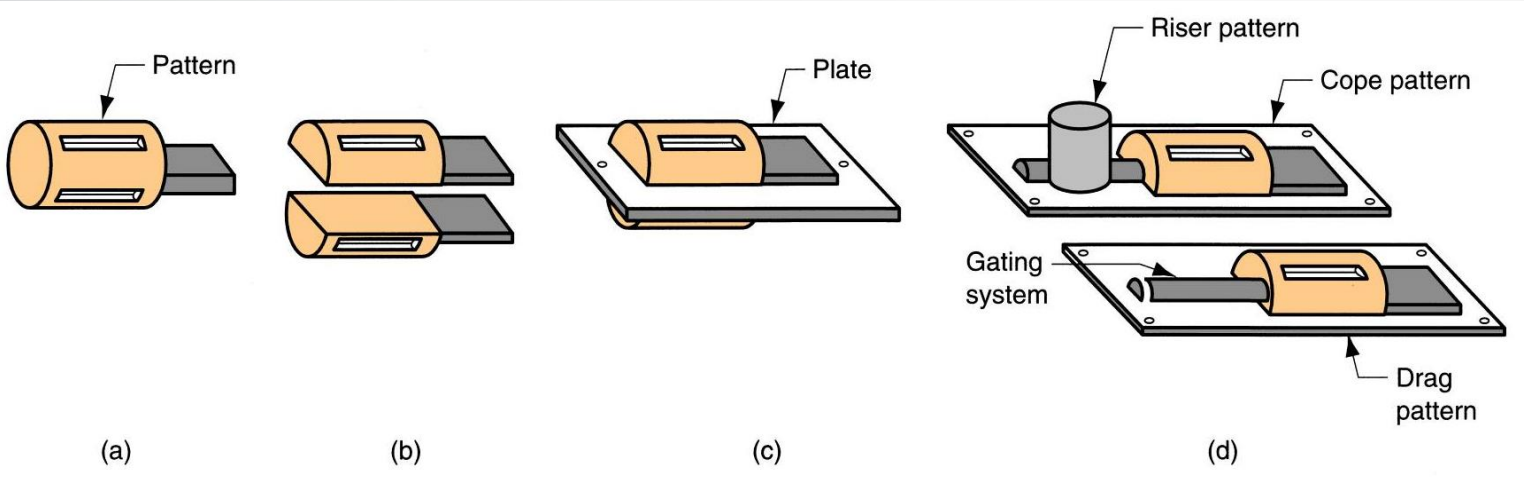
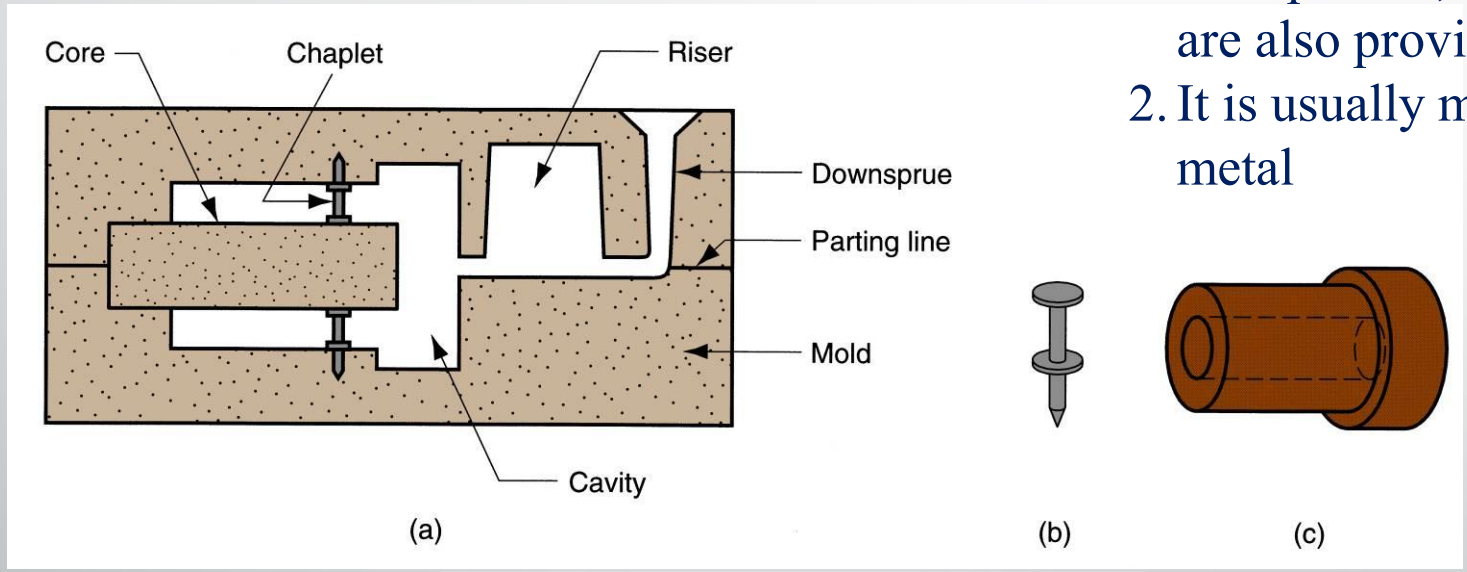


