Metals Forming

Plaster Mold Casting

Similar to sand casting except mold is made of plaster (gypsum - $CaSO_4$-$2H_2O$).

- In mold-making, plaster and water mixture is poured over plastic or metal pattern and allowed to set.
- Wood patterns not generally used due to extended contact with water.
- Plaster mixture readily flows around pattern, capturing its fine details and good surface finish

Advantages and Disadvantages

- Advantages of plaster mold casting:-
  - Good accuracy and surface finish
  - Capability to make thin cross-sections.

- Disadvantages:-
  - Mold must be baked to remove moisture, which can cause problems in casting.
  - Mold strength is lost if over-baked.
  - Plaster molds cannot stand high temperatures, so limited to lower melting point alloys can be casted.

Ceramic Mold Casting

Similar to Plaster Mold Casting except the material of mold is refractory ceramic material instead of plaster.

Advantages of ceramic mold casting:-

The ceramic mold can withstand temperature of metals having high melting points.

Surface quality is same as that in plaster mold casting.

Permanent Mold Casting Processes

- Economic disadvantage of expendable mold casting:-
- A new mold is required for every casting.
- In permanent mold casting, the mold is reused many times.

- The processes include:-
  - Basic permanent mold casting
  - Slush Casting.
  - Low Pressure casting
  - Vacuum Permanent mold casting
  - Die casting
  - Centrifugal casting

The Basic Permanent Mold Process

Uses a metal mold constructed of two sections designed for easy, precise opening and closing.

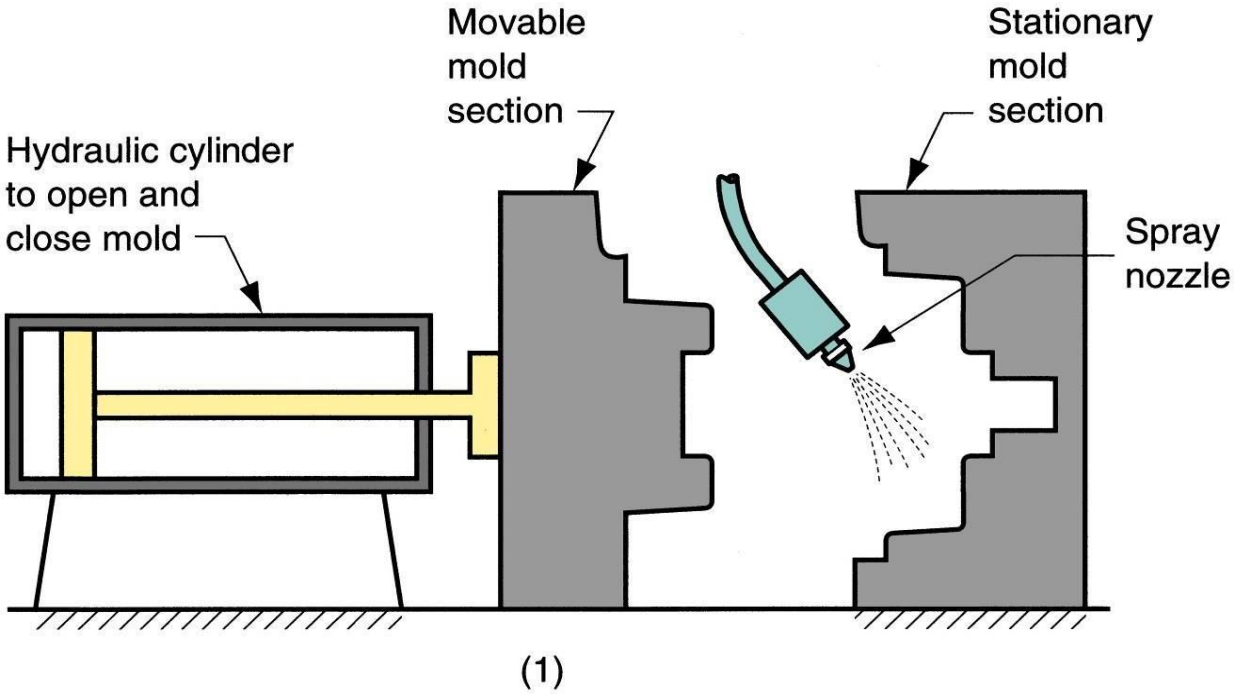
- Molds used for casting lower melting-point alloys (Al, Cu, Brass) are commonly made of **steel** or **cast iron**.

- Molds used for **casting steel** must be made of **refractory material**, due to the very high pouring temperatures.

Permanent Mold Casting

Steps in permanent mold casting:-

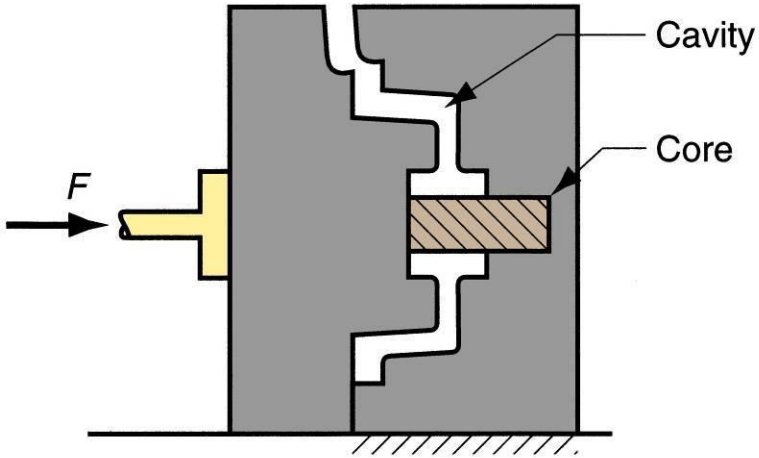
(1) Mold is preheated and coated



Permanent Mold Casting

(2) Cores (if used) are inserted and mold is closed.

