BMM3643 Manufacturing Processes
Metal Casting Processes
(Expendable Mold & Permanent Mold)

by
Dr Mas Ayu Bt Hassan
Faculty of Mechanical Engineering
masszee@ump.edu.my

Chapter Information

Lesson Objectives:

Expendable mold & Permanent Mold

Lesson Objective:

At the end of this lecture, students should be able to understand and explain the following:

- Understand the various types of expandable mold processes
- Understand the process consists in permanent mold casting

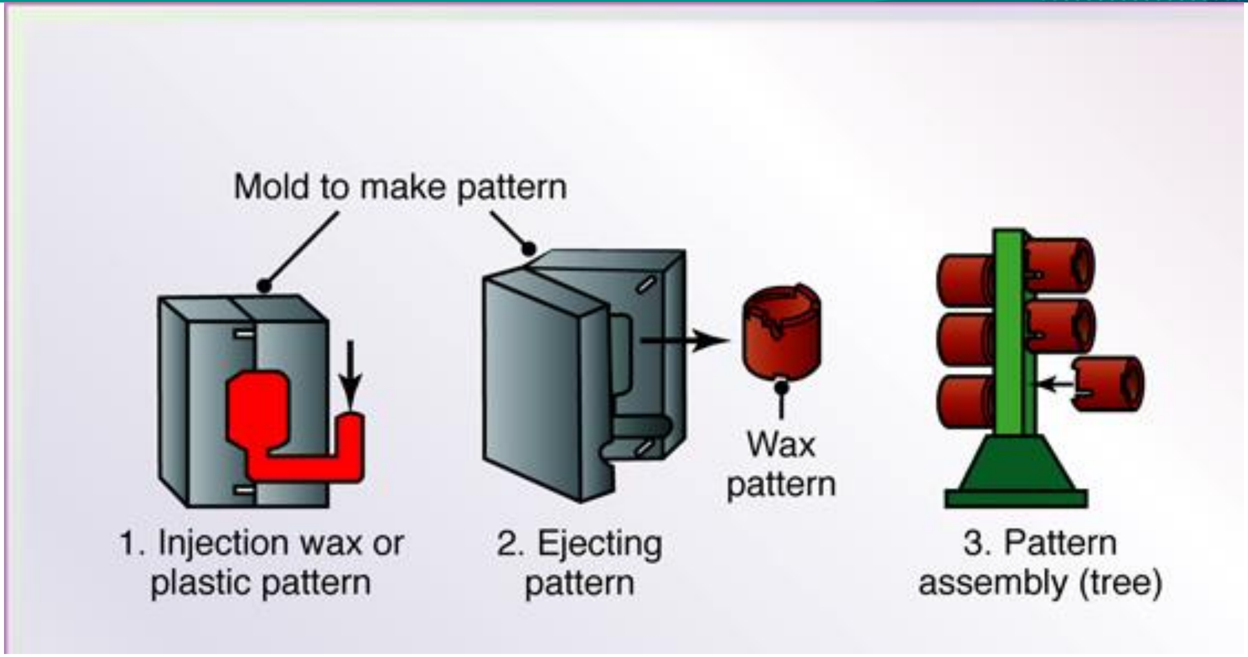
Expandable Mold Casting

- **Expendable mold processes** are using an expendable mould that need be destroyed in order to remove the casting part
- **Mould materials -** sand, plaster, and binders
- Two types of expandable mold processes
  1. Investment casting (lost-wax casting)
  2. Lost foam casting (evaporative foam casting)

Investment Casting

- Also known as the lost-wax process
- The pattern is made of wax or a plastic (e.g. polystyrene by injection moulding)
- Careful handling of wax pattern during moulding is important due to they are not strong unlike plastics.
- The term investment derives from the fact that the pattern is invested with refractory material.
- However, wax can be recovered and reused.
- This is a type of precision casting process.

