

A photograph of a modern building with a red, textured facade and concrete structural elements. The building has a central vertical opening and a curved walkway in the foreground. The image is framed by a large red arc at the bottom.

Thapar Institute of Engineering & Technology – Patiala

Manufacturing Processes UTA026

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THAPAR INSTITUTE
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MANUFACTURING PROCESSES

Die Casting

Permanent-Mould/ Gravity Die Casting

- ***Permanent-mould*** casting uses a metal mould constructed of two sections that are designed for easy, precise opening and closing.
- ***Mould*** are made from materials with high resistance to erosion and thermal fatigue, such as cast iron, steel, bronze, graphite, or refractory metal alloys.
- ***Typical parts*** made are auto-mobile pistons, cylinder heads, connecting rods, gear blanks for appliances, and kitchenware.

Parts made by Permanent-Mould Casting

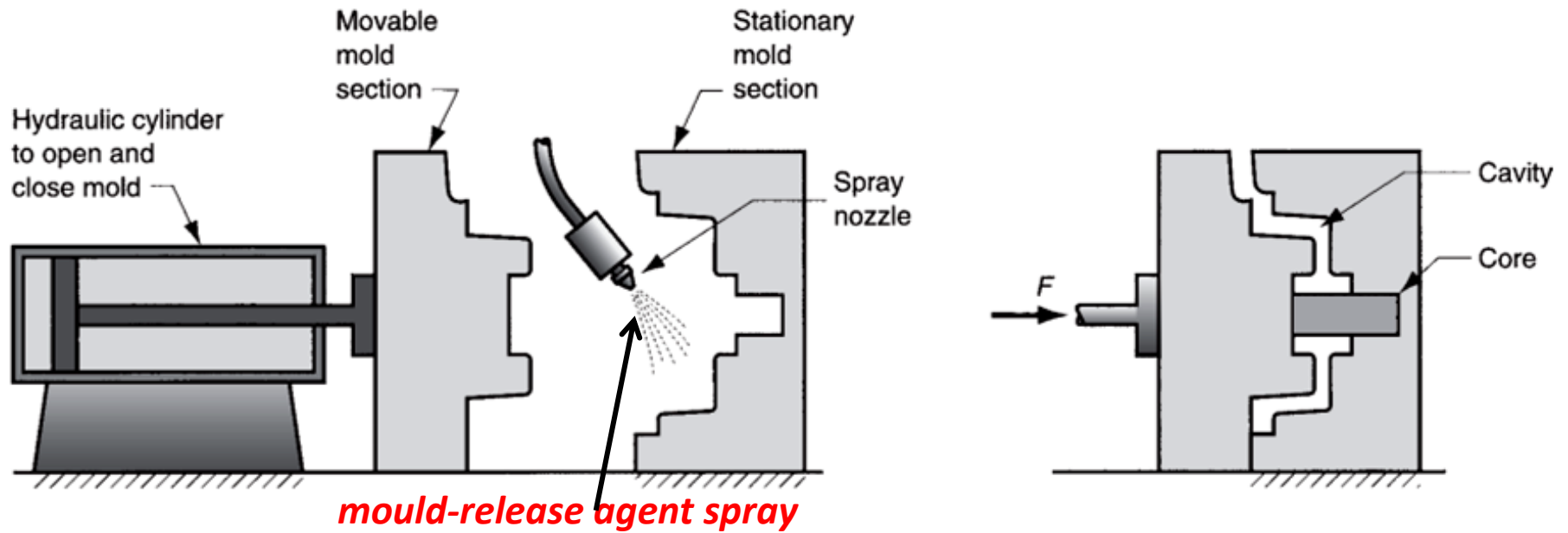


Permanent-Mould Casting

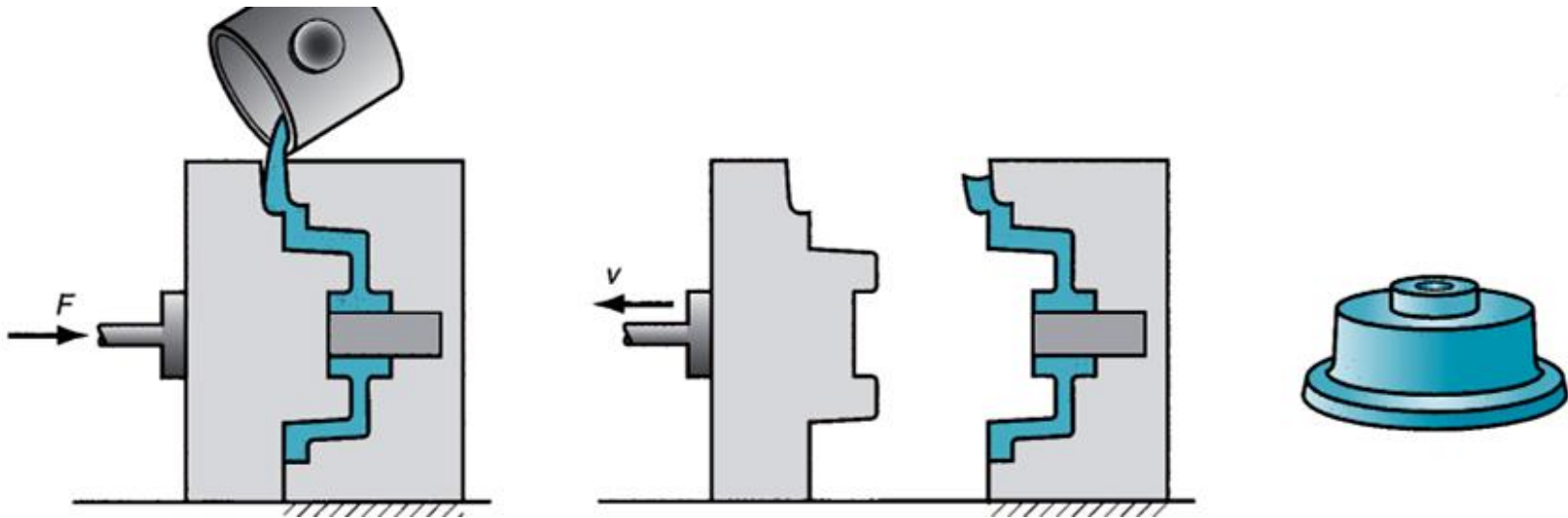
- Parts that can be made economically generally weigh less than 25kg, although special castings weighing a few hundred kilograms have been made using this process.
- ***Metals*** commonly cast in permanent moulds include aluminium, magnesium, copper-base alloys, and cast iron.

Permanent-Mould Casting

- *However*, cast iron requires a high pouring temperature, 1250°C to 1500°C, which takes a heavy toll on mould life.
- The *very high pouring temperatures* of *steel* make permanent moulds *unsuitable* for this metal, unless the mould is made of refractory material.



