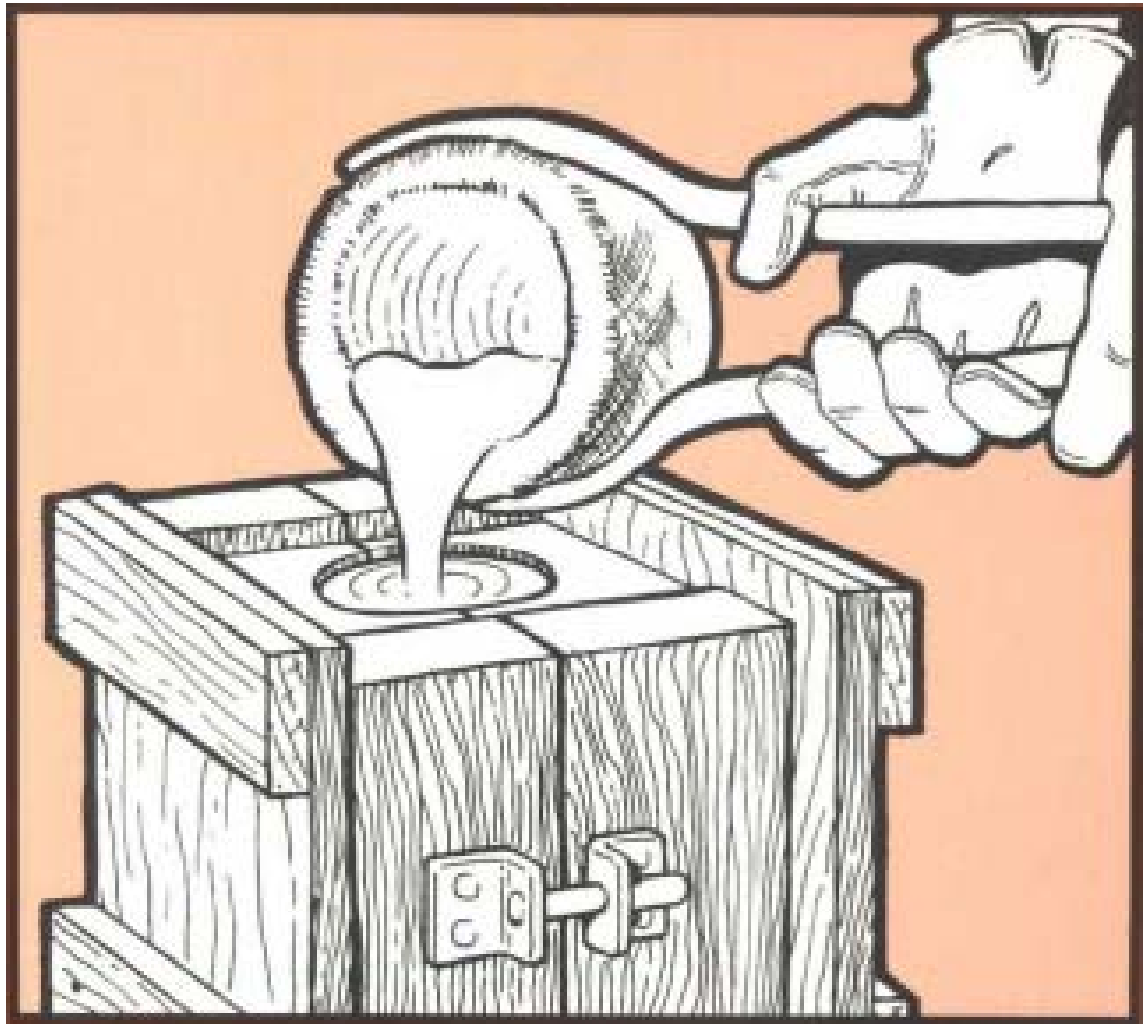
Introduction to
Metal and Sand Casting



Fundamentals of Casting

- Casting, one of the oldest manufacturing processes, dates back to 4000 B.C. when copper arrowheads were made.
- Casting processes basically involve the introduction of a molten metal into a mold cavity, where upon solidification, the metal takes on the shape of the mold cavity.
- Simple and complicated shapes can be made from any metal that can be melted.
- Casting sizes range form few mm (teeth of a zipper) to 10 m (Ship propellers).

The Casting Industry

- 6.5 million kg of castings are produced every year
- The most common materials cast are gray iron, ductile iron, aluminum alloys, and copper alloys
- 35% of the market is in automotive and light truck manufacturing
- Castings are used in applications ranging from agriculture to railroad equipment, automobiles and aircrafts components, and heating and cooling equipments.

Capabilities and Advantages of Casting

1. Can create complex part geometries
2. Can create both external and internal shapes
3. Some casting processes are *net shape;* others are *near net shape*
4. Cast material is isotropic. It has the same physical and mechanical properties along any direction.
5. It is economical, with very little wastage: the extra metal in each casting is re-melted and re-used
6. Can produce a wide variety of sized parts:
   - Large parts: engine blocks, cylinder heads, railway wheels, pipes……etc.
   - Small parts: dental crowns, jewelry, gears, brake components.

