

Manufacturing Practices

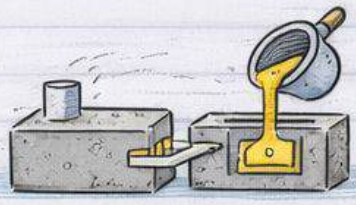


Module-3 Notes

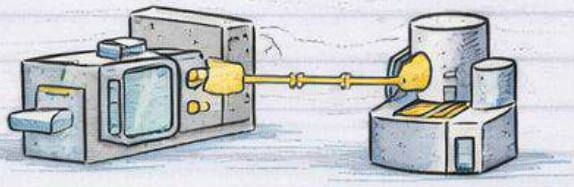
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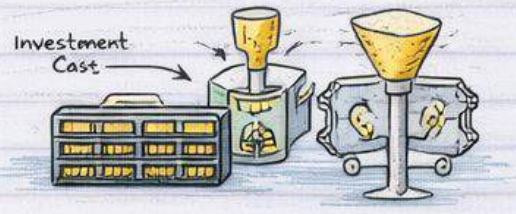
- Intro to Casting



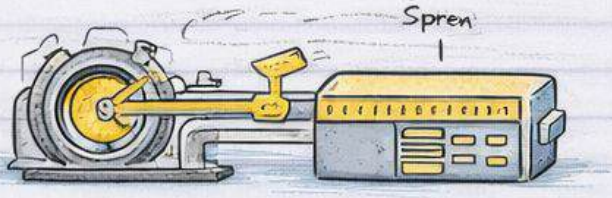
- Die Casting



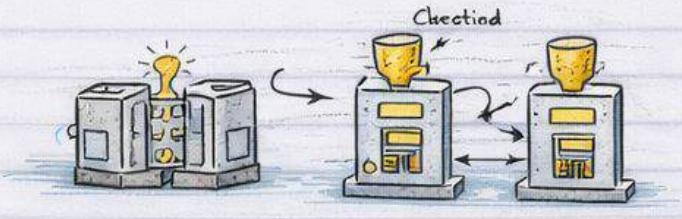
- Precision Casting



- Centirfrupal Casting



- Pressure Casting



- Pressure Casting



2.1. INTRODUCTION TO CASTING

Casting methods are universally used for a wide variety of products. Very small to extremely heavy metal products can be made.
Casting is the best option when it is difficult or economically impossible to produce an item by another process.



DIFFICULT SHAPES



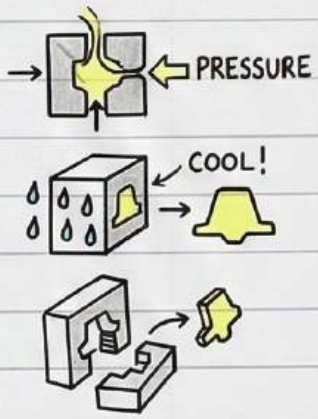
ECONOMICALLY IMPOSSIBLE

Various casting processes:

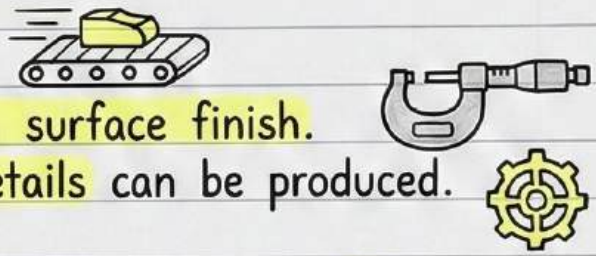
1. Sand mould casting ( of sand box).
2. Plaster mould casting.
3. Metallic mould casting (Gravity, Slush, Pressure, Die casting -  of metal die with molten metal).
4. Centrifugal casting. 
5. Precision casting.
6. CO_2-mould casting.
7. Continuous casting.

