SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF MECHANICAL ENGINEERING

19MEZ405- CASTING DESIGN AND PERFORMANCE

IV YEAR / VIII SEM

UNIT – 1

CASTING PROCESS

UNIT I CASTING PROCESS

Casting Process - Classification, characteristics of sand casting processes, metal mould casting processes and casting processes using other mould/core materials, Pattern materials, types of patterns, Mould and core making materials and their characteristics. The features of casting problem; a survey and scope of foundry industry

UNIT II CASTING DESIGN PRINCIPLES AND PRACTICES

Casting Design Issues and Practices - Casting Design and Processes -Modeling of Casting and Solidification Processing - Solidification of pure metals and al1oys; nucleation and growth in alloys; solidification of actual castings; progressive and directional solidification; centre in feeding resistance; rate of solidification, electrical analog of solidification problems

UNIT III PROCESS DESIGN

Process Design - Pattern design - Riser Design - Gating Design - Design for Economical Sand Molding - Design for Economical Coring – Moulding and Core Making Processing

UNIT IV CASTING DESIGN AND GEOMETRY

Design Problems Involving - Thin Sections - Design Problems Involving Uniform Sections - Design Problems Involving Unequal Sections - Design Problems Involving Junctions - Design Problems Involving Distortion

UNIT V CASTING PERFORMANCE

Corrosion of Cast Irons - Corrosion of Cast Carbon and Low-Alloy Steels - Corrosion of Cast Stainless Steels - Fatigue and Fracture Properties of Cast Irons - Fatigue and Fracture Properties of Cast Steels - Fatigue and Fracture Properties of Aluminum -Alloy Castings - Friction and Wear of Cast Irons - Friction and Wear of Aluminum-Silicon Alloys - Failure Analysis of Castings . Inspection of Castings

TEXTBOOKS

1. Scrope Kalpakjian, “Manufacturing processes for Engineering Materials”, Addision, Wesley, 1997.
2. Fundamentals of metal casting technology - P.C. Mukherjee, Oxford and IBH.

REFERENCES

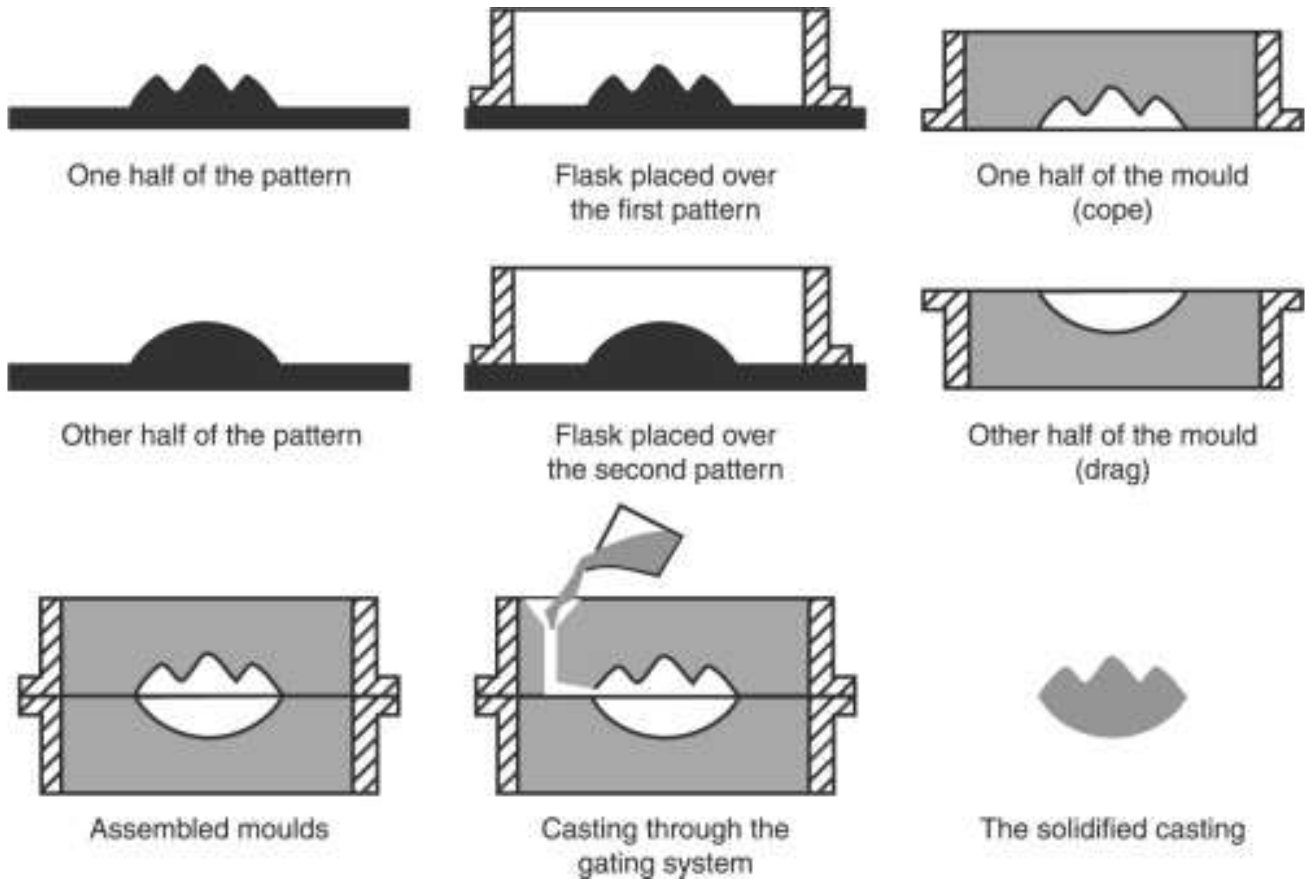
1. Fundamentals of Metal casting, Flinn, Addison Wesley.
2. Principles of Metal casting, Heine, Loper & Rosenthal,McGraw Hill.
3. Product Design and Process Engineering Practice, Niebel & Draper, Salmon & Simons, McGraw Hill Foundry, Issac Pitaman
4. Casting properties of metals and alloys - V. Korolkove.
5. Metal casting-B.Ravi-PHI

