1 METAL CASTING

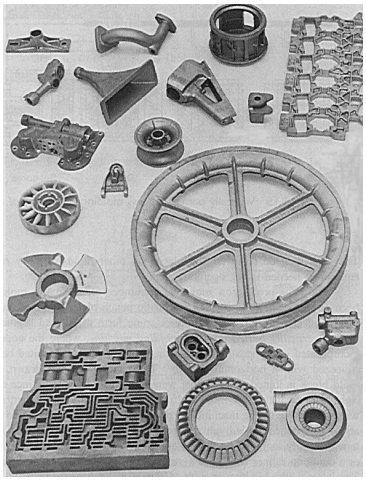
CHAPTER CONTENTS

1.1 OVERVIEW OF CASTING TECHNOLOGY

Definitions

Casting is a process in which molten metal flows into a mold where it solidifies in the shape of the mold cavity. The part produced is also called *casting*.

Advantages	Complex shapes Net-shape ability Very large parts Variety of metals Mass production
Disadvantages	Poor accuracy Poor surface Internal defects Mechanical properties Environmental impact



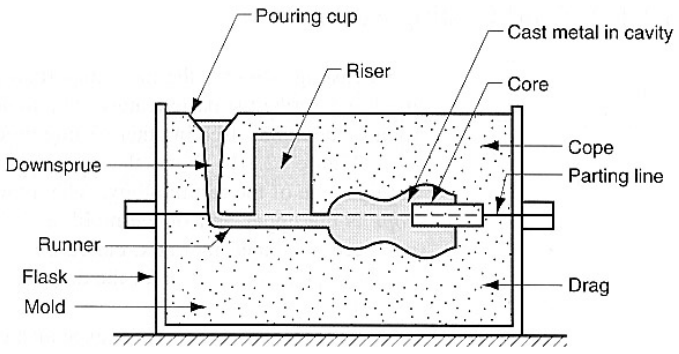
Selection of castings of various materials, shapes, and sizes

Casting technology involves the next steps:

Mold preparation → Metal heating → Pouring → Cooling → Processing

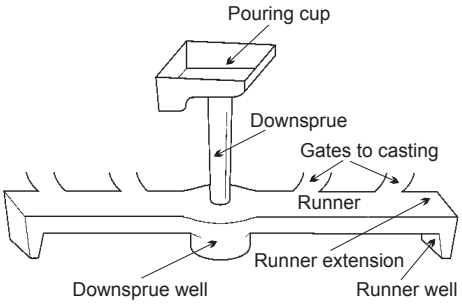
Casting nomenclature

The figure in the right shows the nomenclature of mold and castings in sand casting.



Casting nomenclature

The pouring cup, downsprue, runners, etc., are known as the *mold gating system*, which serves to deliver the molten metal to all sections of the mold cavity.



Gating system in sand casting

Heating and pouring

Heating

The total heat required is estimated as the sum of

1. Heat to raise the temperature to the melting point
2. Heat of fusion
3. Heat to raise the molten metal temperature to the temperature of pouring

Pouring

Major factors affecting the pouring action

1. Pouring temperature
2. Pouring rate
3. Turbulence

Some important equations in pouring:

Velocity of the liquid metal at the base of the sprue:

$$v = \sqrt{2gh}$$

Gravitational acceleration constant, *Sprue height*

Volumetric flow rate:

$$Q = vA$$

Casting's cross-sectional area

Mold filling time:

$$MFT = V/Q$$

Mold cavity volume

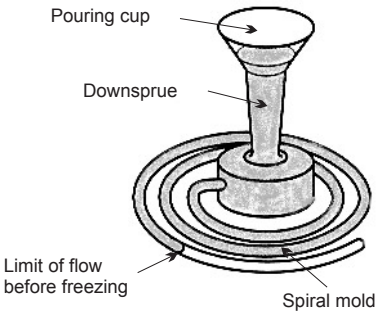
Fluidity

Fluidity is a measure of the capability of a metal to flow into and to fill the mold before freezing. It defines to the great extend the quality of casting.

Factors affecting fluidity:

1. Pouring temperature
2. Metal composition
3. Heat transfer to the surroundings
4. Viscosity of the liquid metal

Standard testing method

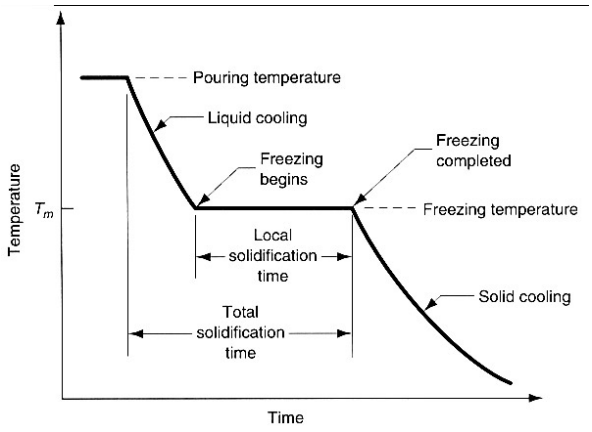


In the foundry practice, test for fluidity is carried out for each ladle just before pouring the molten metal into the mold

