1.1 Introduction

Casting or founding is the process of producing metal or alloy component parts.

The parts of desired shapes are produced by pouring the molten metal or alloy into a prepared mould and then allowing the metal or alloy to cool and solidify.

This solidified piece of metal or alloy is called as casting.

1.1.1 Steps involved in making a casting

Following are the steps to be followed while making a sand casting.

1. **Pattern making**: Make the pattern of wood, metal or plastic.
2. **Sand mixing and preparation**: Select a particular sand, test it and prepare the necessary sand mixtures for mould and core making.
3. **Core making**: With the help of pattern prepare the mould and required cores.
   Note: Mould is a container having a cavity of the shape to be cast, whereas core is a body which is employed to produce a cavity in the casting and is generally made of sand.
4. **Melting**: Melt the metal or alloy to be cast.
5. **Pouring:** Pour the molten metal or alloy into the mould and remove the casting from the mould after solidification of metal.
6. **Finishing:** Clean and finish the casting.
7. **Testing:** Test and inspect the casting and remove the defects, if any.
8. **Heat treatment:** Relieve the casting stresses by using various heat treatments.
9. **Re-testing:** Again inspect the casting and deliver it.

1.2 Advantages and Application of Metal Casting

Advantages

Casting is one of the most versatile manufacturing processes.

It provides the greatest freedom of design in terms of shape, size and quality of product.

Casting provides uniform directional properties and better vibration damping capacity to the cast components.

Complex and uneconomical shapes which are difficult to produce by other processes can be easily produced by casting process.

A product obtained by casting is one piece; hence there is no need of metal joining processes.

Very heavy and bulky parts which are difficult to get fabricated, may be cast.

It also produces machinable parts.

Casting process can be mechanized and generally used for mass production of components.

Applications

A few applications of casting or cast components are given below:

Transportation vehicles (in automobile engine and tractors)

Machine tool structures

Turbine vanes and power generators

Mill housing

Pump filter and valve

Railway crossing and aircraft jet engine blades

Agricultural parts and sanitary fittings

Construction, communication and atomic energy applications, etc.

1.3 Sand Casting

Sand casting is used to produce a wide variety of metal components with complex geometries. These parts can vary greatly in size and weight, ranging from a couple ounces to several tons. Some smaller sand cast parts include components as gears, pulleys, crankshafts, connecting rods, and propellers. Larger applications include housing for large equipment and heavy machine bases.

For sand casting, the most common metals are iron, steel, bronze, brass and aluminum. With these alloys, sand casting can produce small parts that weigh less than one pound or large parts the weight several tons.

The process is used to make medium to large parts such as valve bodies, plumbing fixtures, locomotive components and construction machinery. Its versatility also allows sand casting to produced small parts such as buckles, handles, knobs and hinges.

It is a cost effective and efficient process for small lot production, and yet, when using automated equipment, it is an effective manufacturing process for high-volume production.

Sand casting is also common in producing automobile components, such as engine blocks, engine manifolds, cylinder heads, and transmission cases.

The sand casting process involves the use of a furnace, metal, pattern, and sand mould. The metal is melted in the furnace and then ladled and poured into the cavity of the sand mould, which is formed by the pattern.The sand mould separates along a parting line and the solidified casting can be removed.

Key points on advantages and disadvantages of sand casting:

Advantages

Low cost of mould materials and equipment.

Large casting dimensions may be obtained.

Wide variety of metals and alloys (ferrous and non-ferrous) may be cast (including high melting point metals).

Disadvantages

Rough surface.

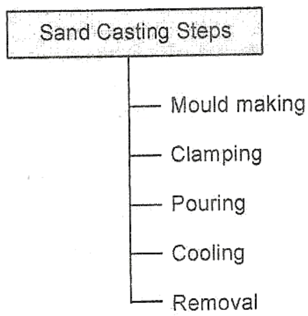
Poor dimensional accuracy.

High machining tolerances.

Coarse Grain structure.

Limited wall thickness: not higher than 0.1”-0.2” (2.5-5 mm).

1.3.1 Steps involved in sand casting process



The process cycle for sand casting consists of five main stages, which are explained below.

a) Mould-making

The first step in the sand casting process is to create the mould for the casting. In an expendable mould process, this step must be performed for each casting. A sand mould is formed by packing sand into each half of the mould. The sand is packed around the pattern, which is a replica of the external shape of the casting.

When the pattern is removed, the cavity that will form the casting remains. Any internal features of the casting the cannot be formed by the pattern are formed by separate cores which are made of sand prior to the formation of the mould. Further details on mould-making will be described in the next section.

