University of Technology
Materials Engineering Department

Casting Technology

Fourth Class

General Materials Branch

Class Code :ofp4npn

Class Objectives

Benjamin Franklin said:

- - *Tell me, I will forget,*
- - *Teach me, I will remember,*
- - *Involve me, I understand*

References

1. S. Kalpakjian, "Manufacturing Engineering and Technology", Addison-Wesley Company, USA, 2012.
2. Black.T, Kosher " De Garmo Materials and Manufactures in Engineering,", John Wiley & Sons, Inc., 2010.
3. P. Mikell Groover, "Fundamentals of modern manufacturing: materials, processes and systems", John Wiley & Sons, Inc., 2011.
4. Helmi A. Youssef, Hassan A. El-Hofy, Mahmoud H. Ahmed ,"Manufacturing Technology: Materials, Processes, and Equipment" ,CRC Press , USA , 2011
5. Vukota Boljanovic, "METAL SHAPING PROCESSES: Casting and Molding; Particulate Processing; Deformation Processes and Metal Removal", Industrial Press, Inc. New York , USA , 2010.

توزيع الدرجات

Terms	Grade
Mid Term	20%
Quiz	5%
Lab	10%
Assignment	5%
Final	60%

Course Subjects

- Fundamentals of metal casting.
- Overview of Casting Technology.
- Heating and Pouring.
- Solidification and Cooling.
- Patterns and Core
- Expendable-Mold Casting Processes (Single Use Mold Techniques).

