UNIT I

Metal Casting Processes

Metal Casting Processes

✓ Investment casting

Introduction:

- **Investment casting is an industrial process and it is also called *lost-wax casting* . *This is* one of the oldest known metal-forming techniques from 5000 years ago.**
- **This castings allow the production of components with accuracy, repeatability, versatility and integrity in a variety of metals and high-performance alloys.**
- **It is generally more expensive per unit than die casting or sand casting, but has lower equipment costs.**

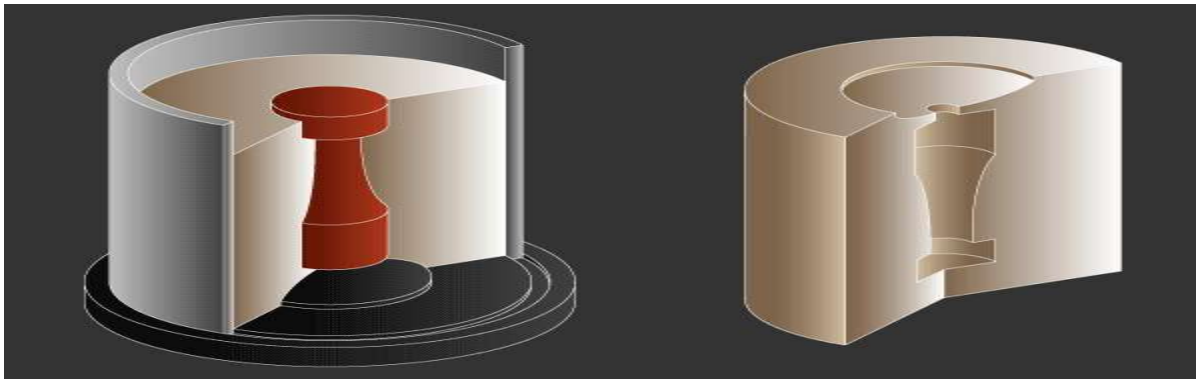
Process:

***Moldmaking*:**

The first step in investment casting is to manufacture the wax pattern for the process. A mold , known as the *master die*, is made of the master pattern. The master pattern may be made from a low-melting-point metal, steel, or wood. Rubber molds can also be cast directly from the master pattern.

***Produce the wax patterns*:**

The pattern for this process may also be made from plastic; however it is often made of wax since it will melt out easily and wax can be reused.

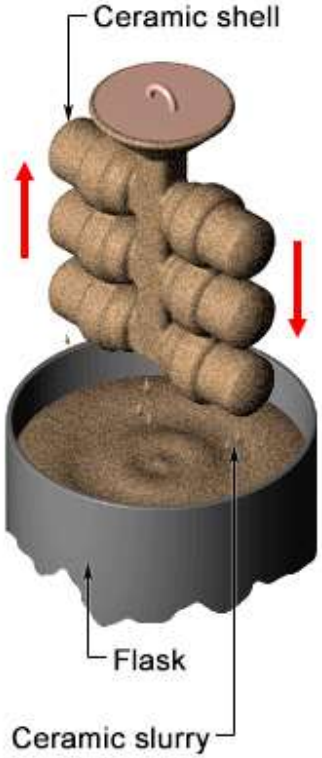


Assemble the wax patterns:

The wax pattern is then removed from the mold . Depending on the application multiple wax patterns may be created so that they can all be cast at once. In other applications, multiple different wax patterns may be created and then assembled into one complex pattern. The multiple patterns are attached to a wax sprue , and then it make a tree. Finally it is *dressed*, which means any other imperfections are addressed so that the wax now looks like the finished piece.

***Investment*:**

- The metal casting pattern is then dipped in a refractory slurry whose composition includes extremely fine grained sand, water and binders. A ceramic layer is obtained over the surface of the pattern. The pattern is then repeatedly dipped into the slurry to increase the thickness of the ceramic coat.



