

((Manufacturing))

Permanent Mold Casting Processes:

In permanent mold casting, the mold is reused many times. The processes include:

- 1) Basic permanent mold casting.
- 2) Slush Casting.
- 3) Low Pressure casting.
- 4) Vacuum Permanent mold casting.
- 5) Die casting.
- 6) Centrifugal casting.

1. The Basic Permanent Mold Process:

It is a process in which fluid metal is poured into metal molds & subjected to hydrostatic pressure [see fig. (1) below]. For hollow parts, either permanent core made of metal or sand is used.

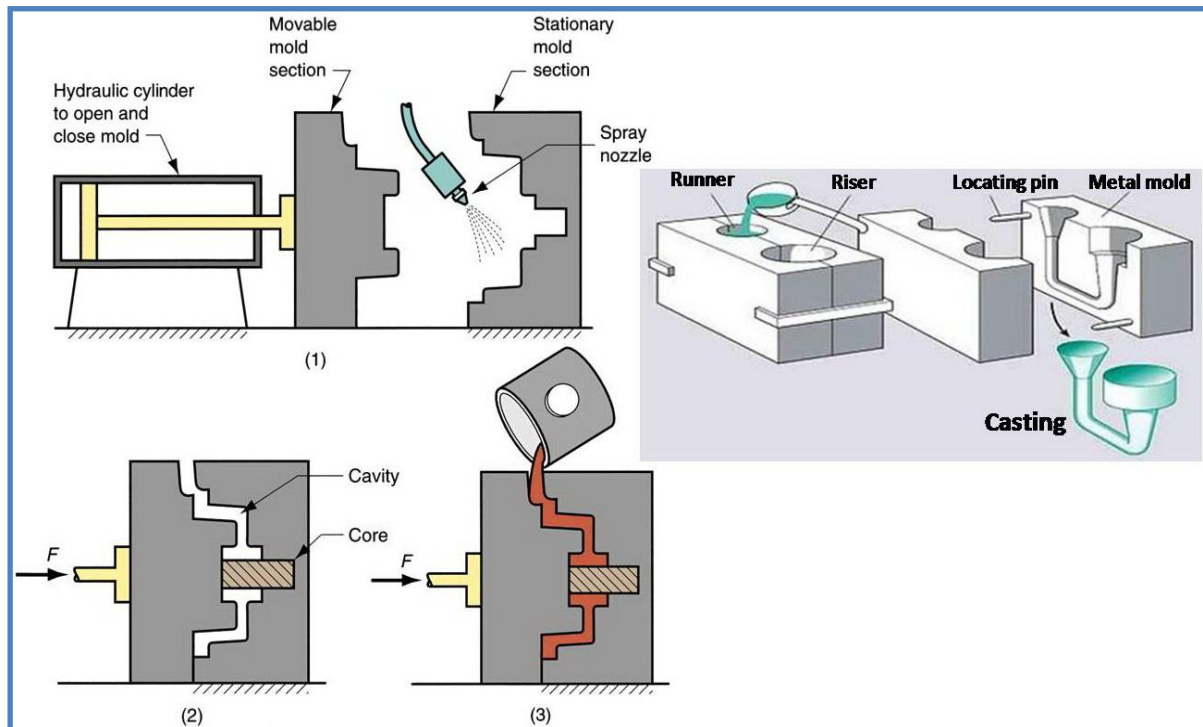


Fig. (1): Steps in Permanent mold casting.

Permanent mold casting is a metal casting process that shares similarities to both sand casting and die casting. As in sand casting, molten metal is poured into a mold which is clamped shut until the material cools and solidifies into the desired part shape.

Permanent mold casting, like die casting, uses a metal mold (die) that can be reused for several thousand cycles. Because the molten metal is poured into the die and not forcibly injected, permanent mold casting is often referred to as gravity die casting.

- Uses a metal mold constructed of two sections designed for easy, precise opening and closing [see fig. (1) above].
- Molds used for casting lower melting point alloys are commonly made of steel or cast iron.
- Molds used for casting steel must be made of refractory material, due to the very high pouring temperatures.