(3) Molten metal is poured into the mold, where it solidifies.



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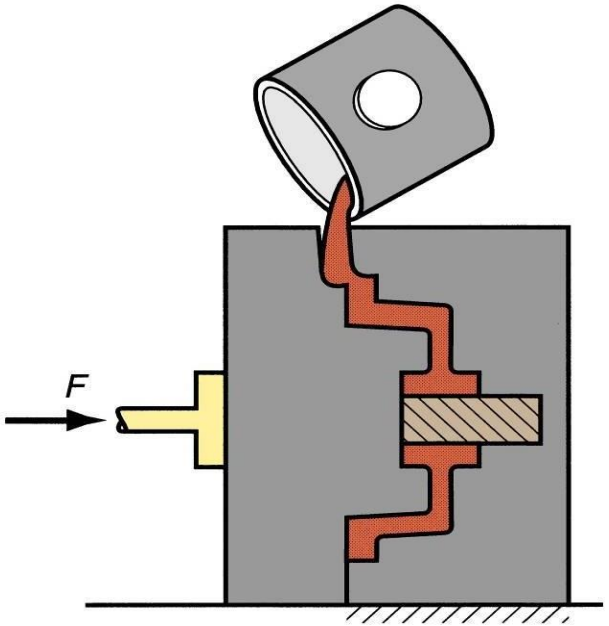
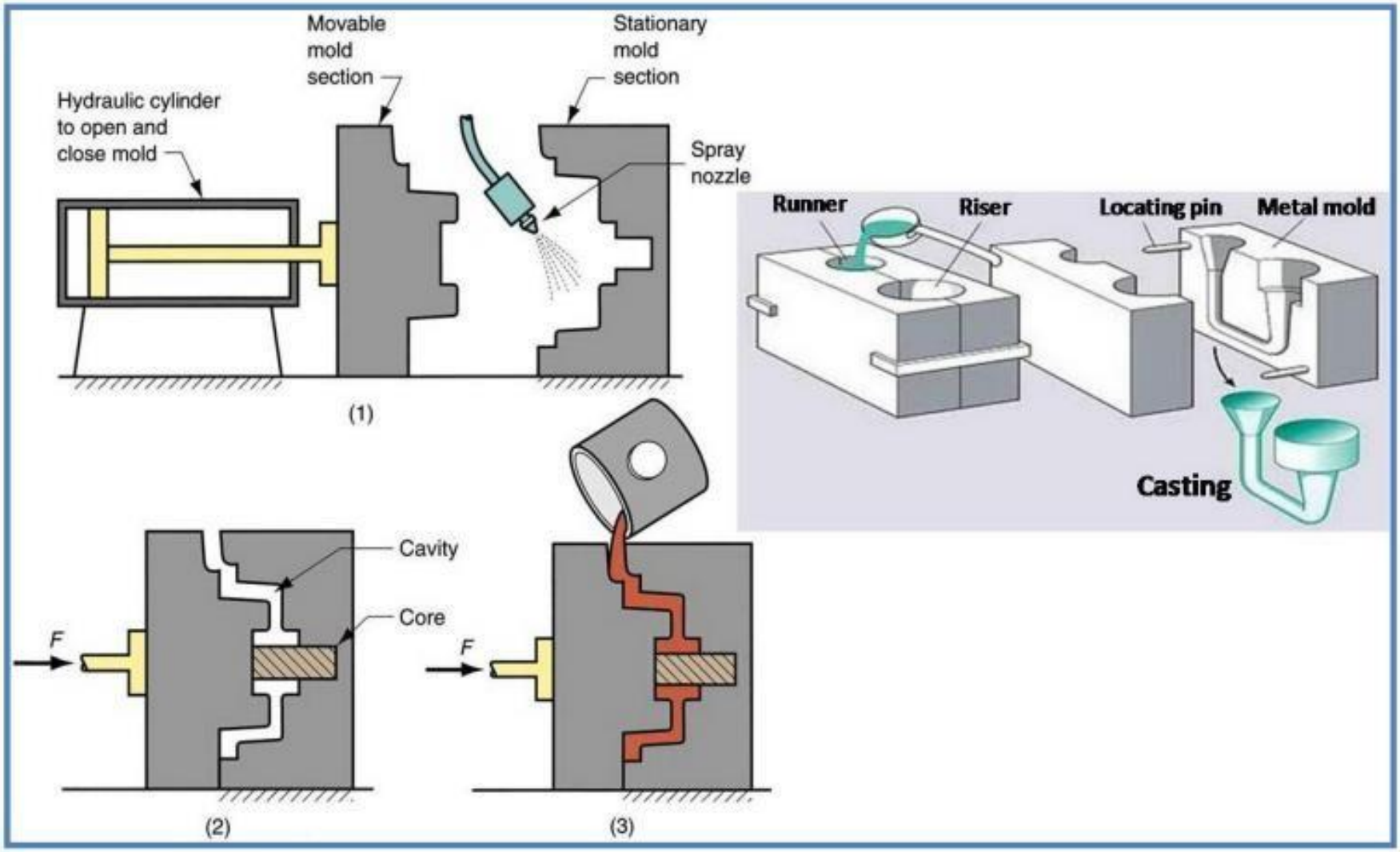


(3)

Permanent Mold Casting

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. Typical core materials include (**oil-bonded sand, resin-bonded sand, plaster, graphite and gray iron**)
4. The mold halves are mated and **preheated**.
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.