Steps in Investment Casting Process



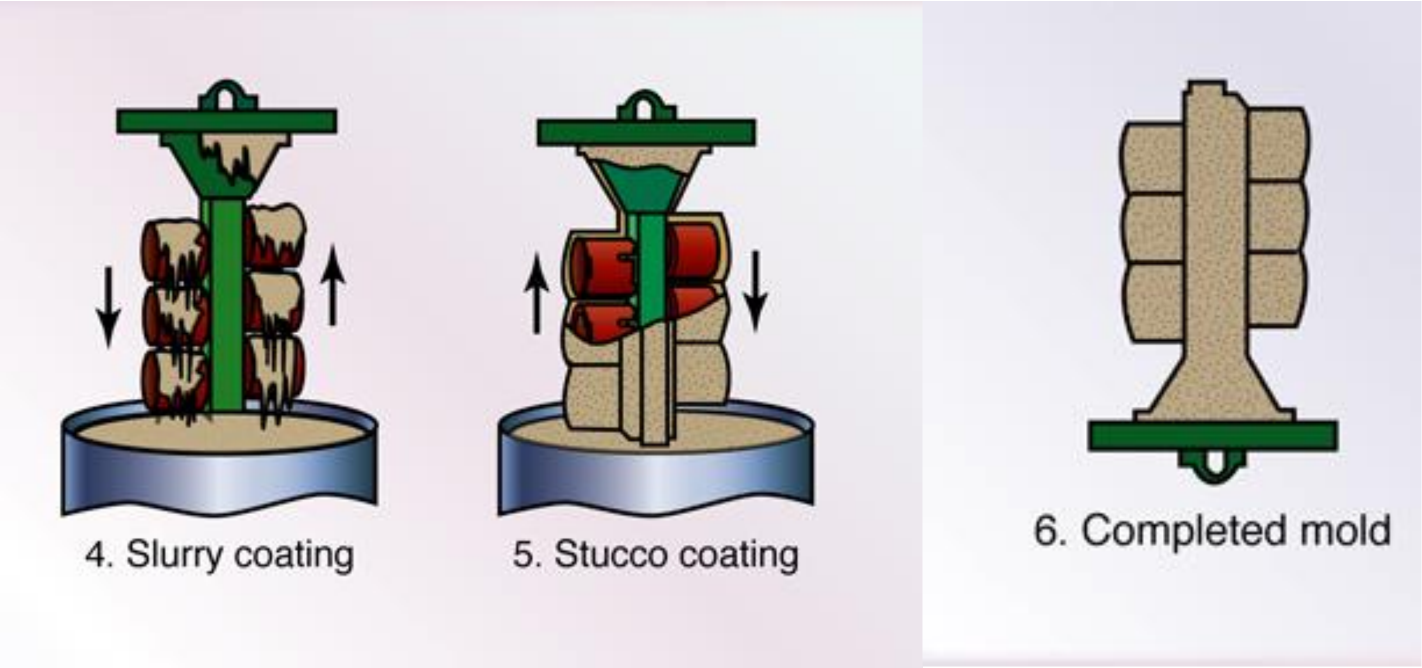
(1) The pattern is made by injecting molten wax or plastic into a metal die in the shape of desired pattern

(2) When the pattern solidified, it is then removed from the injection mould

(3) A number of pattern will be assembled in the form of pattern tree to make one mould, significantly increase the production rate

Source by Kalpakjian Book, 2014

Steps in Investment Casting Process (continue)