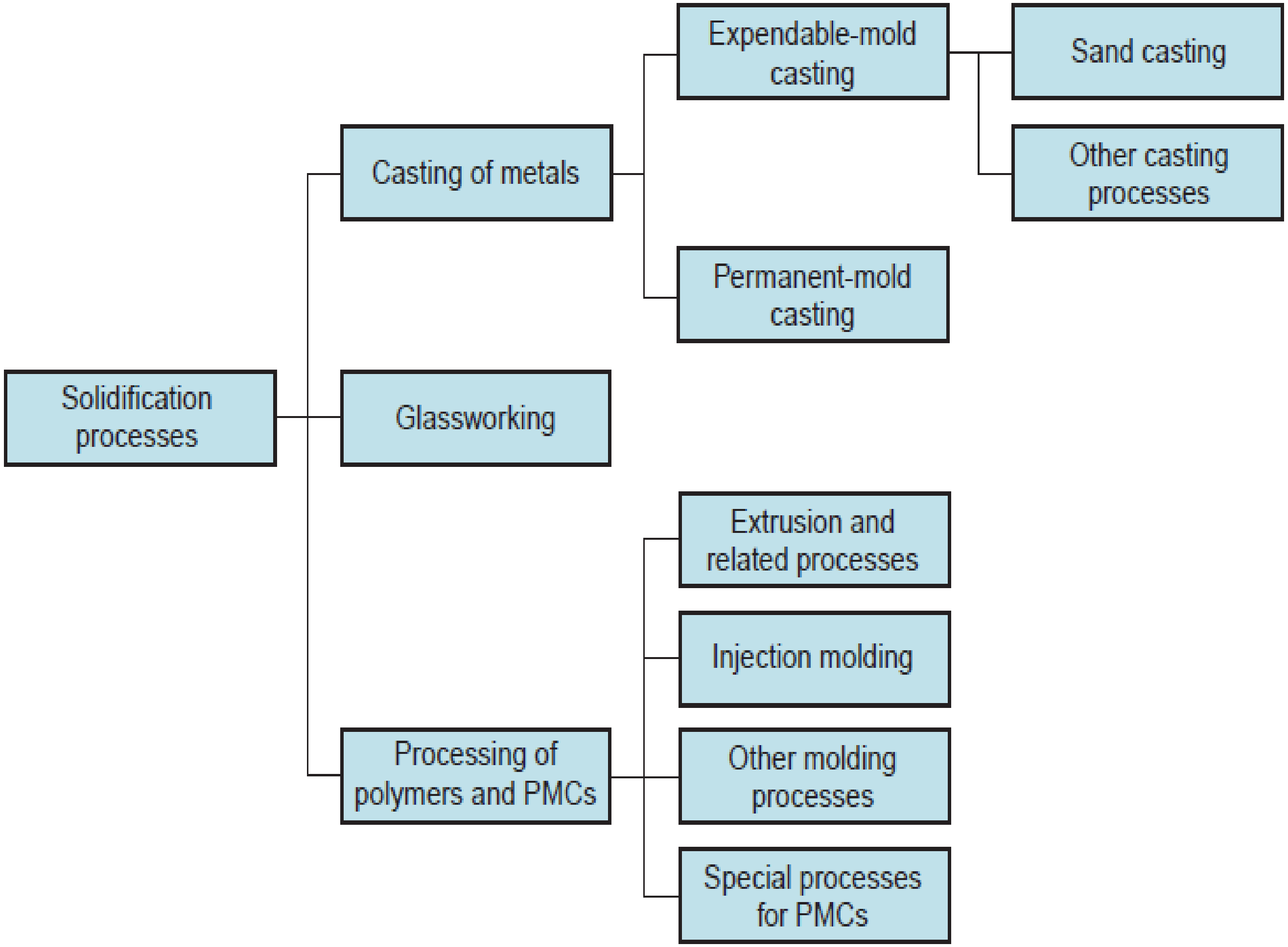
Course Subjects

- Sand Casting
- Continuous Casting
- Shell Casting
- Vacuum Molding
- Plaster-Mold Casting
- Ceramic Mold Casting
- Rubber Mold Casting
- Graphite Mold Casting
- Casting Design
- Cleaning Casting and Finishing

Course Subjects

- Permanent Mold Casting
- Die Casting.
- Centrifugal Casting .
- Single Crystal Casting.
- Other Types of Permanent Mold Casting
- Foundry Practice .
- Process selection
- Computer Application in Permanent Mold Design

Classification of solidification processes



Overview of Casting Technology

Lecture 1

- ***Casting*** is a process in which molten metal flows by gravity or other force into a mold where it solidifies in the shape of the mold cavity.
- The term ***casting*** is also applied to the part that is made by this process. It is one of the oldest shaping processes, dating back 6000 years .

Definition

- The term ***ingot*** is usually associated with the primary metals industries; it describes a large casting that is simple in shape and intended for subsequent reshaping by processes such as rolling or forging.
- It involves the production of more complex geometries that are much closer to the final desired shape of the part or product.

Advantages

1. Casting can be used to create complex part geometries, including both external and internal shapes.
2. Some casting processes are capable of producing parts to net shape. No further manufacturing operations are required to achieve the required geometry and dimensions of the parts.
3. Other casting processes are near net shape, for which some additional shape processing is required (usually machining) in order to achieve accurate dimensions and details.