Permanent Mold Casting



Advantages and Disadvantages

- Advantages of permanent mold casting:-
  - Good dimensional control and surface finish.
  - Very economical for mass production.
  - More rapid solidification caused by the cold metal mold results in a finer grain structure, so castings are stronger.
- Disadvantages:-
  - Generally limited to metals of lower melting point.
  - Complex part geometries can not be made because of need to open the mold.
  - High cost of mold.
  - Not suitable for low-volume production.

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.**

1- Slush Casting

* **Slush Casting:** Slush Casting is a special type of permanent mold casting to create **a hollow casting without using cores**.

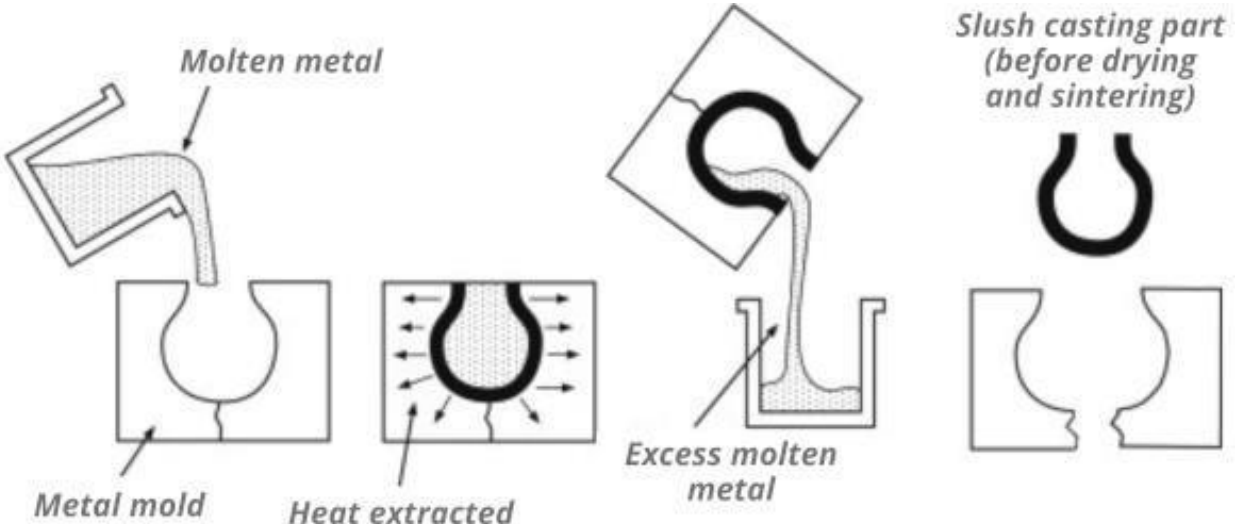
* The basic procedure is the same as used in Basic Permanent Mold Casting.

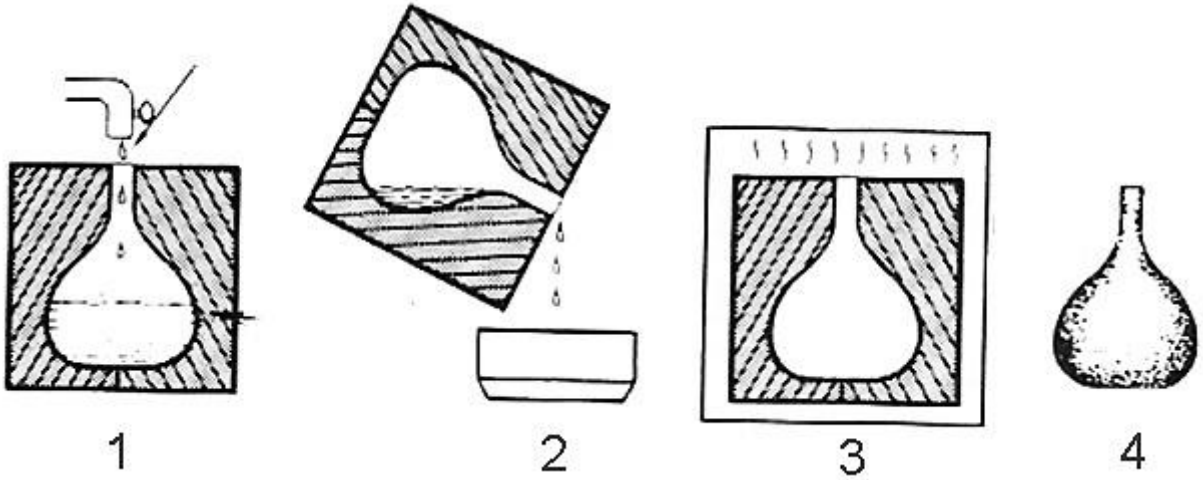
* In the process the material is poured into the mold and allowed to cool until a desired wall thickness is obtained, the not yet solidified molten metal is poured out, leaving the part hollow from inside.

* Metal with low melting point are used: **Zinc, Lead and Tin**.

