Manufacturing Processes– UTA026

Casting - Pouring and Solidifications

Thapar Institute of Engineering & Technology
(Deemed to be University)
Bhadson Road, Patiala, Punjab, Pin-147004
Contact No. : +91-175-2393201
Email : info@thapar.edu

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Pouring the Metal

- After heating, the metal is ready for pouring.
- For this step to be successful, metal must flow into all regions of the mold, most importantly the main cavity, before solidifying.
- Factors affecting the pouring operation include
  - ***a) Pouring temperature***
  - ***b) Pouring rate***
  - ***c) Turbulence***

Pouring temperature

- The ***pouring temperature*** is the temperature of the molten metal as it is introduced into the mold.
- What is ***important*** here is the ***difference*** between the temperature at pouring and the temperature at which freezing begins (Melting point).
- This temperature difference is sometimes referred to as the ***superheat***.
- This term is also used for the ***amount of heat*** that ***must be removed*** from the molten metal between pouring and when solidification commences

Pouring Rate

- Pouring rate refers to the ***volumetric rate*** at which the molten metal is poured into the mold.
- If the rate is ***too slow***, the metal will chill and freeze before filling the cavity.
- If the pouring rate is ***excessive***, turbulence can become a serious problem.

Turbulence

- ***Turbulence*** in fluid flow is characterized by erratic variations in the magnitude and direction of the velocity throughout the fluid.
- The flow is agitated and irregular rather than smooth and streamlined, as in laminar flow.
- Turbulent flow ***should be avoided*** during pouring for several reasons.