CASTING PROCESS

Manufacturing process used to produce solid metal pieces called *castings*. Molten metal is poured into a mold. Once in the mold, the metal cools and solidifies in the shape of the mold cavity.
Casting offers exceptional freedom in forming intricate components. It is also conducive to high-volume production runs, where material quantities can be efficiently controlled to minimize waste and reduce cost. The casting process is also called *founding*.

Sand Casting

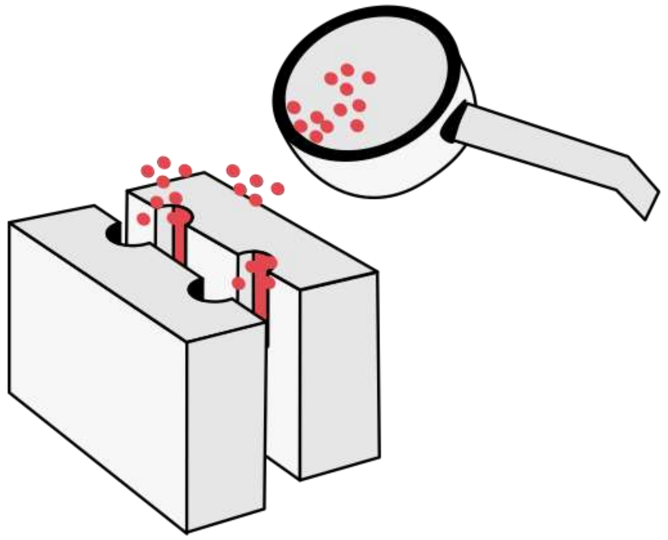
Sand casting is a common production process for manufacturing metal parts of different weights and sizes. It can create intricate, detailed parts using any metal alloy type. Automotive products such as cylinder heads, crankshafts, and engine cylinder blocks are manufactured through this process.