Advantages

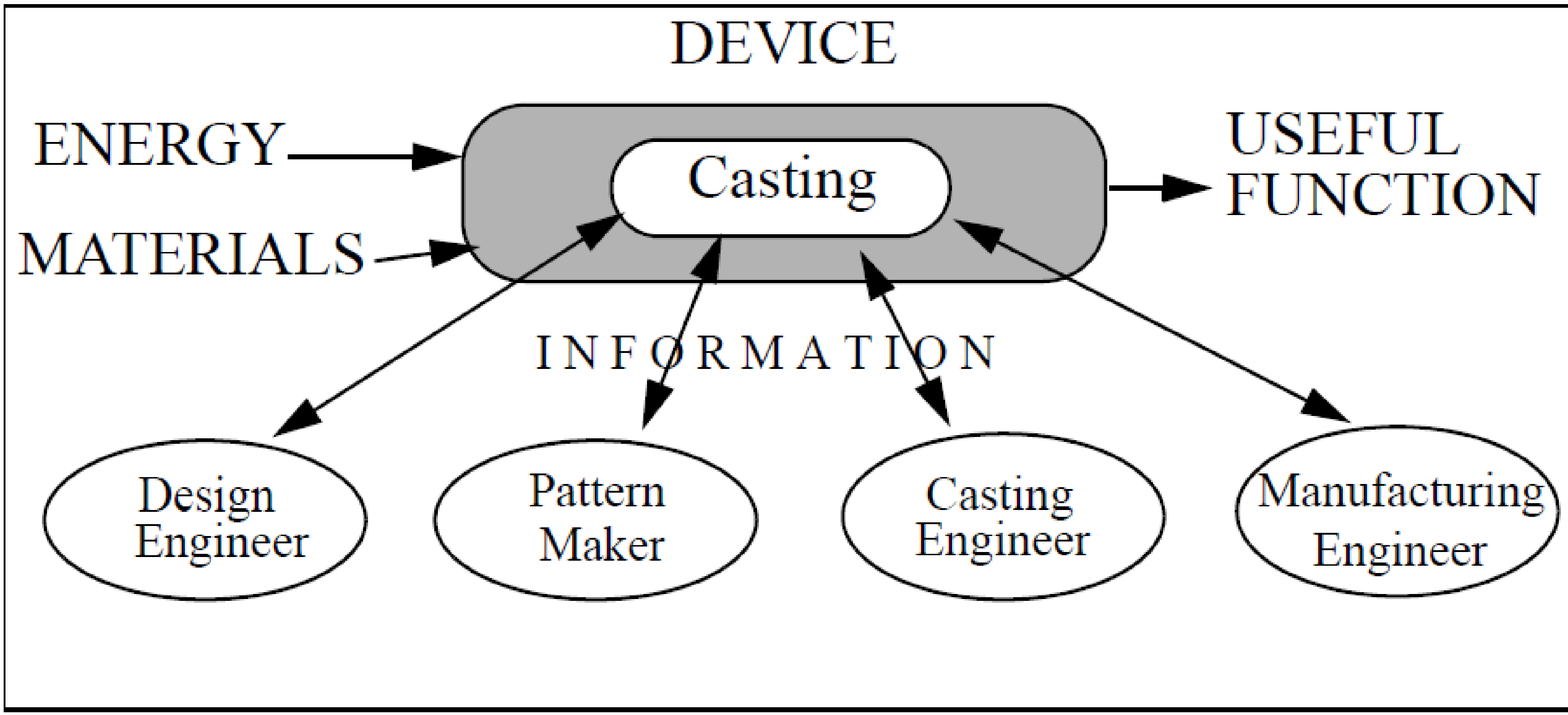
4. Casting can be used to produce very large parts. Castings weighing more than 100 tons have been made.
5. The casting process can be performed on any metal that can be heated to the liquid state.
6. Some casting methods are quite suited to mass production

Limitations

These include limitations on

1. Mechanical properties,
2. Porosity,
3. Poor dimensional accuracy
4. Surface finish for some casting processes,
5. Safety hazards to humans when processing hot molten metal's,
6. Environmental problems