Figure: Types of patterns used in sand casting:

Core in Mold

A core is a full-scale model of interior surfaces of the part.

1. Like pattern, shrinkage allowances are also provided in core. (-ve or +)?
2. It is usually made of compacted sand, metal



(a) Core held in place in the mold cavity by chaplets, (b) possible chaplet design, (c) casting with internal cavity.

CORE BOX

- **Core boxes** are used for making cores. A core box is a wooden or metallic type of pattern and are made either single or in two parts.

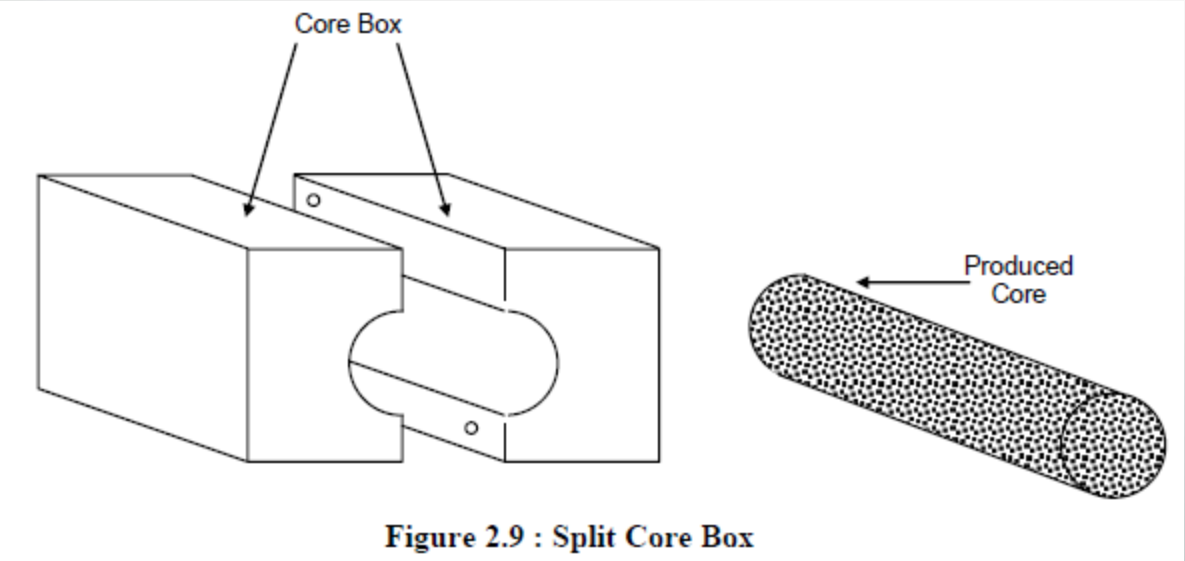
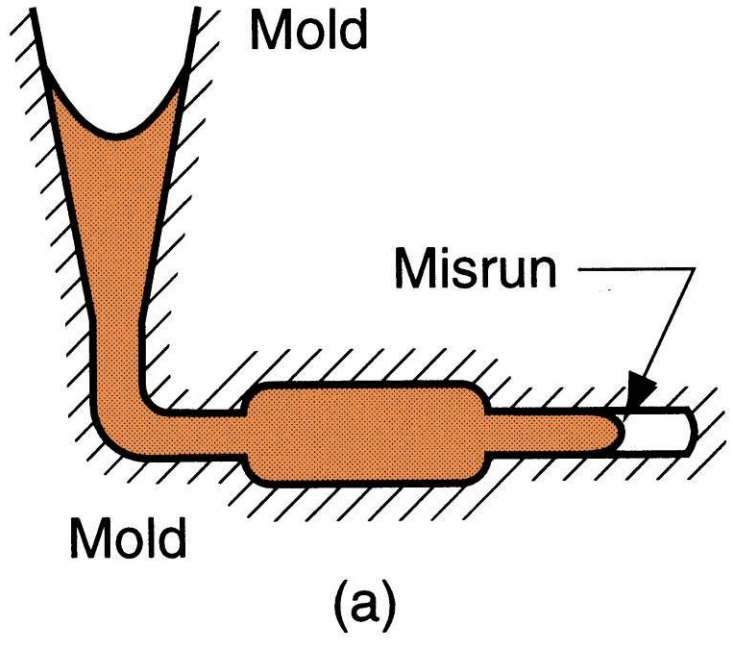