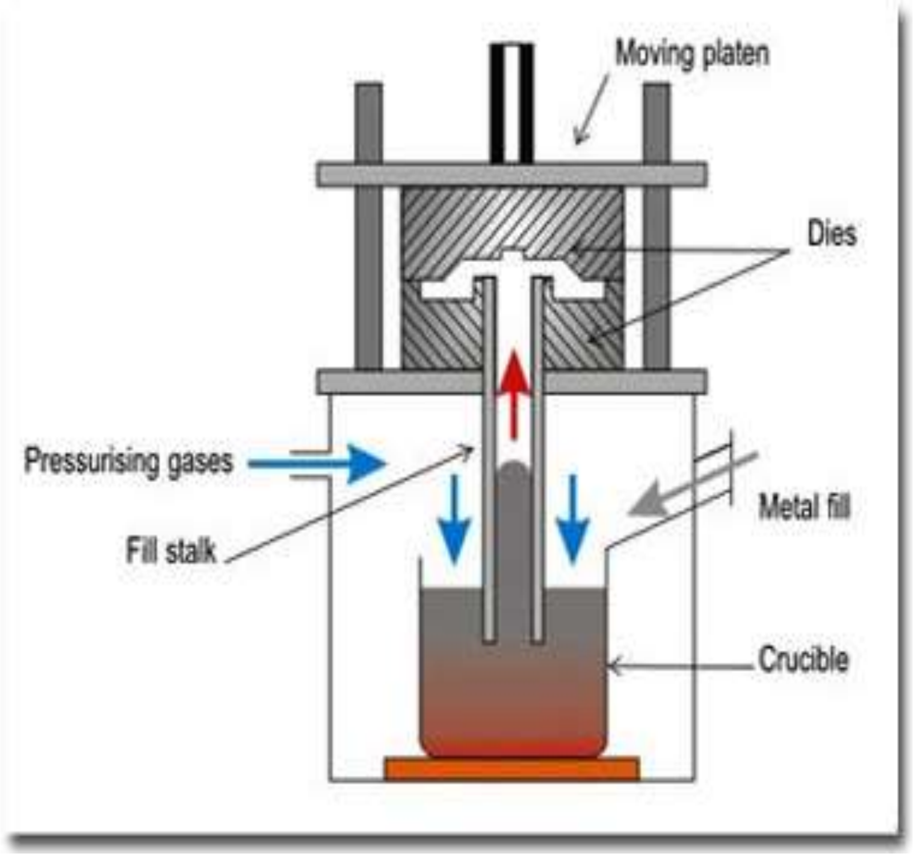
Die Casting Process

Die casting involves melting metals with low melting points and injecting them into an already-made mold. The molds are made of steel using cutting-edge techniques such as CNC machining, ensuring precision, high levels of accuracy, and repeatability when working with metal components.

The first step in this casting process is the creation of a reusable steel mold with two sections. The two sections are then clamped together tightly. Molten metal is then injected after applying a lubricant, which helps regulate its temperature and ease the casting removal from the mold.

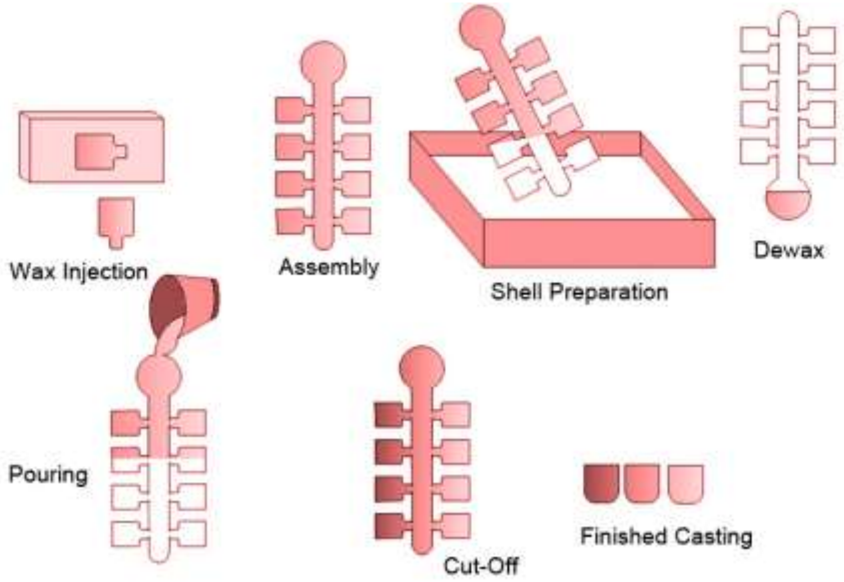


Pressure die casting is a manufacturing process that produces net-shaped, precisely tolerated metal components. The process involves injecting a molten metal (aluminum, zinc, or magnesium) at high speed and pressure into a steel mold (a closed die). One half of the die is moveable while the other half is stationary, both mounted on the casting machine's platen.