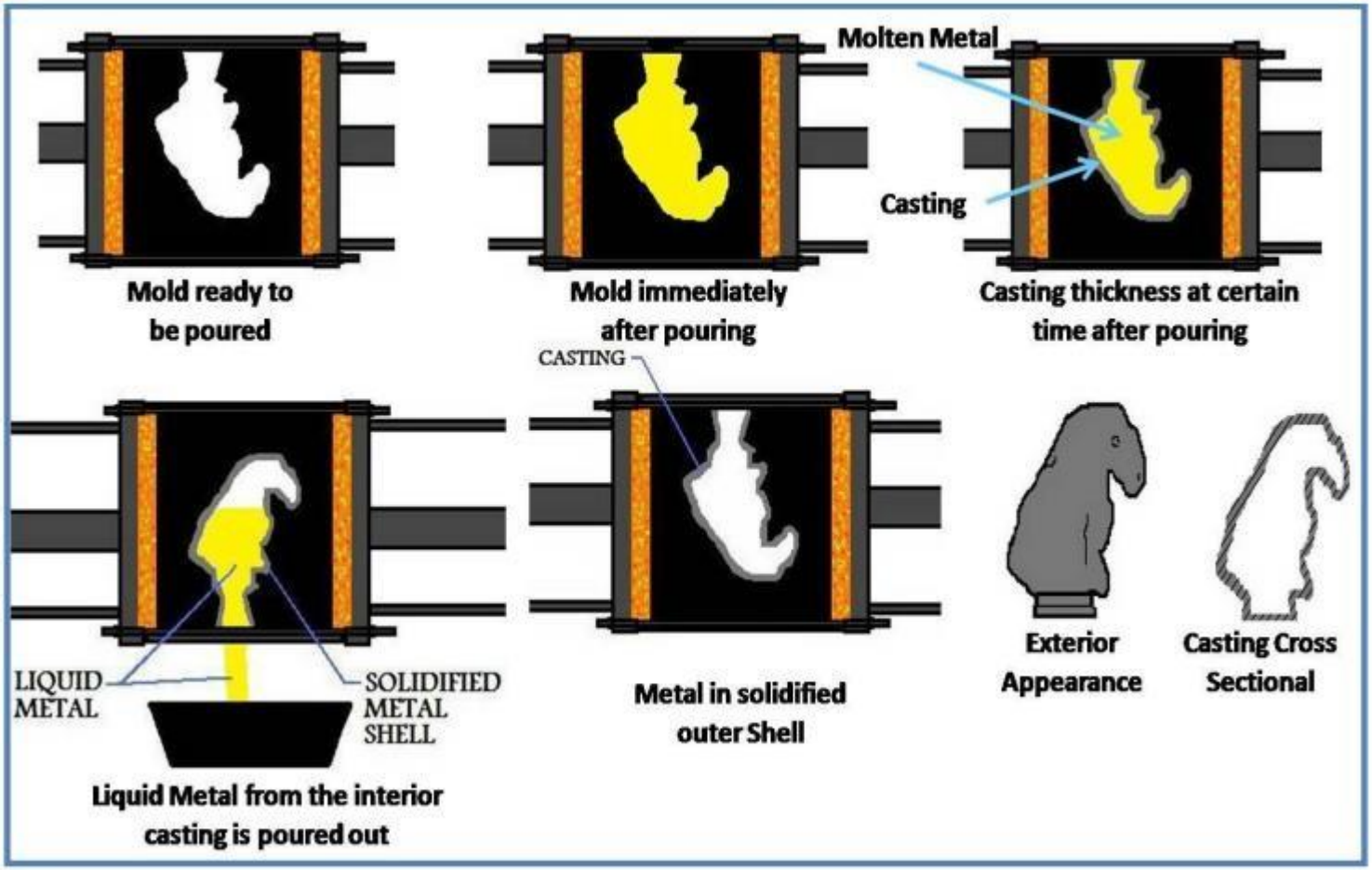
* This is useful for making hollow **ornamental objects such as candlesticks, lamp's holder, Statues, Lamp bases, Pedestals and toys.**

1- Slush Casting



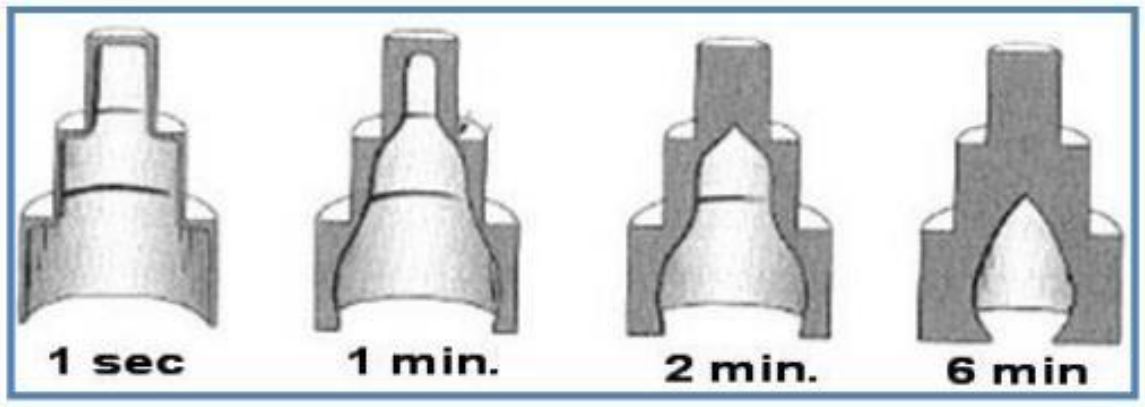


1- Slush Casting



The steps to form a Slush casting

1- Slush Casting



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.

- 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.