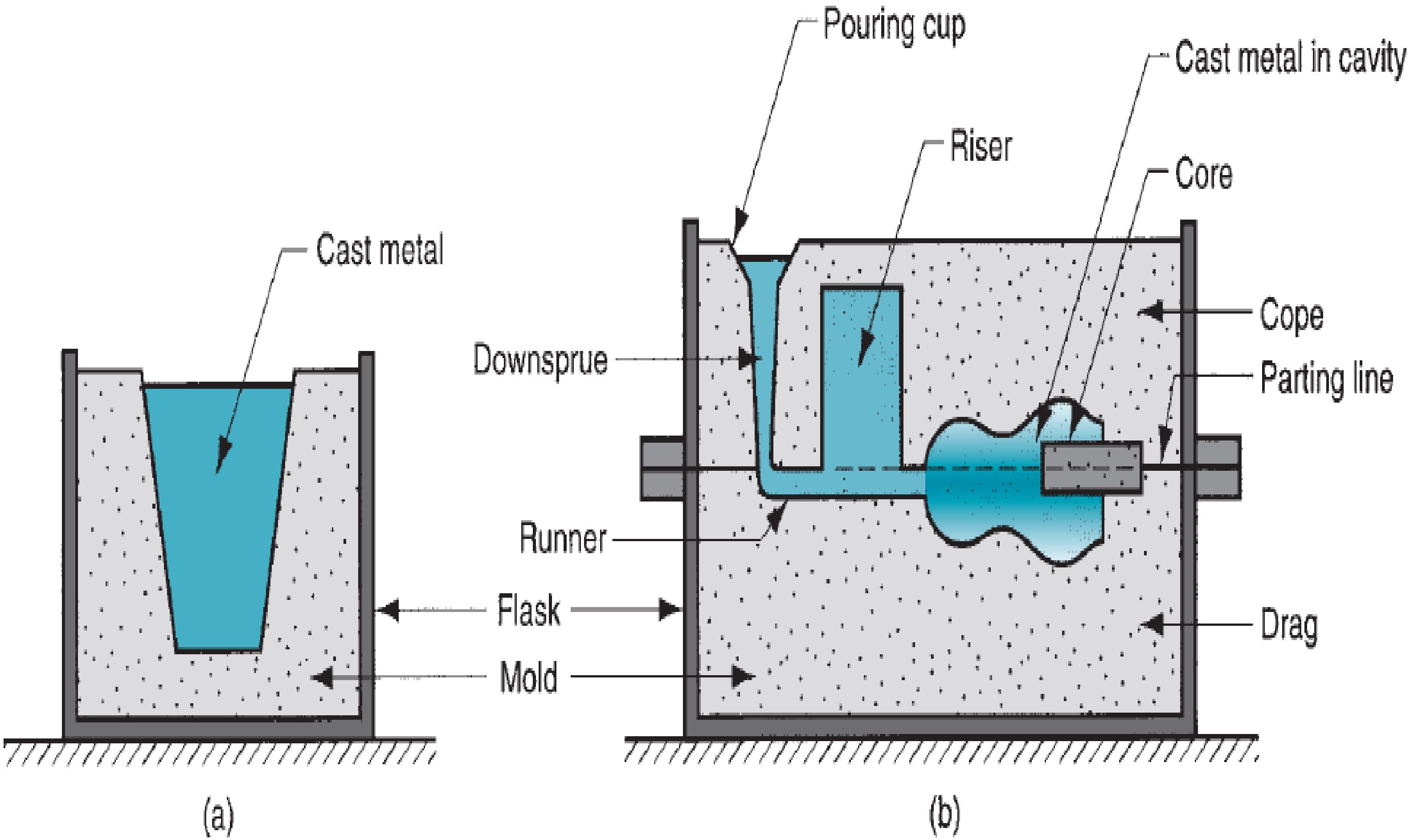
Metal Castings & Materials Engineering



Casting Terms

- As a production process, casting is usually carried out in a ***foundry***.
- ***Foundry*** is a factory equipped for making molds, melting and handling metal in molten form, performing the casting process, and cleaning the finished casting.
- The workers who perform the casting operations in these factories are called ***foundrymen***

