Metals Forming

Centrifugal Casting

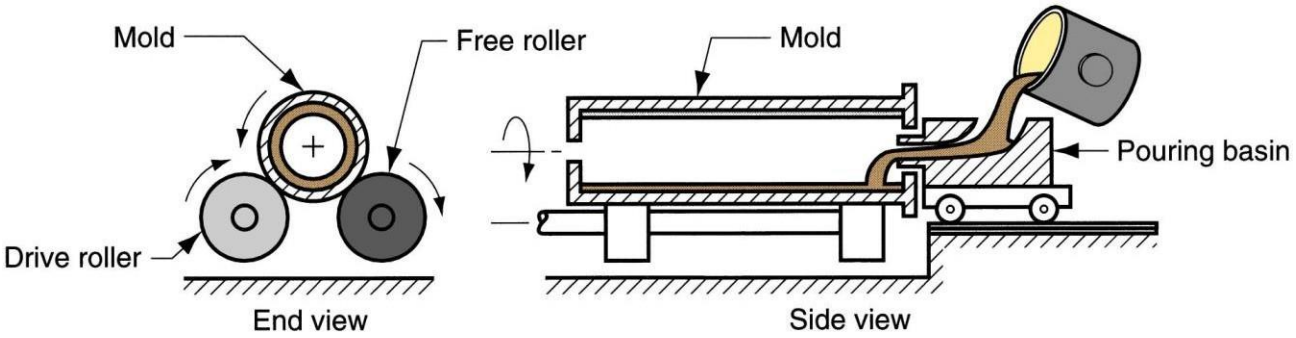
A type of casting processes in which the mold is rotated at high speed so centrifugal force distributes molten metal to outer regions of die cavity

- **The group includes:**
  - True centrifugal casting
  - Semicentrifugal casting
  - Centrifuge casting

(a) True Centrifugal Casting

Molten metal is poured into a rotating mold to produce **a tubular part.**

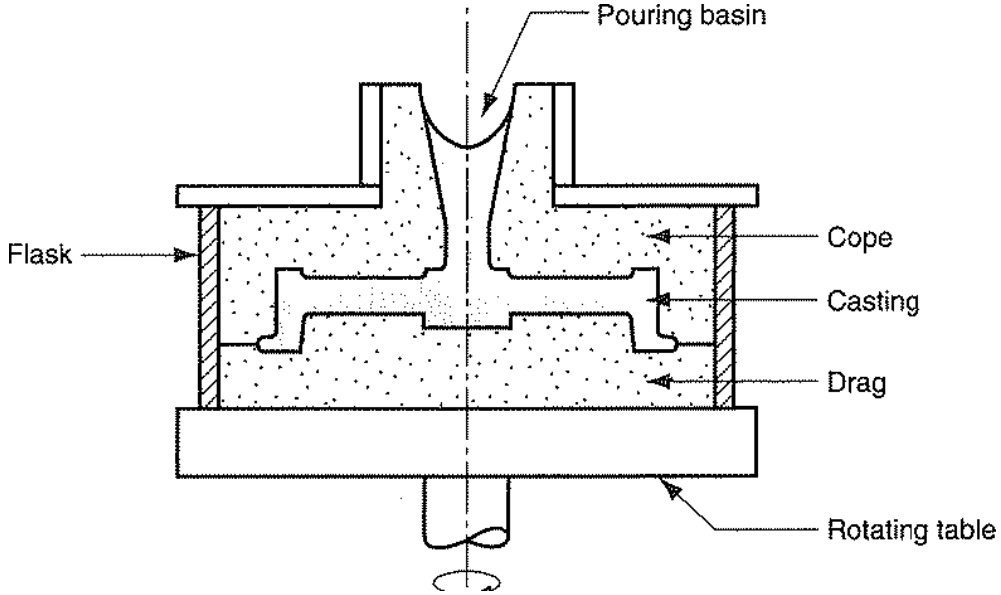
- In some operations, mold rotation commences after pouring rather than before.
- Rotational axes can be either **horizontal or vertical**
- Parts: **pipes, tubes, bushings, and rings**
- Outside shape of casting can be **round, octagonal, hexagonal**, etc , but inside shape is (theoretically) perfectly round, due to radially symmetric forces



(b) Semicentrifugal Casting

Centrifugal force is used to produce solid castings rather than tubular parts.