1- Slush Casting

Advantages

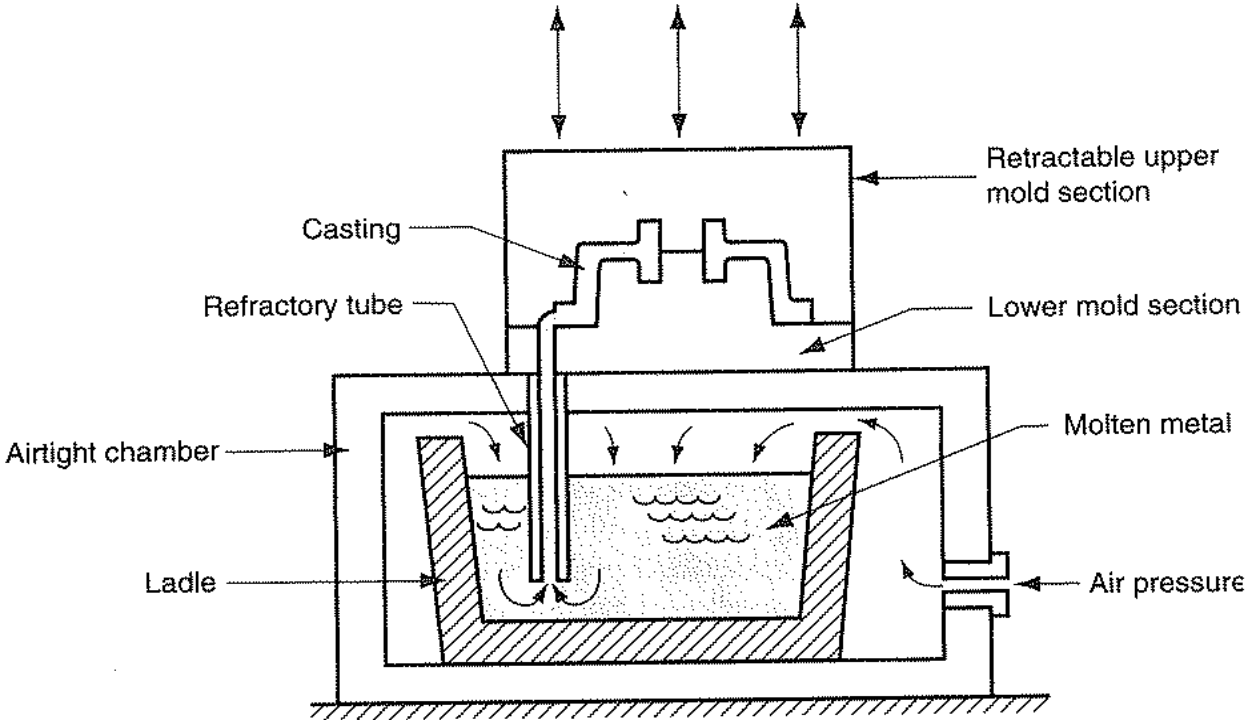
- Slush molding produce hallow casting without core
- It is simple and quick process

Disadvantages

- It can not produce accurate casting
- It is limited to low melting metals

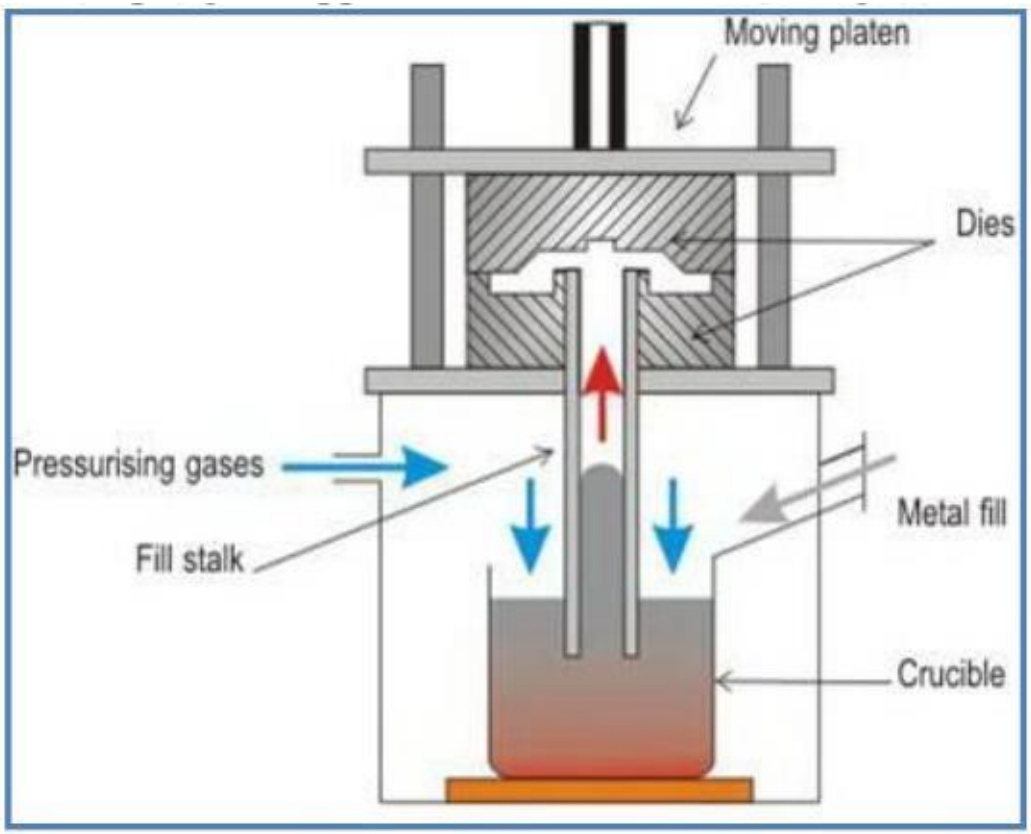
2- Low-pressure Casting

- **In basic** permanent and slush casting processes, metal in cavity is poured under gravity. However, in **low-pressure casting**, the metal is forced into cavity under low pressure (0.1 MPa) of air.



2- Low-pressure Casting

The diagram shows air pressure is used to force the molten metal in the ladle upward into the mold cavity pressure is maintained until the casting has solidified.



Low Pressure Casting process

2- Low-pressure Casting

- 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.

2- Low-pressure Casting

- **Advantages:-**

- Clean molten metal from the center of ladle (cup) is introduced into the mold cavity, rather than metal that has been exposed to air.
- Reduced- gas porosity, oxidation defects,
- Improvement in mechanical properties.