(1) mould is preheated and coated; (2) cores (if used) are inserted and mould is closed



(3) molten metal is poured into the mould; and (4) mould is opened. Finished part is shown in (5).

Preheating of Mould

- The moulds are **clamped together** by mechanical means and **heated** to about 150° to 200°C to facilitate metal flow and reduce thermal damage to the dies due to high-temperature gradients.
- Preheating the moulds in permanent-mold casting is advisable in order to **reduce the chilling** effect of the metal mold, which could lead to low metal fluidity.
- After preheating, a refractory or **mould coating** is applied to the preheated mould, and the mould is clamped shut.

Mould Coating & Vent

- The ***purpose*** of these coatings is to control or direct the cooling, prevent the casting from sticking, and prolong the mould life by minimizing thermal shock and fatigue.
- Since the moulds are not permeable, ***special provision*** must be made for venting.
- This is usually accomplished through the ***slight cracks*** between mould halves or by very small vent holes that permit the escape of trapped air but not the passage of molten metal.

Mould Cooling and Use of Core

- The *mould* often incorporates *special cooling features*, such as a means of pumping cooling water through the channels located in the mould and the use of cooling fins.
- *Cores*, both expendable sand or plaster or retractable metal, can be used to increase the complexity of the casting, and multiple cavities can often be included in a single mould.