Die Casting Processes

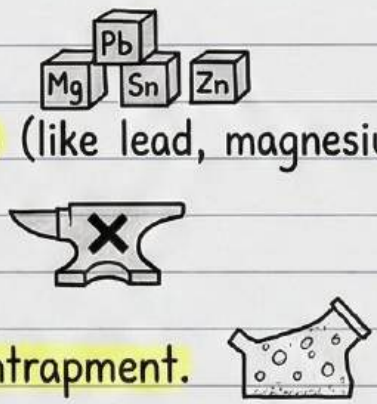
1. **The Concept:**
   - Process of rapid production of precise castings.
   - Molten metal under pressure is forced into split metal dies to fill the entire die and details.
   - The die is water cooled, so casting solidifies very quickly.
   - The two halves are separated and casting is ejected.



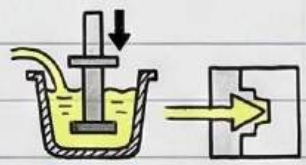
2. **Advantages:**
   - Very high rate of production.
   - Very precise dimensions & high surface finish.
   - Very thin castings with fine details can be produced.
   - Die has very long life.
   - Low floor space needed & low cost of casting. $

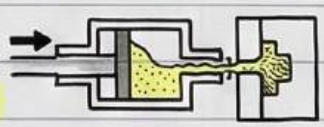


3. **Limitations:**
   - Not economical for low batch size.
   - More suitable for non-ferrous alloys (like lead, magnesium, tin, zinc).
   - Heavy castings cannot be produced.
   - High cost of equipment and die.
   - Castings have porosity due to air entrapment.



4. **Die Casting Machines (Two Types):**
   - Hot Chamber (Plunger Type):
     - Molten metal fills channel by gravity.
     - Plunger forces metal into the die.
     - Plunger (made of refractory material) operated manually/mechanically/hydraulically.
   - Cold Chamber (Horizontal Plunger):
     - Chamber operated pneumatically or hydraulically forces charge into die.
     - Suited to aluminium alloys & high melting temp non-ferrous metals.



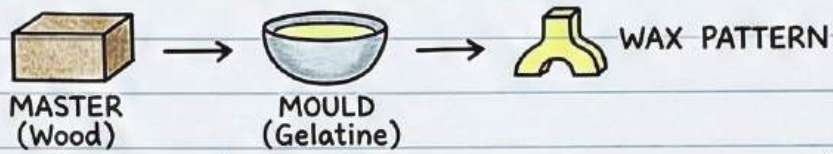


Precision Casting / Lost Wax Process / Investment Moulding

1. **The Concept & Goal:**
   - Also known as 'lost wax process' or 'investment moulding'.
   - Produces very precise castings that do not require subsequent machining.



2. **The Process** (Two Stages):
   - **Stage 1**: Preparation of Master Pattern.
     - A master pattern (wood/metal) is used to form a mould (gelatine/low-melting alloy).
     - Liquid wax is poured into this mould to produce the wax pattern ('investment of the pattern').

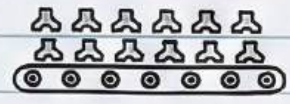


   - **Stage 2**: Wax Pattern & Casting.
     - The wax pattern is used to make the final casting mould.
     - Crucially, the wax pattern is not taken out; it is melted/lost during the process.



3. **Advantages:**
   - High surface finish, machining eliminated/reduced.
   - Very thin castings can be produced.
   - Complex shaped castings possible.
   - Sound and defect-free.
   - Suitable for mass production of small castings.





4. **Limitations:**
   - Not suitable for heavy castings.
   - Requires strict control at all stages.
   - Very expensive process. $$$



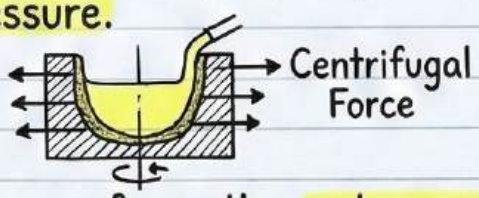
5. **Applications:**
   - Turbines, Motor cars, Sewing machines, Type writers, Calculating machines, Various instruments.



