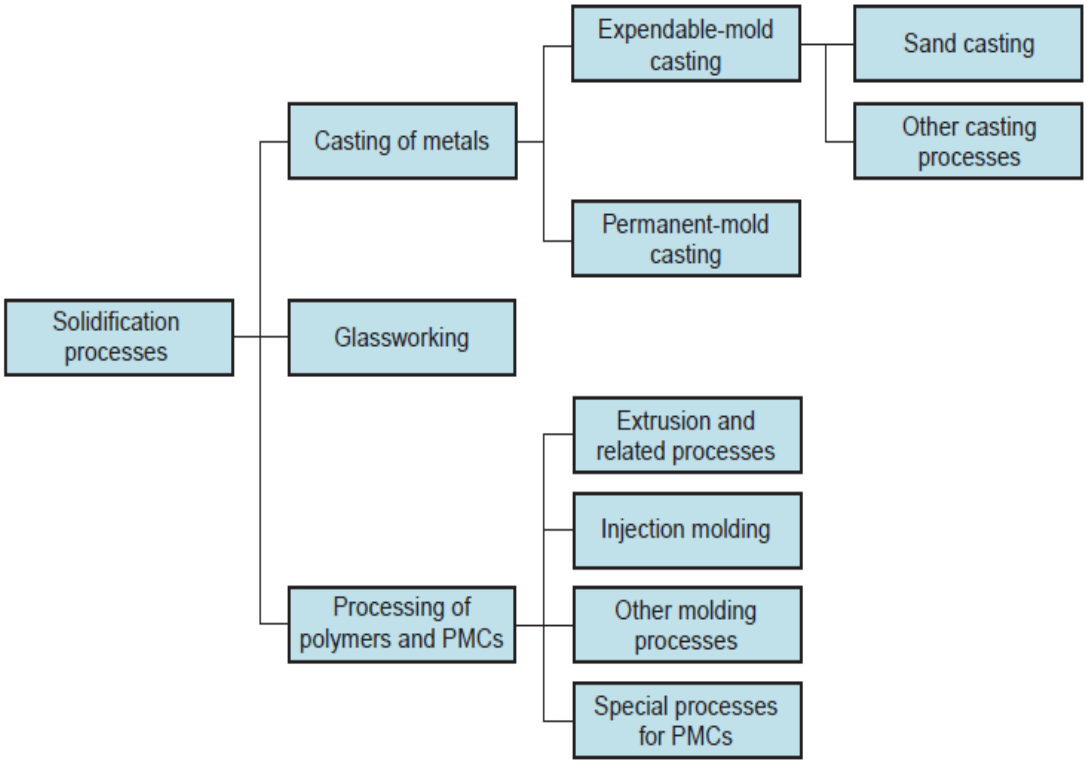
Overview of Casting Technology

Introduction

Manufacturing processes inwhich the startingworkmaterial is either a liquid or is in a highly plastic condition, and a part is created through solidification of the material. Casting and molding processes dominate this category of shaping operations.With reference to Figure 10.1, the solidification processes can be classified according to the engineering material that is processed: (1) metals , (2) ceramics, specifically glasses (3) polymers and polymer matrix composites (PMCs).



Classification of solidification processes

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 .

The principle of casting seems simple: melt the metal, pour it into a mold, and let it cool and solidify; yet there are many factors and variables that must be considered in order to accomplish a successful casting operation.

Casting includes both the casting of ingots and the casting of shapes. 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.
involves the production of more complex geometries that are much closer to the final desired shape of the part or product. It is with the casting of shapes rather than ingots that we are concerned.
A variety of shape casting methods are available, thus making it one of the most versatile of all manufacturing processes. Among its capabilities and advantages are the following:

- Casting can be used to create complex part geometries, including both external and internal shapes.
- 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.
- 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.
- Casting can be used to produce very large parts. Castings weighing more than 100 tons have been made.
- The casting process can be performed on any metal that can be heated to the liquid state.
- Some casting methods are quite suited to mass production.