Features of Permanent mould

- The permanent moulds contain the
 - *mould cavity,*
 - *pouring basin,*
 - *sprue,*
 - *runners,*
 - *risers,*
 - *gates,*
 - *possible core supports,*
 - *alignment pins, and*
 - *some form of ejection system.*

Advantages

- ***Near-net shapes*** can be produced that require little finish machining.
- The mould is ***reusable***.
- ***Good surface finish*** is obtained if the mould is in good condition.
- Dimensions are consistent from part to part, and ***dimensional accuracy*** can often be held to within 0.25 mm.
- ***Directional solidification*** can be achieved.

Advantages

- The result is usually a sound, *defect-free casting* with *good mechanical properties*.
- The faster cooling rates of the metal mould produce a *finer grain structure, reduced porosity, and higher-strength products* than would result from a sand casting process.
- *Labour costs* are kept *low* through automation.

Disadvantages

- On the negative side, the process is generally limited to the *lower-melting-point alloys*, and high mould costs can make low production runs prohibitively expensive.
- The useful life of a mould is generally set by molten metal erosion or *thermal fatigue*.
- When making products of steel or cast iron, mould life can be *extremely short*

Disadvantages

- ***Only simple part geometries*** can be made as compared to sand casting (because of the need to open the mould).
- ***Equipment costs*** can be high because of high mould costs.

Die Casting/Pressure Die Casting

- Die casting is a *permanent-mould* casting process in which the molten metal is injected into the mould cavity under *high pressure*.
- Typical pressures are *7 to 350 MPa*.
- The pressure is maintained *during solidification*, after which the mould is opened and the part is removed.
- *Moulds* in this casting operation are *called dies*; hence the name die casting.

Die Casting-Mould material

- The use of **high pressure** to force the metal into the die cavity is the most notable feature that distinguishes this process from others in the permanent-mould category.
- Moulds used in die casting operations are usually made of **tool steel, mould steel, or maraging steel**.
- **Tungsten and molybdenum** with good refractory qualities are also being used, especially in attempts to die cast **steel and cast iron**.

Die Casting

- ***Dies*** can be single-cavity or multiple-cavity.
- ***Ejector pins*** are required to remove the part from the die when it opens, as in our diagrams.
- ***Lubricants*** must also be sprayed into the cavities to prevent sticking.



Die Casting

- Because the die materials have no natural porosity and the molten metal rapidly flows into the die during injection, venting holes and passageways must be built into the dies at the parting line to evacuate the air and gases in the cavity.
- *The vents are quite small; yet they fill with metal during injection because of high pressure.*
- This metal must later be trimmed from the part.

Die Casting

- Also, formation of *flash* is common in die casting, in which the liquid metal under high pressure squeezes into the small space between the die halves at the *parting line* or *into the clearances around the cores and ejector pins*.
- This flash *must be trimmed* from the casting, along with the sprue and gating system.

Advantages

- **High** production rates possible;
- There is almost a complete **elimination of subsequent machining**;
- **Economical** for large production quantities;
- **Close tolerances** possible, on the order of ± 0.076 mm for small parts
- **Good** surface finish ;
- Rapid cooling provides small grain size and **good strength to the casting**.

Advantages

- *Thin sections are possible*, down to about 0.5 mm.
- **Note** that because of the high pressures involved in die casting, wall thicknesses less than those attainable by other casting methods are possible.

Also, because of the high pressures, the velocity of metal in the runners is higher than other processes; small parts can be cast before the runner solidifies.

Advantages

- But there is a limit to the minimum thickness which can be cast by die casting because of the high thermal conductivity the metal dies exhibit, there is a limiting thickness below which the molten metal will solidify prematurely before completely filling the mold cavity.
- It should be noted that small parts can also be produced in processes such as investment casting, but the smallest parts are in die casting because of the application of high pressures.