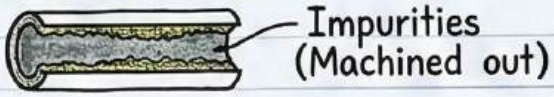


Centrifugal Casting

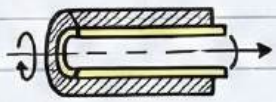
1. The Concept (Process):
   - Molten metal is poured into rotating moulds.
   - Metal is thrown towards the periphery due to centrifugal force under sufficient pressure.



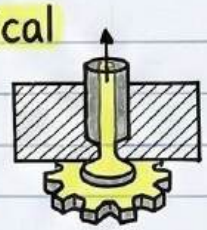
   - Solidification progresses from the outer surface inwards.
   - All areas of weakness/impurities are located at the inner wall.



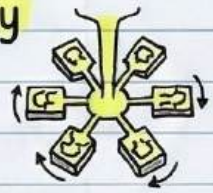
2. Three Types:
   - 1. Fully Centrifugal Casting: Moulds of rotational symmetry (steel/sand) rotated with horizontal axis.
     - Used to produce hollow cylindrical castings (pipes, bushings, gun barrels) without a central core.



   - 2. Semi-Centrifugal Casting: Moulds rotated about vertical axis. Metal fed at axis, flows through gates.
     - A dry sand core may be used for the central hole. Used for large castings like gears, disk wheels.



   - 3. Centrifuged Castings: Multiple moulds located radially about a central sprue. Horizontal rotation.
     - Used for stack moulding of small intricate castings.



3. Advantages:
   - Castings are completely free from porosity defects.
   - Dense and sound castings.
   - No directional variation of properties.
   - Gates, feeders, and cores are eliminated (in some types).
   - Moulds are cheap and less complicated.
   - Light impurities thrown to outer surface (can be machined out).
   - Weakness at central wall can be machined out.

4. Applications:
   - Hollow cylindrical products (cast iron pipes for water/sewage).
   - Steel gun barrels.
   - Symmetrical castings such as gears, disk wheels, pulleys.

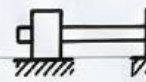
Centrifugal Casting Machines

1. Variable Speed Centrifugal Casting Machine:

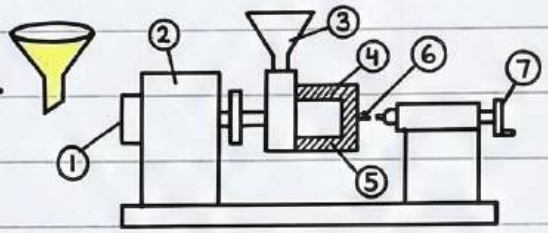
- D.C. Motor (6 kW, 450-1350 rpm): Provides variable speed drive.



- Key Components:
  - Head stock & Tail stock: Support the rotating assembly.
  - Clutch plate: For engaging/disengaging drive.
  - Cooling water spray: Cools the mould during casting.
  - Holding fixture: Holds the mould.
  - Feed hopper: For feeding molten metal.

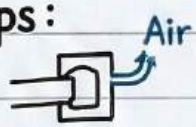




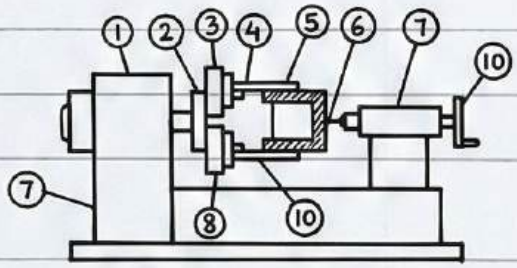


Sketch as per Fig 2.1

2. Centrifugal Casting Machine with Pneumatic Grips:



- Features pneumatic grips for holding the mould.
- Key Components:
  - Electric motor & Variable speed device: Provide controlled rotation.
  - Head stock with pneumatic gripping mechanism.
  - Chuck, Removable plate, Grip plate, Bush, Connecting rod: Form the gripping assembly.
  - Pneumatic cylinder: Operates the grips.