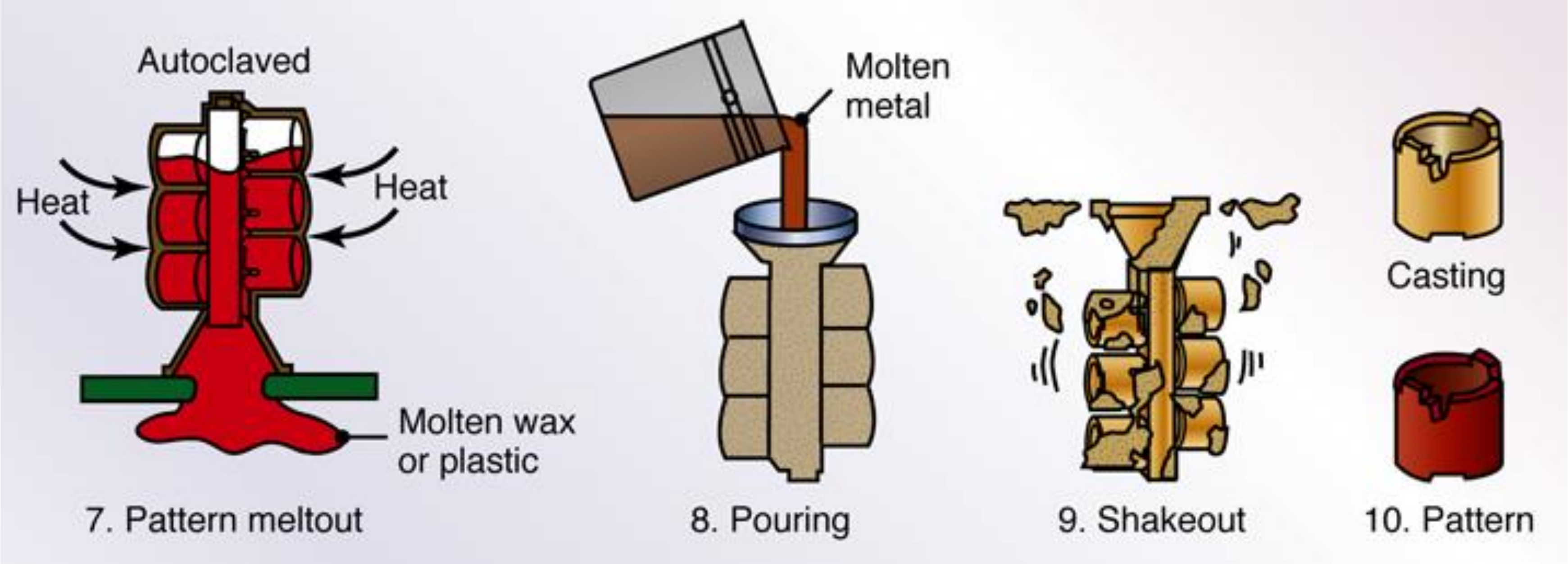


(4) (5) (6) The assemble pattern tree is then dipped into a slurry of refractory material (very fine silica and binders, water, ethyl silicate, and acids).

After initial coating has dried, the pattern will be coated repeatedly to increase the desired mold thickness until it is completed.

Source by Kalpakjian Book, 2014

Steps in Investment Casting Process (continue)



(7) The mold will be dried and heated to a temperature 90 – 175°C. It is held for about 12 hours to melt out the wax. After that it is fired to 650 – 1050°C for about 4 hours to remove the water and burn off any residual wax.

(8) Then the molten metal will be poured and left to solidify.

(9) (10) The mold is shake-out and casting will be removed.

Source by Kalpakjian Book, 2014

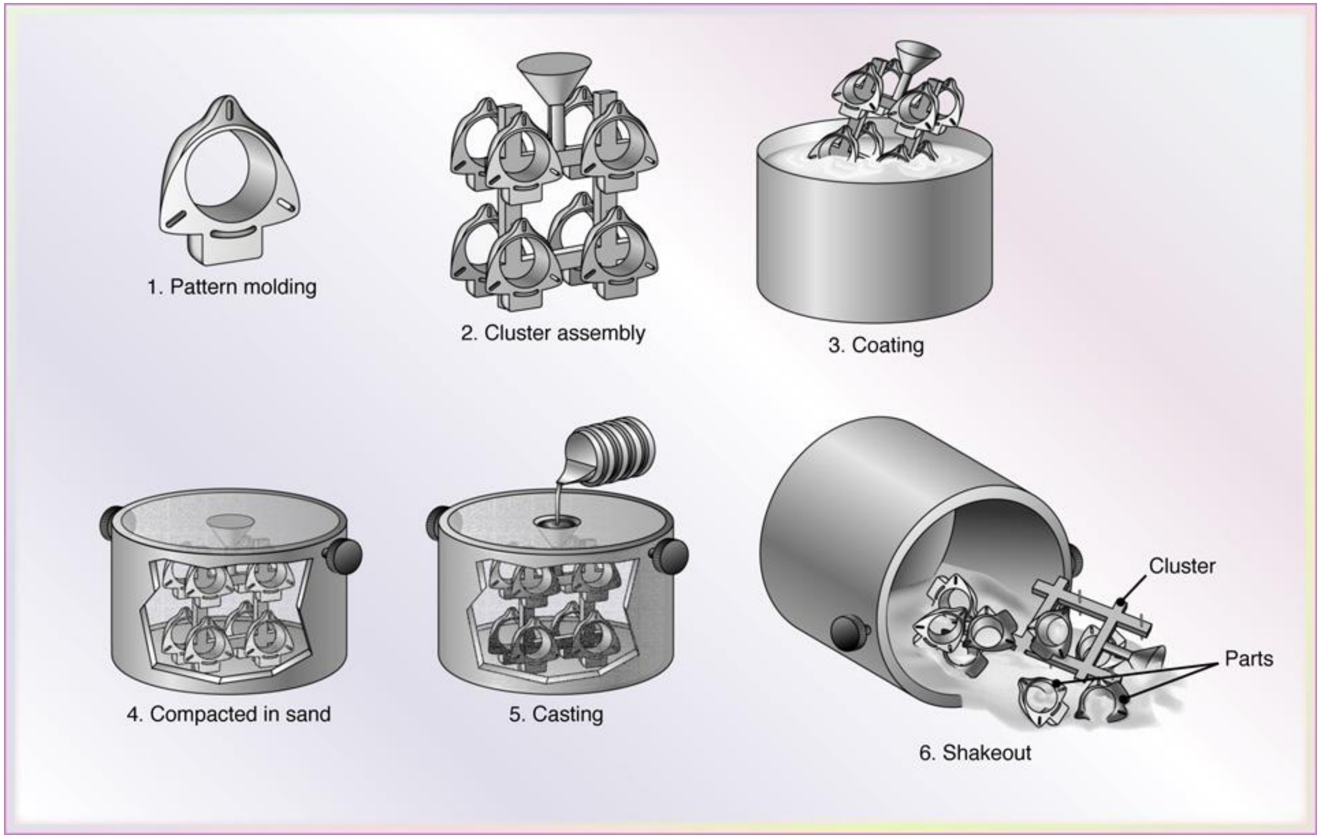
Advantages and Disadvantages of Investment Casting