***Dewax & burnout*:**

The investment is then allowed to completely dry, which can take 16 to 48 hours . Drying can be enhanced by applying a vacuum or minimizing the environmental humidity. Most shell failures occur at this point because the waxes used have a thermal expansion Coefficient., so as the wax is heated it expands and induces great stresses. The mold is then subjected to a *burnout*, which heats the mold between 870 °C and 1095 °C to remove any moisture and residual wax, and to sinter the mold.

***Pouring*:**

The investment mold is then placed cup-upwards into a tub filled with sand but if there are thin sections in the mold it may be filled by applying positive air pressure or pressure assisted Pouring .Then after pouring the mold is left for cooling.

***Removal*:**

The shell is hammered, vibrated, water jeted , or chemically dissolved to release the casting. The sprue is cut off and recycled.

Advantages of Investment casting:

- Many Intricate forms with undercuts can be cast.
- A very smooth surface is obtained with no parting line.
- Dimensional accuracy is good.
- Certain unmachinable parts can be cast to preplanned shape.
- It may be used to replace die-casting where short runs are involved.
- With this casting we can get the exact shape of the pattern.

Disadvantages of Investment casting:

- This process is expensive, is usually limited to small casting, and presents some difficulties where cores are involved.
- Holes cannot be so small.
- Investment castings require very long production-cycle times versus other casting processes.
- This process is practically infeasible for high-volume manufacturing, due to its high cost and long cycle times.

✓ Plaster mold casting

Plaster mold casting is a metalworking casting process similar to sand casting except the molding material is plaster of Paris instead of sand. Like sand casting, plaster mold casting is an expendable mold process, however it can only be used with non-ferrous materials.

Process

First, the plaster is mixed and the pattern is sprayed with a thin film of parting compound to prevent the plaster from sticking to the pattern. The plaster is then poured over the pattern and the unit shaken so that the plaster fills any small features. The plaster sets, usually in about 15 minutes, and the pattern is removed. The mold is then baked, between 120 °C (248 °F) and 260 °C (500 °F), to remove any excess water. The dried mold is then assembled, preheated, and the metal poured. Finally, after the metal has solidified, the plaster is broken from the cast part. The used plaster cannot be reused.

✓ Die casting

Mold:

- The mold is made of special die steels.

Die: The mold made of metals is called “die”.

- These steels have very high melting point and must resist very high temperatures
- This mold is only preferred when a large no. of castings are to be prepared

Reason: This is a expensive mold.

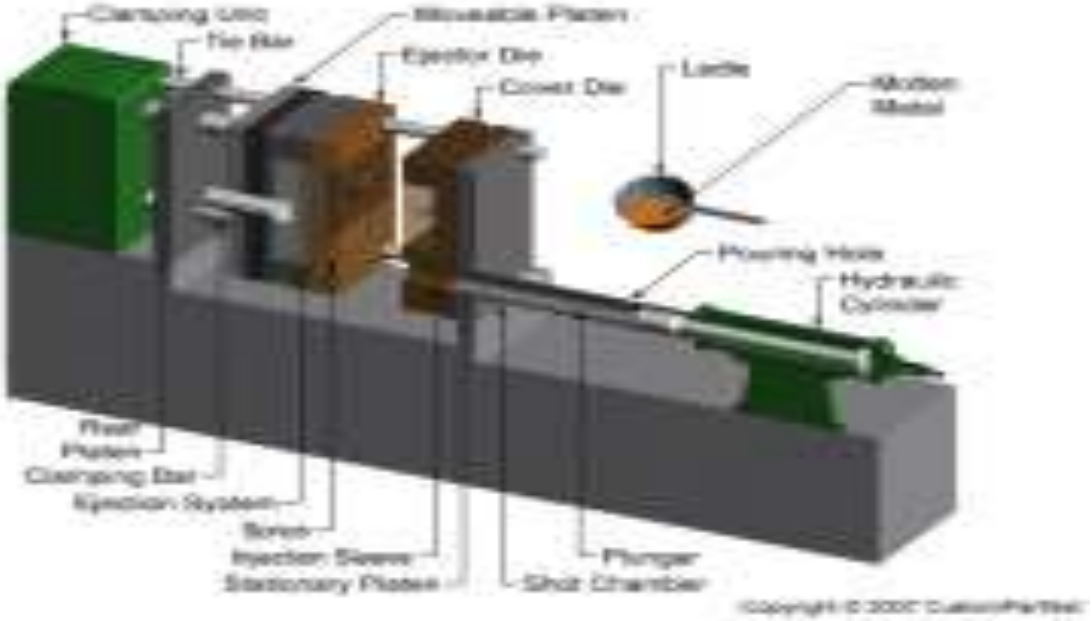
- The die is in two halves.