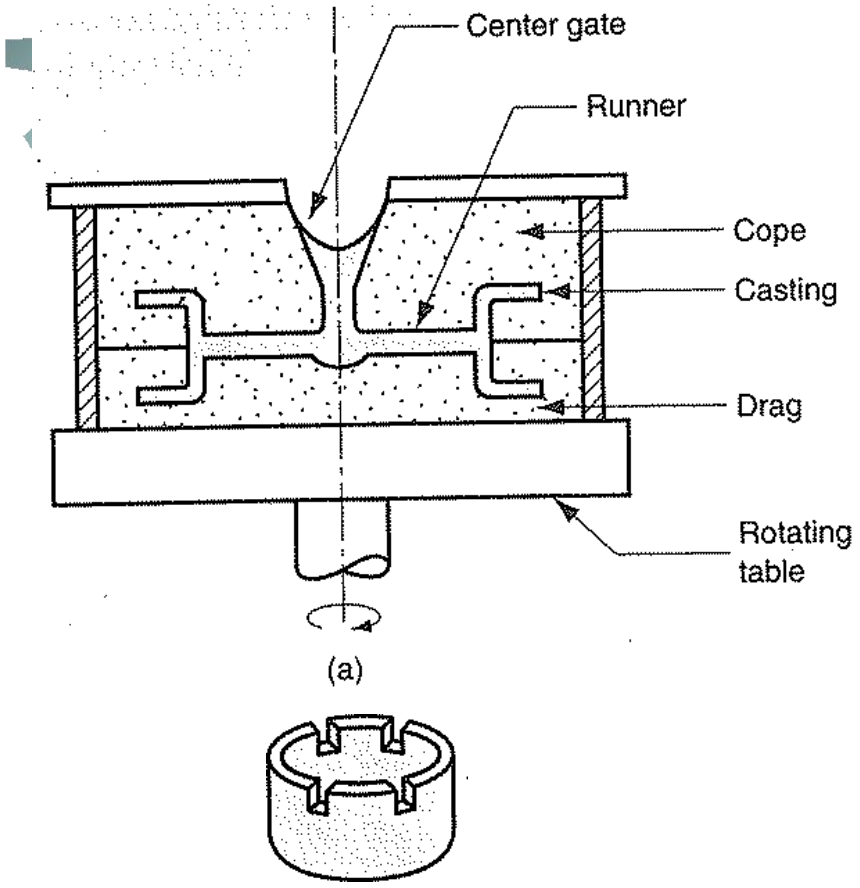
- Molds are designed with risers at center to supply feed metal
- Density of metal in final casting is greater in outer sections than at center of rotation



* Axes of parts and rotational axis does not match exactly.
* Often used on parts in which center of casting is machined away, thus eliminating the portion where quality is lowest

Examples: wheels and pulleys.

(c) 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

Casting Defects

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

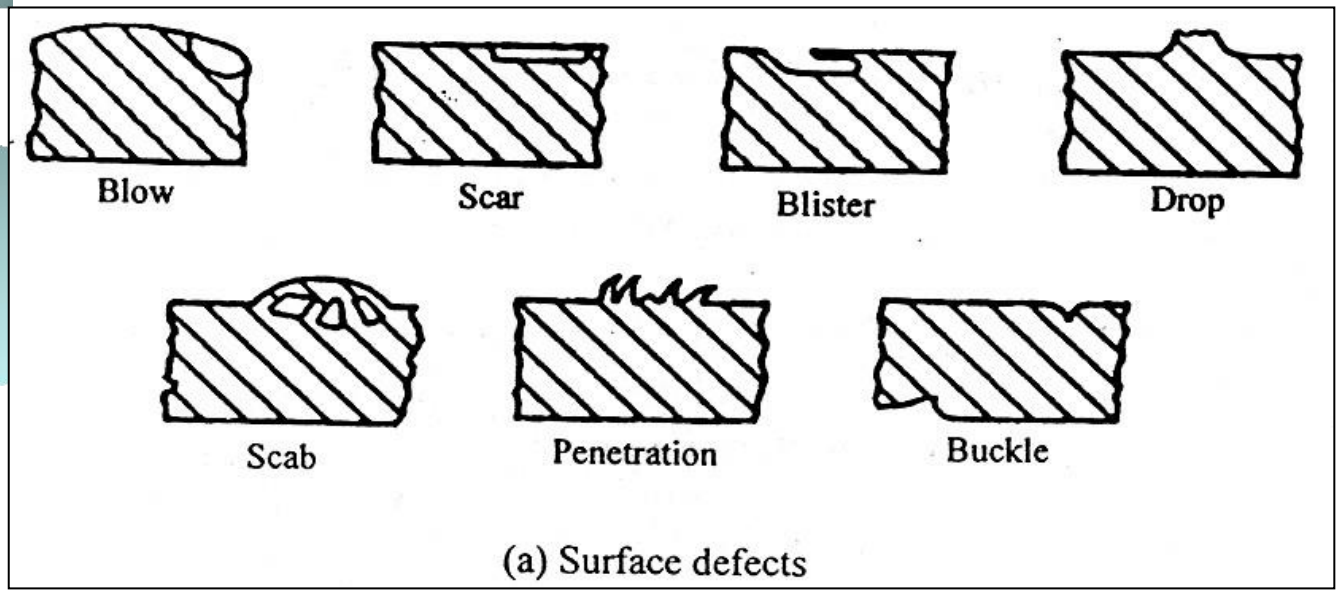
- Fault in design of casting pattern.
- Fault in design on mold and core.
- Fault in design of gating system and riser.
- Improper choice of moulding sand.
- Improper metal composition.
- Inadequate melting temperature and rate of pouring.