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

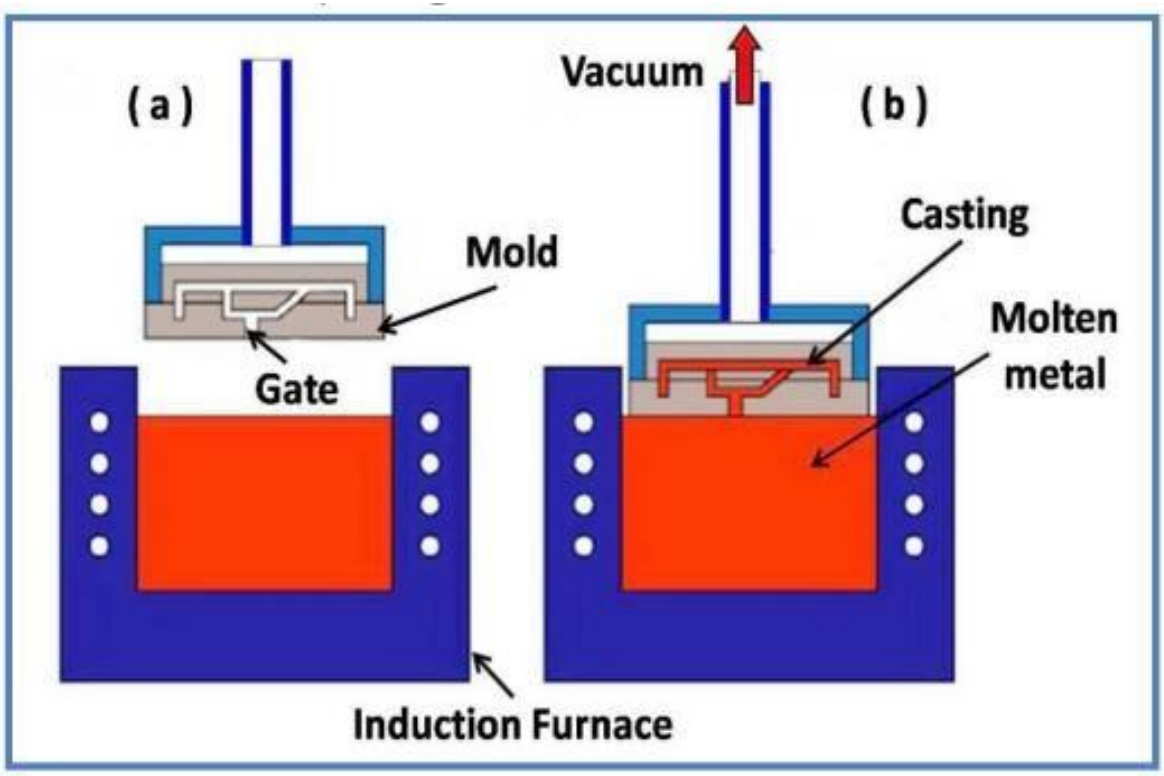
3- Vacuum Permanent-Mold Casting

- This is a variation of low-pressure permanent casting
- Instead of rising molten into the cavity through air pressure, vacuum in cavity is created which caused the molten metal to rise in the cavity from metal pool.

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).

3- Vacuum Permanent-Mold Casting



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

3- Vacuum Permanent-Mold Casting

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.

4- Die Casting (high pressure casting)

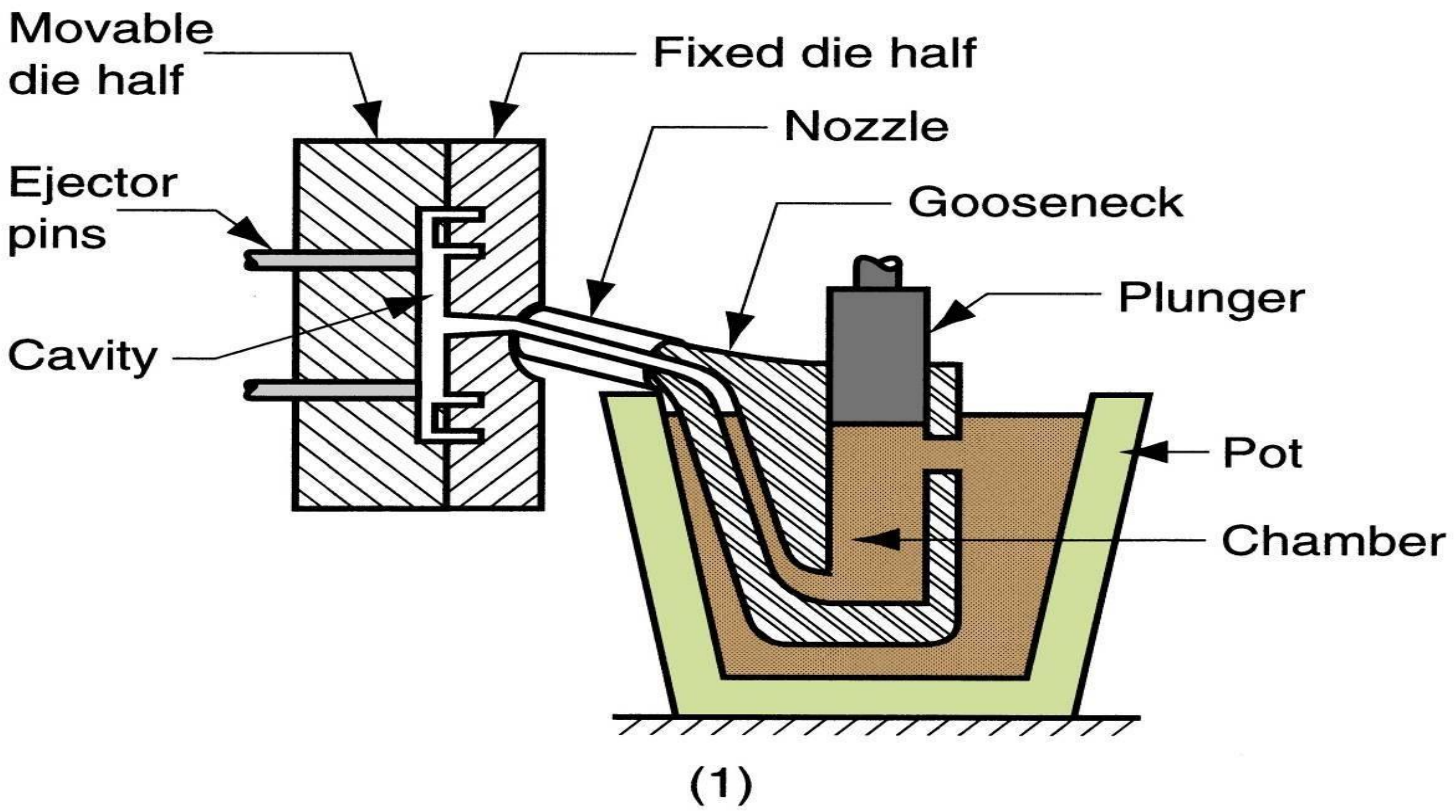
A permanent mold casting process in which molten metal is injected into mold cavity under high pressure