The mould-making time includes positioning the pattern, packing the sand, and removing the pattern. The mould-making time is affected by the size of the part, the number of cores, and the type of sand mould. If the mould type requires heating or baking time, the mould-making time is substantially increased.

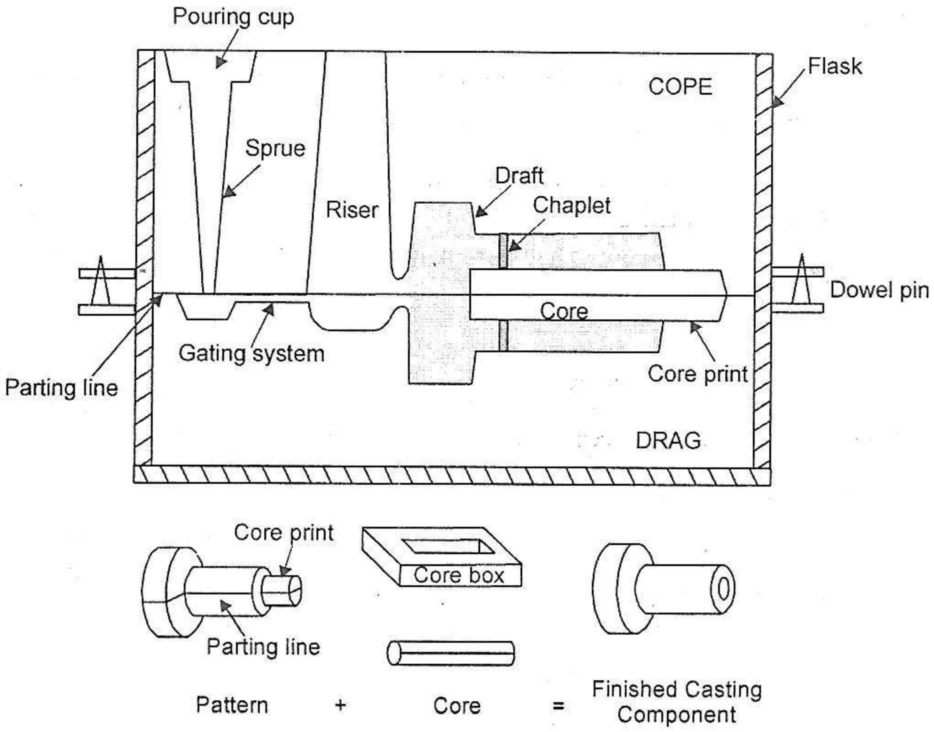


Figure 1.1: Cross section of a typical two-part mould, showing various features

Also, lubrication is often applied to the surfaces of the mould cavity in order to facilitate removal of the casting. The use of a lubricant also improves the flow the metal and can improve the surface finish of the casting. The lubricant that is used is chosen based upon the sand and molten metal temperature.

b) Clamping

Once the mould has been made, it must be prepared for the molten metal to be poured. The surface of the mould cavity is first lubricated to facilitate the removal of the casting.

Then, the cores are positioned and the mould halves are closed and securely clamped together. It is essential that the mould halves remain securely closed to prevent the loss of any material.

c) Pouring

The molten metal is maintained at a set temperature in a furnace. After the mould has been clamped, the molten metal can be ladled from its holding container in the furnace and poured into the mould.

The pouring can be performed manually or by an automated machine. Enough molten metal must be poured to fill the entire cavity and all channels in the mould. The filling time is very short in order to prevent early solidification of any one part of the metal.

d) Cooling

The molten metal that is poured into the mould will begin to cool and solidify once it enters the cavity. When the entire cavity is filled and the molten metal solidifies, the final shape of the casting is formed.

The mould cannot be opened until the cooling time has elapsed. The desired cooling time can be estimated based upon the wall thickness of the casting and the temperature of the metal. Most of the possible defects than can occur are a result of the solidication process. If some of the molten metal cools too quickly, the part may exhibit shrinkage, cracks, or incomplete sections.

e) Removal

After the predetermined solidification time has passed, the sand mould can simply be broken, and the casting removed. This step, sometimes called shakeout, is typically performed by a vibrating machine that shakes the sand and casting out of the flask. Once removed, the casting will likely have some sand and oxide layers adhered to the surface. Shot blasting is sometimes used to remove any remaining sand, especially from internal surfaces, and reduce the surface roughness.

f) Trimming

During cooling, the material from the channels in the mould solidifies attached to the part. This excess material must be trimmed from the casting either manually via cutting or sawing, or using a trimming press.