NOTE

- ***Risers are not used*** in the die-casting process since the high injection pressures ensure the continuous feed of molten metal from the gating system into the casting.
- ***The porosity*** that is often found in die castings is not shrinkage porosity; it is more likely to be the result of either entrapped air or the turbulent mode of die filling.
- This porosity tends to be confined to the interior of castings, and its formation ***can be minimized*** by smooth metal flow, good venting, and proper application of pressure.

NOTE

- ***Sand cores cannot be used*** in die casting because the high pressures and flow rates cause the cores to either disintegrate or have excessive metal penetration.
- As a result, ***metal cores are required***, and provisions must be made for their retraction, usually before the die is opened for removal of the casting.

NOTE

- Die temperatures are usually maintained at about 150° to 250°C below the solidus temperature of the metal being cast in order to promote rapid freezing.

Die Life

- ***Die life*** is usually limited by wear (or erosion), which is strongly dependent on the temperature of the molten metal.
- ***Surface cracking*** can also occur in response to the large number of heating and cooling cycles that are experienced by the die surfaces.
- If the rate of temperature change is the dominant feature, the problem is called ***heat cracking*** .
- If the number of cycles is the primary cause, the problem is called ***thermal fatigue*** .

Types of Die Casting

1. Hot Chamber DIE casting
2. Cold Chamber DIE casting

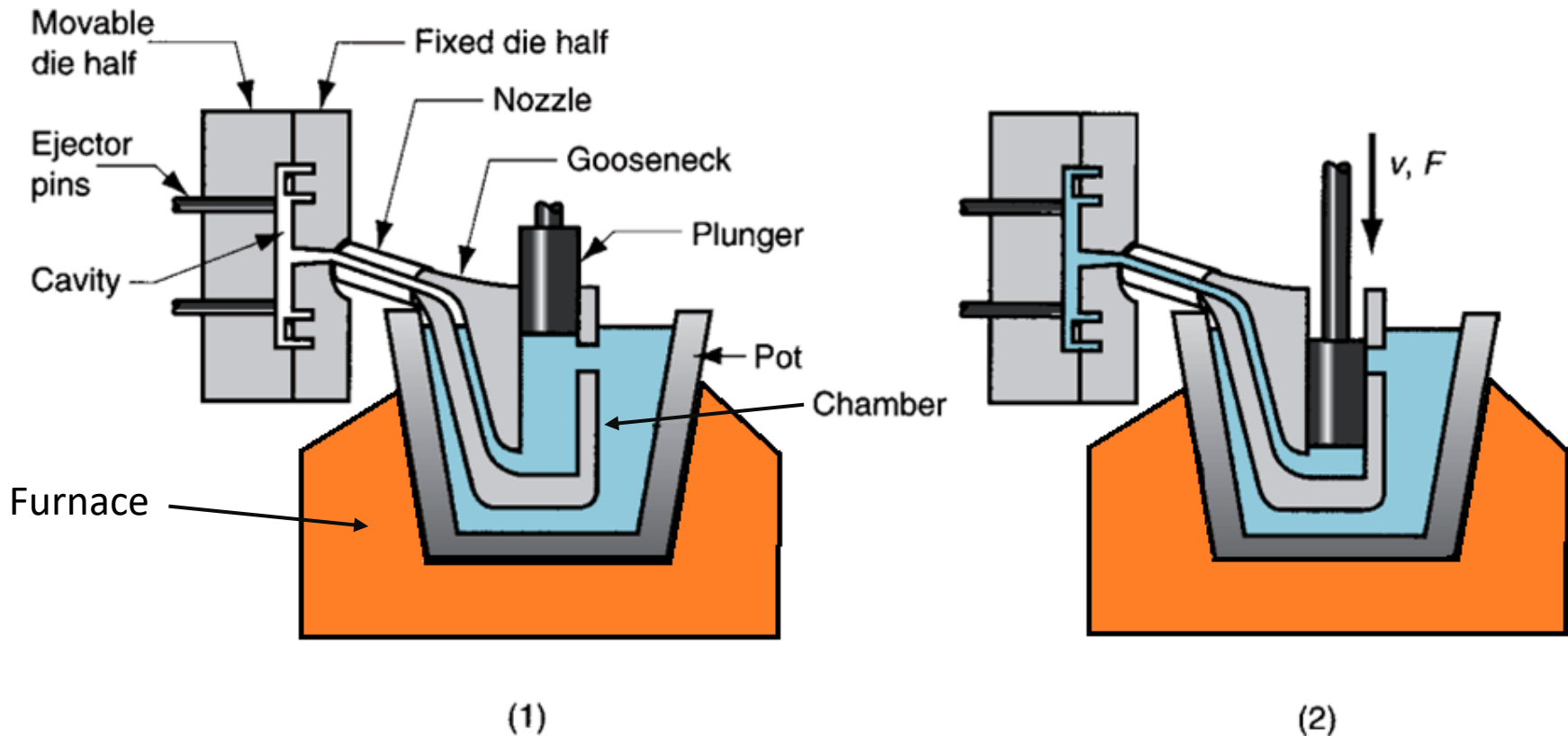
1. Hot Chamber DIE casting

- In hot-chamber machines, the metal is melted in a container attached to the machine, and a piston is used to inject the liquid metal under high pressure into the die.
- Typical injection pressures are **7 to 35 Mpa**.
- Production rates up to **100 shots per minute** can be achieved.
- It has **faster cycling** time than cold chamber die casting because there is no handling or transfer of molten metal.

1. Hot Chamber DIE casting

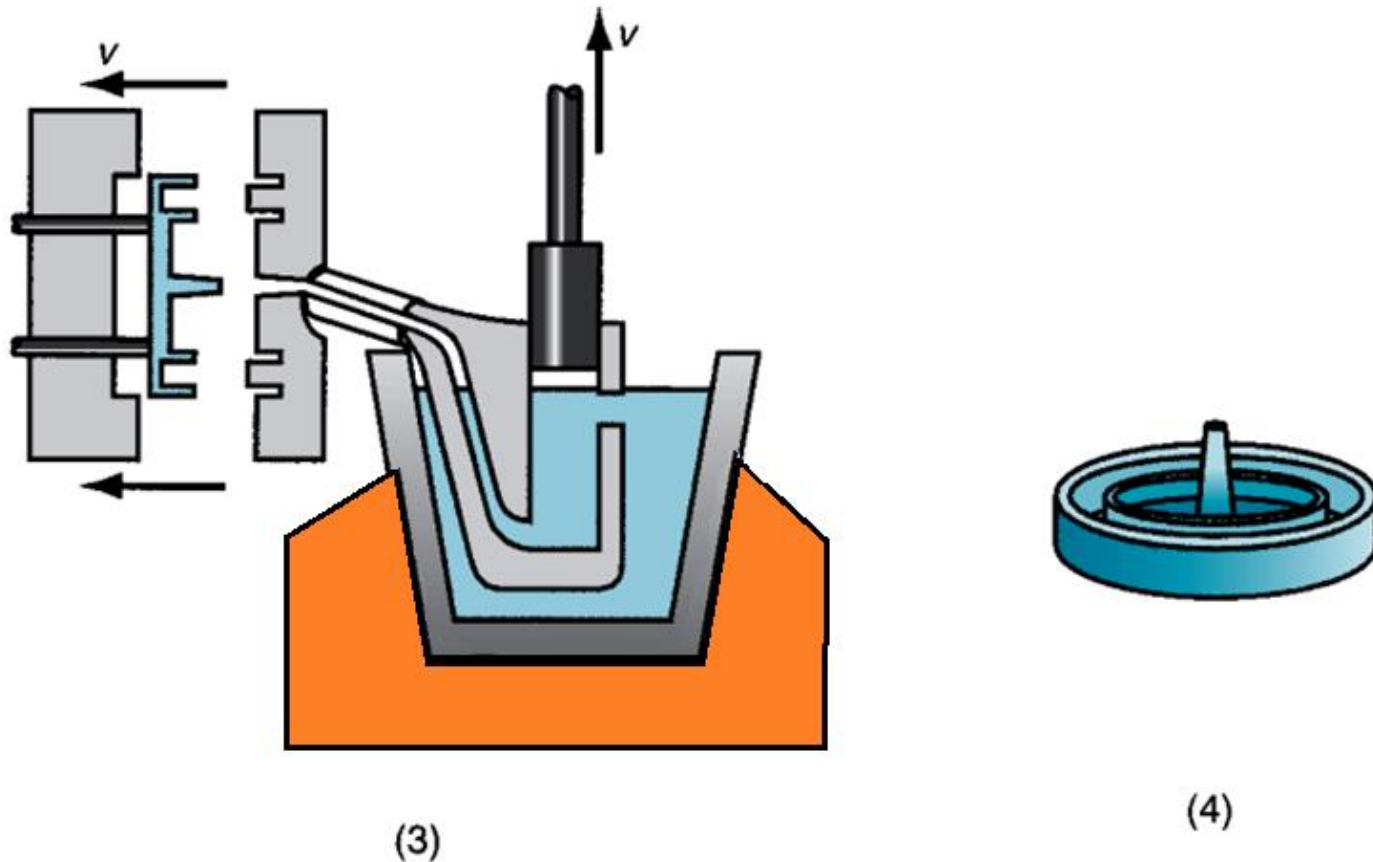
- Hot-chamber die casting imposes a ***special hardship/damage*** on the injection system because much of it is submerged in the molten metal.
- The process is therefore limited in its applications to ***low-melting-point*** metals that do not chemically attack the plunger and other mechanical components.
- The metals include ***zinc(419.5 °C), tin(231.9 °C), lead(327.5 °C).***