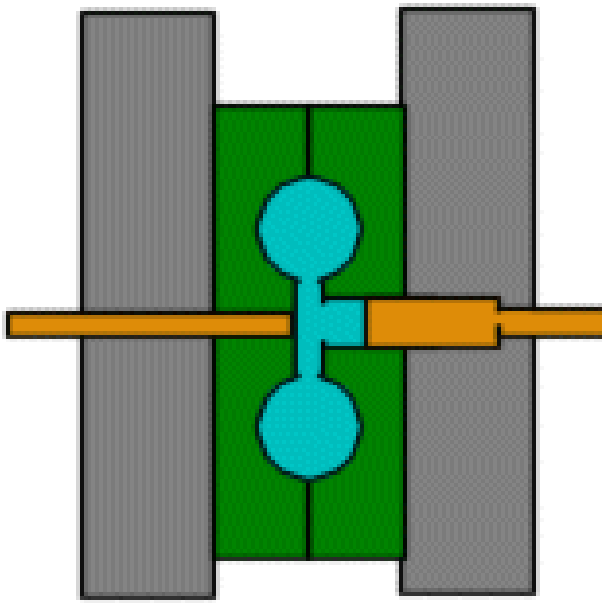
- One half is fixed while other is moveable to allow the casting to be removed.

Process:

A die-cycle is completed in following steps:

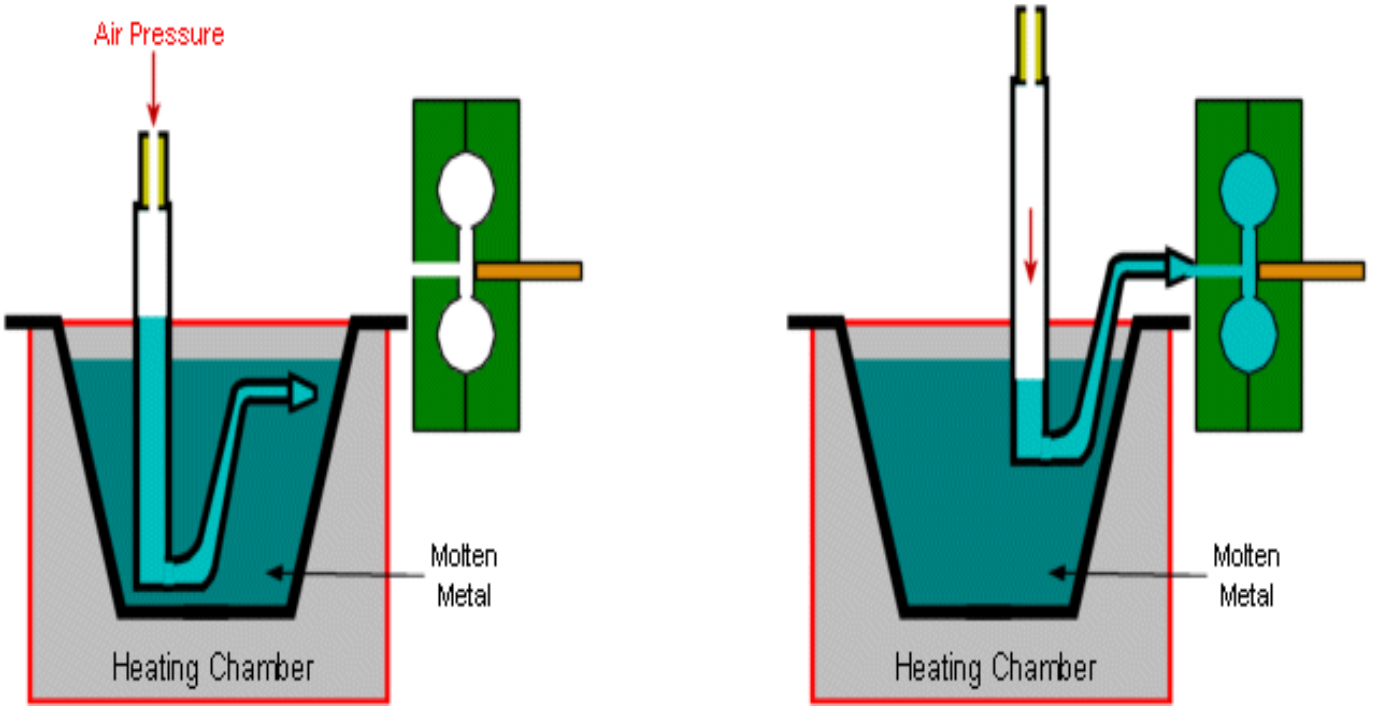
- The ladle brings the molten metal from the furnace and pours it into the shot sleeve.
- Plunger pushes the molten metal into the cavity in the die, with a pressure of nearly 9800 psi.