- Advantages:
  – Products with great complexity and intricacy can be cast
  – Closed dimensional tolerance with very good surface finish
  – Wax usually can be recovered for reuse
  – Not required any additional machining because it is a net shape process
- Disadvantages
  – Required many processing steps
  – Involved with expensive process due to involve with the making of die mold

Lost-foam Casting

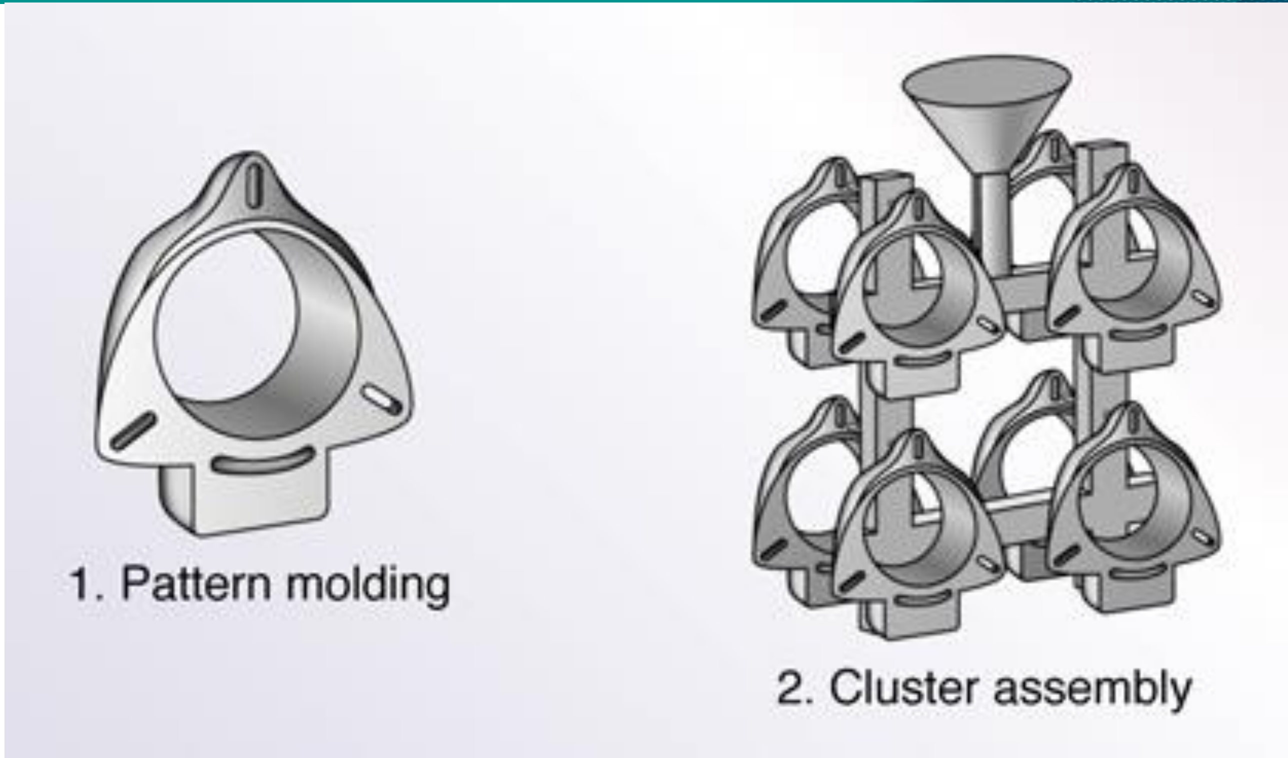
- Quite same to investment casting process (precision casting)
- Uses polystyrene pattern which evaporates once the molten metal poured into the mold to form the casting.
- It is important casting process for ferrous and non-ferrous metal especially in automotive industry.

Lost-foam Casting



Schematic of the expandable-pattern casting process, also known as lost-foam or evaporative casting. Source by Kalpakjian Book, 2014.