Figure 2.9 : Split Core Box

Casting Defects

General Defects: Misrun

A casting that has solidified before completely filling mold cavity



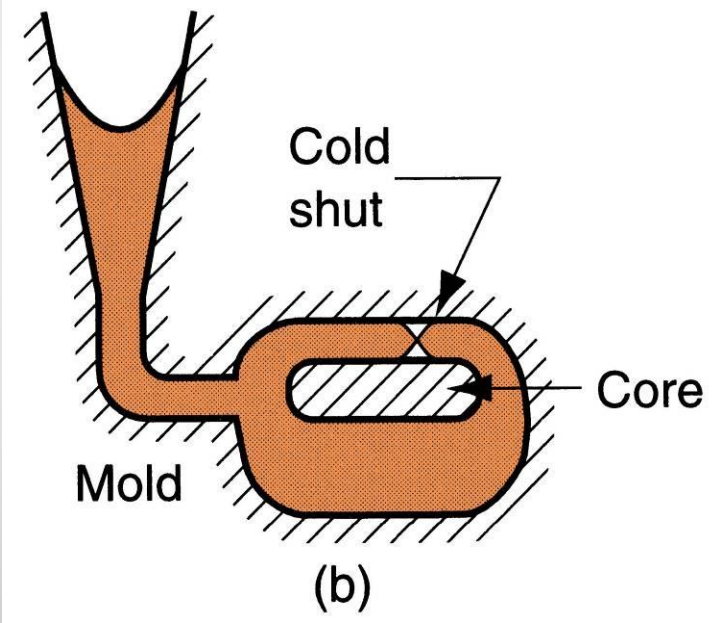
Reasons:

a. Fluidity of molten metal is insufficient
b. Pouring temperature is too low
c. Pouring is done too slowly
d. Cross section of mold cavity is too thin
e. Mold design is not in accordance with Chvorinov's rule: V/A at the section closer to the gating system should be higher than that far from gating system

Some common defects in castings: (a) **misrun**

General Defects: Cold Shut

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



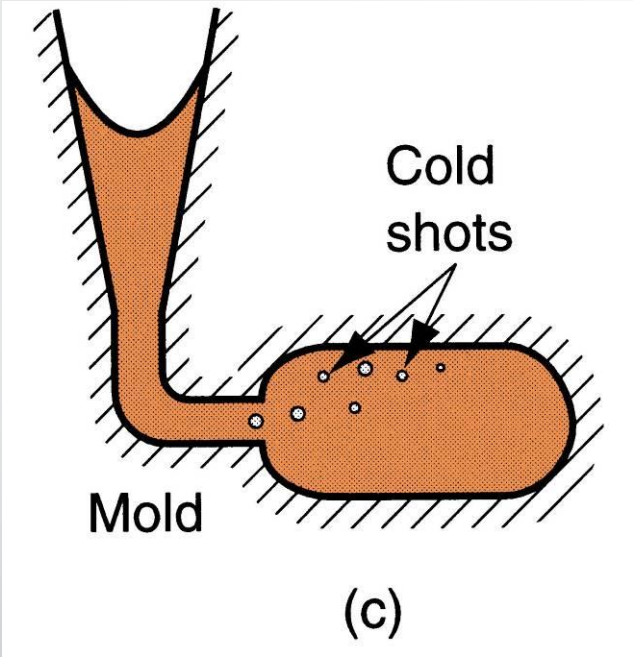
Reasons:

Same as for misrun

Some common defects in castings: (b) **cold shut**

General Defects: Cold Shot

Metal splashes during pouring and solid globules form and become entrapped in casting