- Pressure is maintained during solidification, then mold is opened and part is removed
- **Molds** in this casting operation **are called *dies***; hence the name die casting
- Use of high pressure (**7-35MPa**) to force metal into die cavity is what distinguishes this from other permanent mold processes.

4- Die Casting (high pressure casting)

- Designed to hold and accurately close two mold halves and keep them closed while liquid metal is forced into cavity
- **Two main types:**
  1. Hot-chamber machine
  2. Cold-chamber machine

4- Die Casting Machines



Hot-Chamber Die Casting

4- Hot-Chamber Die Casting

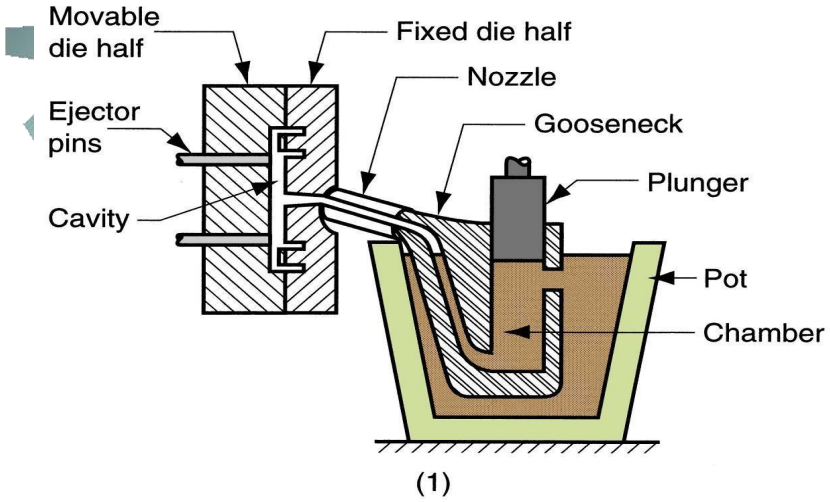
Metal is melted in a container, and a piston injects liquid metal under high pressure into the die,

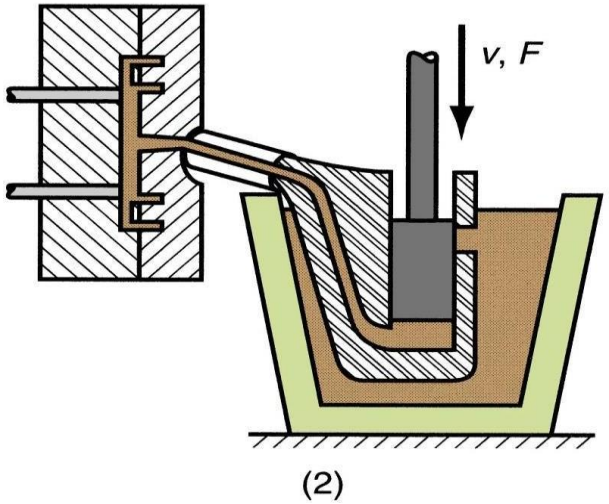
- High production rates - 500 parts per hour,
- Injection pressure: 7-35MPa
- Applications limited to low melting point metals that do not chemically attack plunger and other mechanical components
- Casting metals: **zinc, tin, lead, and magnesium.**

4- Hot-Chamber Die Casting

Cycle in hot chamber casting:-

(1) With die closed and plunger withdrawn, molten metal flows into the chamber





(2) Plunger forces metal in chamber to flow into die, maintaining pressure during cooling and solidification.

Because the die material does not have natural permeability (like sand has), vent holes at die cavity needs to be made.

