Mechanical Engineering

Section A :

Production Engineering

Section B :

Maintenance Engineering

Comprehensive Theory

with **Solved Examples** and **Practice Questions**

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Section A :

Production Engineering

Comprehensive Theory

with **Solved Examples** and **Practice Questions**

Chapter 1

Metal Casting

INTRODUCTION

Casting is the oldest and still most widely used process. A mould cavity is created out of sand or some permanent material and liquid metal is poured into this cavity. The product is taken out after solidification. If the mould is broken after each cast then it is called expendable mould. If the same mould is used for a number of castings, it is called permanent mould.

To create a mould cavity followings are required:

- Pattern
- Moulding material
- Tools

Advantages of casting:

1. It is used to produce intricate shapes because molten metal flows into a small sections in the mould cavity.
2. Both hard and soft, ductile and brittle materials can be produced.
3. Large size castings can be produced, upto 200 tonnes.
4. It is less expensive process.

Limitations:

1. Dimensional accuracy and surface finish is very poor.
2. Sand casting is labourious and time consuming process.
3. Gas defects can be produced in the casting components.
4. Casting objects are not having uniform mechanical properties due to non-uniform cooling.

1.1 Pattern

Pattern is the replica final object to be produced with some modifications. Modifications are in the form of core prints or allowances.

1.1.1 Pattern Allowance

1. Shrinkage or contraction allowance
2. Draft or taper
3. Machining of finish allowance
4. Shake or rapping allowance
5. Distortion or Camber allowance.

1.1.1.1 Shrinkage Allowance

When the liquid metal is cooled from pouring to ambient temperature during solidification, there is a shrinkage or contraction of the material.

T_P : Pouring temperature, T_f : Freezing temperature, T_a : Ambient temperature

- Liquid metal cools from pouring to freezing temperature shrinkage is liquid shrinkage.
- During phase transformation at constant temperature shrinkage is solidification shrinkage.
- When the solid casting cools from freezing to ambient temperature shrinkage is solid shrinkage.
- Liquid and solidification shrinkage can be compensated by providing riser. Solid shrinkage can be compensated by providing shrinkage allowance on the pattern.

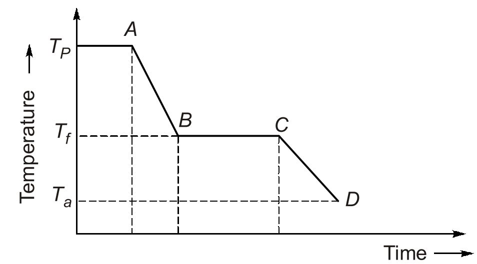


Fig. 1.1 Temperature versus time graph for a pure metal

1.1.2 Machine Allowance

Casting produces poor surface finish and tolerance. To get smooth surface finish in casting machining is required, due to machining casting size is reduced, to overcome this machining or finish allowance is provided on the pattern, it is expressed in terms of each surface of casting (mm/surface).

1.1.3 Draft Allowance

Around 1/2 to 2° (shown in Figure 1.2) taper is provided over the pattern for easy removal from the sand mould. Draft or Taper allowance provided for easy removal of pattern without damaging mould

$$x = h \tan \theta$$

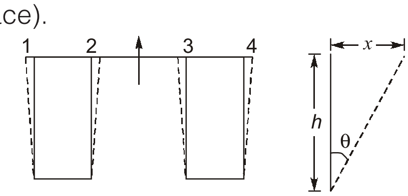


Figure 1.2 Draft Allowance

Internal surface require more taper when compared to external surfaces because for the external surfaces the mould strength is more compared to internal surfaces (since dimensions on internal side are less hence less strength).

1.1.4 Rapping or Shake Allowance

For easy removal of the pattern from the mould, clearance is required between pattern and mould. This can be produced by shaking the pattern. Due to shaking size of cavity is increased, to overcome this size of the pattern can be reduced in the form of shake allowance. It is negative allowance.

1.1.5 Distortion or Camber allowance

Some typical application like V-shape, U-shape and flat objects with very less thickness can distort, keep it in there shape. In order to arrest that distortion opposite to the direction of distortion we need to provide some allowance on the pattern in the form of distortion allowance.

NOTE

Shrinkage allowances for important material:

Material	Allowance
Bismuth	Negligible
Cast iron	10 mm/metre length
Aluminium	12-15 mm/metre length
Steel	20 mm / metre length
Brass	23 mm / metre length
Zinc, Lead	25 mm / metre length

1.2 Terms Associated With Casting

- **Flask:**
  (i) A moulding flask is one which holds the sand mould intact.
  (ii) It is made up of wood for temporary applications or more generally of metal for long term use.
- **Core:** It is used for making hollow cavities in casting.
- **Pouring Basin:** A small funnel shaped cavity at top of the mould into which the molten metal is poured.
- **Sprue:** The passage through which the molten metal from the pouring basin reaches the mould cavity.
- **Runner:** The passage way in the parting plane through which molten metal flow before they reach the mould cavity.
- **Gate:** The actual entry point through which molten metal enters the mould cavity.