1. Hot Chamber DIE 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.

1. Hot Chamber DIE casting



(3) plunger is withdrawn, die is opened, and solidified part is ejected. Finished part is shown in (4).

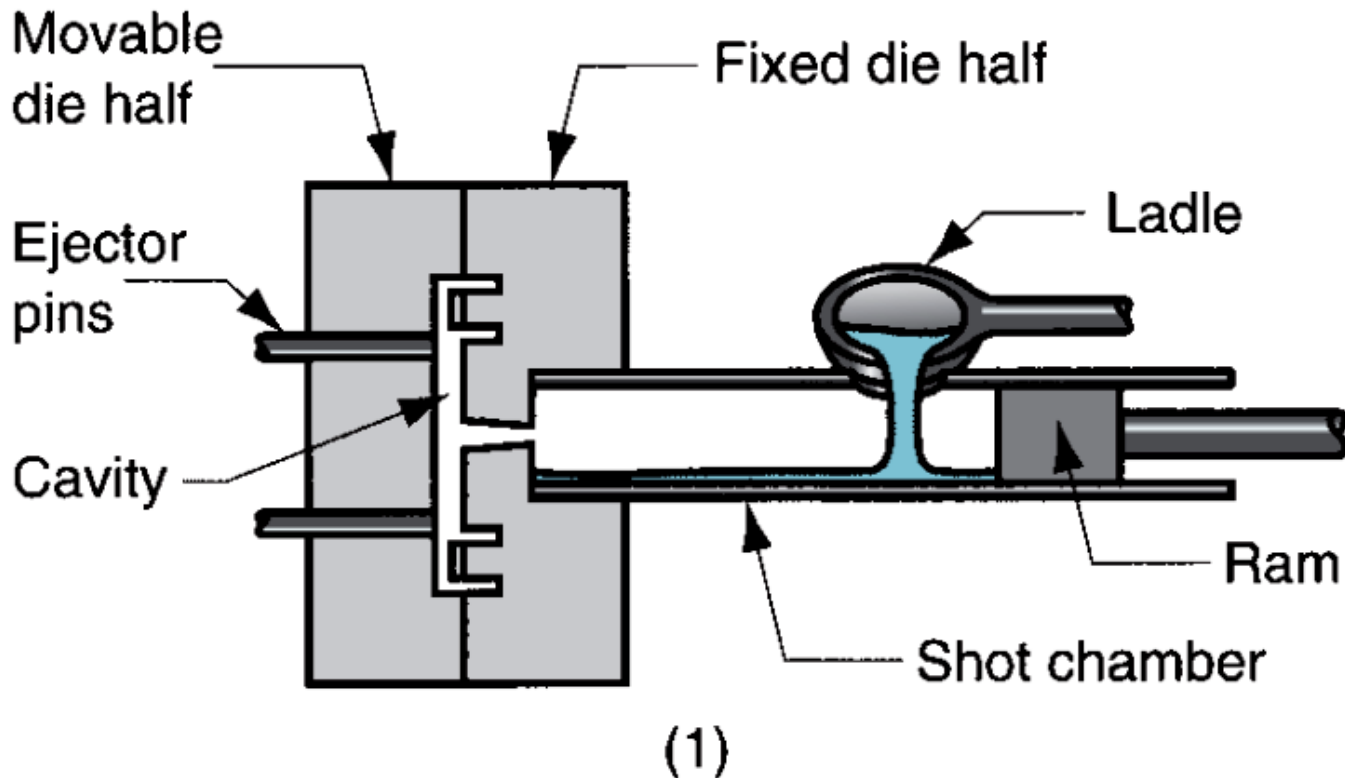
2. Cold Chamber DIE casting

- In cold-chamber die casting machines, molten metal is poured into an unheated chamber from an **external melting container**, and a piston is used to inject the metal under high pressure into the die cavity.