Casting Defects

Classification of casting defects

Casting defects		
Surface Defect	**Internal Defect**	**Visible defects**
Blow Scar Blister Drop Scab Penetration Buckle	Blow holes Porosity Pin holes Inclusions Dross	Wash Rat tail Swell Misrun Cold shut Hot tear Shrinkage/Shift

Surface Defects



(a) Surface defects

- **These are due to**

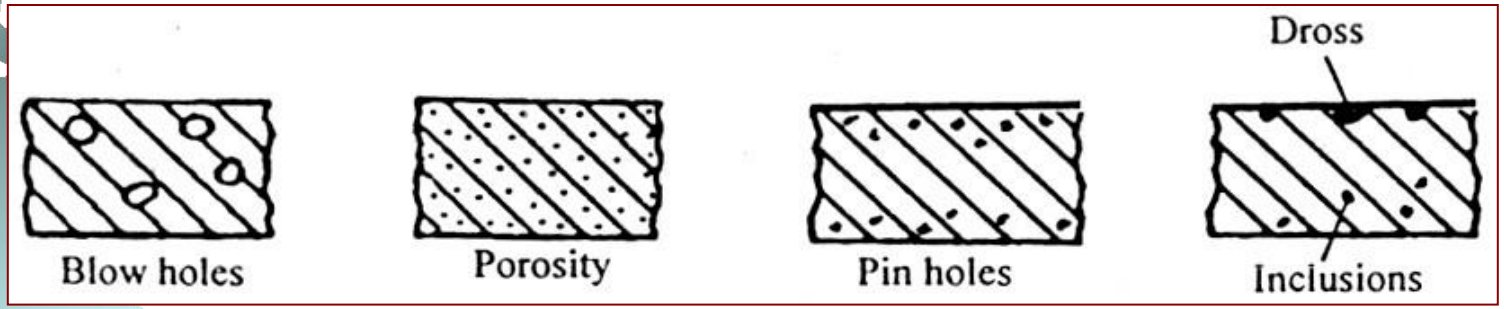
*** poor design** *** quality of sand molds** *** poor ramming.**

- **Blow is relatively large cavity produced by gases which displace molten metal from convex surface.**
- **Scar is shallow blow generally occurring on a flat surface.**

Surface Defects

- **Blister** is a scar covered with a thin layer of metal. **These are due to** improper permeability or venting. Sometimes excessive gas forming constituents in moulding sand.
- **Drop** is an irregularly-shaped projection on the cope surface caused by dropping of sand.
- **A scab** when an up heaved sand gets separated from the mould surface and the molten metal flows between the displaced sand and the mold.
- **Penetration** occurs when the molten metal flows between the sand particles in the mould. **These defects are due** to inadequate strength of the mold and high temperature of the molten metal adds on it.
- **Buckle** is a vee-shaped depression on the surface of a flat casting caused by expansion of a thin layer of sand at the mould face. A proper amount of volatile additives in moulding material could eliminate this defect by providing room for expansion.