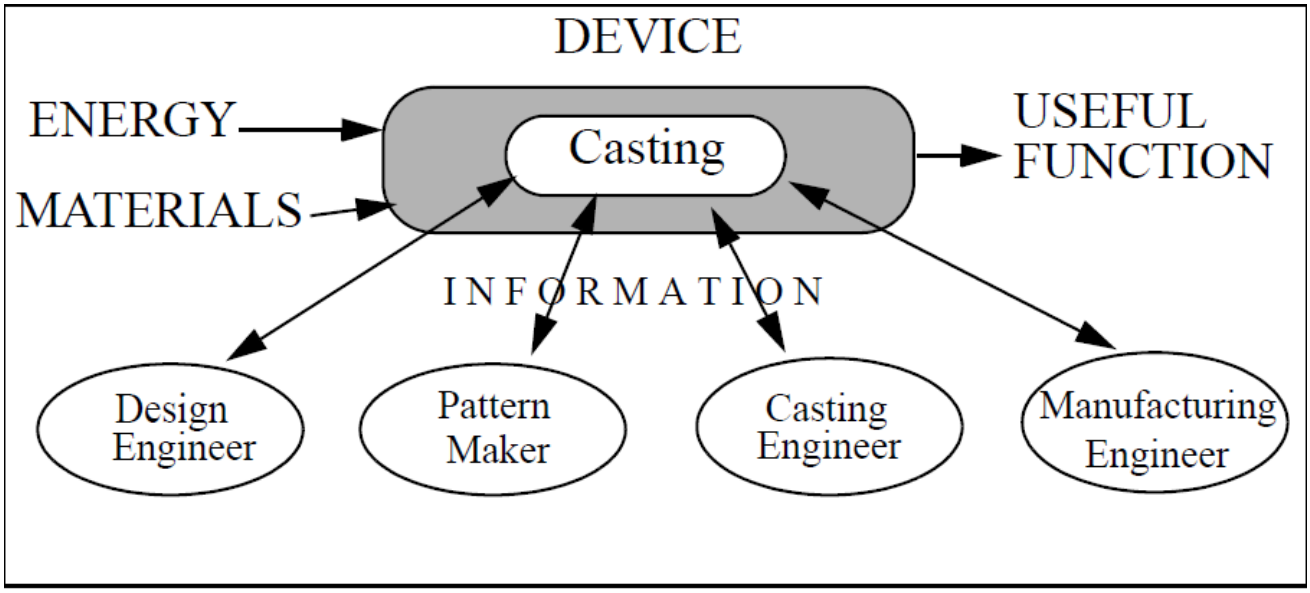
There are also disadvantages associated with casting different disadvantages for different casting methods. These include limitations on mechanical properties, porosity, poor dimensional accuracy and surface finish for some casting processes, safety hazards to humans when processing hot molten metal's, and environmental problems. Parts made by casting processes range in size from small components weighing only a few ounces up to very large products weighing tons. The list of parts includes dental crowns, jewelry, statues, wood-burning stoves, engine blocks and heads for automotive vehicles, machine frames, railway wheels, frying pans, pipes, and pump housings.
All varieties of metals can be cast, ferrous and nonferrous.
Casting can also be used on other materials such as polymers and ceramics; however, the details are sufficiently different that we postpone discussion of the casting processes for these materials until later chapters. This chapter and the next deal exclusively with metal casting. Here we discuss the fundamentals that apply to virtually all casting operations..

Metal Castings & Materials Engineering

Metal castings form integral components of devices that perform useful functions for human beings, an idea shown schematically below:
The cast component has a shape, size, chemical composition and metallurgical microstructure which is determined by engineering decisions arrived at by:

- *Design Engineers (Mechanical Engineers)*
- *Pattern Makers (Skilled craftsman, CAD)*
- *Casting Engineers (Metallurgical Engineers)*
- *Manufacturing Engineers (Mechanical, Metallurgical Engineers)*

The engineering professionals that carry out this process work together, sharing information so that the casting will perform as intended in a timely and cost effective manner.
It should be noted that the casting may only be a small part of the useful device (usually in more sophisticated devices like an automobile where there may be hundreds of components), or it may be the entire device (simple device like a frying pan).