- Injection pressures used in these machines are typically **14 to 140 Mpa**.
- Compared to hot-chamber machines, **cycle rates are not usually as fast** because of the need to ladle the liquid metal into the chamber from an external source.

2. Cold Chamber DIE casting

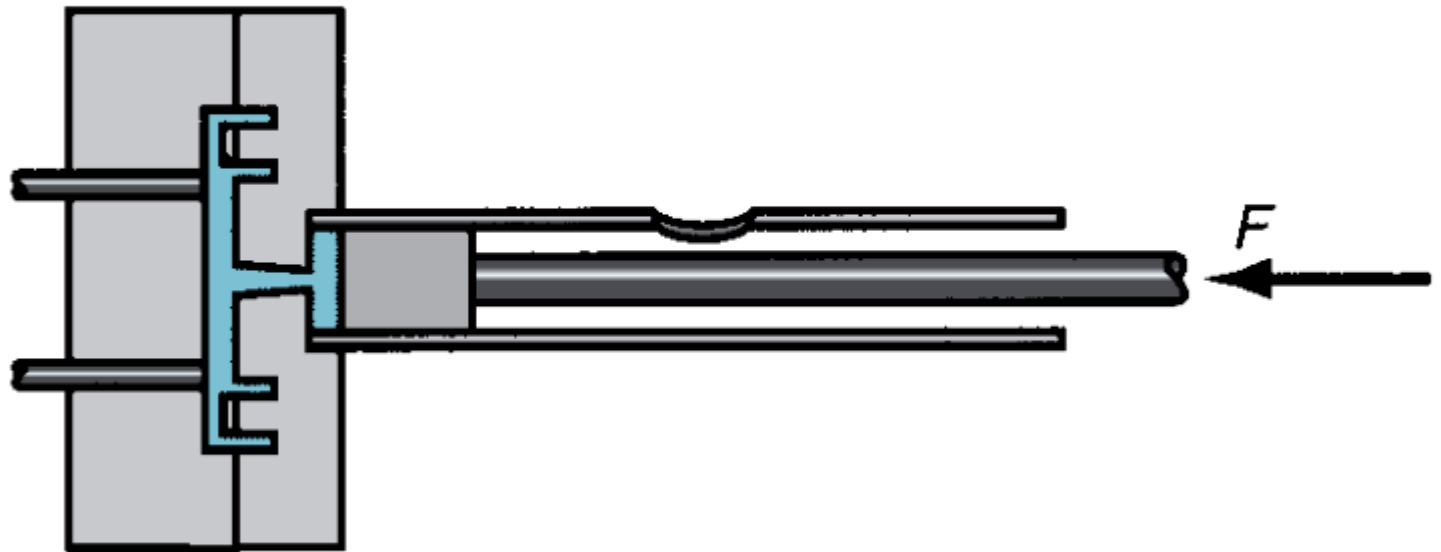
- Nevertheless, this casting process is a high production operation.
- Cold-chamber machines are typically used for casting *aluminium(660.3°C), brass (900 to 940 °C), and magnesium alloys (650 °C +)*.