Sketch per Fig 2.2

3. Benefits & Speed Selection:

- Ensures high quality of babbitting and improved productivity.
- Provides stepless speed regulation and fast mounting of bearing.
- Speed of bearing rotation (n) is selected by formula:

$$n = \frac{1240}{\sqrt{r}}$$

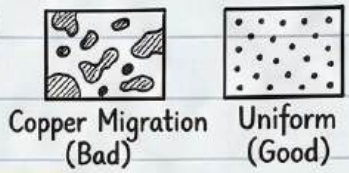
where r = bearing bore radius (cm).



Pressure Casting

1. Purpose & Goal:

- Used to ensure high quality of centrifugal casting of babbitt.
- Prevents copper migration which can occur due to improper rotation speed or cooling rate.

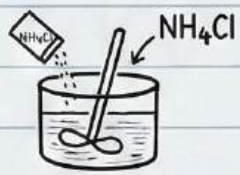


- Achieves a uniform and homogeneous distribution of the structural composition of babbitt lining.
- Crucial for certain applications requiring high reliability.

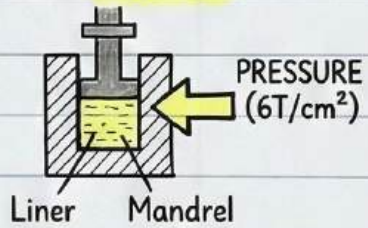
2. The Process (Step-by-Step):

- **Preparation**: Check tinning surface of liner. Heat working plunger & grip fixture in a portable electric furnace. Place assembled liner in crucible & mandrel (ensuring machining allowance).

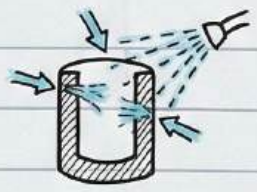
- **Pouring & Mixing**: Pour babbitt and deoxidize by mixing with dry ammonium chloride using a propeller.



- **Injection**: Open stop valve.
- **Injection**: Open stop valve. Operate the press. The working plunger pushes molten metal through a pipeline and nozzle.
- **Pressure Application**: Metal is forced into the space between the liner and mandrel at a high pressure of 6 tonnes/cm^2.

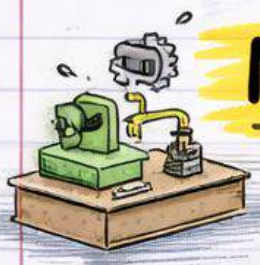


- **Cooling & Removal**: Cool liner and grip fixture after a few seconds with compressed air and water spray. Remove liner for inspection.

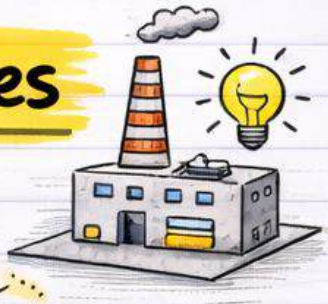


3. Key Machine Components:

- Working plunger & Press: Apply pressure.
- Electric crucible & Furnace: Melt and hold the metal.
- Pipeline & Nozzle: Direct the flow.
- Liner & Mandrel: Form the casting cavity.