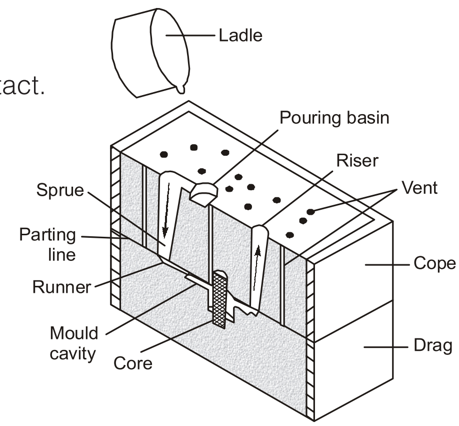


Figure 1.3 Cross section of a sand mould

- **Chaplet:** Chaplets are used to support cores inside the mould cavity to take care of its own weight and overcome the metallostatic forces.
- **Chills:** Chills are metallic objects, which are placed in the mould to increase the **cooling rate** of casting to provide uniform or desired cooling rate.
- **Riser:** It is a reservoir of molten metal in the casting so that hot metal can flow back into the mould cavity when there is **a reduction in volume** of metal due to contraction.

1.3 Types of Patterns

A pattern is a replica of the final object to be made by the casting process, with some modifications. This may be made of wood, plastic or metal. The selection of a pattern depends on the size and shape of the casting, the dimensional accuracy and the quantity of casting required and the molding process.

1.3.1 Solid or Single Piece Pattern

For a simple shape of objects, this pattern can be used. One of the surface of the pattern is flat.

1.3.2 Split Piece Pattern

This is used to produce complex shapes, pattern can be split into number of split pieces.

1.3.3 Loose Piece Pattern

It used when parts with internal webs, projections, undercuts, etc.

1.3.4 Gated Pattern

The gate and runner is the integral part of the pattern. This would eliminate the hand cutting of the runner and gates and hence improved productivity.

1.3.5 Match Plate Pattern

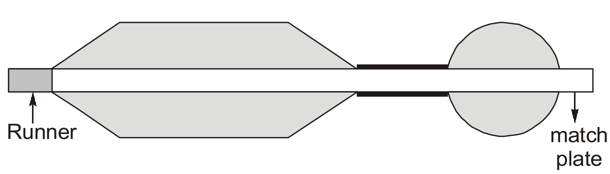


Figure 1.4

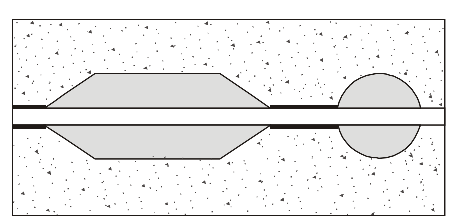


Figure 1.5

This pattern is made in two halves mounted on both sides of a match plate (of wood or metal) conforming to the contour of the parting surface. The match plate is accurately placed between the cope and the drag flasks by means of locating pins. For small castings, several patterns can be mounted on the same match plate to increase the production rate.

1.3.6 Cope and Drag Pattern

- The cope and drag halves of the mould are made separately.
- It requires accurate alignment by guide and locating pins.
- This types of patterns are used for casting which are heavy and inconvenient for handing and also for continuous production.
- It is used to produce big size casting.

1.3.7 Sweep Pattern

- Normally made of wood, it is used to generate surfaces of revolution in large castings, and to prepare moulds out of a paste-like material, Here "sweep" refers to the section that rotates about an edge to yield circular sections.
- To produce 3 dimensional complex cavity using two dimensional plane pattern we can select sweep pattern.
- Two dimension plane pattern will be sweeped inside the mould cavity by 360° by fixing one of its end. Due to this, the cost of producing 3-dimensional pattern will reduced.

e.g.: Cone, cylinder, large size bells etc..