Steps in permanent mold casting (referring to fig. (1) above):

1. A metal mold is made in two halves.
2. The mold is then coated with a refractory coating, or sometimes graphite is used instead. This acts as a thermal barrier, and as a parting agent.
3. Cores are then added as required [see fig. (1) above]. Typical core materials include (oil-bonded sand, resin-bonded sand, plaster, graphite and gray iron - most common)

4. The mold halves are mated and preheated to about (300-400°F).
5. Low melting point molten metal is poured into the dies.
6. Water channels or heat-sink fins are used to cool the mold quickly.
7. The mold is opened, and ejector pins are used to force the part out of the mold – this leaves small circular depressions on the surface of the part.
8. The sprue is removed, and the stub is ground off.

Advantages of permanent mold casting:

- Good dimensional control and surface finish
- More rapid solidification caused by the cold metal mold results in a finer grain structure, so castings are stronger

Limitations:

- Generally limited to metals of lower melting point
- Simpler part geometries compared to sand casting because of need to open the mold
- High cost of mold, and mold production is a time consuming.

Applications of Permanent Mold Casting:

- Due to high mold cost, process is best suited to high volume production and can be automated accordingly.
- Typical parts: automotive pistons, pump bodies, and certain castings for aircraft and missiles.
- Metals commonly cast: aluminum, magnesium, copper-base alloys, and cast iron.

2. **Slush Casting:**

Slush Casting is a special type of permanent mold casting to create a hollow casting without using cores [see fig. (2) below]. In the process the material is poured into the mold and allowed to cool until a desired wall thickness is obtained, the not yet solidified molten metal is poured out.

- It is a relatively inexpensive process.
- This is useful for making hollow ornamental objects such as candlesticks, lamp's holder, statues etc.

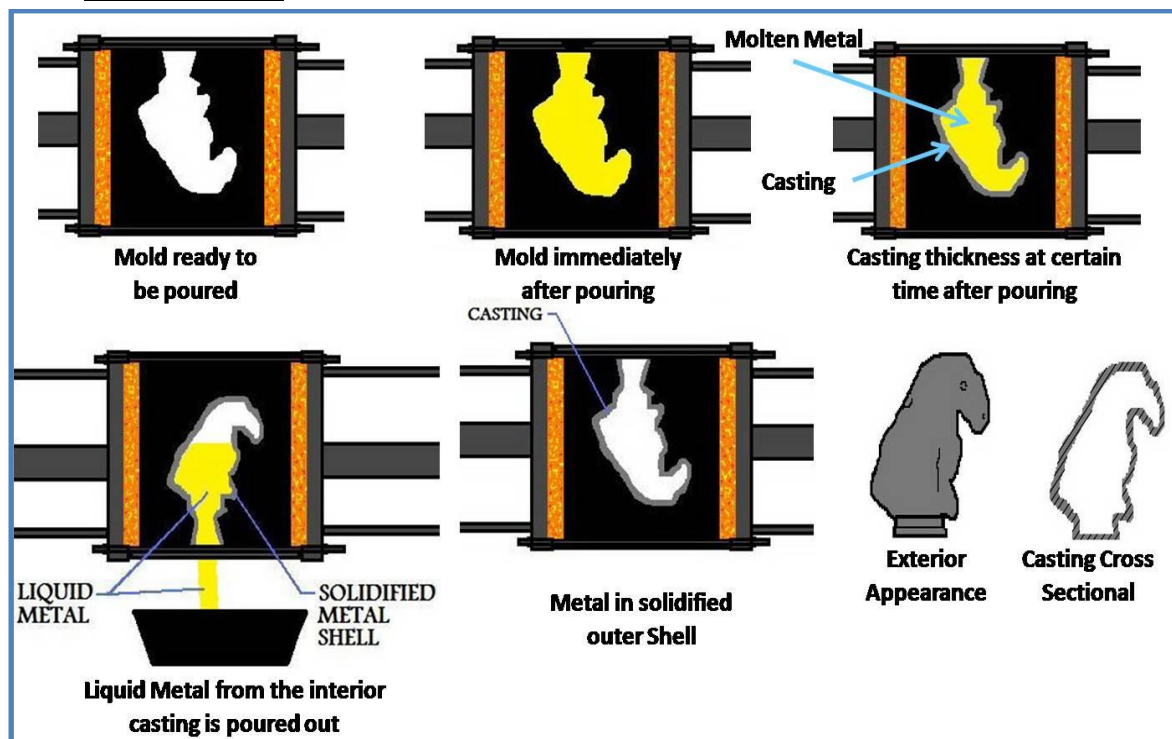


Fig. (2): The steps to form a Slush casting.