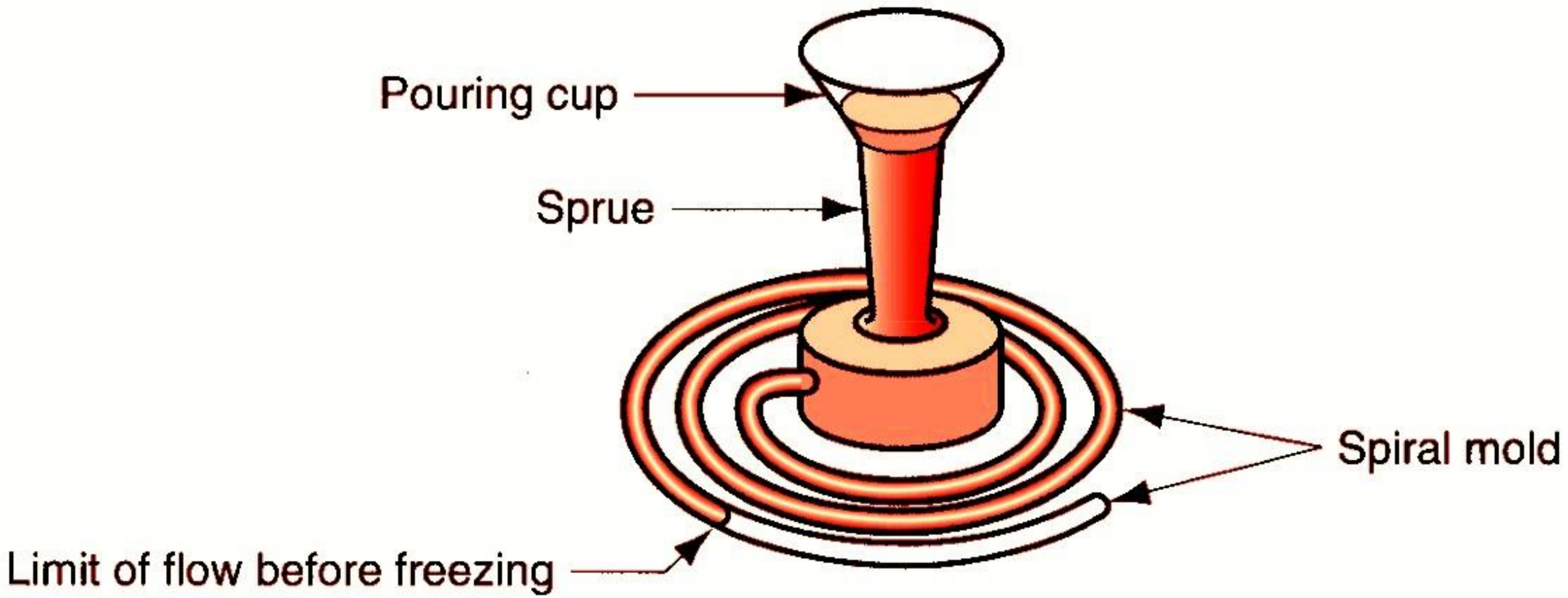
Turbulence

- It tends to accelerate the ***formation of metal oxides*** that can become entrapped during solidification, thus degrading the quality of the casting.
- Turbulent flow tends to promote ***absorption of gases***.
- Turbulence also aggravates ***mold erosion***, the gradual wearing away of the mold surfaces due to impact of the flowing molten metal.

Fluidity

- The molten metal flow characteristics are often described by the term fluidity, a measure of the capability of a metal to flow into and fill the mold before freezing.
- Fluidity is the inverse of viscosity; as viscosity increases, fluidity decreases.
- Standard testing methods are available to assess fluidity, including the spiral mold test shown in Figure .

Fluidity



- Fluidity is indicated by the length of the solidified metal in the spiral channel
- A longer cast spiral means greater fluidity of the molten metal

Solidification of Metals

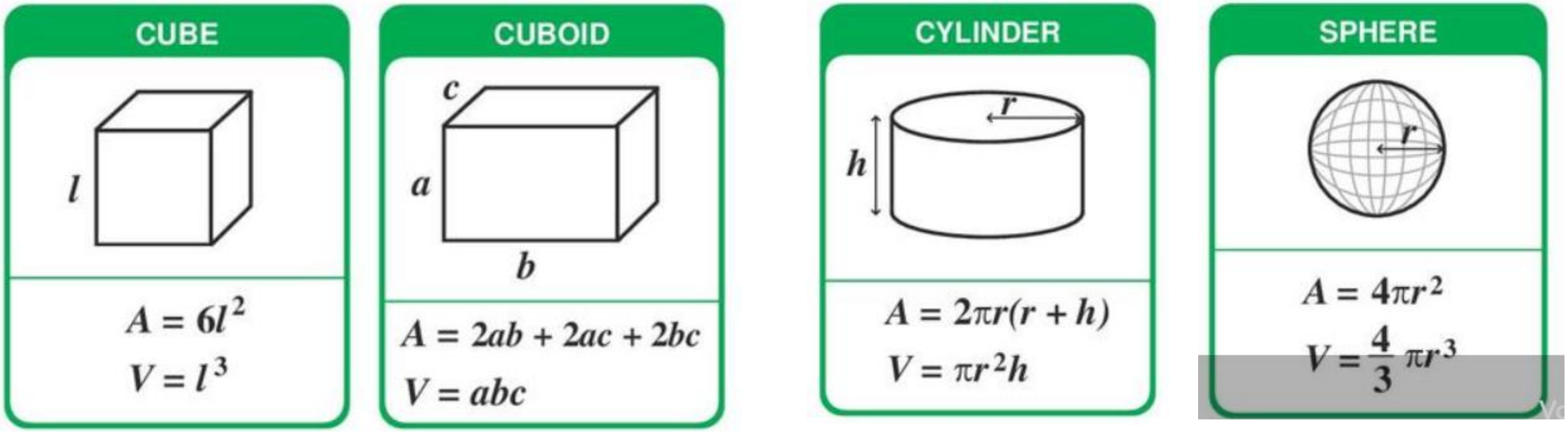
- Transformation of molten metal into solid state
- Solidification differs depending on whether the metal is
  - A pure element or
  - An alloy
- The total solidification time is the time required for the casting to solidify after pouring.
- This time is dependent on the size and shape of the casting by an empirical relationship known as Chvorinov's rule, which states: the formulae…next page

Solidification of Metals

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

- T_{TS} = total solidification time, minutes
- V = volume of the casting, cm^3
- A = surface area of the casting, cm^2
- *n* = an exponent usually taken to *n*=2
- C_m = the ***mold constant***

Solidification of Metals



shape	a	b	c	L	Surface area	volume	V/A
cube	2	2	2	2	24	8	0.33
Cuboid	1	2	3		22	6	0.27
Cylinder	R=1	h=2			18.84	6.28	0.33
Sphere	R=1				12.56	4.18	0.33

Keeping volume of shapes constant : Surface area would be different
Or vice-versa.........Calculate on your own for variations.......