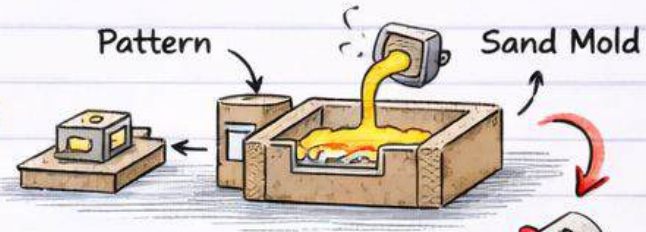
Manufacturing Practices
Module-4 Notes



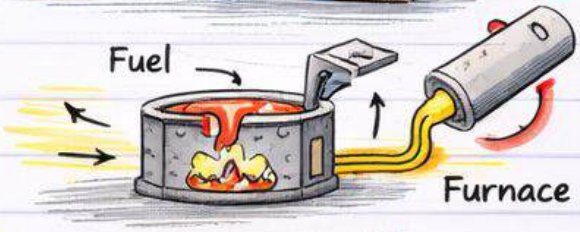
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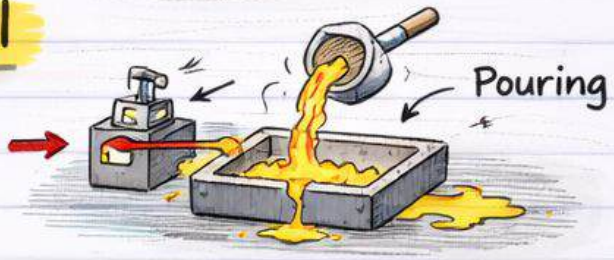
- Casting Practices Intro



- Melting Furnances



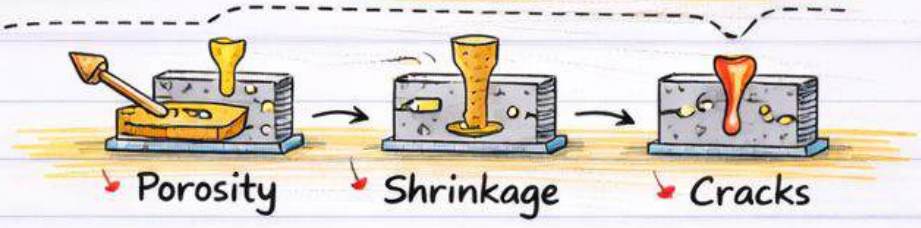
- Pouring of Molten Metal



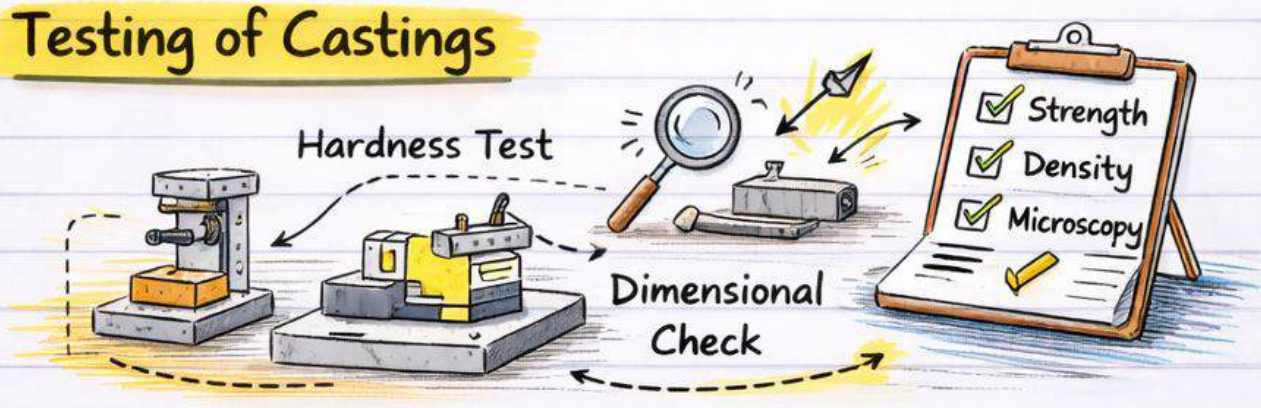
- Cleaning of Castings

- Casting Defects





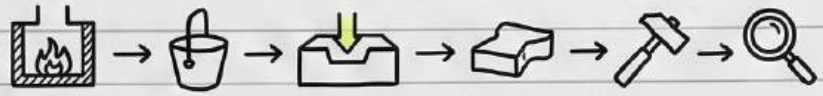
- Testing of Castings



CASTING PRACTICES: INTRODUCTION

2.1. Introduction:

- The casting process consists of charging a furnace, melting, pouring the metal into moulds, solidification, removal of casting, fettling and inspection.