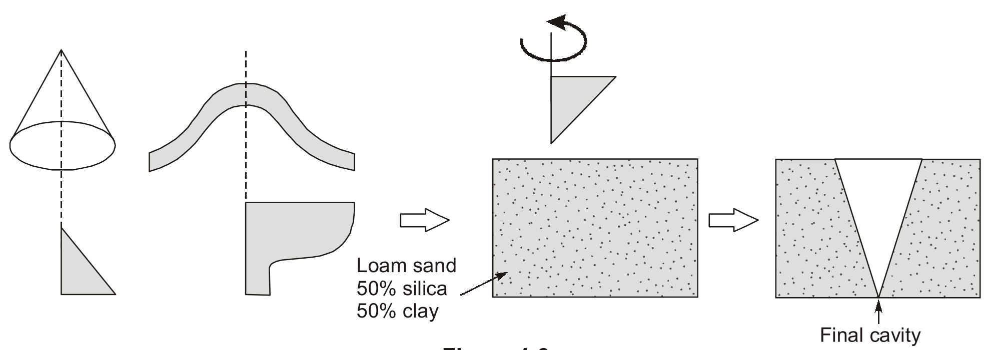


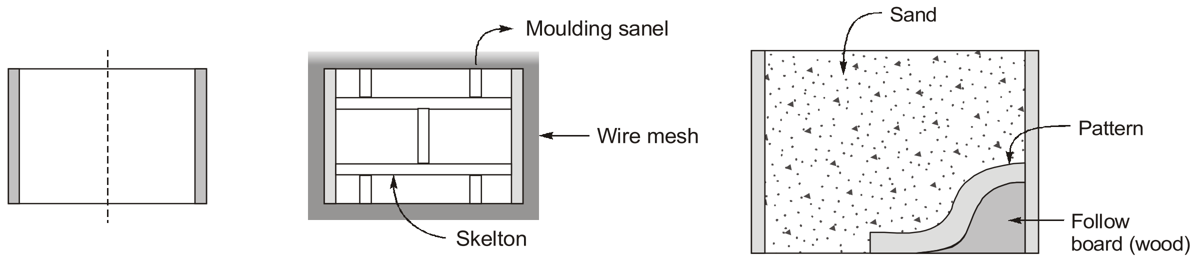
Figure 1.6

1.3.8 Follow board Pattern

- If the pattern is having over hanging portion and lack of strength than due to ramming force, it will distorted. To support the pattern inside the mould follow board will be used.

1.3.9 Skeleton Pattern

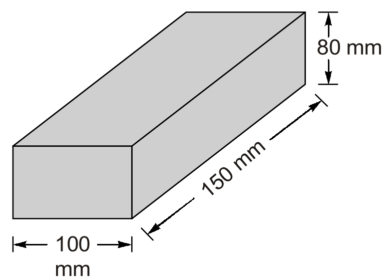
- This type of pattern will be used to produce large size shells and cylinders.
- To produce these object very large size pattern is required.
- To minimize the material consumption on preparing the pattern we can use skeleton pattern
- 3-dimensional skeleton is produced using small wooden work piece to get cylinder shape on skeleton wire mesh will be added.
- It is used to prepare shells and drums.



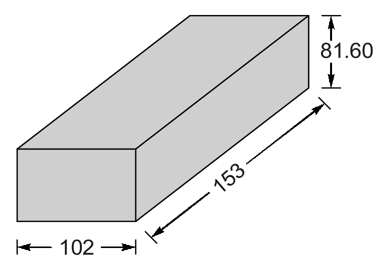
(a) **(b)**

Figure 1.7

Example 1.1 Design a pattern for the casting shown below if it is produced by steel material by considering shrinkage?



Solution :



We know shrinkage allowance for steel is 20 mm/m

$\therefore$ For 1 mm steel shrinkage allowance should be of 0.02 mm

$\therefore$ Length allowances = $150 \times 0.02 = 3.00$ mm

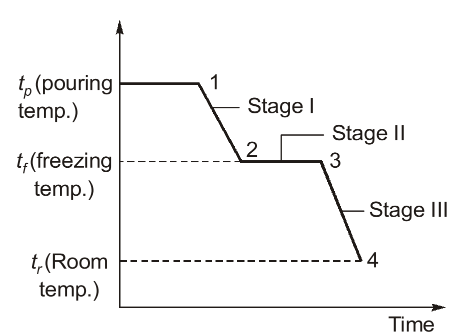
Breadth allowance = $100 \times 0.02 = 2$ mm

Width allowance = $80 \times 0.02 = 1.60$ mm

$\therefore$ Actual length, breadth and width of pattern will be 153, 102 and 81.60 mm respectively.

Example 1.2 A cubical casting of 50 mm size undergoes volumetric solidification shrinkage of 4%, volumetric solid contraction of 6%. There is no riser is used and pattern making allowance is not considered. What is the size of casting?

Solution :



Given data, Side = 50 mm

$\therefore$ Solidification shrinkage = 4%

Volumetric solid contraction = 6%

And after that solid contraction will take place by 6%

Volume left after solid contraction is 94% of volume left after solidification shrinkage.

Actual volume = $(50)^3$ mm^3

Volume left after solidification shrinkage = $(50)^3 \times 0.96$

Volume left after solid contraction is

$$= \{[(50)^3 \times 0.96] \times 0.94\} = [(50)^3 \times 0.96 \times 0.94] = 112800 \text{ mm}^3$$

Now, we know Volume of tube = $(\text{Side})^3$

$$\text{Side} = \sqrt[3]{\text{Volume}} = \sqrt[3]{112800} = 48.32 \text{ mm}$$

New size of casting is 48.32 mm long.

1.4 Properties of Moulding Sand

1.4.1 Refractoriness

- It is the ability of moulding sand to withstand high temperature of molten metals without fusion.
- Refractoriness of moulding sand is always greater than pouring temperature of liquid metal.

1.4.2 Green Strength

- The moulding sand that contain moisture is termed as green sand.
- The green sand should have enough strength so that the mould retain its shape.

1.4.3 Dry Strength

- When molten metal poured into a mould, the sand around the mould cavity is quickly converted in dry sand as the moisture in the sand immediately evaporates due to heat in the molten metal.
- At this stage it should retain the mould cavity and at the same time withstand the metallostatic forces applied by the liquid metal.

1.4.4 Hot Strength

It is the strength of the sand that is required to hold the shape of the mould cavity after all the moisture is eliminated.