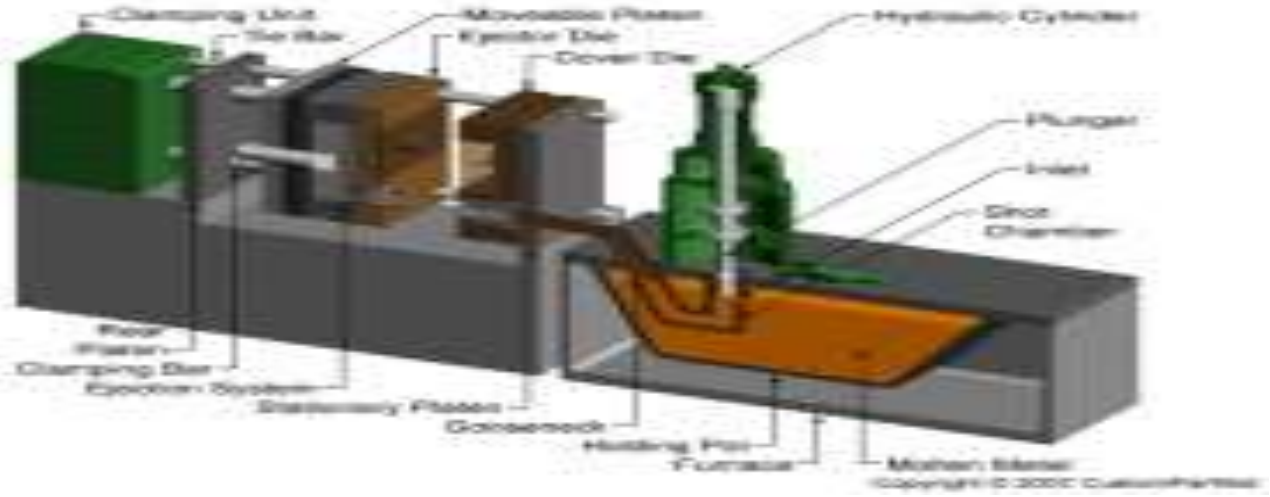
Die Casting

- When metal is filled in the neck; incase of air-operated m/c, it is raised up to the die and locked in contact with the die opening.