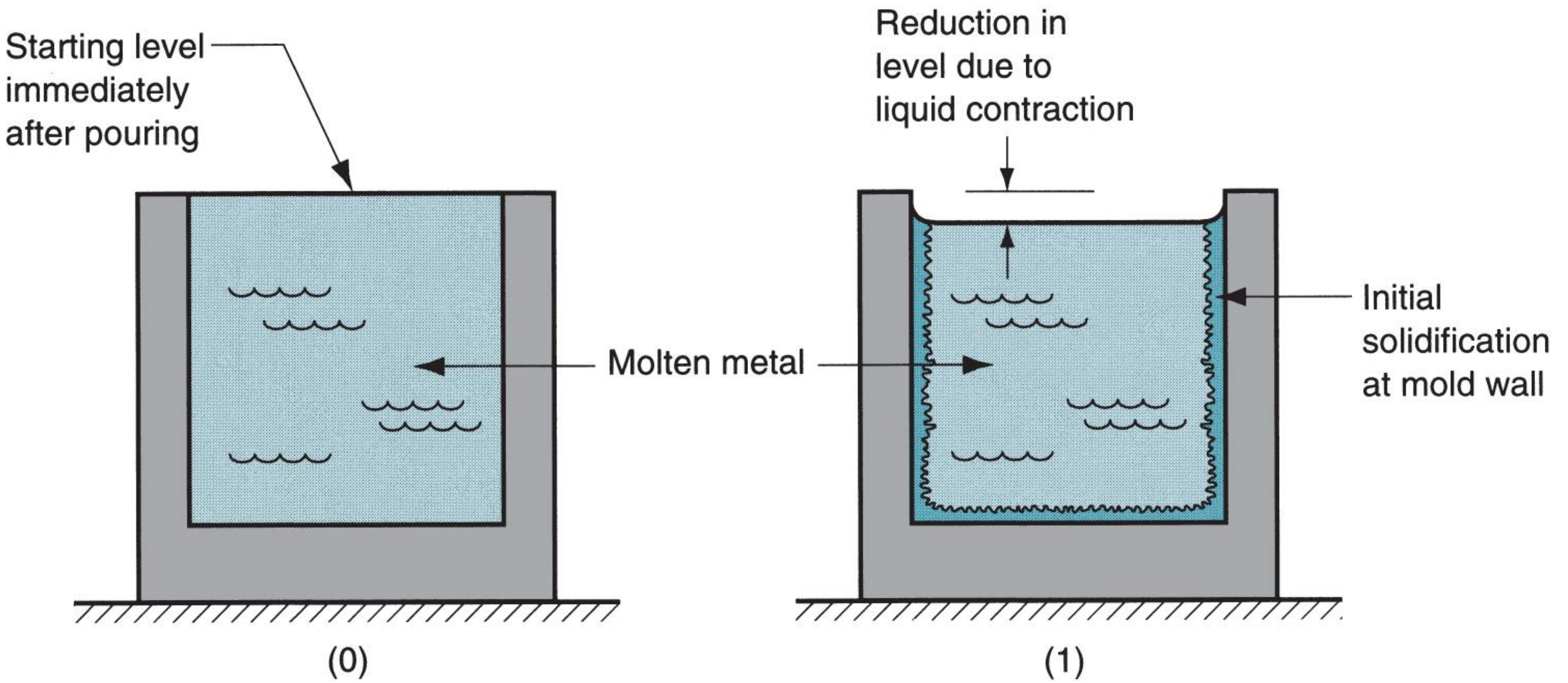
Solidification of Metals

- A casting with a higher ***volume-to-surface area*** ratio cools and solidifies more slowly than one with a lower ratio
- To feed molten metal to main cavity, **Total Solidification Time (TST)** for riser must greater than **TST** for main casting
- **Riser** must be designed to have a **larger volume-to-area ratio** so that the main casting solidifies first
- This **minimizes** the effects of shrinkage