- The process is divided into steps:
  1. Metal melting, 2. Metal pouring, 3. Solidification, 4. Removal of casting, 5. Fettling, 6. Inspection.

2.1.1. Metal Melting:



- Furnace is charged with hard coke and fired.
- Crucible is heated, then charged with the desired quantity of metal.
- Covered with hard coke and a lid. Air blower is switched on.
- Metal is converted into molten state.

2.1.2. Metal Pouring:



- Remove crucible with tongs, transfer to a carrier.
- Pour metal into the mould with correct pouring rate.
- Place additional weight over the cope to avoid lifting during pouring.

2.1.3. Solidification:

- Wait for sufficient time for metal to cool off and completely solidified.

2.1.4. Removal of Casting:

- Break the sand mould, extract the casting.
- Remove adhering sand, collect sand for reuse.

2.1.5. Fettling:



- Remove dry sand core, cut off gate and riser.
- Remove unwanted projections, pins, nails, etc., and clean adhering sand.

2.1.6. Inspection:

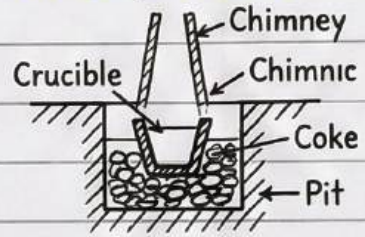
- Inspect for defects, analyze causes, and make a list of preventive measures. [cite: 114]

MELTING FURNACES

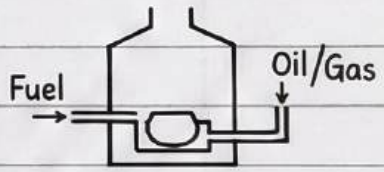
1. **Crucible Furnaces**:
   - Simplest of all the furnaces.
   - Used in most of the small foundries where melting is not continuous and a large variety of metals is to be melted in small quantities.
   - Melting takes place inside a melting pot, called crucible, made of clay and graphite.



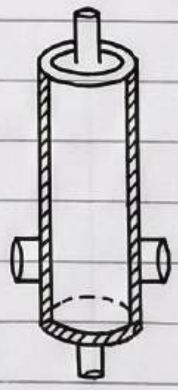
(i) **Coke-fired Furnaces** (Fig. 2.1):
   - Generally installed in a formed pit.
   - Used for melting small quantities of ferrous metals for producing iron castings and also for non-ferrous metals.
   - Provided with refractory lining inside and a chimney at the top.
   - Coke is used as fuel.



(ii) **Oil and Gas Fired Furnaces** (Fig. 2.2):
   - Utilise oil or gas as a fuel.
   - Mixture of fuel and air is fed into the furnace, which burns inside to produce heat.
   - Furnace essentially consists of a cylindrical steel shell, with refractory lining inside.
   - The crucible is seated on a pad formed at the bottom.

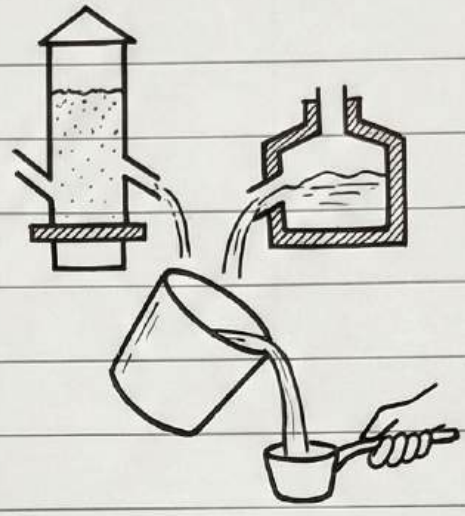


2. **Cupola Furnace** (Fig. 2.3):
   - Used for melting of cast iron in foundry.
   - Has a construction in the form of a hollow vertical cylinder made of strong mild steel plates.