Die Casting

- Plunger is pushed down by a pressure of nearly 5000 psi to inject the molten metal into the cavity in the die.
- After the die is filled, metal is left to solidify.
- Pressure is maintained during solidification by a plunger or compressed air.
- After solidification, pressure is removed, the die is opened and knock-out/ejector pins are used to eject the casting out.



Die Casting

Die cycle:

- A cycle is a complete set of events in which one casting is produced.
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It consists of following steps:

  - Closing the die.
  - Shot: Injection of molten metal in die.
  - Solidification of metal under pressure.
  - Opening the die.
  - Ejection of casting from the die.

Die Casting

Types/methods:

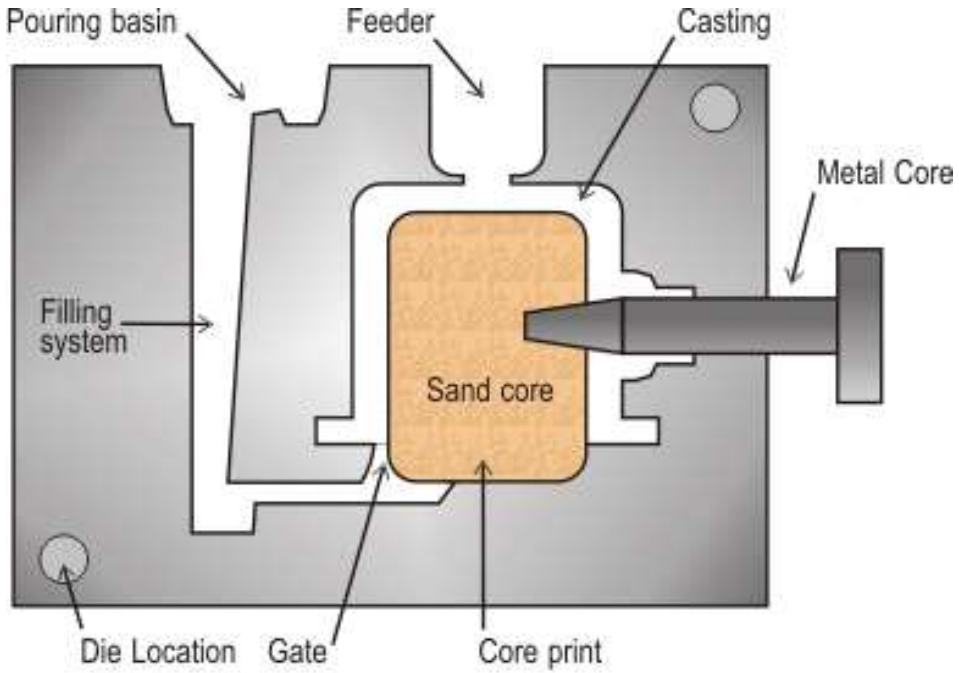
Die casting is done by two methods:

1. Gravity Die Casting/Permanent die casting
    - i- Slush casting
    - ii- Low pressure die casting
1. Pressure Die Casting
    - i- Hot chamber die casting
    - ii- Cold chamber die casting
    - iii- Centrifugal casting

Die Casting

Gravity Die Casting/Permanent die casting:

- Molten metal is poured under gravity (i.e. without pressure).



Die Casting

Pressure Die Casting:

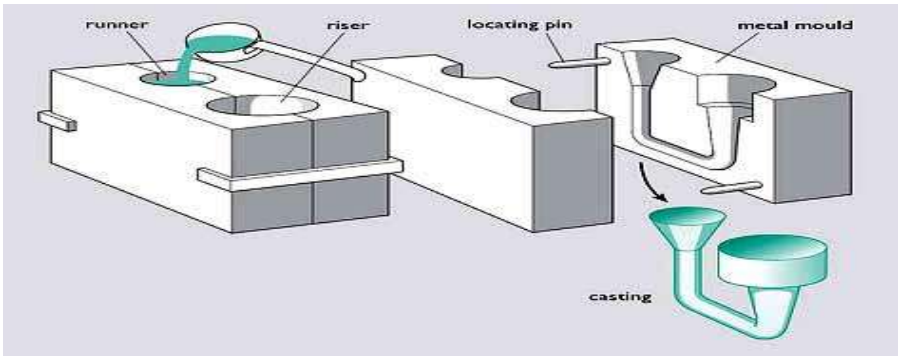
- Molten metal is poured under pressure.

