

# Casting



## Training Objective

After watching the program and reviewing this printed material, the viewer will learn the essentials of the various metal casting processes used in industry today.

- The basic principles of casting are explained.
- The three primary casting methods are detailed.
- Mold and pattern construction is shown.
- Typical alloys cast and their finished characteristics are explained.

A cast product or casting is produced by the pouring of molten metal into a mold where it then solidifies into a geometric shape. In other instances, molten metal is injected into a die having a cavity in the desired shape of the part.

Casting is generally the quickest way to produce either a small amount of prototypes or very large production quantities. The casting process is used by almost every industry as all metals can be cast. Common mill forms such as bar and plate are produced from cast metal.

The hallmark of a casting is its uniform grain structure. In contrast to wrought metals with their directional grain structure, the cast structure is said to be “isotropic.” While cast material density is less than that of wrought metals, isostatic pressing can improve mechanical properties while surface porosity can be eliminated by sealing with either a resin or a metal coating.

Many casting processes use patterns that form the cavity of the mold and can be made of wood, plastic, or metal. Patterns which are expendable (consumed by the mold making process or by the poured metal during casting) are made of wax, plastic, or polystyrene foam. Patterns are oversized to make up for metal shrinkage as it solidifies. They will also have taper (draft) to ease pattern release and make allowance for finishing and metal transfer through the mold. Cores are also needed to create any recesses, undercuts, and hollows required in the part.

The three primary casting processes are:

- expendable mold/reusable pattern
- expendable mold/expendable pattern
- permanent mold/no pattern

The expendable mold/reusable pattern method includes the sand mold, plaster mold, and ceramic mold casting. Sand mold casting is the most common with virtually no limit to the size of casting that can be made. Though not very precise in dimension or detail, sand mold casting is the least expensive. Usually found as horizontally oriented halves, the upper part of the sand mold is called the “cope” and the lower half the “drag.” Sands for the molds are classified as green-sand molds, no-bake molds, and in-shell molds. Each produce castings of particular quality characteristics and detail and are also selected according to the metal being cast and finish requires. Also used are no-bake sand molds, metal-shell molds, plaster molds, and ceramic molds. Each is suitable in its own way for castings of a particular size, fineness of detail, and dimensional accuracy.

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The expendable mold/expendable pattern method includes investment casting and evaporative-foam casting. Investment casting is also known as the “lost-wax process” because the pattern material, wax, is consumed during the mold making process. Some plastics may also be substituted for the more commonly used wax.

Investment casting patterns are produced by injection molding. As the patterns are consumed, multiple patterns are assembled on a pattern “tree.” The subsequent shell mold is produced by dipping the pattern in a slurry mix several times with a drying period between dips. The wax pattern is then melted out, leaving the hollow mold. Both ferrous and non-ferrous metals can be investment cast. Such castings, usually less than 4-1/2 kilograms, exhibit close tolerances, thin cross sections, and smooth finishes.

Evaporative-foam casting refers to the use of expendable polystyrene foam patterns in molds of dry, unbonded sand. These patterns may be for a single part or if for a complex shape, an assembly of patterns is used. Patterns may also be clustered to produce multiple parts in a single pouring. The advantage of the foam method includes elimination of the cope and drag, cores are not needed, light weight patterns, no parting lines, and very smooth finishes. Many different metals can also be cast.

Permanent mold/no pattern casting is initially very expensive in producing the mold, but such molds, machined out of metal or graphite, can be reused thousands of times. Three variations of this method include:

- permanent-mold casting
- die casting
- centrifugal casting

The permanent mold method, because of the chilling effects of the molds, produces parts of superior mechanical properties, close tolerances, and smooth finishes. The method is well suited for casting the non-ferrous materials. The molds are usually pre-heated to help metal flow and casting may be done horizontally as well as vertically. After pouring, the casting is cooled by auxiliary cooling systems as well as the mass of the mold itself. Cores may be of metal, sand, or plaster. The internal mold surfaces are also insulated and/or lubricated with various coatings.

Die casting is a high production method for thin wall, precision, and usually smaller parts of non-ferrous metals. Typically the molten metal is injected under high pressure into usually horizontal die assemblies. The injection can produce either a single part or multiple parts, in which case the injected charge is called a “shot.” The two principle types of die casting machines are the “hot chamber” and the “cold chamber.” Hot chambers are used mainly for zinc and other low melting temperature metals. The cold chamber machines are used for the higher melting magnesium, and copper. As a final operation, and upon release from the mold, the ejected part goes through a trimming operation.

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Centrifugal casting produces very dense parts and is used for all metal types. The casting solidifies in rapidly rotating permanent or expendable molds. There are both “true centrifugal casting” and “semi-centrifugal casting.” True centrifugal casting is used to produce large-diameter tubes, bi-metal tube, and rolls of virtually any thickness and length. The outside diameter is controlled by the mold and the inside diameter by the amount of metal poured into the mold. In the “semi” variation the mold surrounds the casting and controls the shape being cast. These molds usually rotate horizontally while the “true” method can operate vertically as well.

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## Review Questions

1. A characteristic of a casting is its:
  - a. density
  - b. porosity
  - c. uniform grain structure
  - d. irregular grain structure
  
2. The mechanical properties of a casting is improved by:
  - a. sealing with resin
  - b. isostatic pressing
  - c. forging
  - d. sintering
  
3. The least expensive method of expendable mold/reusable pattern casting uses the:
  - a. ceramic mold
  - b. sand mold
  - c. plaster mold
  - d. foam mold
  
4. The alternate name for the “lost wax” casting process is:
  - a. evaporative casting
  - b. permanent mold casting
  - c. investment casting
  - d. die casting
  
5. Evaporative foam casting is used to cast:
  - a. aluminum only
  - b. aluminum and magnesium
  - c. copper alloys
  - d. a variety of ferrous and nonferrous alloys
  
6. The foam method also eliminates the need for:
  - a. post-chilling
  - b. post-machining
  - c. copes and drags
  - d. part surface sealing
  
7. Permanent mold casting requires cores that are made of:
  - a. plaster
  - b. metal
  - c. sand
  - d. all of the above
  
8. Die casting is used mainly to produce:
  - a. larger ferrous metal parts
  - b. smaller ferrous metal parts
  - c. smaller non-ferrous metal parts
  - d. copper and brass parts

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## Answer Key

1. c
2. b
3. b
4. c
5. d
6. c
7. d
8. c