4- Cold-Chamber Die Casting

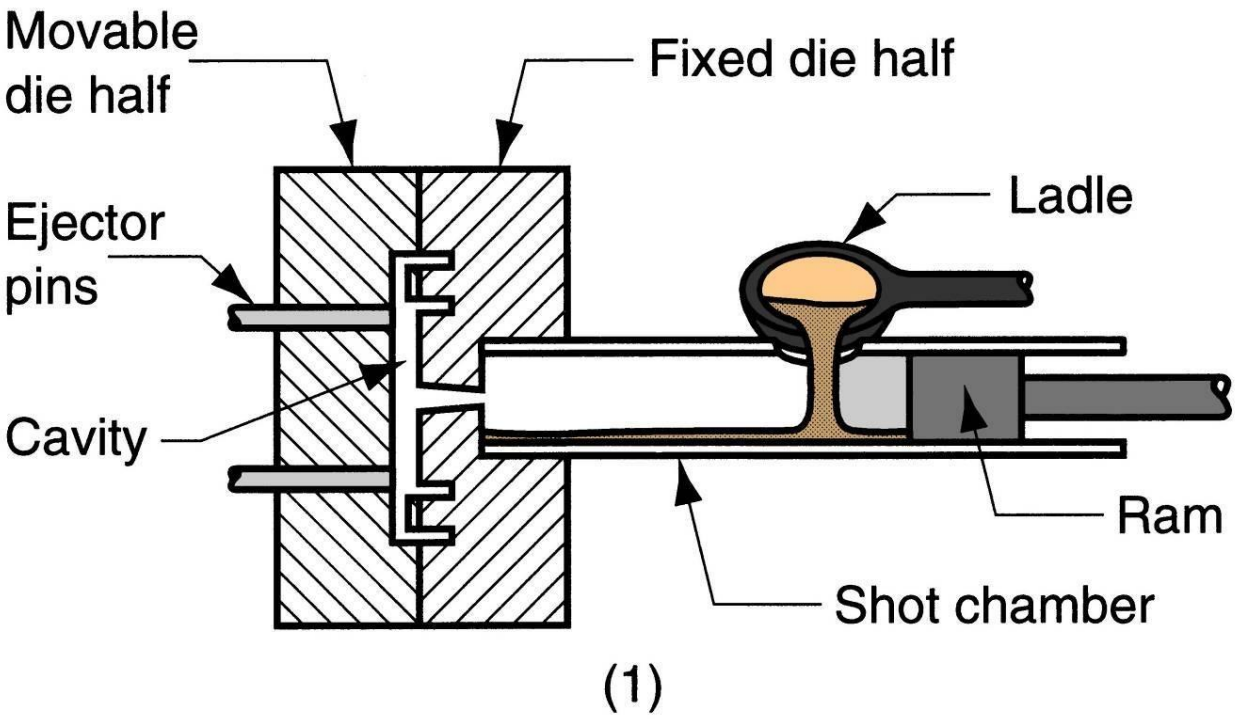
Molten metal is poured into unheated chamber from external melting container, and a piston injects metal under high pressure (14-140MPa) into die cavity

- High production but not usually as fast as hot-chamber machines because of pouring step

- Casting metals: aluminum, brass, and magnesium alloys
- **Advantage of cold chamber is that high melting point metals can be casted: Why???**

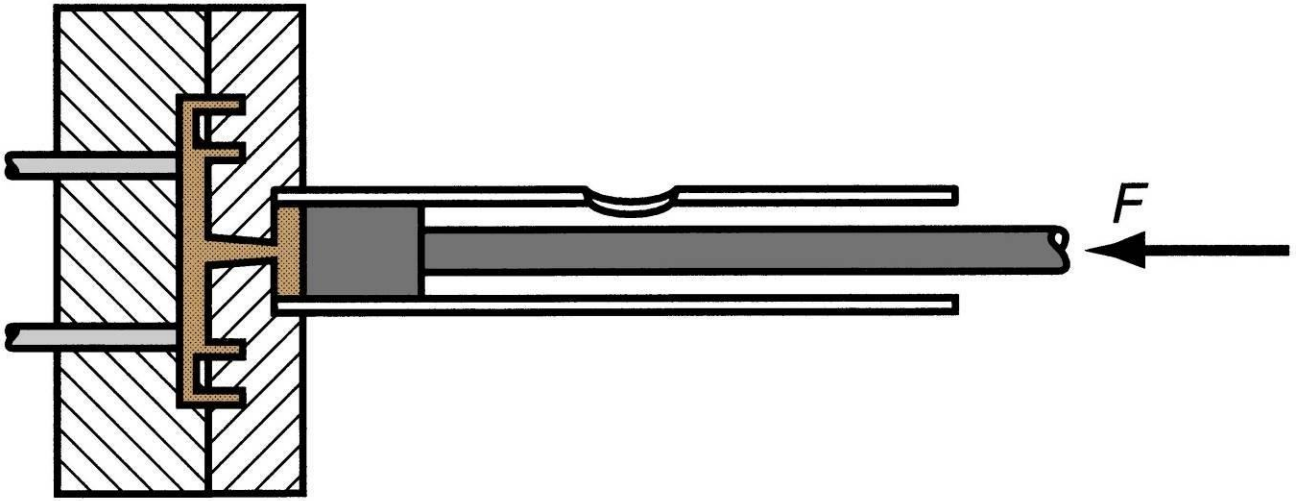
4- Cold-Chamber Die Casting

Cycle in cold-chamber casting:



(1) with die closed and ram withdrawn, molten metal is poured into the chamber

4- Cold-Chamber Die Casting



(2)

(2) ram forces metal to flow into die, maintaining pressure during cooling and solidification.

Molds for Die Casting

- Molds usually made of tool steel, mold steel, or maraging steel.
- Tungsten and molybdenum (good refractory qualities) are used to make die for casting steel and cast iron
- Ejector pins are required to remove part from die when it opens.
- **Lubricants** must be sprayed into cavities to prevent sticking

Advantages and Limitations

- Advantages of die casting:
  - Economical for large production quantities
  - Good accuracy (±0.076mm)and surface finish
  - Thin sections are possible
  - Rapid cooling provides small grain size and good strength to casting
- Disadvantages:
  - Generally limited to metals with low metal points
  - Part geometry must allow removal from die, so very complex parts can not be casted
  - Flash and metal in vent holes need to be cleaned after ejection of part