1.4.5 Permeability

The gas evolving capability of moulding sand is known as permeability. This will be expressed by permeability number.

$$P_n = \frac{VH}{PAT}$$

V = Volume of air passing through the specimen (2000 cm^3)
H = Height of standard specimen (5.08 cm)
P = Pressure of the air passing through the specimen (gm/cm^2)
A = Area of cross section of cylindrical specimen.
T = Time required to pass through specimen (minutes)

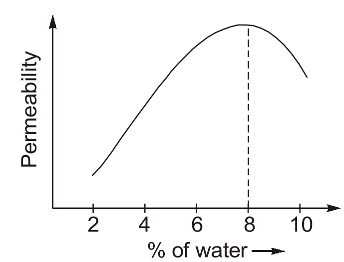


Figure 1.8

By adding water upto 8% the permeability value will increase, beyond 8% permeability will start decreasing.

1.4.6 Grain Fineness Number (GFN)

- GFN will indicate the average grain size distribution of a given moulding sand.
- Greater the grain fineness number finer the grain size.
- GFN can be determine by conducting sieve shaker test.

1.4.7 Flowability

- The ability of sand to flow due to ramming force to fill the mould flask is known as flowability.

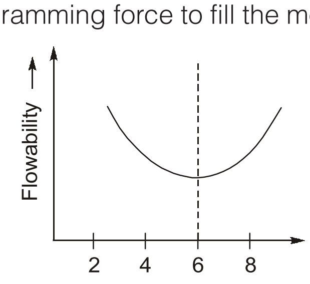


Figure 1.9

1.4.8 Collapsibility

- Ability of the moulding sand due to which it will not offer any resistance against the contraction of casting material is called collapsibility.
- During the solid contraction of the casting part, if the mould creates resistances, cracks will appear over the casting.
- Saw dust or wood powder is added to improve collapsibility.
- Since when molten metal poured, wood powder burns to ash due to this mould near casting is easily collapse and provide less resistance due to shrinkage.

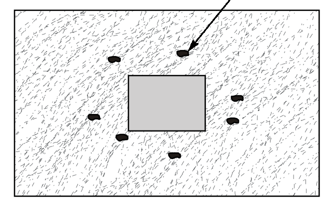


Figure 1.10

1.4.9 Adhesiveness

The bond formation between two different material i.e moulding sand and mould flask, and mould sand and pattern.

1.4.10 Cohesiveness

The bond formation between two similar material i.e between clay particles is known as cohesiveness.

1.4.11 Toughness

- Ability to resist impact and shock loads by the moulding sand.
- Shatter index test is done for toughness measurement, shocks observed when molten metal is poured.

NOTE

Universal testing machine	:	Used for testing green strength
Sand Muller	:	Used for mixing and preparing moulding sand.
Cup test	:	Used for testing formability.
Charpy test	:	Used for testing toughness.
Knoop test	:	Used for testing microhardness of the material.

Example 1.3 2000 C.C of air is passing through a standard cylinder specimen for 1.5 min. The manometer indicate pressure as 5 gm/cm^2, what is the permeability number?

Solution:

$$P_n = \frac{VH}{PAT}$$

Given, $V = 2000$ c.c; $H = 5.08$ cm; $T = 1.5$ min; $P = 5$ gm/cm^2

$$P_n = \frac{2000 \times 5.08 \times 4}{1.5 \times 5 \times \pi \times (5.08)^2} = 66.8$$

Composition of Moulding Sand

Composition of Moulding Sand	
Silica sand	70 - 85%
Clay	10 - 20%
Water	2 - 8%
Additive	1 - 6%

1.18.1 Die Casting

1.18.1.1 Hot Chamber Die Casting

- The hot chamber process involves the use of a piston, which traps a certain volume of molten metal and force it into the die cavity through a gooseneck and nozzle.
- The pressure range up to 350 MPa, with an average of about 150 MPa.
- The metal is held under pressure until it solidifies in the die. To improve die life and to aid in rapid cooling die are usually cooled by circulating water or oil through various passage way in the die block.
- Low melting point alloys such as zinc, magnesium tin and lead are commonly cast using this process.
- Die casting involves the preparation of components by injecting molten metal at high pressure into a metallic die.
- In this process the mould is made up of some permanent material like cast iron, die steels.
- Two halves can either be placed horizontally or vertically and when liquid metal is poured under gravity it is called gravity die casting.
- When liquid metal is injected into this permanent mould it is called pressure die casting.

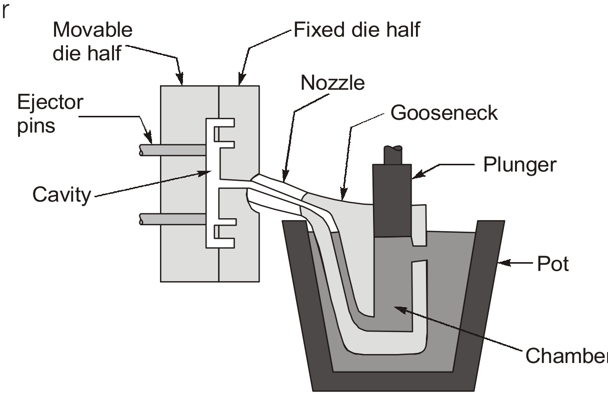


Fig. 1.25: Hot chamber die casting process

Advantage

1. Same mould can be used again and again this increases the production rate as high as 150 – 250 casts per hour.
2. Dimensional tolerance as of the order of 0.08 to 0.16 μm
3. Rapid cooling produces high strength.
4. It is very economical for large scale production.