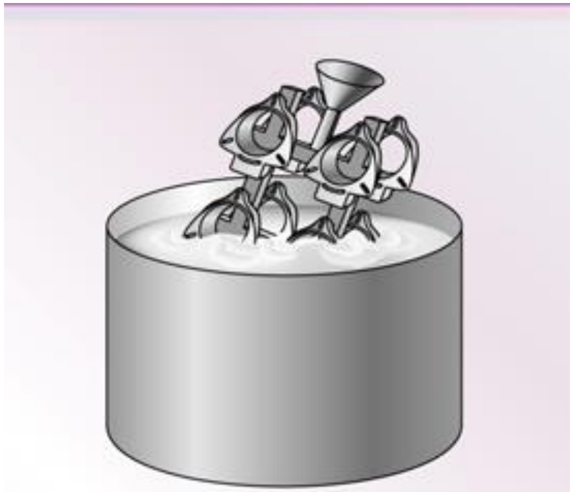
Steps in Lost-foam Casting

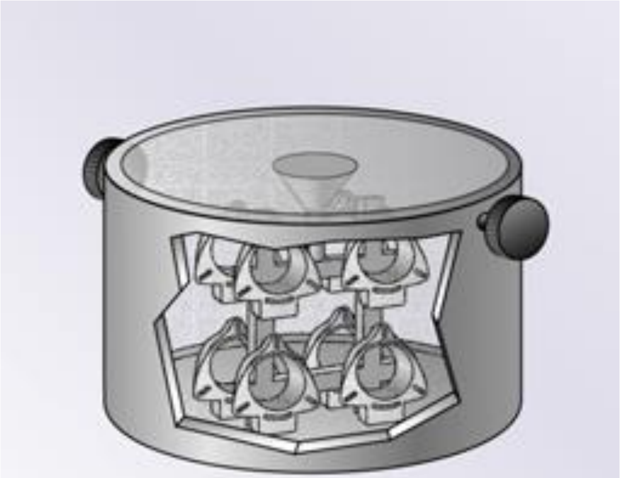


1. Raw material (expandable polystyrene, EPS) is placed in a preheated die (usually aluminium). Once heated, the polystyrene expands and takes the shape of the die cavity.
2. After cooled, the die will be opened and the polystyrene pattern removed. They may be arranged in cluster assembly.

Source by Kalpakjian Book, 2014

Steps in Lost-foam Casting (continue)

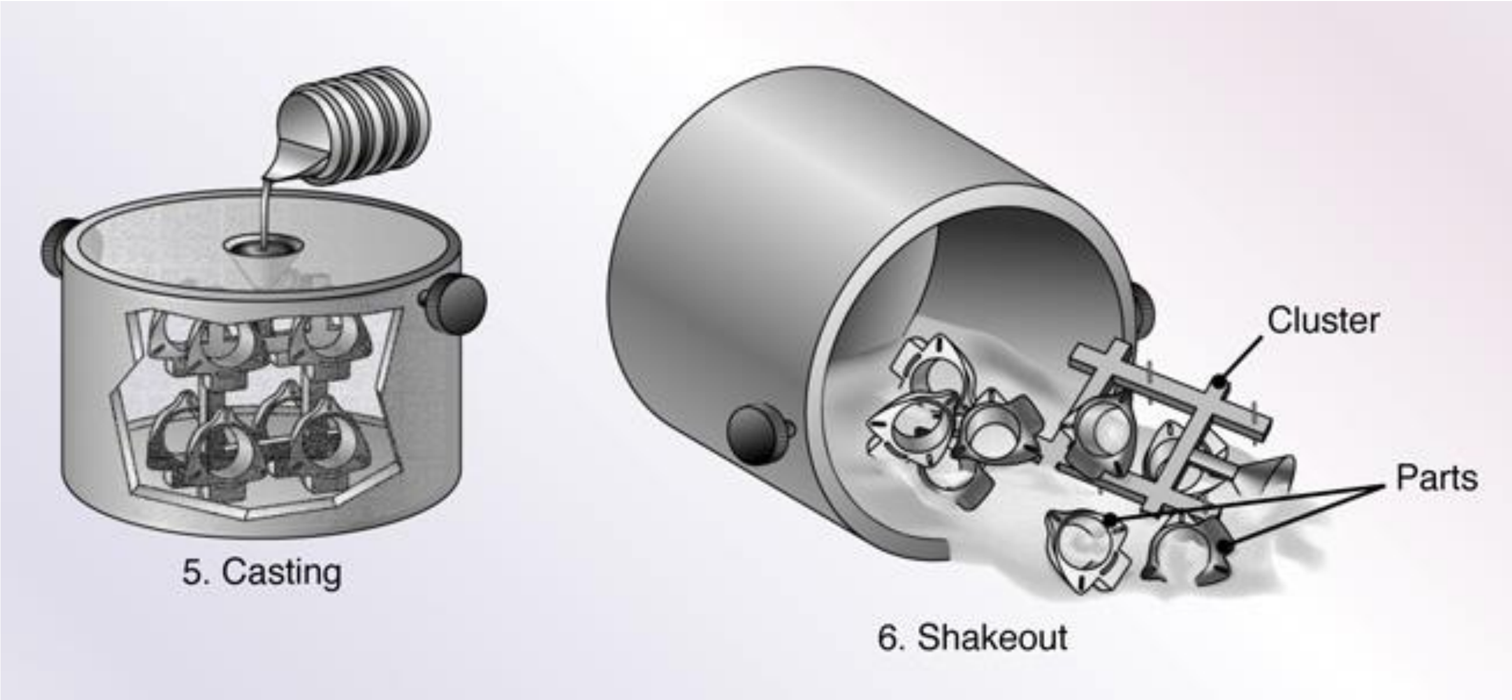

3. Coating


4. Compacted in sand

3. The pattern will be coated with refractory slurry, dried and placed in a flask.
4. The flask filled with loose, fine sand that supports the pattern. The pattern is then compacted inside it.