The time required to trim the excess material can be estimated from the size of the casting's envelope. A larger casting will require a longer trimming time. The scrap material the results from this trimming is either discarded or reused in the sand casting process. However, the scrap material may need to be reconditioned to the proper chemical composition before it can be combined with non-recycled metal and reused.

1.4 Pattern Making

A pattern is a mould forming tool in the hands or foundry men.

A pattern is defined as a model or replica of the object to be cast.

A pattern exactly resembles the casting to be made except for the various allowances.

If one object has to be cast, then also pattern is required.

It is a model or form around which sand is packed to give rise to a cavity called as **mould cavity**, in which molten is poured and the casting is produced.

The ways in which a pattern differ from a casting are as follows:

- A pattern is slightly larger than the casting cecause a pattern carries allowance to compensate for metal shrinkage.

- Also, pattern carries allowances for machining so as to clean and finish the required surfaces.
- Pattern also has the necessary draft for its easy removal from the sand mass.
- It carries additional projections, called as coreprints, to produce seats for the cores.
- A pattern may not have holes and slots which a casting will have. Such holes and slots make a pattern complicated, hence can be drilled in the casting after it has been made.
- The material from which casting and pattern is made, is also different.

1.4.1 Functions of a Pattern

The main functions of a pattern are as follows:

To prepare a mould cavity of appropriate shape and size for the purpose of making a casting.

To produce seats for the cores in the mould in which cores can be place, for producing cavity in the casting. Such seats in the mould are called as **core prints.**

To establish the parting line and parting surfaces in the mould.

To minimize casting defects.

To help for positioning of a core before the moulding sand is rammed.

It should minimize the overall casting cost.

1.5 Pattern Materials

Selection of materials for pattern

The following factors should be considered while selecting proper material for pattern:

The number of casting to be made; metal patterns are preferred for large quantity of production.

Degree of accuracy in dimensions and the quality of surface finish required on the casting.

Method of moulding to be used i.e. hand or machine.

Type of casting method to be used i.e. sand casting, investment casting, etc.

Shape, size and complexity of the casting.

Casting design parameters.

Type of moulding material to be used.

1.5.1 Materials for Making Patterns

The common materials of which the patters are made are as follows:

1. Wood 2. Metal 3. Plastic 4. Plaster 5. Wax

1. Wood :

It is the most common material for making patterns for sand casting because of following advantages:

Advantages

It is cheap and easily available in large quantities.

It can be easily shaped and machined to different configurations and forms.

Good surface finish can be easily obtained.

Due to lightness in weight its manipulation is easy and it can also be repaired easily.

Limitations

Wooden patterns are weak as compared to metal patterns.

They cannot withstand rough handling.

They possess poor wear resistance and hence they are abraded easily by sand action.

They absorb moisture, hence get warped and change the shape and size.

Applications

Wooden patterns are mostly used where number of casting to be made is small and the size of pattern is large.

The common woods used in pattern making are:

(a) White pine (b) Mahogany (c) Maple (d) Cherry (e) Teak

2. Metals

Metal patterns are cast from wooden patterns.

Advantages

They do not absorb moisture.

They are stronger and accurate, hence more life as compared to wooden patterns.

They have greater resistance to abrasion and wear.

They can withstand rough handling.

Limitations

As compared to wooden patterns they are more expensive.

They are heavier than wooden patterns.

Ferrous material patterns get rusted.

They cannot be repaired easily.

Applications

Metal patterns are used where large numbers of castings have to be produced from the same pattern.

The various metals and alloys employed for making patterns are:

(a) Aluminum and its alloys (b) Steel (c) Brass (d) Cast iron

(e) White metal

3. Plastic:

Plastic is now a days considered as a pattern material due to their following advantages:

Advantages

Light weight and high strength.

Resistance to wear and corrosion.

Provides good surface finish.

They are easy to make and less costly also.

Limitations

Plastic patterns are fragile; hence light sections may need metal reinforcements.

They may not work well when subjected to conditions of severe shock.

4. Plaster:

Plaster of paris or gypsum cement is used as a patterns material because of following advantages:

Advantages

Complicated shapes can be cast without any difficulty.

It can be easily worked with the help of wood working tools.

It has high compressive strength.

Unlike metals it expands while solidifying.

Applications

Plaster is used for making small and intricate patterns and core boxes.

5. Wax

Wax is used for specialized applications such as investment casting, etc.

Advantages

They provide good surface finish.

After being moulded, the wax pattern is not taken out; rather the mould is inverted and heated and the molten wax comes out or gets evaporated, hence there is no chance of the mould cavity getting damaged while removing the pattern.

Also, the provide high accuracy to the castings.

Applications

Wax patterns are exclusively used in investment casting process.