Limitations

1. The maximum size of casting is limited upto certain size only.
2. This is not suitable for all material because of the limitation of the die material. Normally zinc, magnesium and lead etc.
3. The air in the die cavity gets trapped inside the casting and is therefore a problem often with die castings. It is used for producing crank casting, fuel injection pump, value bodies, small size connecting rods and carburettors etc.

1.18.1.2 Cold Chamber Die Casting

- In cold chamber process, molten metal is poured and injected into short chamber.
- The metal is forced into the die cavity at pressure usually range from 100 MPa to 150 MPa.
- The machines may be horizontal or vertical in which case the shot chamber is vertical and the machine is similar to a vertical press.
- Aluminium, magnesium and copper are normally cast using this method.

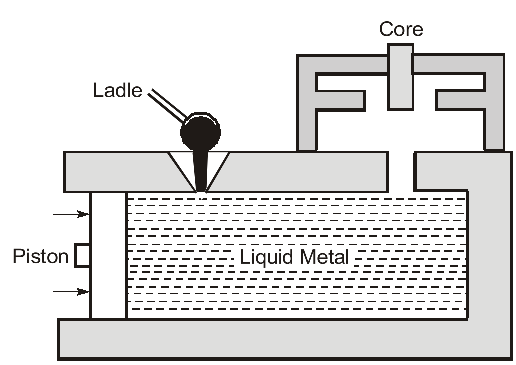


Figure 1.26 Cold Chamber Die Casting

The main difference between these two is that in the hot chamber die casting, the holding furnace for the liquid metal is integral with the die casting machine,

Where as the cold chamber machine, the metal is melted in a separate furnace and than poured into the die casting machine with a ladle for each casting cycle which is also called shot.

1.18.2 Slush Casting

Liquid metal is allowed to solidify on the die. Solidified skin develops first in a casting and that this skin then become thicker with time. Hollow casting with thin wall can be made by permanent mold casting using this principle, a process called slush casting. The molten metal is powered into the metal mold; after the desired thickness of solidified skin is obtained, the mold is inverted or swing and the remaining liquid metal is powered out. The mold halves are then opened and the casting is removed.

Such casting is important for small production run and is generally used for making ornamental and decorative objects. (Such as lamp bases and stems) and toys from lower melting point metal such as zinc, tin and lead alloys.

NOTE

- Very thin sections, ornaments, lamp bases, statue and other brass items are made up by this process.
- Liquid metal is poured into the die cavity and since solidification will start from the surface, without completely solidifying the liquid metal, the mould is inverted and excess metal is removed from the cavity.
- Toys, decorative items and lamp shades are made by this process.

1.18.3 Centrifugal Casting

- This is a process where the mould is rotated rapidly about its axis (central axis) as the metal poured into it.
- Because of the centrifugal force, a continuous pressure will be acting on the metal as it solidifies.
- The slag oxides and other inclusions being lighter, gets separated from the metal and segregates towards centre.

Types of Centrifugal Casting

1.18.3.1 True Centrifugal Casting

- In this process a metallic mould (in two parts with flange) is rotated at 3000 rpm using a rotating devices.
- Liquid metal is than poured into it at the centre.
- The mould is slightly inclined from the horizontal position so that the liquid metal covers the entire work length of moulds.

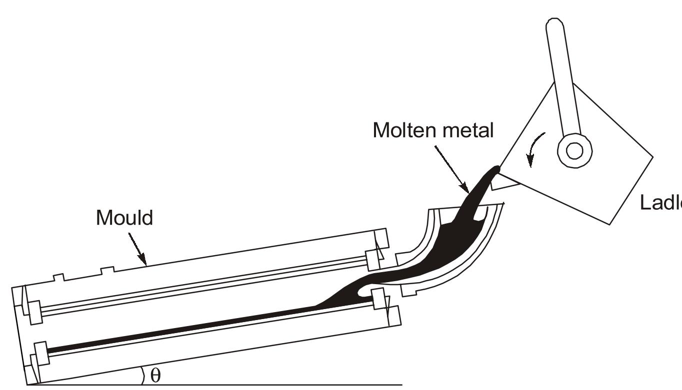


Figure 1.27 True Centrifugal Casting

- Fine grains with high density settles down at the outside surface due to higher centrifugal force. The grains towards centre will be coarse with less density.

Applications

- The mechanical properties of centrifugally cast jobs are better compared to other process, because the inclusions such as slag and oxides segregates towards the centre and can be easily removed by machining.
- After the pressure acting on the metal throughout the solidification, causes the porosity get eliminated giving rise to dense metal.
- Upto a certain dimensions and thickness of object, proper directional solidification can be obtained.
- No core is required for making concentric holes in case of true centrifugal casting.
- There is no need for gates and runners, which increases the casting yield, reaching almost 100%.
- The axis of rotation can be either horizontal vertical or any angle in between.