Internal Defects

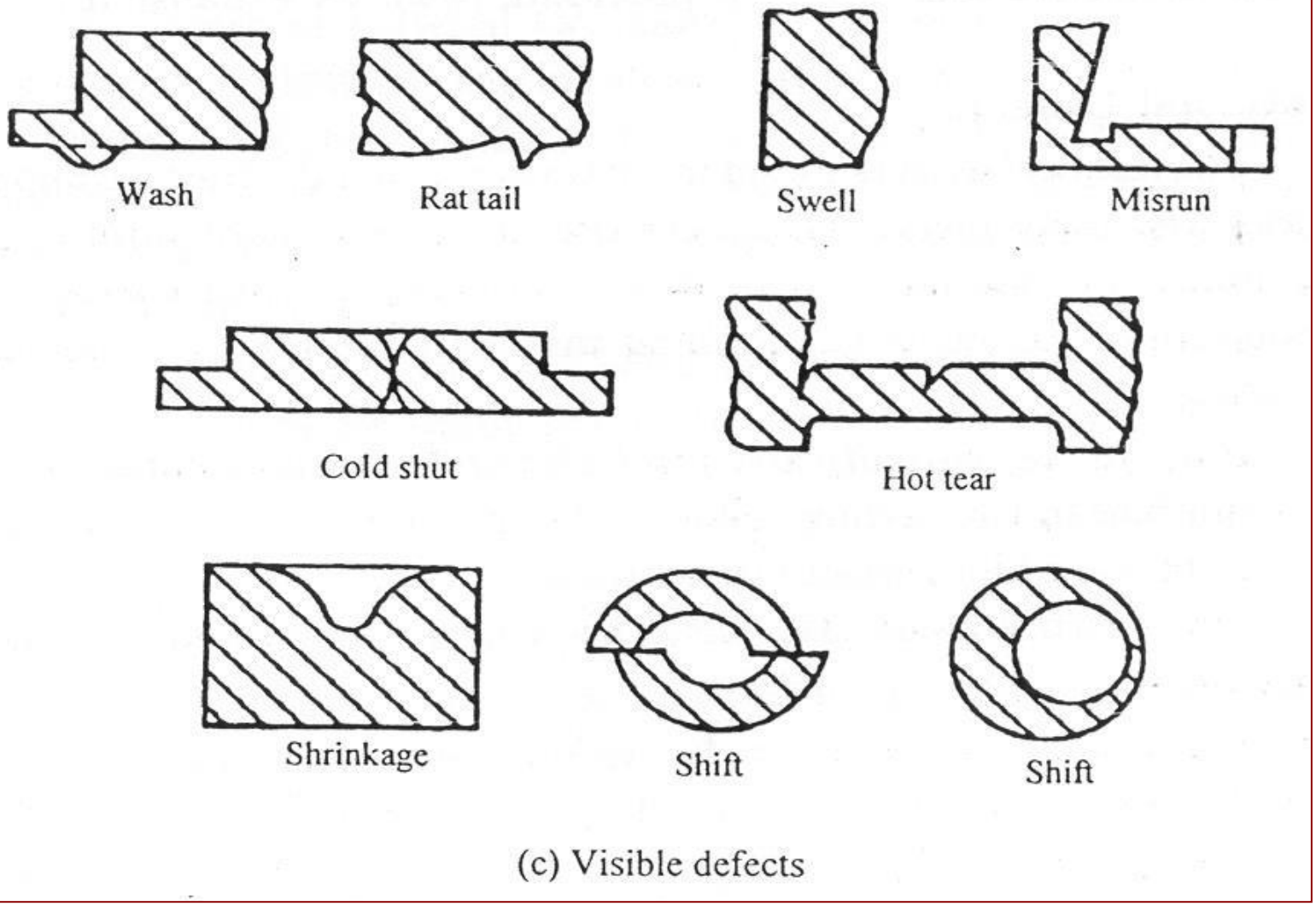


- The internal defects found in the castings are mainly due to trapped gases and dirty metal. These defects also occur due to

* Gases get trapped due to hard ramming * improper venting * excessive moisture or excessive gas forming materials are used for mould making.

- **Blow holes** are large spherical shaped gas bubbles, while **porosity** indicates a large number of uniformly distributed tiny holes.
- **Pin holes** are tiny blow holes appearing just below the casting surface.
- **Inclusions** are the non-metallic particles in the metal matrix.
- **Dross** lighter impurities appearing the casting surface..

Visible Defects



(c) Visible defects

Visible Defects

- **These defects are due**

Insufficient mould strength * insufficient metal * low pouring temperature * bad design of casting

- **Wash** is a low projection near the gate caused by erosion of sand by the flowing metal.

- **Rat tail** is a long, shallow, angular depression caused by expansion of the sand.

- **Swell** is the deformation of vertical mould surface due to hydrostatic pressure caused by moisture in the sand.

Visible Defects

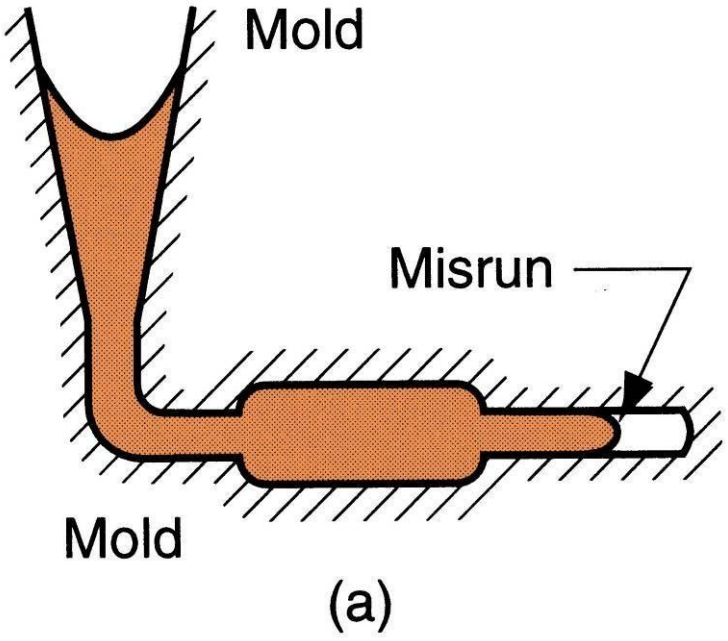
- **Misrun and cold shut** are caused by insufficient superheat provided to the liquid metal.
- **Hot tear** is the crack in the casting caused by high residual stresses.
- **Shrinkage** is essentially solidification contraction and occurs due to improper use of Riser.
- **Shift** is due to misalignment of two parts of the mould or incorrect core location.