2. Cold Chamber DIE casting



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

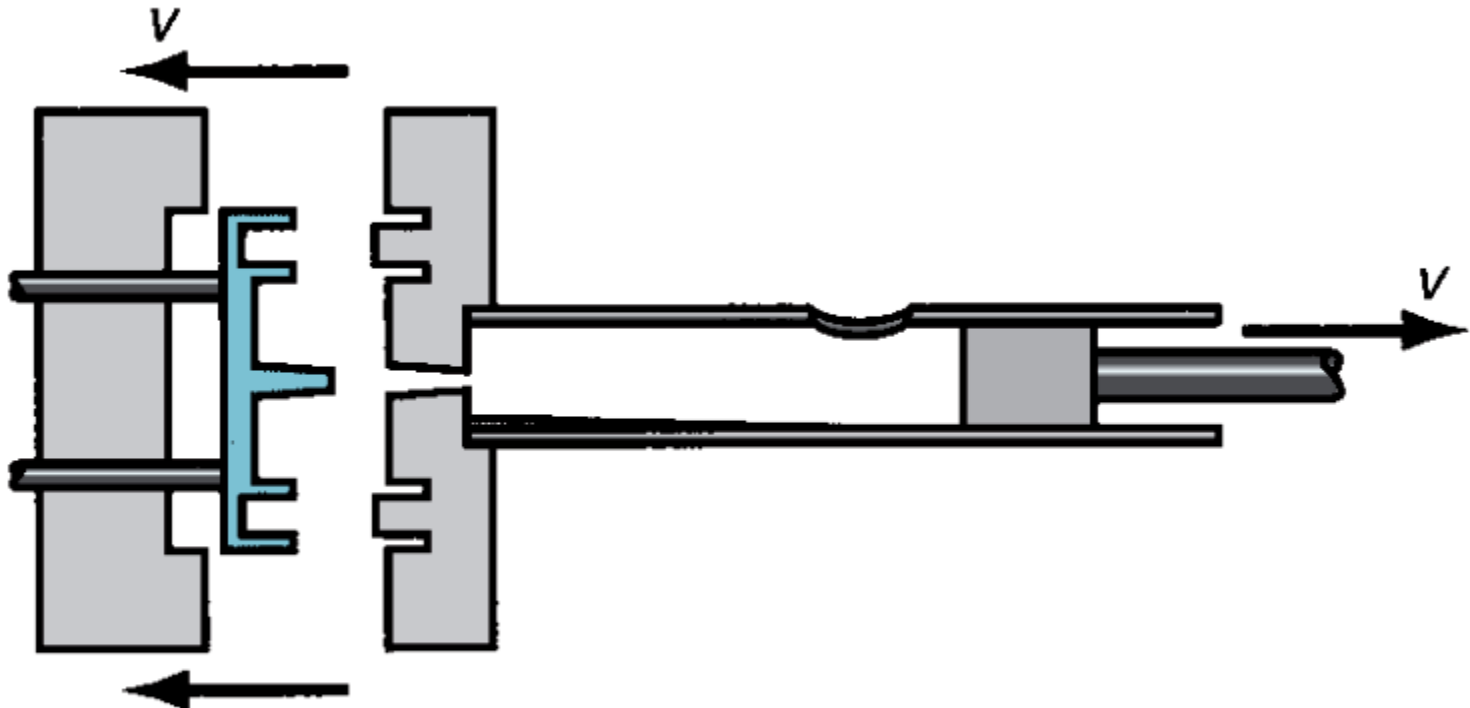
2. Cold Chamber DIE casting



(2)

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

2. Cold Chamber DIE casting



(3)

((3) ram is withdrawn, die is opened, and part is ejected