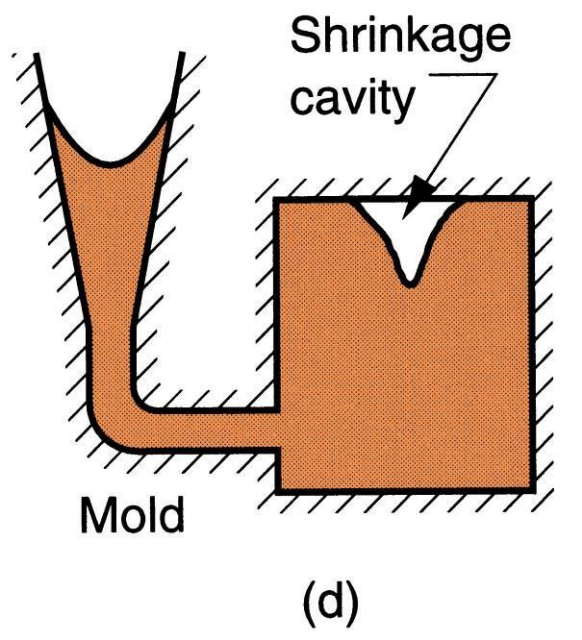


Gating system should be improved to avoid splashing

Some common defects in castings: (c) **cold shot**

General Defects: Shrinkage Cavity

Depression in surface or internal void caused by solidification shrinkage

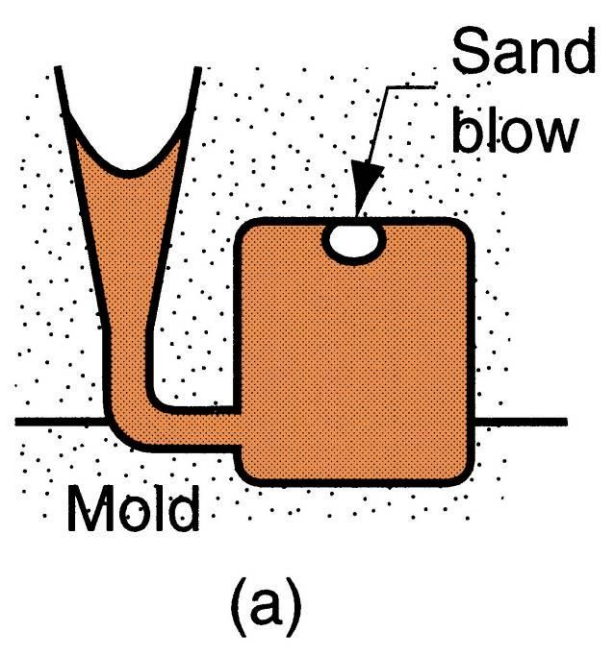


Proper riser design can solve this issue

Some common defects in castings: (d) **shrinkage cavity**

Sand Casting Defects: Sand Blow

Balloon-shaped gas cavity caused by release of mold gases during pouring

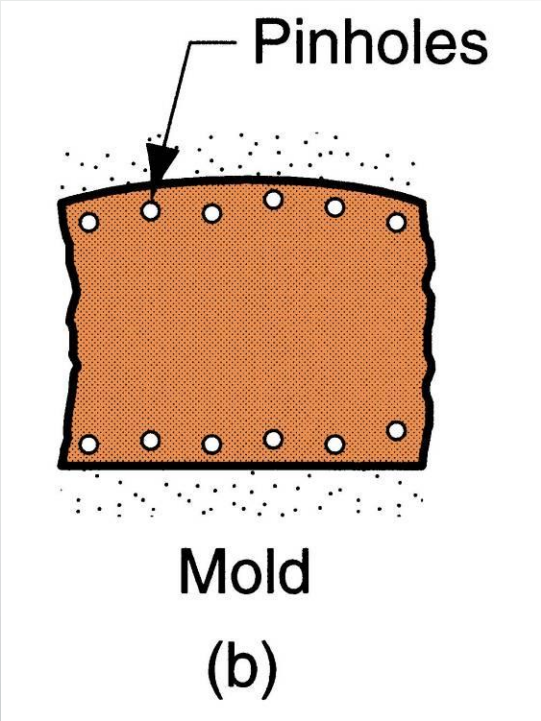


Low permeability of mold, poor venting, high moisture content in sand are major reasons