General Defects: Misrun

General Defects in Casting

(a) misrun

A casting that has solidified before completely filling mold cavity



(a) misrun

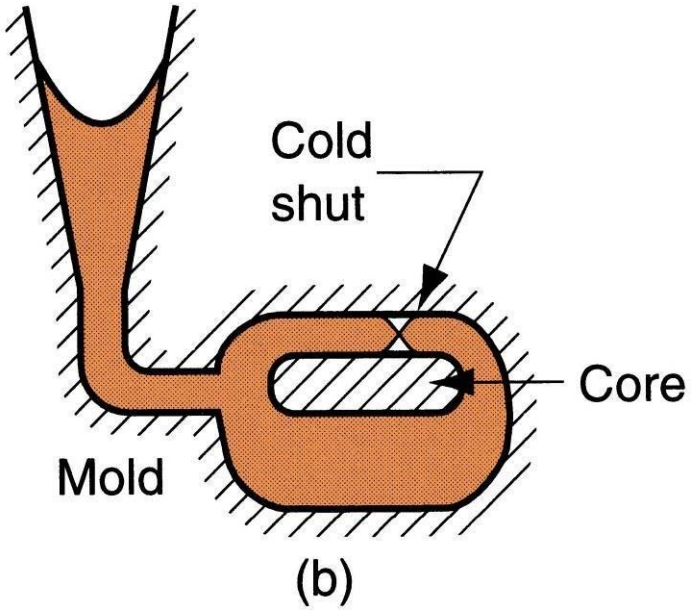
Reasons:

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 recommended rule: V/A at the section closer to the gating system should be higher than that far from gating system

General Defects: Cold Shut

(b) Cold shut

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



(b) Cold shut

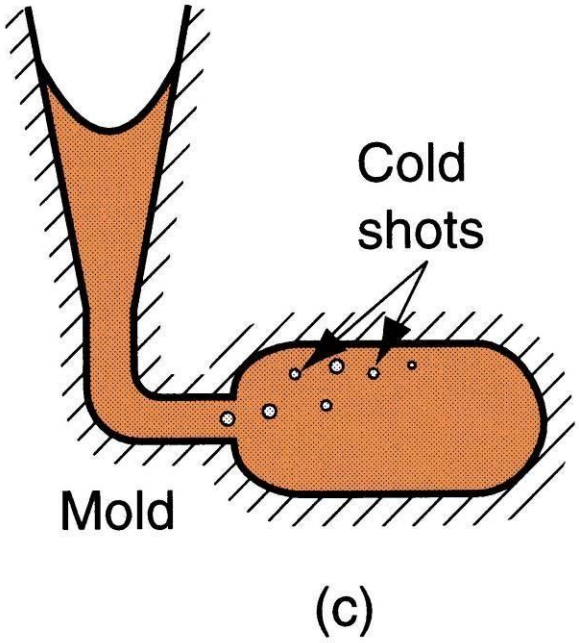
Reasons:

Same as for misrun

General Defects: Cold Shot

(c) Cold shot

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



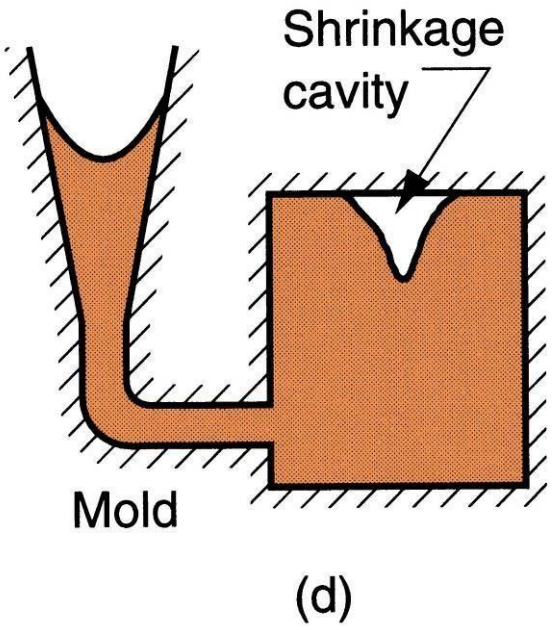
(c) Cold shot

Gating system should be improved to avoid splashing

General Defects: Shrinkage Cavity

(d) Shrinkage cavity

Depression in surface or internal void caused by solidification shrinkage



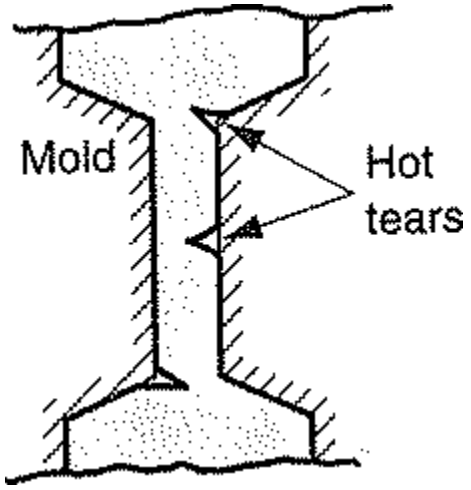
(d) Shrinkage cavity

Proper riser design can solve this issue

General Casting Defects: Hot Tearing

(e) Hot tearing

Hot tearing/cracking in casting occurs when the molten metal is not allowed to contract by an underlying mold during cooling/ solidification.