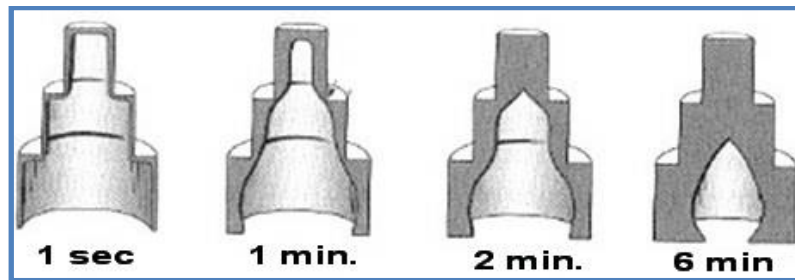


Fig. (3): Variation of the Shell thickness with time of solidification.

- The thickness of the shell is controlled by the amount of time allowed before the mold is drained as shown in Fig. (3) above.
- Low-melting-point metals such as lead, zinc, and tin are used.
- The exterior appearance is important, but the strength and interior geometry of the casting are minor considerations.

3. Low Pressure Casting:

Instead of using gravity to assist in the metal pour and flow in the mold, a low pressure of up to 0.1 MPa (15 psi) gas is applied to the molten metal [see fig. (4) below].

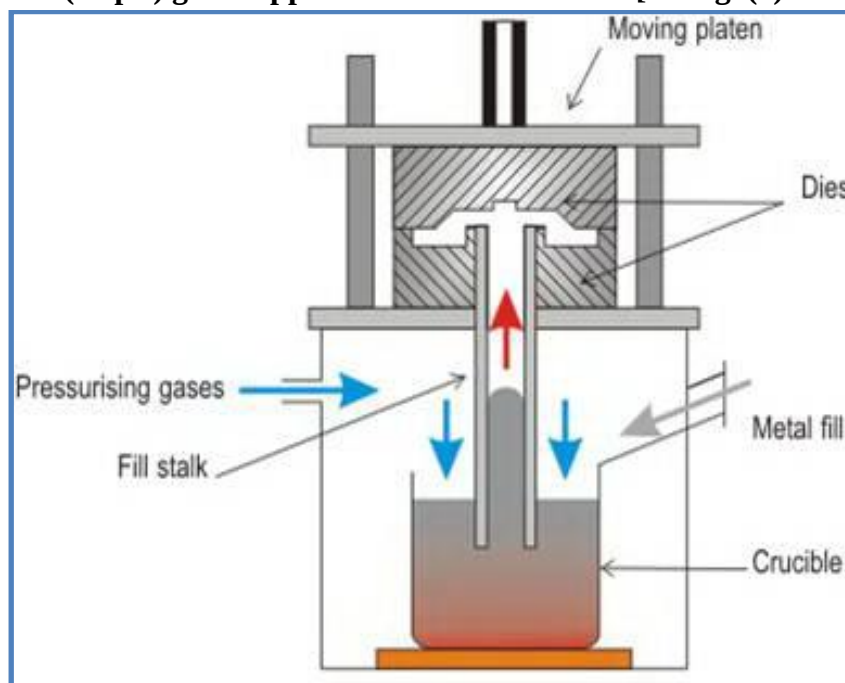


Fig. (4): Low Pressure Casting process.

- The maintenance of pressure on the melt causes complete fill of the mold and compensates for any shrinkage on cooling.
- Thin wall castings can be made.
- The metal cools inwardly in the mold to the stalk and freezes while the pressure (P) is held.
- Then the pressure is released & the still molten in stalk return to the pot.

Advantages:

1. The advantage of this approach over traditional pouring is that clean molten metal from the center of the ladle is introduced into the mold, rather than metal that has been exposed to air.
2. Gas porosity and oxidation defects are minimized.
3. Mechanical properties are superior.

Low – Pressure Casting (L– P casting) is a stage between hydrostatic casting (Permanent mold) & high – pressure die casting.