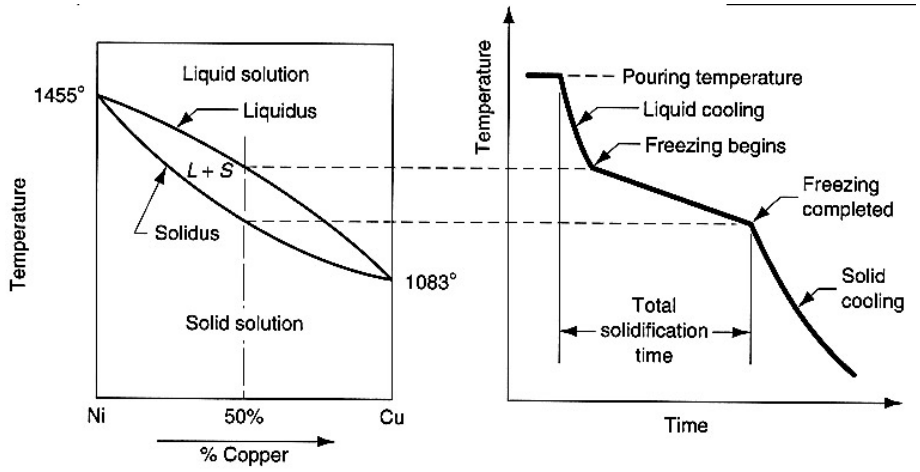
Solidification and cooling

Solidification of metals

Pure metals solidify at a constant temperature equal to their freezing point



Most *alloys* freeze over a temperature range



Solidification time

Chvorinov's rule

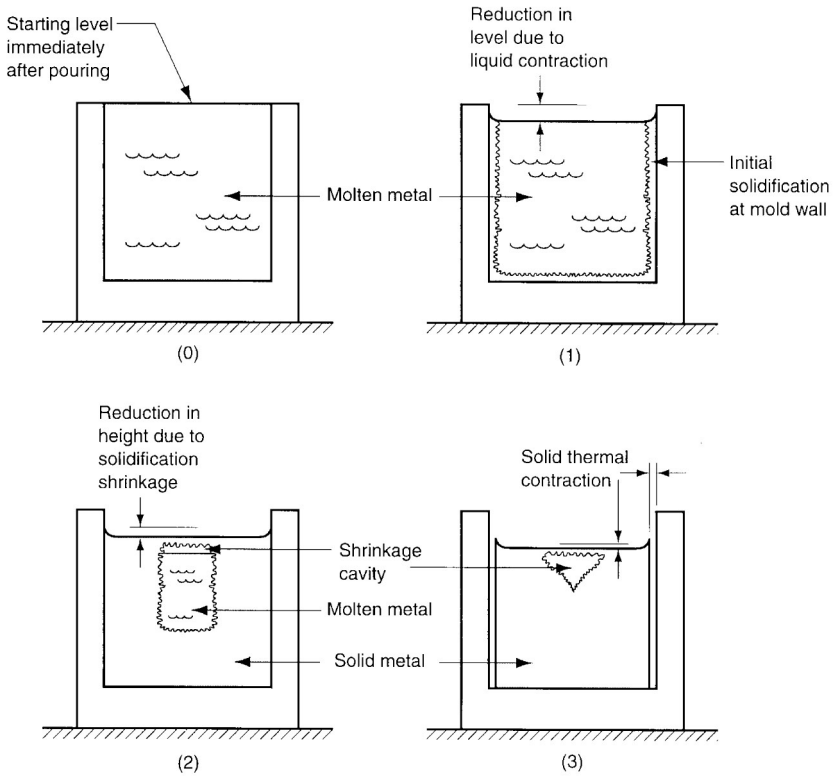
$$TST = C_m\left(\frac{V}{A}\right)^n$$

TST—total solidification time
C_m—mold constant
V—volume of the casting
A—surface area of the casting
n—constant, usually n=2

Example:
Calculate the total solidification time for a 10/100/200-mm steel plate if C_m = 0.2 min/mm^2
Solution:

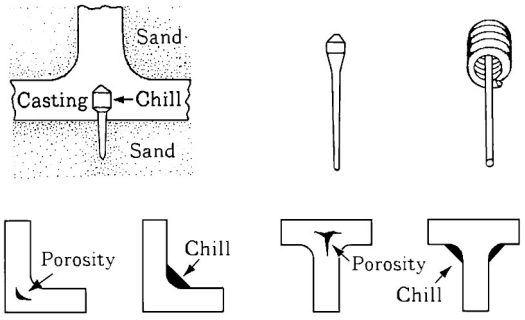
Shrinkage

Shrinkage of a cylindrical casting during solidification and cooling: (0) starting level of molten metal immediately after pouring; (1) reduction in level caused by liquid contraction during cooling; (2) reduction in height and formation of shrinkage cavity caused by solidification shrinkage; and (3) further reduction in height and diameter due to thermal contraction during cooling of the solid metal. Dimensional reductions are exaggerated for clarity in our sketches.



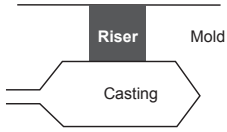
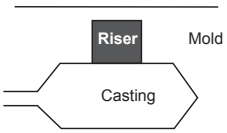
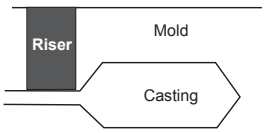
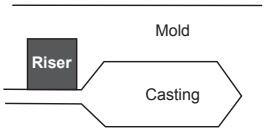
Directional solidification

1. By a proper design of the casting
2. By external and internal chills



Riser design

Several riser designs are used in practice as shown in the figure.
The riser must remain molten until after the casting solidifies.
The *Chvorinov's Rule* is used to calculate the riser's dimensions.

Riser design	Open	Blind
Top		
Side		

Possible types and positions for risers in sand casting