The Mold



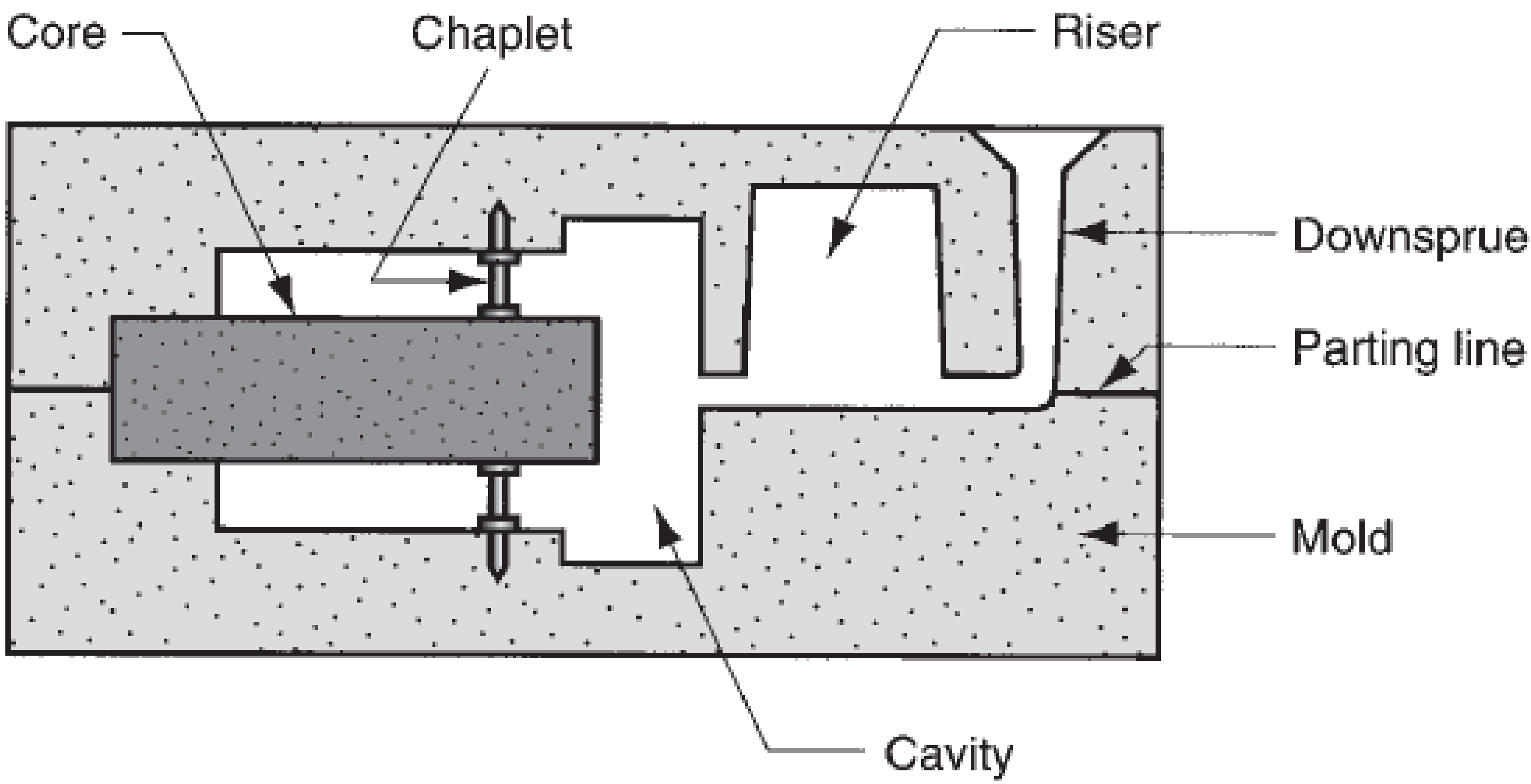
Cast metal
Pouring cup
Cast metal in cavity
Riser
Core
Downsprue
Cope
Parting line
Runner
Flask
Mold
Drag
(a)
(b)

Type of Mould

Casting processes divide into two broad categories, according to type of mold used:

1. *Expendable-mold casting*
2. *Permanent-mold casting. (2nd Course)*

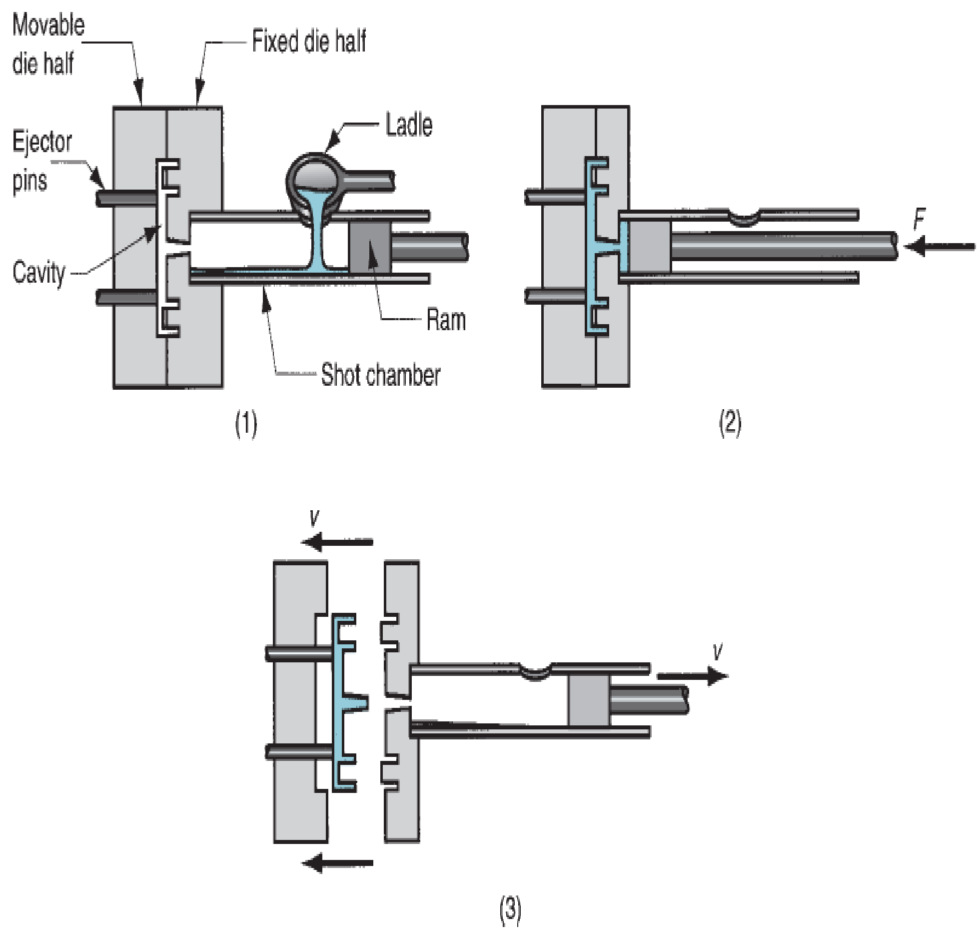
An expendable mold



(a)

Permanent Mold Casting

A permanent mold is one that can be used over and over to produce many castings. It is made of metal (or, less commonly, a ceramic refractory material) that can withstand the high temperatures of the casting operation.



Permanent Mold Casting

- The mold cavity and gating system are machined into the mold and thus become can integral part of it.
- To produce castings with internal cavities, cores made of metal or sand aggregate are placed in the mold prior to casting.
  Typical core materials are oil-bonded or resin-bonded sand, plaster, graphite,
- Gray iron, low-carbon steel, and hot-work die steel.
- Gray iron is used most commonly, particularly for large molds for aluminum and magnesium casting. Inserts also are used for various parts of the mold.

Permanent Mold Casting

- In order to increase the life of permanent molds, the surfaces of the mold cavity usually are coated with a refractory slurry (such as sodium silicate and clay) or sprayed with graphite every few castings. These coatings also serve as parting agents and as thermal barriers, thus controlling the rate of cooling of the casting.
- Mechanical ejectors (such as pins located in various parts of the mold) may be required for the removal of complex castings; ejectors usually leave small round impressions

Permanent Mold Casting

- The molds 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. Molten metal is then poured through the gating system.
- After solidification, the molds are opened and the casting is removed. The mold often incorporates special cooling features, such as a means of pumping cooling water through the channels located in the mold and the use of cooling fins.