Source by Kalpakjian Book, 2014

Steps in Lost-foam Casting (continue)

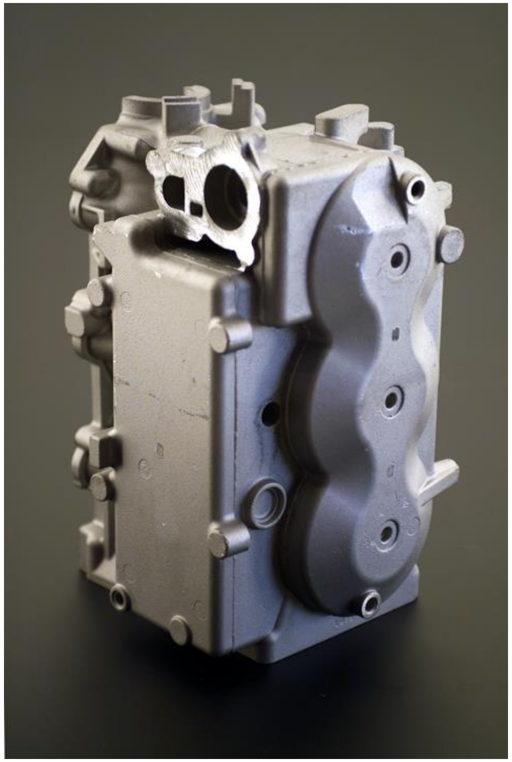


5. The molten metal will be poured into the mold. This immediately will vaporizes the pattern and molten metal fills the mold cavity. The heat degrades polystyrene and the products will be vented into surrounding sand.
6. Once cooled, the parts are shakeout to get the final products.

Source by Kalpakjian Book, 2014

Example of Lost-foam Casting Product

(a)



(b)

(a) Molten metal was poured into the mold for lost-foam casting to produce 60-hp. 3-cylinder marine engine; (b) Finished engine block. Source: Courtesy of Mercury Marine.

Advantages and Disadvantages of Lost-foam Casting

- Advantages:
  - No parting lines, cores, risers etc.
  - Inexpensive flasks are satisfactory.
  - Polystyrenes are in expensive
  - Net shape process (no secondary work)
- Disadvantages:
  - The pattern handling requires great care and the coating process is time-consuming.
  - Good process control is very important as a scrapped casting needs replacement not only the mold but the pattern as well.

Permanent Mold Casting

- **Permanent mould processes** – using permanent mould that can be used for many times to make finished parts
- The mold is made of metal (or a ceramic refractory material)
- Part shapes are limited by the need to allow removal from die cavity
- Permanent mould processes are more economic for mass production rate
- The processes include:
  - Die casting (Hot chamber & Cold chamber)