- There are two types of pressure die casting.
  - Hot-Chamber die casting
  - Cold-chamber die casting

Die Casting

Gravity Die Casting:

- In gravity die casting or Permanent Mold Casting, fluid metal is poured by hand into metal molds.
- Both ferrous and non-ferrous metals can be casted.
- Production rate is slow.
- The casting is not so smooth or dimensionally accurate.



Die Casting

Cold-Chamber Die Casting:

- In this pressure die casting process, the basin of molten metal is not a part of the m/c.
- Molten metal is poured from an external melting container and a piston is used to inject the metal under high pressure into the die cavity.
- Injection pressure used in this machine typically 14 to 140 Mpa.
- High melting alloys of brass, aluminum, and magnesium are casted in cold-chamber m/c.

Hot-Chamber Die Casting:

- In this pressure die casting process, the basin of molten metal is a part of the m/c.

- Low melting (less than 700^{o}C) alloys of zinc, tin, and lead are casted in hot-chamber m/c.

- It is mainly used for small castings (0.03kg to 40kg).
- The injection pressure are 7 to 35 MPa.

Die Casting

The actual mold life varies:

- **Alloy being cost:** as higher the melting point, shorter the mold life
- **Mold material:** Grey cast iron has the best resistance to thermal fatigue and machines easily.
- **Pouring temperature:** High pouring temperature reduce the mold life, increases shrinkage problems and induce longer cycle time.
- **Mold temperature:** Low temperature produce misruns and high temperature results the mold erosion.
- **Mold configuration:** Difference in section size of mold and casting can produce

Die Casting

Advantages:

- High production rates can be possible
- Good surface finish, smooth cavity produces smooth castings.
- Large number of castings can be produced by metal mold and economical justification for large production.
- The process is fully or semi-automatic, which reduces labor cost.
- Rapid cooling provides small grains size and good strength.

Die Casting

- The process is very fast and can produce large number of castings in a small time.
- As casting is done under high pressure so the grains are highly compacted, increasing the strength of the casting.
- High dimensional accuracy.

Die Casting

Disadvantages:

- Metal dies are very expensive so high volume production is usually required to justify the expense.
- Die casting machines are expensive too.
- Machining for producing the cavity is expensive.
- Nozzle and piston both require replacements and repairing.
- High melting alloys cannot be prepared in hot chamber m/c.

Die Casting

- Expert metallurgical and production control is required for perfect castings.
- Careful gating and vent systems are to be considered.
- Although cold chamber process is applicable to most of alloys but due to ladling operation its production speed is slow.
- The hard and strong metals such as iron and steel cannot be die-cast.

References

1. Manufacturing Technology, Volume-I, Fourth Edition by PN RAO, McGraw Hill Education (India) Private Limited
2. Manufacturing Processes, Second Edition by H.N. Gupta, R.C. Gupta, Arun Mittal, New Age International (P) Ltd PublishersIbrahim Zaid (2006), Mastering CAD/CAM, 2nd Edition, Tata McGraw-Hill, ISBN: 978-0-070-63434-3.
3. Manufacturing Process Technology I & II, Course instructor: Prof. Shantanu Bhattacharya, Associate Professor, Department of Mechanical Engineering, Indian Institute of Technology, Kanpur.
4. Course url: https://onlinecourses.nptel.ac.in/noc17_me03
5. A Text Book of Manufacturing Technology (Manufacturing Processes) By RK Rajput, Laxmi Publications Private Limited
6. S. Jung, T. W. Simpson, New modularity indices for modularity and clustering of product architecture, Journal of Engineering (2017) 1–22. doi:10.1080/09544828.2016.1252835.

Thank you