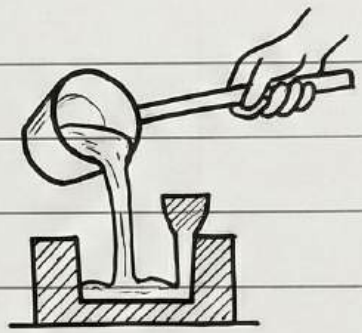
POURING OF MOLTEN METAL

The molten metal from the cupola (ferrous metals) or the furnace (non-ferrous metal) is run into a large receiving ladle. From large ladle, metal is distributed into small pouring ladles.

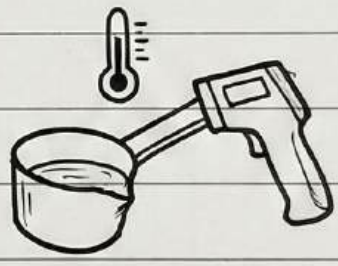


Precautions during pouring:

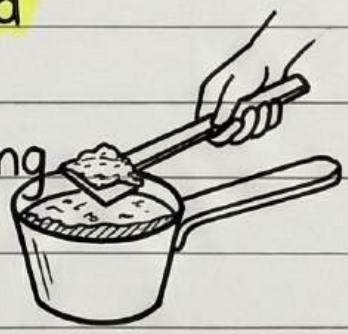
1. The pouring should be done continuously at a constant rate until moulds, gates and risers are full.



2. The pouring should be done when metal is at right temperature. Temperature is checked with an optical pyrometer.

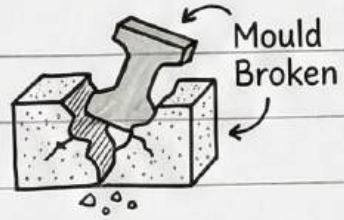


3. The floating slag should be skimmed back with the help of a skimming bar by an assistant before discharging the metal into the mould.



CLEANING OF CASTINGS

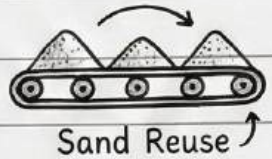
After cooling and solidification in the mould, the mould is broken and casting is taken out of the sand.



1. The sand is removed by hand, hammers, tongs and shovels or on a vibrating steel grid.



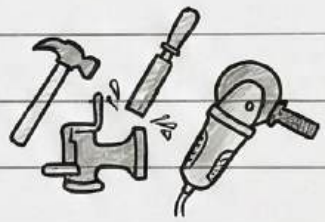
2. The sand is shaken out of the mould and collected for reuse on a conveyor.



3. The casting after freeing from the sand is cleaned with a wire brush.



4. The runners and feeders are removed by using hammers, chisels, hacksaw, grinders, files, etc.



5. For large steel castings, gas cutters may be used.



6. All traces of sand are removed by shot blasting machines.



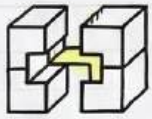
7. All remains of runners, risers, joints of the mould and core and other irregularities are removed by the use of files, portable flors, flexible grinders, chisels and other hand tools.



Casting Defects

Sand castings are subject to certain defects which are controllable by proper foundry practice.