(e) Hot tearing

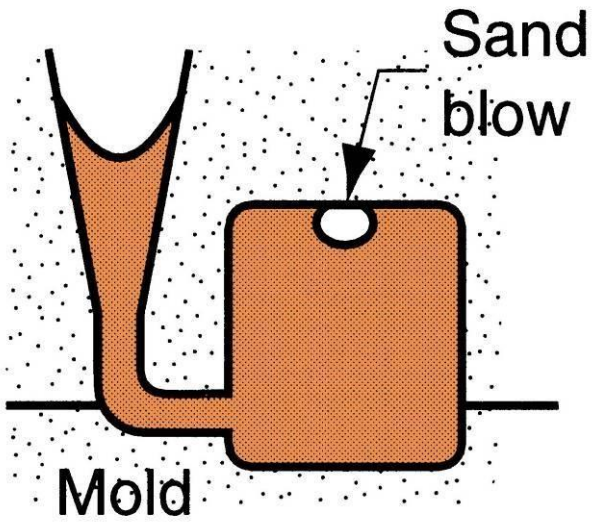
The collapsibility (ability to give way and allow molten metal to shrink during solidification) of mold should be improved

Sand Casting Defects: Sand Blow

Common defects in sand castings:

(a) Sand blow

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



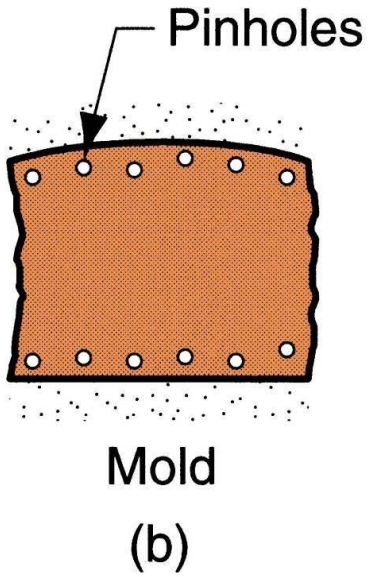
(a) Sand blow

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

Sand Casting Defects: Pin Holes

(b) Pin holes

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



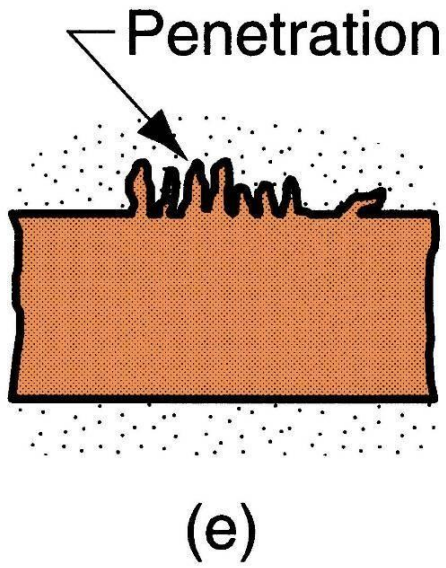
(b) Pin holes

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

Sand Casting Defects: Penetration

(e) 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



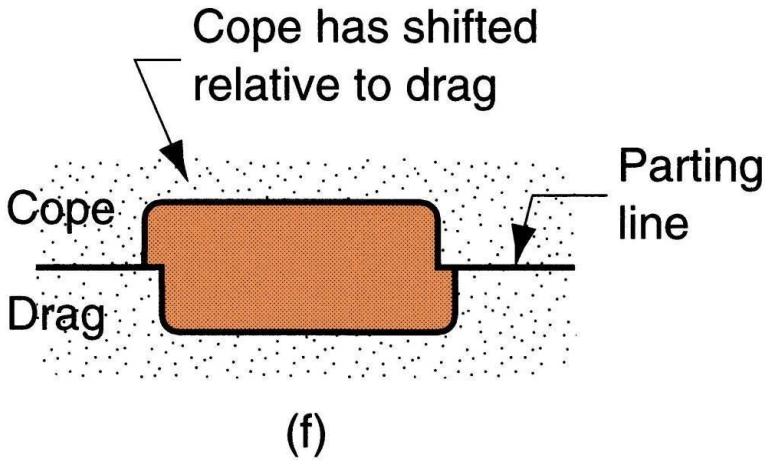
(e) Penetration

*** Harder packing of sand helps to alleviate this problem,**
*** Reduce pouring temperature, if possible,**
*** Use better sand binders.**