Limitation of true centrifugal casting

- Only certain shapes which are axis symmetric and having concentric holes are suitable for true centrifugal casting.
- The equipments is expensive and thus is suitable only for large shell production.

1.18.3.2 Semicentrifugal Casting

- In this process mould is placed on the horizontal plane and it is rotated along vertical axis.
- The outer portion of the mould will be filled by purely centrifugal action and as the liquid metal approaches towards centres of centrifugal component decreases and gravity component increases.
- The central portion is purely filled by gravity.
- The speed of rotation and percentage yield is lower than true centrifugal casting.
- It is used for making wheel, pulley, spoke wheel, alloyed wheels, etc.

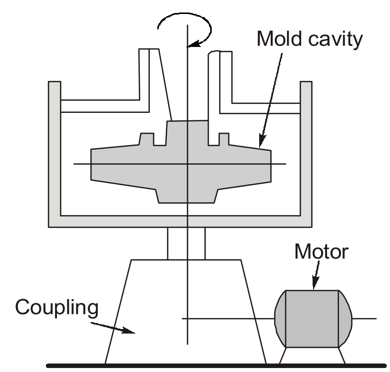


Figure 1.28
Semicentrifugal Casting

1.18.3.3 Centrifuging Casting

- As shown in Figure that a number of casting are placed on the periphery of a drum and are connected to the central sprue through individual gates.
- After solidification, gating system is disconnected to get the casted part.
- The percentage yield in this case is less.
- The casting need not to be axisymmetric and the process is primarily used in making patterns for investment casting.
- The centrifugal process is used in order to obtain higher metal pressure during solidification.
- When casting shapes are not axis symmetrical this is suitable and for small jobs of any shape.
- It is used for making pattern used in investment casting.

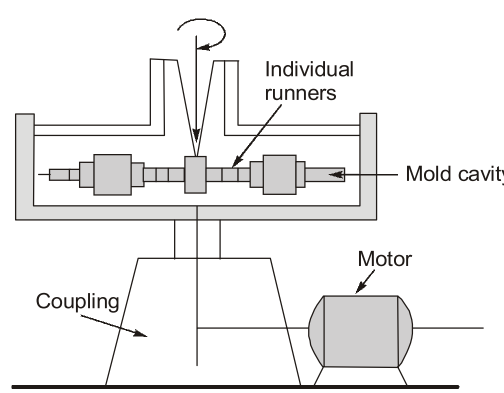


Figure 1.29 Centrifugal Casting

1.18.4 Continuous Casting

To produce long objects continuously in mass production this technique is used. Liquid metal is allowed through die opening, the output of the die is a solid crust on which water is sprayed to cool the metal at a faster rate. Production rate is very high. Better mechanical properties are not possible. Die is produced by copper.

Applications: To produce long length bars, rods, billets, slabs, etc.

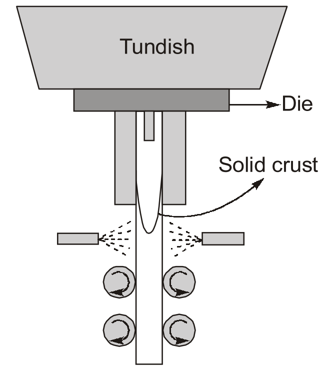


Figure 1.35

1.19 Casting Defects

1. Drop

Irregular projection on the top of casting caused by dropping of sand from cope.

2. Buckle

V-shaded depression occurring on flat casting due to expansions of sand at the mould face before liquid metal solidifies. (Figure 1.30)

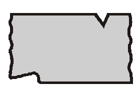


Figure 1.30 Buckle

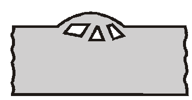


Figure 1.31 Scab

3. Scab

Protruding surface of casting at roof. (Figure 1.31)

4. Swell

Liquid metal displaces the sand at the wall regions due to hydrostatic pressure. (Figure 1.32)

5. Mould Shift

Due to misalignment between the two halves. (Figure 1.33)

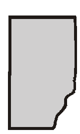


Figure 1.32 Swell

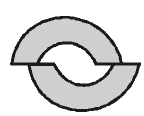


Figure 1.33 Mould Shift

6. Discontinuities

Discontinuities is defined in casting in terms of cracks, hot tearing and cold shut. If the solidifying metal is constrained from shrinking freely, cracking and tearing can occur. Although many factors are involved as tearing, coarse grain size and the presence of low melting point segregates along the grain boundaries, increase the tendency for hot tearing. Cold shut is an interface in a casting that lacks complete fusion because of the meeting of two streams of liquids metal from different gates.

7. Misrun

Due to lack of fluidity and pouring temperature before filling of the metal in the cavity it solidifies.

8. Inclusions

It form during melting, solidification and molding. Generally nonmetallic, they are regarded as harmful because they act as stress raisers and reduce the strength of casting. Inclusion may form during melting when molten metal reacts with the environment or with the crucible or mold material. Chemical reaction among components in the molten metal may produce inclusion slag and other foreign material entrapped in the molten metal also become inclusion.