Investment Casting

Investment casting, also referred to as lost wax casting, uses a disposable wax pattern coated with a ceramic material, which solidifies into the shape of the casting. The first step in this casting process is making a wax pattern, often made from wax or plastic. Since this process requires accurate measurements, several trials, and errors make the investment casting an expensive manufacturing process. The wax is injected into a mold, carefully removed, and then coated with a binding agent or a refractory material to create a thick shell. Besides, multiple patterns are assembled onto the main sprues.

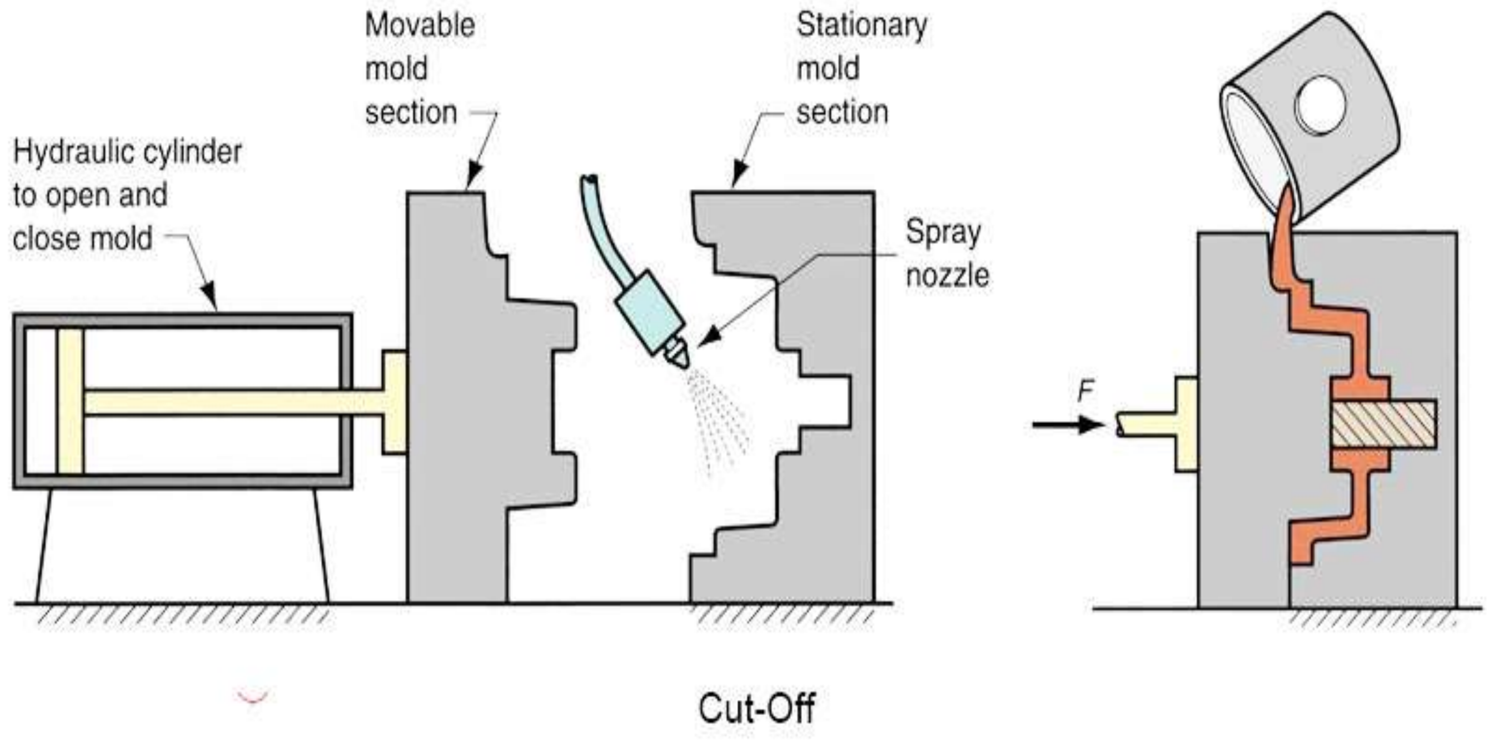


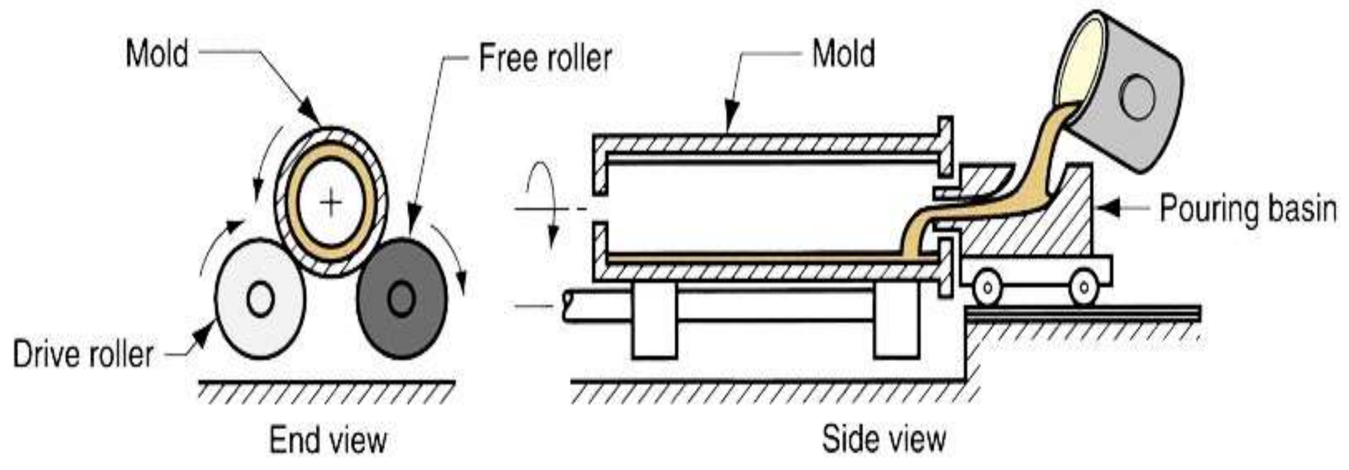
Permanent mold casting is similar to centrifugal and die casting, especially in reusable molds. These molds can be made of graphite, steel, etc, and used to cast materials such as cast iron aluminum, zinc, lead, and magnesium alloy. Besides, it has a variety of applications for projects that require duplication or mass production.

The molds for this casting process have two parts that fit firmly with an opening at the top section for injecting molten metal. When the metal solidifies, the two parts are separated to reveal the finished casting.

Centrifugal casting, formerly the deLavaud process, produces long, cylindrical pieces such as cast iron pipes by relying on the g-forces created in a rotating mold.

The centrifugal casting involves pouring molten metal into a mold that rotates vertically or horizontally, enclosed in a water spray or a water jacket. Molten metal is carefully injected into the mold using a ladle through a trough. As the molten metal gets into the casting, it stretches to both ends of the mold.





Characteristics of Sand casting Process