Sand Casting Defects: Mold Shift

(f) Mold shift

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



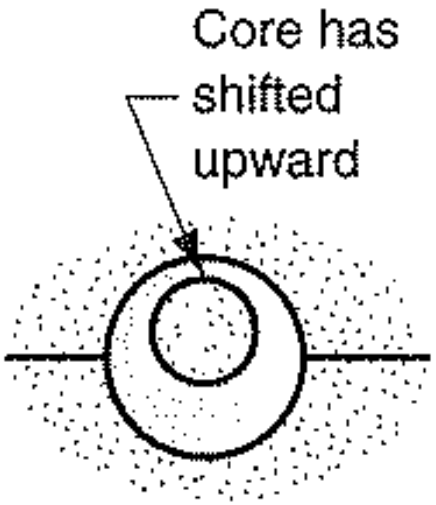
(f) Mold shift

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

Sand Casting Defects: Core Shift

(g) Core shift

it is core that is displaced, and the displacement is usually vertical.



(g) core shift

*** It is caused by buoyancy force of molten metal.**

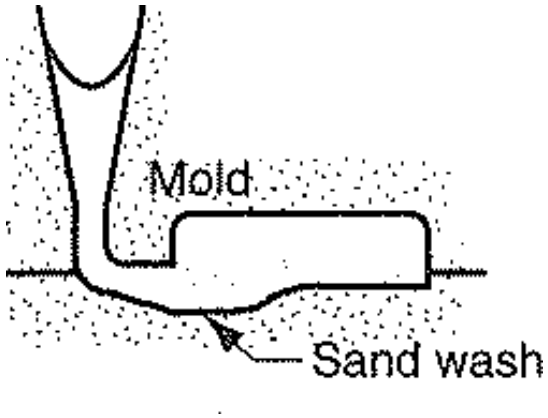
*** Core must be fastened with chaplet**

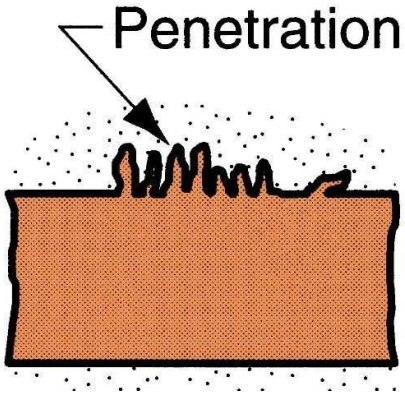
Sand Casting Defects: Sand Wash

(h) Sand wash

An irregularity in the casting surface caused by erosion of sand mold during pouring.

- **Turbulence in metal flow during pouring should be controlled.**
- **Also, very high pouring temperature cause erosion of mold.**



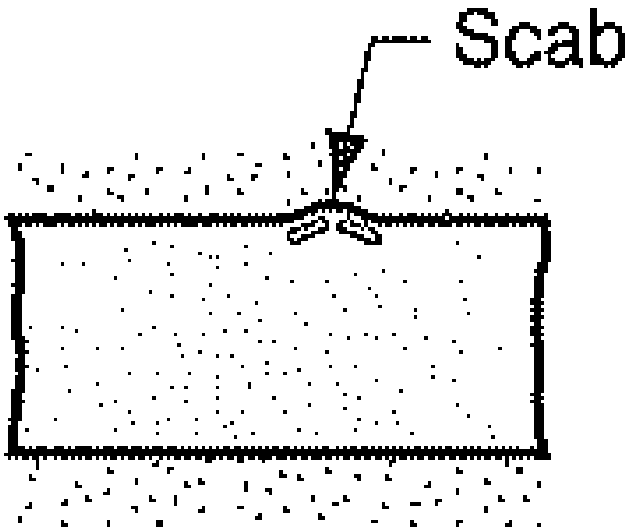


(h) Sand wash

Sand Casting Defects: Scabs

(i) scab

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



(i) Scab

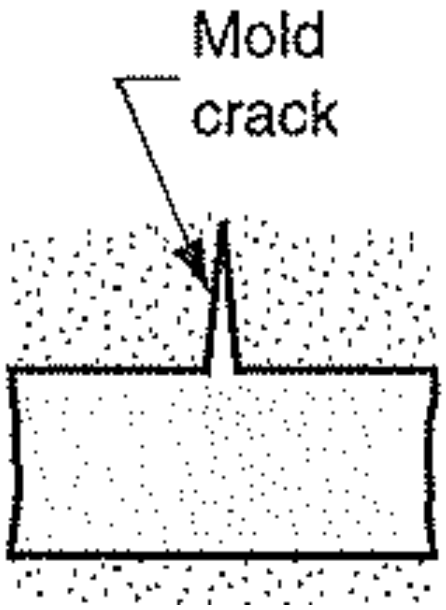
It is caused by portions of the mold surface flaking off during solidification and becoming embedded in the casting surface.