1.20 Cupola

This is the commonly used melting furnace in foundries. Cupolas are refractory lined vertical steel vessels charged with alternating layers of metal, coke and flux, Although they require major investments and are being replaced by induction furnaces, cupolas operate continuously, have high melting rates and produce large amounts of molten metal.

1.20.1 Melting of Cast Iron

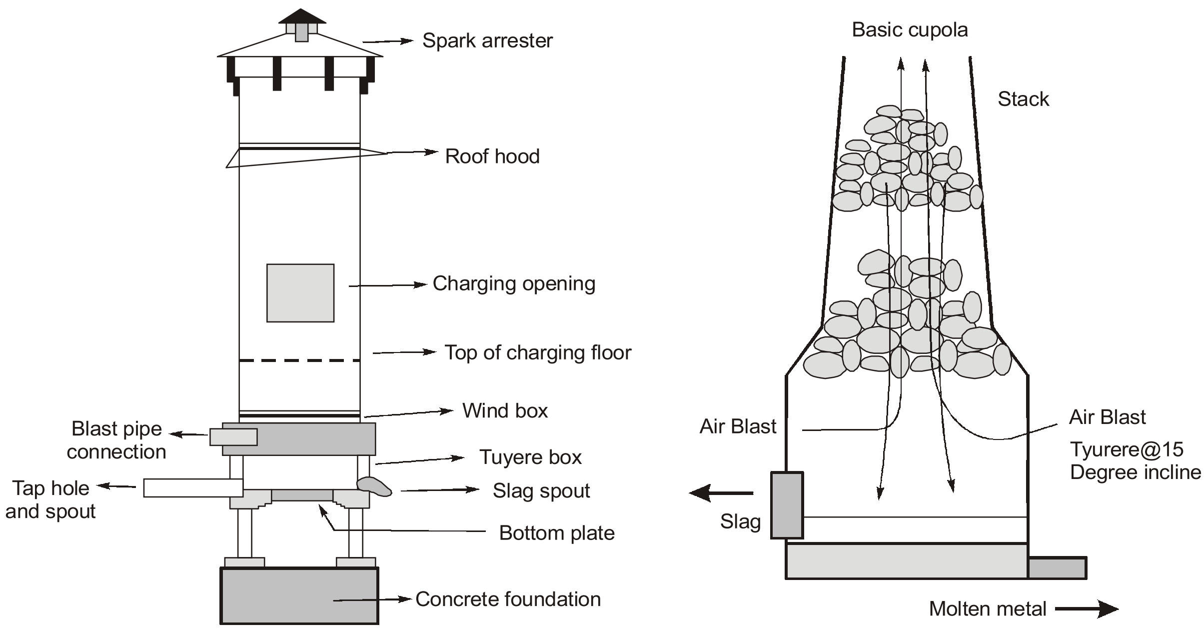


Figure 1.34 Melting of Cast Iron

Wide spread use of the cupola for gray-iron melting rests upon its unique advantage.

1. **Continuous melting :** Foundry production is initiated since a cable of molten iron may be tapped from the furnace at regular intervals. The flow of molten iron metal and moulds for pouring may be synchronized for quality production as required by the automotive, agricultural equipment.
2. **Low Cost of Melting :** Raw material and operating costs are lower than only other type of melting furnace producing equivalent damage.
3. Chemical composition control is possible by proper furnace operation with continuous melting.
4. Adequate temperature control for fluidity in pouring casting can be obtained.

1.21 Non-Destructive Testing

Various techniques are available for finding the internal soundness of components without sectioning or other destructive tests. The ability to detect the invisible subsurface defects not only aids in maintaining high quality standards, but provides a valuable help to the development of manufacturing methods.

Some of the non-destructive methods of testing which have become well established will be discussed in this chapter. A non-destructive test is an examination of a component in any manner which will not impair its future use. Although non-destructive tests do not provide direct measurement of mechanical properties, yet they are extremely useful in revealing defects in components that could impair their performance when put in service.

Non-destructive tests make components more reliable, safe and economical. Various non-destructive tests commonly used are as follows :

1.22 Visual Inspection

Defects which are easily located by visual inspection are surface cracks, tears, blowholes, metal penetration, rat tails and buckles, swells, shifts, surface roughness, shrinkage, etc. Visual inspection is carried out with the naked eye or using a magnifying glass. Visual inspection ensures that none of the features of a casting has been omitted or malformed by molding errors, short running or mistakes in fettling.

An inspector carrying out visual examination identifies casting defects and assigns their cause to some foundry operation or raw materials so that corrective measures can be employed. Visual inspection is simplest, fastest and most commonly employed, but it needs greater skill on the part of the inspector to locate and identify different manufacturing defects.

Only visual inspection may be sufficient for many castings such as manhole covers, drains, counterbalance weights, etc., however, countless other castings require added inspection for dimensional accuracy, subsurface defects and mechanical and other properties.