4. Vacuum Permanent Mold Casting:

It is similar to the low-pressure permanent mold casting, except a vacuum is used instead of a pressure [see fig. (5) below]. The steps in this process are:

1. The mold is mounted on a moving head.
2. The head is lowered into molten metal in an induction furnace so that the lower face of the mold is submerged.
3. Reduced air pressure from the vacuum in the mold is used to draw the liquid metal into the cavity (rather than forcing it by pressure).

Advantages:

- Reduced air porosity, greater strength.
- Thin wall castings can be made as in the low-pressure permanent mold casting.
- In addition, the yields are high since no risers are used.
- This process is relatively inexpensive and can be automated.

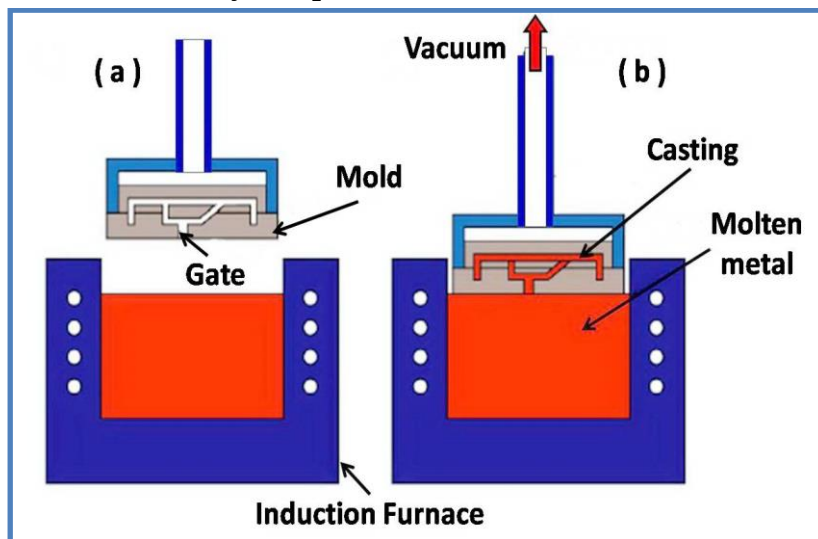


Fig. (5): Vacuum Permanent mold casting (a) before the process (b) Casting preformed.

4. Squeeze Casting:

Squeeze casting is a combination of casting and forging.

The steps in this process are [figure (6)]:

1. The molten metal is poured into a preheated open face lower die.
2. The upper die (the punch) is advanced into lower die to close and create the mold cavity.
3. Pressure is applied to the punch and lower die while the part solidifies. This pressure is lower than normally required for forging.
4. The punch is retracted, and the part is knocked out with an ejector pin.

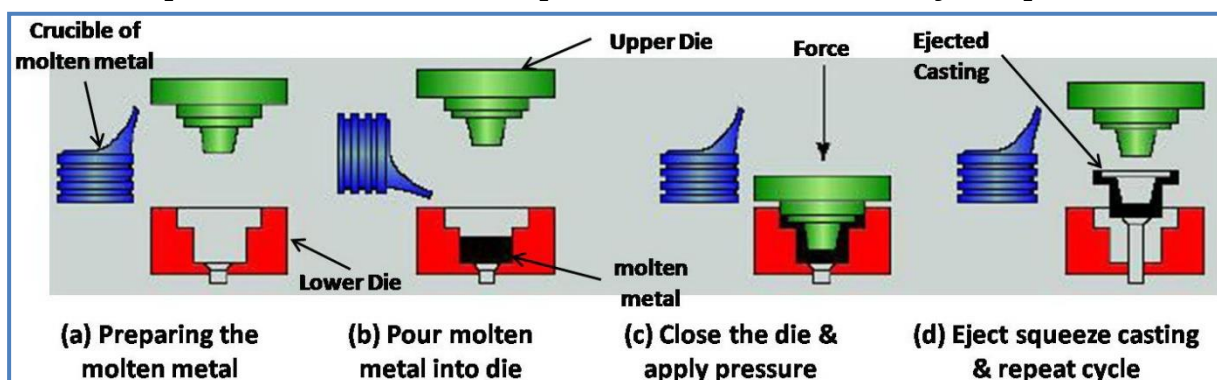


Fig. (6): Squeeze Casting Process.