- Sand casting is a **highly versatile** metal casting process that produces components ranging from small pins to large locomotive parts. It accommodates various metals, including **ferrous and non-ferrous alloys**, making it the **most widely used casting method** globally.

- The properties of moulding sand, such as refractoriness, permeability, thermal conductivity and flowability, ensure that the molten metal **fills the mould properly** and that the final product has the **desired characteristics**, impacting both quality and process efficiency.

- Sand casting offers advantages such as **cost-effectiveness**, suitability for **various production scales**, and compatibility with a wide range of metals. However, challenges such as **surface finish variability**, cooling rate control issues, and the need for skilled labour highlight its limitations.

Properties of Moulding Sand

A moulding sand should possess the following 6 properties

1. Porosity
2. Flowability
3. Collapsibility
4. Adhesiveness
5. Cohesiveness or strength
6. Refractoriness

1.Porosity or Permeability:

It is the ability of sand by which it allows the gases to pass through it easily.

Some gases gets dissolved in molten metal and when this molten metal starts to solidify, these dissolved gases comes out of the molten metal and try to escape out of the moulding sand. If the sand is not enough porous than these gases will not be able to go out of the mould and gets trapped into the casting and produces holes and pores in metal casting. Also if the molten metal comes in contact with the moist sand, steam or water vapor is produced. This steam or vapors also results in the formation of holes in the casting if they do not able to escape out of the mould. So it is advised to use sufficiently porous moulding sand to eliminate the porosity defect in metal casting.

2. Flowability :

The ability of moulding sand to behave like a fluid when it is rammed is called flowability.