Permanent Mold Casting

- Although the permanent-mold casting operation can be performed manually, it is often automated for large production runs.
- The process is used mostly for aluminum, magnesium, and copper alloys, as well as for gray iron, because of their generally lower melting points,
- although steels also can be cast using graphite or heat-resistant metal molds

Permanent Mold Casting

- Although equipment costs can be high because of high die costs, labor costs are kept low through automation. The process is not economical for small production runs and is not suitable for intricate shapes, because of the difficulty in removing the casting from the mold.
- However, easily collapsable sand cores can be used, which are then removed from castings, leaving intricate internal cavities. This process then is called semi-permanent-mold casting.

Advantages of Permanent Mold Casting

1. Near-net shapes can be produced that require
2. little finish machining.
3. The mold is reusable
4. good surface finish is obtained if the mold is in good condition.

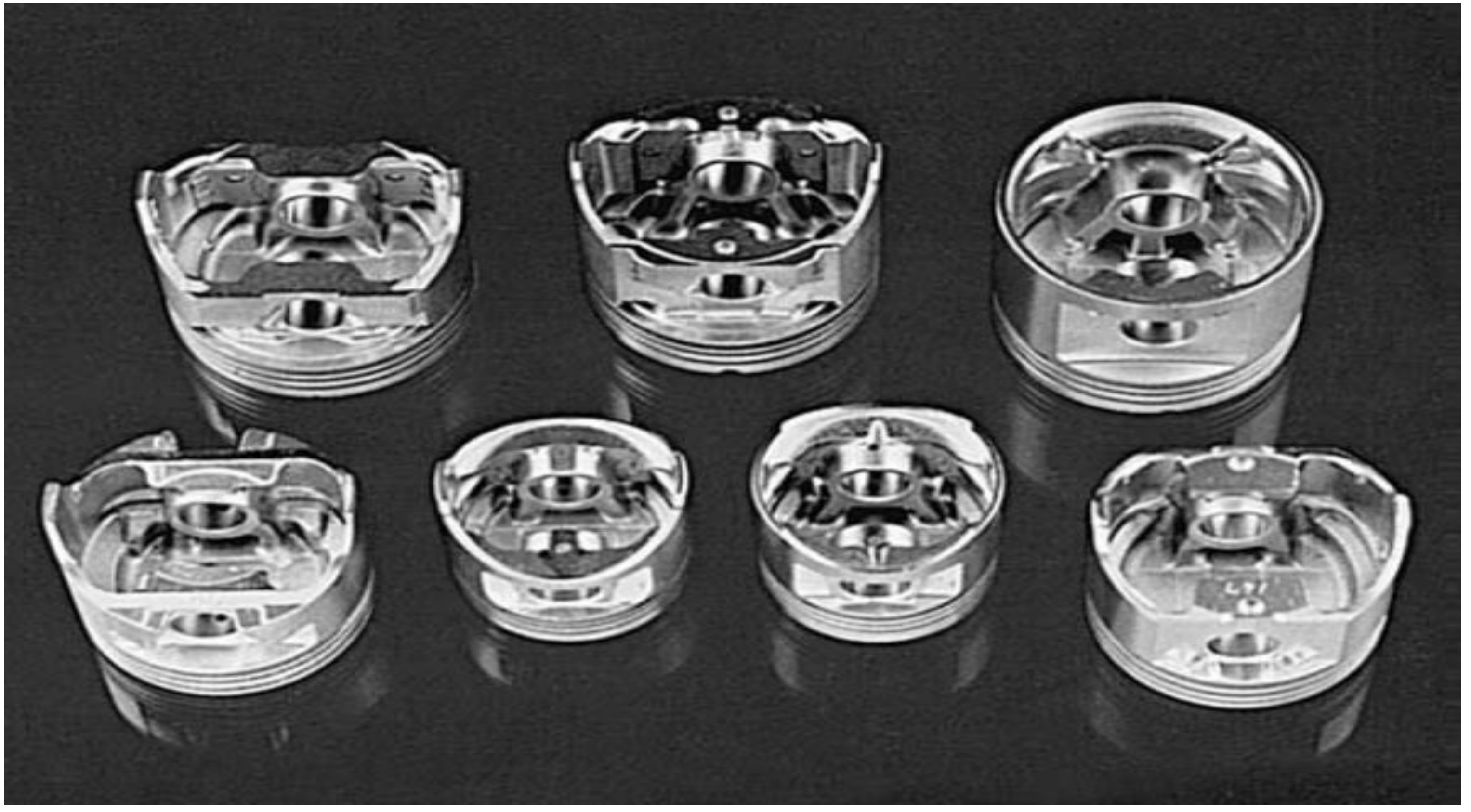
Permanent Mold Casting

5. Dimensions are consistent from part to part, and dimensional accuracy can often be held to within 0.25 mm (0.010 in.).
6. Directional solidification can be achieved through good design or can be promoted by selectively heating or chilling various portions of the mold or by varying the thickness of the mold wall.

Permanent Mold Casting

7. The result is usually a sound, defect-free casting with good mechanical properties.
8. The faster cooling rates of the metal mold produce a finer grain structure, reduced porosity, and higher-strength products than would result from reduced porosity, and higher-strength products than would result from Expandable Mold Casting

Disadvantage



Disadvantage

1. The process is generally limited to the lower-melting-point alloys,
2. High mold costs can make low production runs prohibitively expensive.
3. The useful life of a mold is generally set by molten metal erosion or thermal fatigue.
4. When making products of steel or cast iron, mold life can be extremely short. For the lower temperature metals, one can usually expect somewhere between 10,000 and 120,000 cycles.

Factors on Mold Life

1. ***Alloy being cast***. The higher the melting point, the shorter the mold life.