Improve mold strength by reducing grain size and changing binders.

Sand Casting Defects: Mold Crack

(j) 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

(j) **Mold crack**

Metals for Casting

- Casting alloys can be classified as:
  - Ferrous
  - Nonferrous

Ferrous Casting Alloys: Cast Iron

- Most important of all casting alloys
- Tonnage of cast iron castings is several times that of all other metals combined
- Several types: (1) white cast iron, (2) grey cast (3) nodular/ductile cast iron (4) malleable iron, and (5) alloy cast irons.
- The ductility of Cast Iron increases from 1-4.
- Typical pouring temperatures ~ 1400°C, depending on composition

Ferrous Casting Alloys: Steel

- The mechanical properties of steel make it an attractive engineering material
- The capability to create complex geometries makes casting an attractive shaping process
- **Difficulties when casting steel:**
  - Pouring temperature of steel is higher than for most other casting metals ~ 1650°C
  - At such temperatures, steel readily oxidizes, so molten metal must be isolated from air.
  - Molten steel has relatively poor fluidity.

Nonferrous Casting Alloys: Aluminum

- Generally considered to be very castable
- Pouring temperatures low due to low melting temperature of aluminum (T_m = 660°C).
- **Properties:**
  - Light weight
  - Range of strength properties by heat treatment
  - Easy to machine

Nonferrous Casting Alloys: Copper Alloys

- Includes bronze, brass, and aluminum bronze
- Properties:
  - Corrosion resistance
  - Attractive appearance
  - Good bearing qualities
- Limitation: high cost of copper
- Applications: pipe fittings, marine propeller blades, pump components, ornamental jewelry

Comparison of Casting Processes

Casting Processes	Advantages	Limitations
Sand casting	• Almost any metal can be cast. • No limit on size and shape. • Low equipment cost. • Economical for low-volume production.	• Coarse finish. • Dimensional accuracy not so good. • Finishing required. • Low production rate.
Investment casting	• Almost any metal can be cast. • Good surface finish. • Good dimensional accuracy. • Fairly high production rate. • Intricate shapes can be cast. • Low finishing cost.	• Limitation on part size. • Expensive pattern and mould. • High labour cost.
Permanent mould casting	• Good surface finish. • Good dimensional accuracy. • High production rate.	• High mould cost. • Suitable for high volume production. • Suitable for casting of simple shapes. • Suitable for low-melting-point metals.

Comparison of Casting Processes

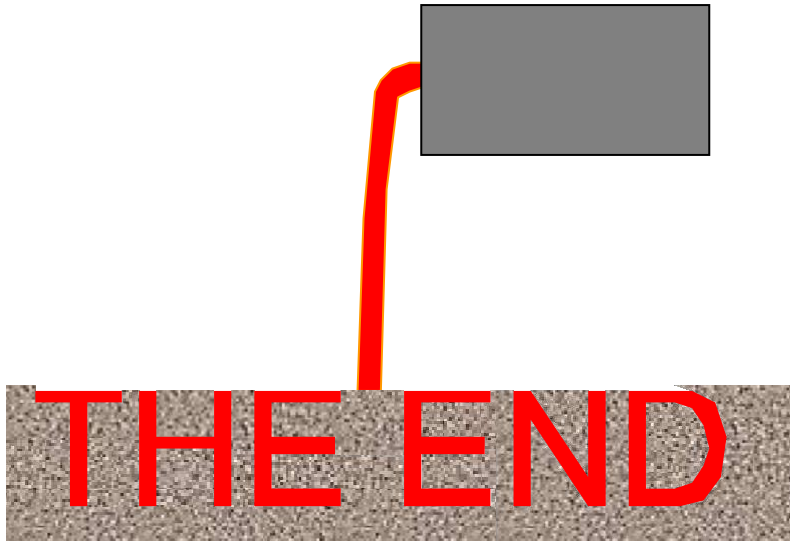
Die casting	• Excellent surface finish. • Excellent dimensional accuracy. • High production rate. • Complex shapes can be cast. • Little or no finishing cost.	• Limitation on part size. • High cost of die. • Generally limited to casting of non-ferrous metals.
Centrifugal casting	• High production rate. • Good dimensional accuracy and surface finish.	• Expensive set-up. • Good for production of cylindrical parts only.

Assignment No. 1

Propose the best suitable casting process to make an aluminum cup. During selecting a process, keep the following points in view:

1. *No of cups= 4*
2. *Product cost= as low as possible*
3. *Surface quality= good. Quality is not as important as cost*
4. *Defects= some defects are acceptable*
5. *Processing time= not important*

Draw an analysis for each major type of casting process with reference to above conditions. Then choose one casting process and write a report in its support .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