Common defects in sand castings: (a) **sand blow**

Sand Casting Defects: Pin Holes

Formation of many small gas cavities at or slightly below surface of casting

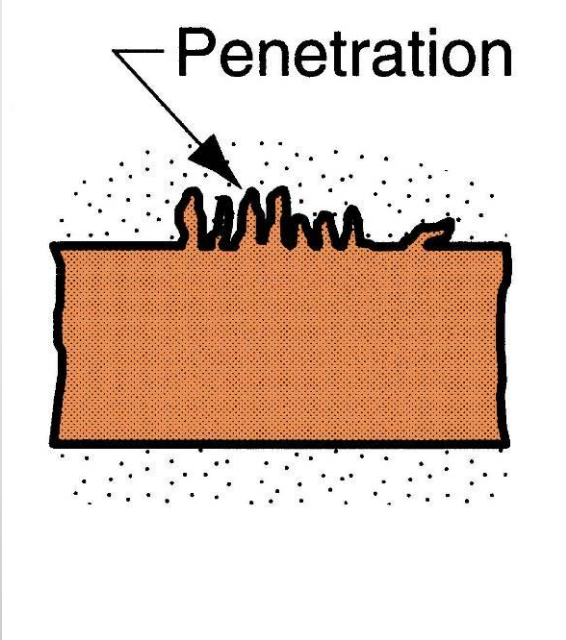


Caused by release of gas during pouring of molten metal.
To avoid, improve permeability & venting in mold

Common defects in sand castings: (b) **pin holes**

Sand Casting Defects: Penetration

When fluidity of liquid metal is high, it may penetrate into sand mold or core, causing casting surface to consist of a mixture of sand grains and metal

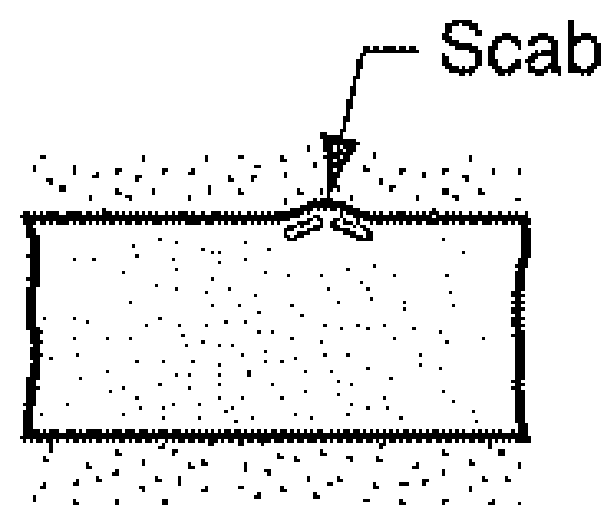


Harder packing of sand helps to alleviate this problem
Reduce pouring temp if possible
Use better sand binders

Common defects in sand castings: (c) **penetration**

Sand Casting Defects: Scabs

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



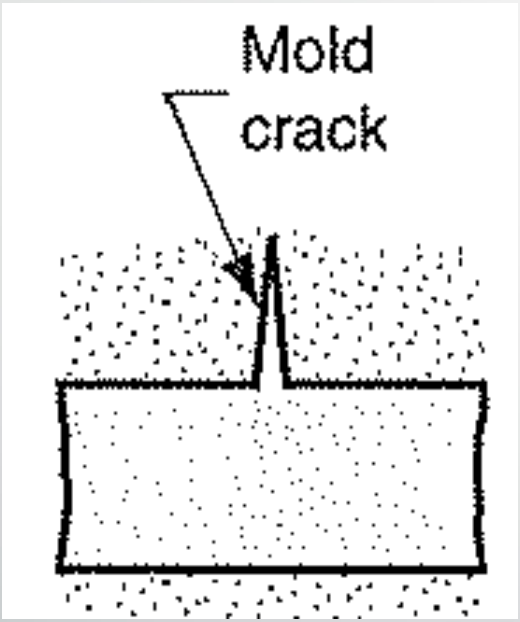
It is caused by portions of the mold surface flaking off during solidification and becoming embedded in the casting surface

Improve mold strength by reducing grain size and changing binders

Common defects in sand castings: (d) **scab**

Sand Casting Defects: Mold Crack

Occurs when the strength of mold is not sufficient to withstand high temperatures



Improve mold strength by reducing grain size and changing binders

Common defects in sand castings: (e) **mold crack**

THANK YOU