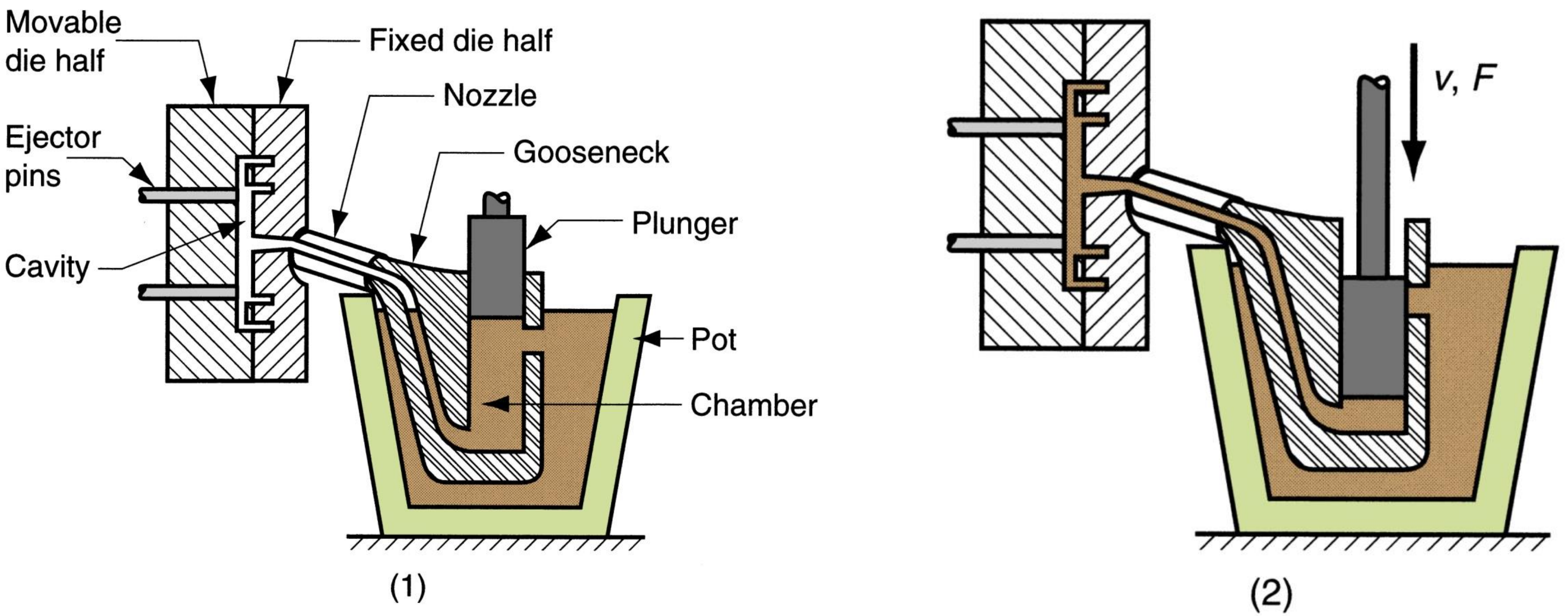
Die Casting

- High pressure is required to inject a molten metal into mold cavity.
- Pressure must be maintained during solidification, then the mold is open and finished part is remove.
- It is known as die casting due to mold is also called as dies in this operation.
- Requirement of high pressure to force molten metal into die cavity is what distinguishes this process from any other permanent mold processes.

Hot-Chamber Die Casting

- Metal will be melted in a container, and a piston injects molten metal under high pressure ranging from 0.7 – 700 MPa into the die.
- High production rates
- Selection of metals are limited to low melting-point metals that do not chemically attack plunger and other mechanical components.
- Casting metals can be used are zinc, magnesium, tin and lead

Process in hot-chamber casting

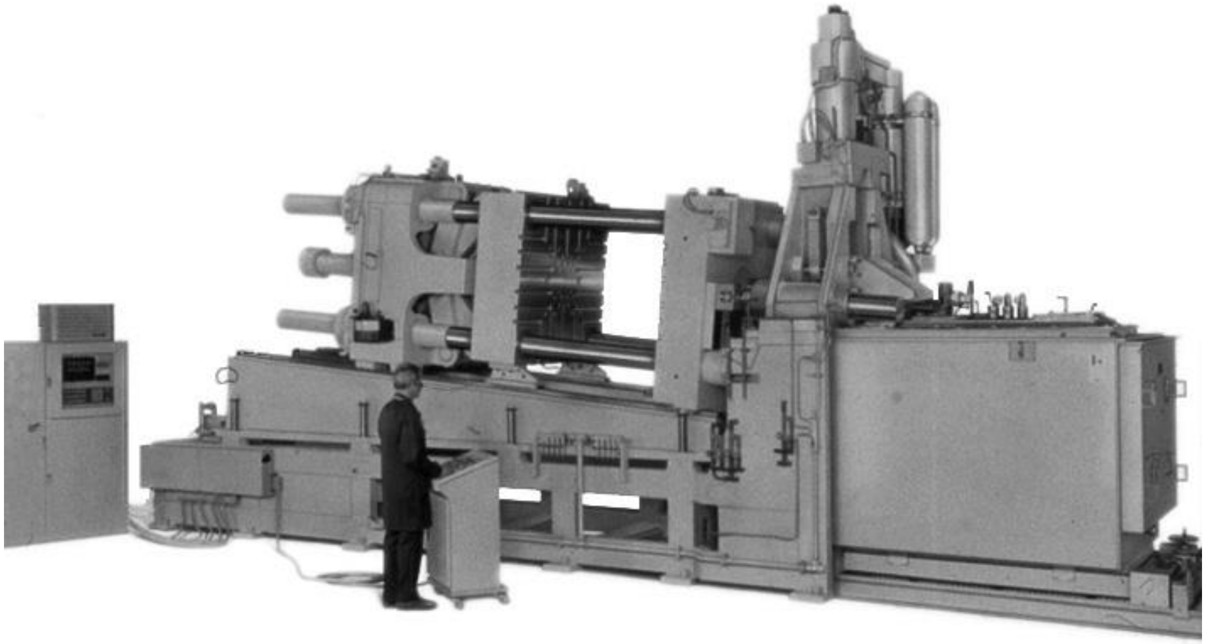


(1) with die closed and plunger withdrawn, molten metal flows into the chamber.