Due to this property the sand can easily occupy the space in molding box and take up its shape. This allows the sand to compress to a compact density and let it pack around the pattern. The sand should be of high flowability, so that it can be easily compacted for uniform density and to obtain a good impression of the pattern in the mould. The flowability of the sand can be increases as we increases the clay and water content in the sand.

3. Collapsibility :

The ability of the moulding sand to collapse after solidification of the molten metal is called collapsibility.

After the solidification of molten metal, the sand should get collapse for free contraction of the metal. If free contraction of the metal will happen than if eliminates naturally the tearing or cracking of the contracting metal.

4. Adhesiveness :

The ability of the sand particles to get stick with another body is called adhesiveness.

The sand should have sufficient adhesiveness so that it can easily get cling to the sides of the moulding boxes and does not fall out to the box when it is removed.

5. Cohesiveness or Strength

The ability of the sand particles to stick with each other is called cohesiveness.

The strength of the sand depends upon how cohesive the sand particles are. The sand should have sufficient strength so that it can easily capable to retain its shape during conveying, turning or closing and pouring. If it is not of appropriate strength than it will not be able to hold its shape and the mould may damage during pouring of molten metal. Low strength sand leads to pouring casting defects in metals. To avoid pouring defects, the sand should be of sufficient strength to produce mold of desired shape and also retain this shaped even when the molten metal is poured in the moulding cavity.

The sand strength can be of two types

(i) Green strength: The strength of sand possessed by it in its green or moist state is called green strength. The mould with adequate green strength retains its shape and do not collapse even when the pattern is removed from the moulding box.

(ii) Dry strength: The strength possessed by the sand in its dry or baked state is called dry strength. Enough dry strength allows the sand to withstand erosive forces due to molten metal and helps to retain its shape.

6. Refractoriness

The ability of the moulding sand to withstand the high temperature of the molten metal without fusing into it is called refractoriness.

The moulding sand must have enough refractoriness property to produce excellent quality of casting free from defects. The sand with lack of refractoriness melts and gets fuse in the casting and spoils the quality of the cast metal. The refractoriness is the measure of sinter point of the sand not its melting point.

This is all about the six properties of moulding sand. Every types of moulding sand used in the casting process must have these six properties.

Metal mold casting processes

Sand casting

A traditional process that involves pouring molten metal into a mold made from sand. The sand can be reused after the metal has cooled.

Investment casting

Also known as the lost wax process, this process uses a refractory material to create a mold. The castings produced are smooth and have high dimensional accuracy.

Die casting

This process involves using high pressure to mold materials, usually non-ferrous metals like aluminum, copper, tin, and zinc.

Permanent mold casting
This process involves pouring molten metal into a metal mold using gravity.

Lost foam casting
Similar to investment casting, but uses polystyrene foam instead of wax to create the mold.

Other casting processes
Continuous casting
Used to produce standard products continuously and cost-effectively. Metals like aluminum, copper, lead, and steel are continuously cast.

Pressure die casting
Involves injecting molten metal alloy into a steel mold under high pressure. This process is used to produce large volumes of metal components

• Pattern Materials

Patterns for sand castings are subjected to considerable wear and tear due to ramming action that is required and the abrasive action of the sand

• Should be impervious to moisture because of changing surroundings • Made of: wood, metal, plastics, plaster and synthetic materials

• Woods => white pine, sugar pine; The wood should be straight grain, light, easy to work, little tendency to develop crack and warp.

• More durable: Mahogany

• For large castings: metal such as cast iron or aluminium

• When metal pattern are cast from the wooden master pattern, double shrinkage must be provided on the wooden master pattern

• Assume metal pattern is made of aluminium and castings are made of CI, the shrinkage allowance for the wooden master pattern is: 5/32 inch per foot for Al+ 1/8 inch per foot CI = 9/32 inch per foot.

Pattern

The pattern and the part to be made are not same. They differ in the following aspects.

1.A pattern is always made larger than the final part to be made. The excess dimension is known as Pattern allowance. Pattern allowance => shrinkage allowance, machining allowance

2.Shrinkage allowance: will take care of contractions of a casting which occurs as the metal cools to room temperature.

Liquid Shrinkage: Reduction in volume when the metal changes from liquid state to solid state. Riser which feed the liquid metal to the casting is provided in the mould to compensate for this.

Solid Shrinkage: Reduction in volume caused when metal looses temperature in solid state.

Shrinkage allowance is provided on the patterns to account for this.