Shifts (Mismatch)
Causes: Core misplacement, Mismatching of flasks
Remedies: Proper alignment of pattern, dies, moulding boxes



Warpage (Undesirable distortion)
Causes: Different rates of solidification, Stresses at intersection
Remedies: Proper casting design, Addition of ribs



Fin
Causes: Incorrect assembly of moulds, Insufficient weighting
Remedies: Use sufficient weighting, Correct assembly



Swell (Enlargement)
Causes: Defective ramming
Remedies: Proper ramming of sand



Blowholes (Cluster of holes)
Causes: Excessive moisture, Low sand permeability, Too hard ramming
Remedies: Adjust moisture content, Use proper grain size, Ensure sufficient venting



Drop
Causes: Low strength sand, Soft ramming
Remedies: Avoid the causes



Dirt (Embedded)
Causes: Crushing of moulds, Slag in molten metal
Remedies: Use dirt traps, Proper fluxing



Honeycomb or Sponginess
Causes: Dirt or scurf in metal, Imperfect skimming
Remedies: Prevent sand wash, proper skimming



Metal Penetration
Causes: Low sand strength, Large grain size
Remedies: Avoid causes



Sand Holes
Causes: Loose sand washing into mould, Rapid pouring
Remedies: Proper cleaning of mould, Careful pouring



Pin Holes
Causes: High moisture content, Absorption of H_2 and CO gases
Remedies: Control moisture, Increase sand permeability



Scabs (Face projection)
Causes: Too fine sand, Low permeability
Remedies: Mix wood flour into sand



Shrinkage Cavity (Void/depression)
Causes: Uncontrolled solidification, High pouring temperature
Remedies: Use directional solidification, Use chills, padding



Hot Tears (Cracks)
Causes: Poor design, Abrupt sectional changes
Remedies: Improve casting design, Proper corner radii



Cold Shut and Misrun
Causes: Improper filling, Thin sections, Slow pouring
Remedies: Use high pouring temperature, Proper gating



Poured Short
Causes: Insufficient metal in the ladle
Remedies: Sufficient metal in the ladle



Internal Air Pocket
Causes: Rapid pouring, Poor venting
Remedies: Use correct pouring temperature, Ensure sufficient venting

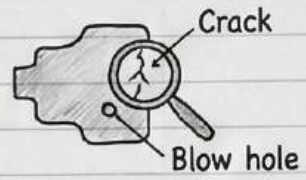


TESTING OF CASTINGS

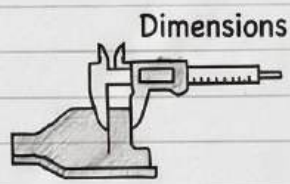
After cleaning and fettling, the castings are checked for possible defects and flaws. The testing and inspection tests may be classified as follows:

1. Visual inspection
2. Dimensional inspection
3. Mechanical and chemical testing
4. Non-destructure methods of inspection
5. Metallurgical inspection

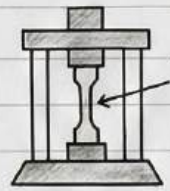
1. Visual Inspection:
   - Carried out for possible surface defects such as cracks, blow holes, slag inclusions, incomplete filling of metal, sand inclusion, local collapses of mould and cores.



2. Dimensional Inspection:
   - Carried out to measure the dimensions of the casting liable to distortions due to core movement during pouring.
   - Very important for investment castings, shell mould casting and die casting.



3. Mechanical and Chemical Testing:
   - Mechanical tests include tensile strength, bending strength, fatigue strength, wear resistance and hardness of cast metal.
   - Chemical tests include composition, percentage of alloying elements in cast metal.



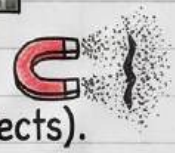


4. Non-destructure Tests:
   - Used to locate the defects present in the interior of the casting.
   - Includes: 1. Sound test (erratic sound reflections)
     2. Impact test (striking with a hammer)
     3. Pressure test (to detect leaks or weak spots).
     4. Radiographic tests (using X-rays and γ-rays).
     5. Magnetic particle tests (for steel and iron, particles align to cracks).
     6. Fluorescent dye penetration test (for small surface defects).
     7. Ultrasonic tests (high frequency sound waves reflected from interior cracks).











5. Metallurgical Inspection:
   - Methods used: 1. Chill test
     2. Fracture test
     3. Macro-etching test
     5. Microscopic test.
   - Carried out by experts in special laboratories.