OVERVIEW OF CASTING TECHNOLOGY

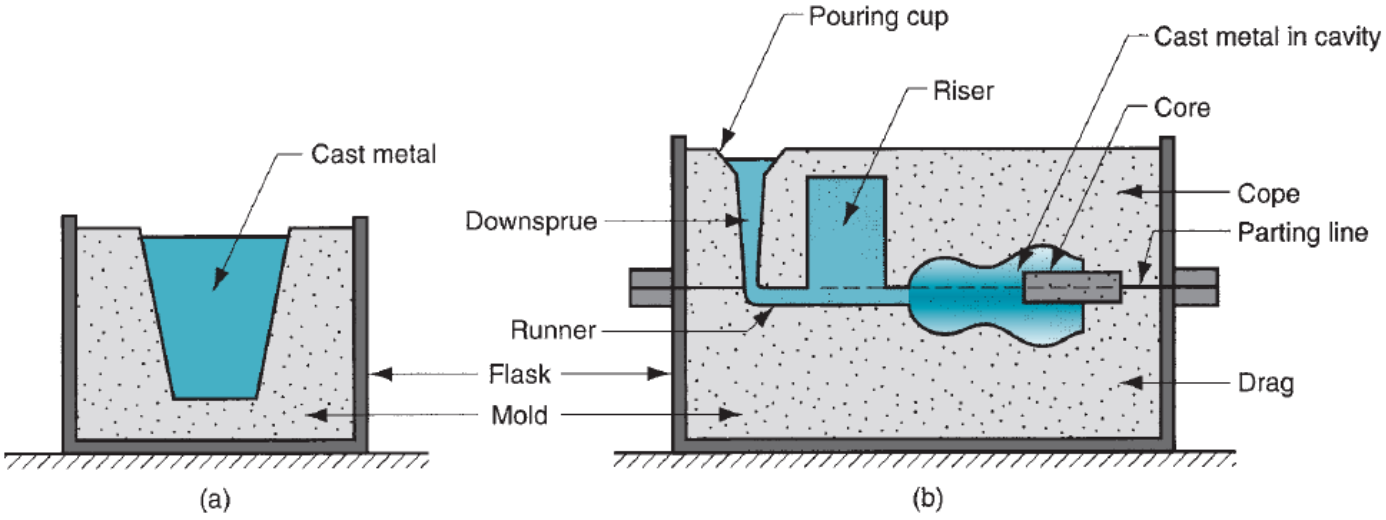
As a production process, casting is usually carried out in a ***foundry***. A foundry is a factory equipped for making molds, melting and handling metal in molten form, performing the casting process, and cleaning the finished casting. The workers who perform the casting operations in these factories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

Discussion of casting logically begins with the mold. The ***mold*** contains a cavity whose geometry determines the shape of the cast part. The actual size and shape of the cavity must be slightly oversized to allow for shrinkage that occurs in the metal during solidification and cooling. Different metals undergo different amounts of shrinkage, so the mold cavity must be designed for the particular metal to be cast if dimensional accuracy is critical.

Molds are made of a variety of materials, including sand, plaster, ceramic, and metal. The various casting processes are often classified according to these different types of molds.

To accomplish a casting operation, the metal is first heated to a temperature high enough to completely transform it into a liquid state. It is then poured, or otherwise directed, into the cavity of the mold.

In an ***open mold***, Figure 1(a), the liquid metal is simply poured until it fills the open cavity. In a ***closed mold***, Figure 1(b), a passageway, called the gating system, is provided to permit the molten metal to flow from outside the mold into the cavity.



The closed mold is by far the more important category in production casting operations. As soon as the molten metal is in the mold, it begins to cool. When the temperature drops sufficiently (e.g., to the freezing point for a pure metal), solidification begins. Solidification involves a change of phase of the metal.

Time is required to complete the phase change, and considerable heat is given up in the process. It is during this step in the process that the

metal assumes the solid shape of the mold cavity and many of the properties and characteristics of the casting are established.
Once the casting has cooled sufficiently, it is removed from the mold. Depending on the casting method and metal used, further processing may be required. This may include trimming the excess metal from the actual cast part, cleaning the surface, inspecting the product, and heat treatment to enhance properties. In addition, machining may e required to achieve closer tolerances on certain part features and to remove the cast surface.
Casting processes divide into two broad categories, according to type of mold used:

A. *expendable-mold casting*
B. *permanent-mold casting.*

An expendable mold means that the mold in which the molten metal solidifies must be destroyed in order to remove the casting. These molds are made out of sand, plaster, or similar materials, whose form is maintained by using binders of various kinds. Sand casting is the most prominent example
of the expendable-mold processes. In sand casting, the liquid metal is poured into a mold made of sand. After the metal hardens, the mold must be sacrificed in order to recover the 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. In permanent-mold casting, the mold consists
of two (or more) sections that can be opened to permit removal of the finished part. Die casting is the most familiar process in this group.
More intricate casting geometries are generally possible with the expendable-mold processes. Part shapes in the permanent-mold processes are limited by the need to open the mold. On the other hand, some of the permanent mold processes have certain economic advantages in high production operations.