1.23 Hammer Test

Certain defects such as internal shrinkage, porosity, blowholes, slag inclusions, etc., which of course contribute to lack of casting soundness if present, but depending upon the application of the casting, do not affect its adequate functioning and the casting is quite acceptable to the user, are detected in the following manner:

- The casting is suspended above the floor, clear from all sides. At different places, it is gently struck with a hammer.
- The sound produced is carefully noted either by ear or with the help of electronic equipments.
- There is a difference between the pitch and quality of sound coming from sound metal and that observed from the portion of the casting containing above-mentioned defects. In other words, the soundness of a portion of the casting is judged by the quality of the ring it produces.

Presence of large defects in an otherwise sound casting can be detected by this method.

1.24 Radiography

The use of X-ray and γ-ray radiography, in inspecting castings for such defects as blow holes, cracks, shrinkage cavities and slag inclusions, is of primary metallurgical interest to a foundryman. These defects are of special importance in components designed to withstand high temperatures and pressures employed in power plants, atomic reactors, chemical and pressure vessels and oil refining equipments, because they, (i.e., defects) cause stress concentration which may frequently lead to part failure.

Principle

- Radiography technique is based upon exposing the components to short wavelength radiations in the form of X-rays (wavelength less than 0.001×10^{-8} cm to about 40×10^{-8} cm) or gamma (γ) rays (wavelength about 0.005×10^{-8} to 3×10^{-8} cm) from a suitable source such as an X-ray tube or cobalt-60.
- The characteristic feature of X-ray or γ-ray which makes them to work is their power to penetrate matters opaque to light. X-rays operating at 400,000 volts can inspect steel castings having thickness up to 62 mm.

Student's Assignments 1

1. Two casting one is sphere and other is cube both are having same volume and made of same material. Determine the ratio of solidification time of the cube to sphere.

Ans. $\dfrac{(t_s)_{cu}}{(t_s)_{sp}} = 0.649$

2. Two casting one is sphere another is cylinder with $h = d$. Both are made up of same material and having same volume. Show that spherical cross section will take more time to solidify them compare to cylindrical cross section.?

Ans. $\dfrac{(t_s)_{sp}}{(t_s)_{cyl}} = 1.31$

Student's Assignments 2

1. Match List-I (Moulding process) with List-II (Binding agent) and select the correct answer.

List-I
A. Green sand
B. Cores sand
C. Shell moulding
D. Carbon dioxide process

List-II
1. Silicate
2. Organic
3. Clay
4. Plaster of Paris
5. Plastic

Codes:

	A	B	C	D
(a)	3	2	5	1
(b)	3	2	4	1
(c)	2	3	5	4
(d)	2	3	4	5

2. Gray cast iron block 200 × 100 × 100 mm are to be cast in sand moulds. Shrinkage allowance for pattern making is 1%. The ratio of the volume of pattern to that of the casting will be.

(a) 0.97 (b) 0.99
(c) 1.01 (d) 1.03

3. Match **List-I** (Produce) with **List-II** (Process of manufacture) and select the correct answer.

List-I
A. Automobile piston in aluminium alloy.
B. Engine crankshaft in spheroidal graphite iron
C. Carburettor housing in aluminium alloy.
D. Cast titanium blades

List-II
1. Pressure die casting
2. Gravity die casting
3. Sand casting
4. Precision investment casting.
5. Shell moulding

Codes:

	A	B	C	D
(a)	3	2	1	5
(b)	3	2	5	1
(c)	2	1	3	4
(d)	4	1	2	3

4. Match **List-I** with **List-II** and select the correct answer.

List-I
A. Die casting
B. Centrifugal casting
C. Centrifuging
D. Continues casting

List-II
1. Molten metal is forced into the die under pressure
2. Axis of rotation does not coincide with axis of mould
3. Metal solidifies when mould is rotating
4. Continuously pouring molten metal into mould
5. Plastic

Codes:

	A	B	C	D
(a)	1	3	2	4
(b)	4	3	2	1
(c)	1	2	3	4
(d)	4	2	3	1

5. An expendable pattern is used in
(a) Slush casting (b) Squeeze casting
(c) Centrifugal casting (d) investment casting

6. Which one of the following processes consist of central sprue to feed metal into cavities through a number of radial gates?
(a) Centrifuging
(b) Semi-centrifugal casting
(c) True centrifugal casting
(d) Precision casting

7. Which of the following materials are used for making patterns in investment casting method?
1. Wax
2. Rubber
3. wood
4. Plastic
Select the correct answer.
(a) only 1 and 3 (b) only 2 and 3
(c) only 1, 2 and 4 (d) only 2, 3 and 4

8. Which one of the following would produce strongest components?
(a) Die casting (b) Hot rolling
(c) Cold rolling (d) Forging

9. In hot chamber method a die casting
(a) only low melting point metals can be used.
(b) high melting point metals can be cast.
(c) Die is kept hot by electrical heating
(d) Die is kept cold by circulating water.

10. Ornamental objects, statues, toys etc are cast by
(a) Die casting (b) Pressed casting
(c) Centrifugal casting (d) Slush casting

ANSWERS

1. (a)	2. (d)	3. (a)	4. (a)	5. (d)
6. (a)	7. (c)	8. (d)	9. (a)	10. (d)

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