Limitations of Casting

1. Limitations on mechanical properties
2. Poor dimensional accuracy and surface finish for some processes (sand casting)
3. Safety hazards to workers due to hot molten metals
4. Porosity (empty spaces within the metal - reduces the strength of metal)

TABLE 5.2

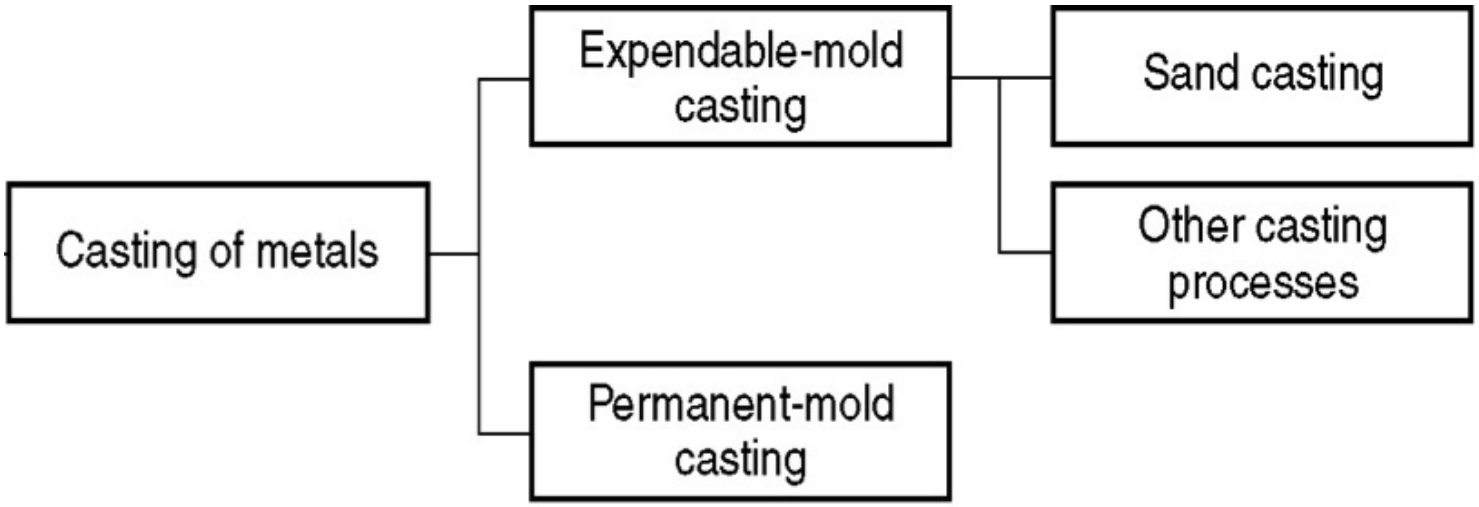
TYPICAL APPLICATIONS FOR CASTINGS AND CASTING CHARACTERISTICS

TYPE OF ALLOY	APPLICATION	CAST-ABILITY*	WELD-ABILITY*	MACHIN-ABILITY*
Aluminum	Pistons, clutch housings, intake manifolds, engine blocks, heads, cross members, valve bodies, oil pans, suspension components	G–E	F	G–E
Copper	Pumps, valves, gear blanks, marine propellers	F–G	F	G–E
Gray iron	Engine blocks, gears, brake disks and drums, machine bases	E	D	G
Magnesium	Crankcase, transmission housings	G–E	G	E
Malleable iron	Farm and construction machinery, heavy-duty bearings, railroad rolling stock	G	D	G
Nickel	Gas turbine blades, pump and valve components for chemical plants	F	F	F
Nodular iron	Crankshafts, heavy-duty gears	G	D	G
Steel (carbon and low alloy)	Die blocks, heavy-duty gear blanks, aircraft undercarriage members, railroad wheels	F	E	F–G
Steel (high alloy)	Gas turbine housings, pump and valve components, rock crusher jaws	F	E	F
White iron (Fe_3C)	Mill liners, shot blasting nozzles, railroad brake shoes, crushers and pulverizers	G	VP	VP
Zinc	Door handles, radiator grills, carburetor bodies	E	D	E

*E, excellent; G, good; F, fair; VP, very poor; D, difficult.

Two Categories of Casting Processes

1. **Expendable mold processes:** uses a mold which is **destroyed** to remove casting:
   - ❖ **Mold materials: sand, plaster, and similar materials, plus binders**
     - ➢ **Advantage**: more complex shapes possible
     - ➢ **Disadvantage:** production rates often limited by time to make mold rather than casting itself
2. **Permanent mold processes:** uses a mold which can be used over and over:
   - ❖ **Made of metal (or ceramic refractory material)**
     - ➢ **Advantage: higher** production rates
     - ➢ **Disadvantage:** geometries limited by need to open the mold



Product Design Considerations

1. Geometric simplicity - Avoid unnecessary complexity.
2. Corners - Avoid sharp corners (preferred fillet radius).
3. Section thickness - Uniform section thickness to avoid shrinkage cavities and hot spots.
4. Inclination allowance (draft) - Facilitate removal of parts from mold in permanent casting, and for easy drag the pattern from the sand mold.
5. Use of cores - minimize the use of core
6. Dimensional tolerance and surface finish - proper choice of casting method.
7. Machining allowance - For assembly purposes, typically 1.5 to 6 mm.
8. Shrinkage allowance – For to compensating the shrinkage of the part.

Sand Casting

Casting Processes

1. Preparing a mold cavity of the desired shape with proper allowances (inclination, shrinkage, and machining).
2. Melting the metal with acceptable quality and temp.
3. Pouring the metal into the cavity and providing means for the escape of air or gases.
4. Solidification process, must be properly designed and controlled to avoid defects.
5. Mold removal.
6. Finishing, cleaning and inspection operations.
7. Heat treatment of casting is sometimes required to improve metallurgical properties