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

Source by Kalpakjian Book, 2014

Hot-Chamber Die-Casting Machine

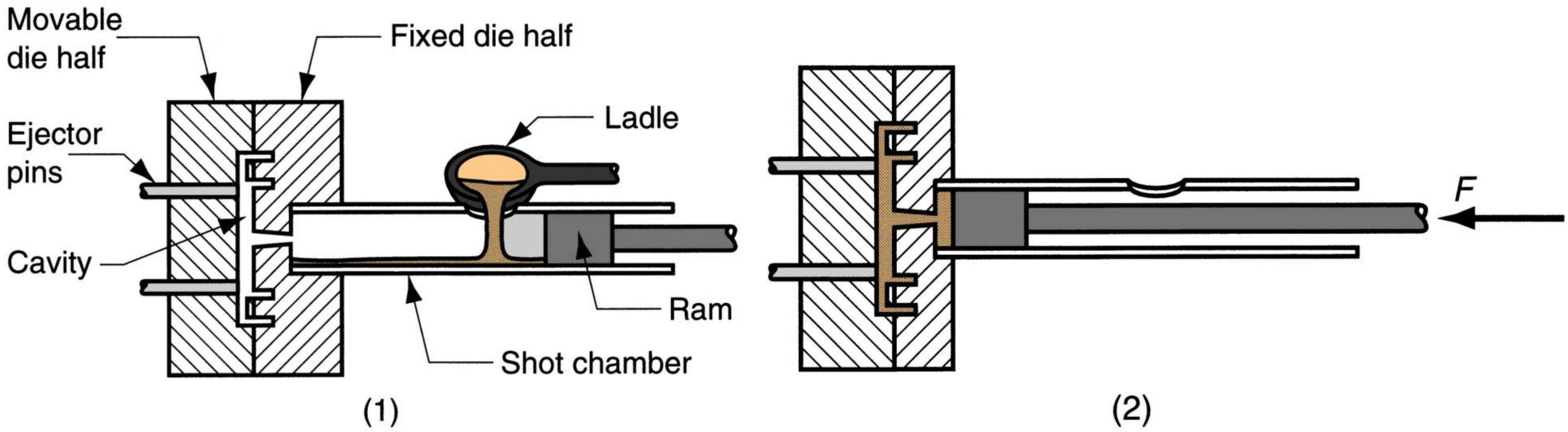


800-ton hot-chamber die-casting machine, DAM 8005 (made in Germany in 1998). This is the largest hot-chamber machine in the world and costs about $1.25 million. Source by Kalpakjian Book, 2014.

Cold-Chamber Die Casting

- Molten metal will be poured into unheated chamber from external melting container, and a piston injects the molten metal under high pressure into die cavity.
- High production rate however, usually not as fast as hot-chamber process because of pouring step.
- Casting metals can be used such as magnesium alloys, brass and aluminum.
- Advantage: able to cast higher melting point of metals and alloys.

Process in cold-chamber casting



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

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

Source by Kalpakjian Book, 2014

Advantages and Limitations of Die Casting

- Advantages:
  - Economical for mass production of products
  - Good dimensional accuracy and surface finish
  - Rapid cooling provides small grain size and good strength to casting
  - Thin sections are possible
- Disadvantages:
  - Part geometry must allow removal from die cavity
  - Limited to metals with low melting points

SUMMARY OF CASTING PROCESSES

TABLE 11.1

Summary of Casting Processes

Process	Advantages	Limitations
Sand	Almost any metal castl no limit to part size, shape or weight; low tooling cost	Some finishing required; relatively coarse surface finish; wide tolerances
Shell mold	Good dimensional accuracy and surface finish; high production rate	Part size limited; expensive patterns and equipment
Evaporative pattern	Most metals cast with no limit to size; complex part shapes	Patterns have low strength and can be costly for low quantitites
Plaster mold	Intricate part shapes; good dimensional accuracy and sutface finish; low porosity	Limited to nonferrous metals; limited part size and volume of production; mold-making time relatively long
Ceramic mold	Intricate part shapes; close-toleranve parts; good surface finish	Limited part size
Investment	Intricate part shapes; excellent surface finish and accuracy; almost any metal cast	Part size limited; expensive patterns, molds and labor
Permanent mold	Good surface finish and dimensional accuracy; low porosity; high production rate	High mold cost; limited part shape and complexity; not suitable for high-melting-point metals
Die	Excellent dimensional accuracy and surface finish; high production rate	High die cost; limited part size; generally limited to nonferrous metals; long lead time
Centrifugal	Large cylindrical or tubular parts with good quality; high production rate	Expensive equipment; limited part shape

Source by Kalpakjian Book, 2014

End of sub-chapter Metal Casting Processes

(Expandable Mold & Permanent Mold)