- This differs from the usual permanent-mold casting process in which the die halves are closed prior to pouring or injection.
- Owing to the hybrid nature of the process, it is also known as liquid-metal forging.
- The pressure applied by the upper die in squeeze casting causes the metal to completely fill the cavity, resulting in good surface finish and low shrinkage.
- The required pressures are significantly less than in forging of a solid metal billet and much finer surface detail can be imparted by the die than in forging.

Application:

- Squeeze casting can be used for both ferrous and non-ferrous alloys, but aluminum and magnesium alloys are the most common due to their lower melting temperatures.
- Automotive parts are a common application.

5. Semi – Solid Metal Casting:

It is a family of net-shape and near net-shape processes performed on metal alloys at temperatures between the liquidus and solidus [figure (7)].

- The alloy is a mixture of solid and molten metal during casting like slurry; it is in the mushy state.
- In order to flow properly, the mixture must consist of solid metal globules in a liquid rather than the dendritic solid shapes that form during freezing of a molten metal.
- This is achieved by forcefully stirring the slurry to prevent dendrite formation and instead encourage the spherical shapes, which in turn reduces the viscosity of the work metal
- With the fraction solid being in the range of 30 to 65%.

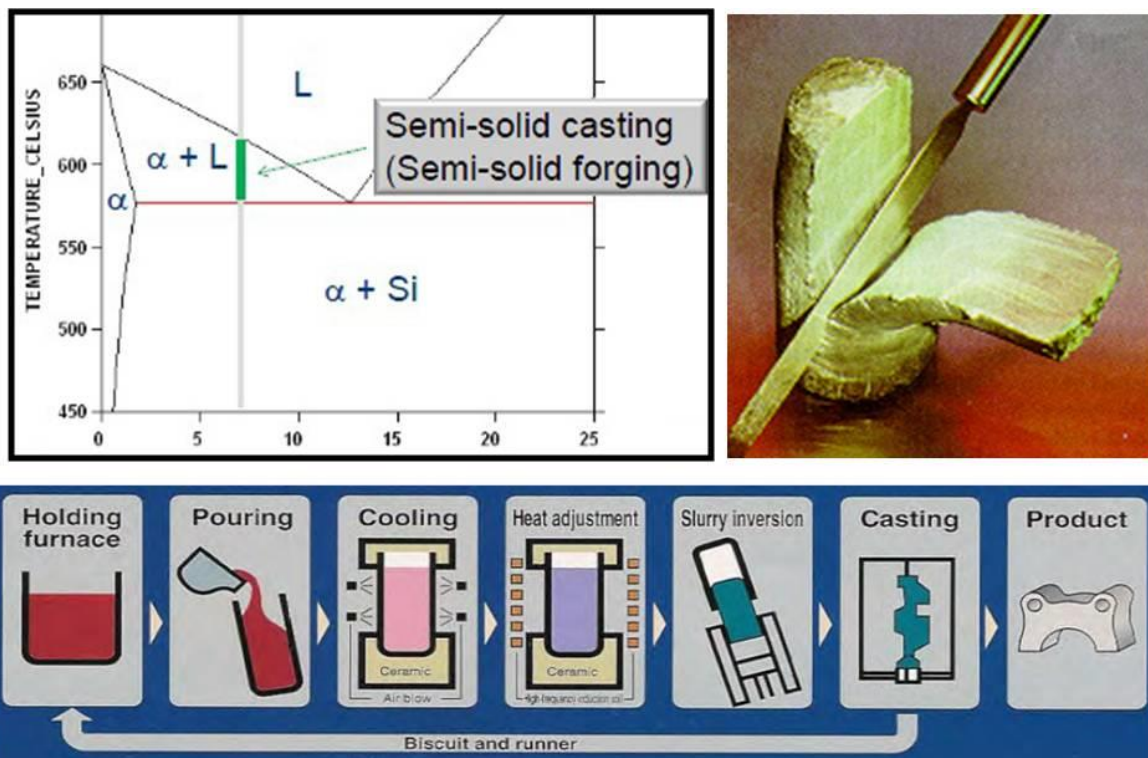


Fig. (7): Semi – Solid Metal Casting Process.

Metals: Aluminum, magnesium, and some copper alloys.

Size Range: Ounces to about 1 pound, limited to a diameter of feed stock. Some SSM Houses can produce parts up to 15-20 pounds.