2. ***Mold material***. Gray cast iron has about the best resistance to thermal fatigue and machines easily. Thus it is used most frequently for permanent molds.
3. ***Pouring temperature***. Higher pouring temperatures reduce mold life, increase shrinkage problems, and induce longer cycle times.
4. ***Mold temperature***. If the temperature is too low, one can expect misruns and large temperature differences in the mold. If the temperature is too high, excessive cycle times result and mold erosion is aggravated.
5. ***Mold configuration***. Differences in section sizes of either the mold or the casting can produce temperature differences within the mold and reduce its life. The permanent molds contain the mold cavity, pouring basin, sprue, runners

Permanent Mold Casting

- ***Process:*** Mold cavities are machined into mating metal die blocks, which are then preheated and clamped together. Molten metal is then poured into the mold and enters the cavity by gravity flow. After solidification, the mold is opened and the casting is removed.
- ***Advantages:*** Good surface finish and dimensional accuracy; metal mold gives rapid cooling and fine-grain structure; multiple-use molds (up to 120,000 uses); metal cores or collapsible sand cores can be used.
- ***Limitations****:* High initial mold cost; shape, size, and complexity are limited; yield rate rarely exceeds 60%, but runners and risers can be directly recycled; mold life is very limited with high-melting-point metals such as steel.
- ***Common metals****:* Alloys of aluminum, magnesium, and copper are most frequently cast; irons and steels can be cast into graphite molds; alloys of lead, tin, and zinc are also cast.
- ***Size limits:*** 100 grams to 75 kilograms (several ounces to 150 pounds).

Permanent Mold Casting

- ***Thickness limits****:* Minimum depends on material but generally greater than 3 mm (in.); maximum thickness about 50 mm (2.0 in.).
- ***Geometric limits:*** The need to extract the part from a rigid mold may limit certain geometric features. Uniform section thickness is desirable.
- ***Typical tolerances:*** 0.4. mm for the first 2.5. cm (0.015 in. for the first inch) and 0.02 mm for each
- additional centimeter (0.002 in. for each additional inch); 0.25mm (0.01 in.) added if the dimension crosses a parting line.
- ***Draft allowance****:* 2°–3°.
- ***Surface finish****:* 2.5 to 7.5 μm (100–250 μin.) rms