Shrinkage in solidification and Cooling

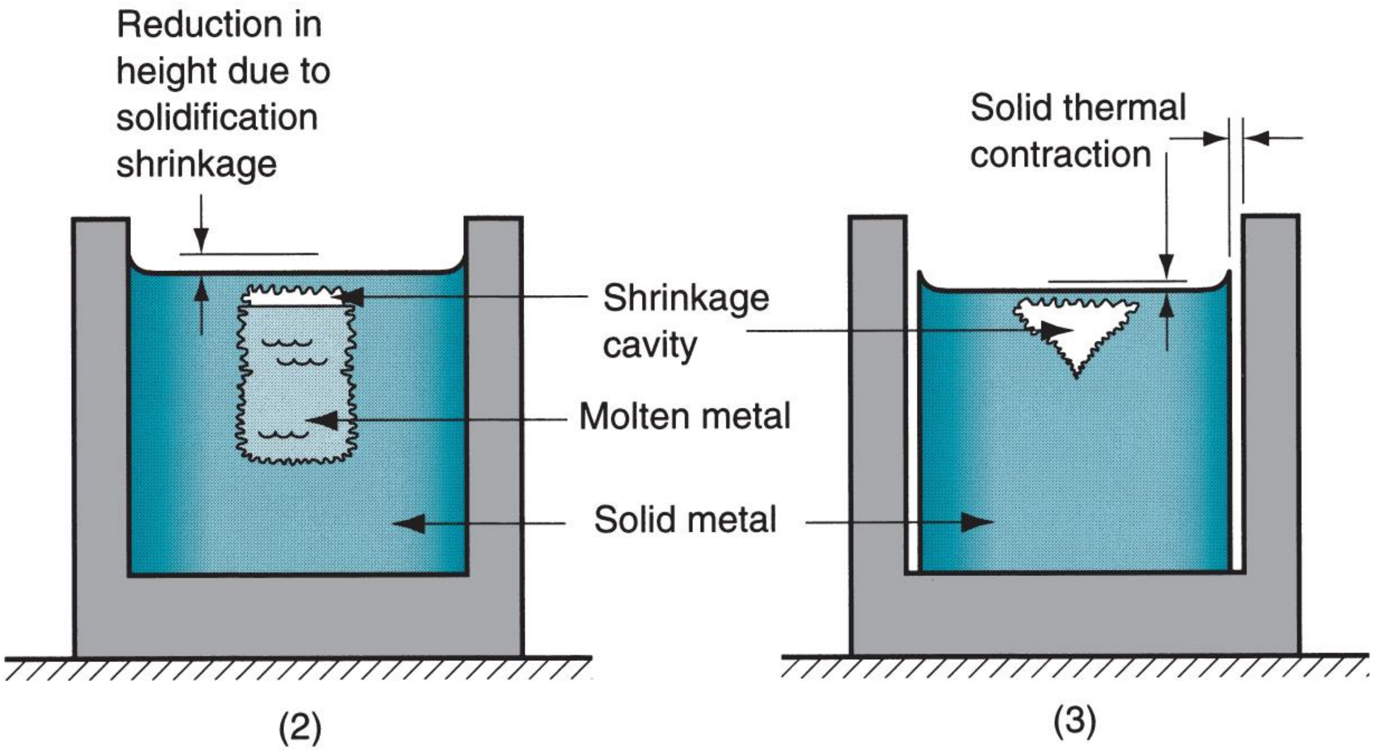
- Shrinkage usually occurs during cooling and freezing.
- Shrinkage occurs in three steps:
  1) liquid contraction during cooling prior to solidification;
  2) contraction during the phase change from liquid to solid, called solidification shrinkage; and
  3) thermal contraction of the solidified casting during cooling to room temperature.

Shrinkage in solidification and Cooling



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 (dimensional reductions are exaggerated for clarity).

Shrinkage in solidification and Cooling



(2) reduction in height and formation of shrinkage cavity caused by solidification shrinkage; (3) further reduction in height and diameter due to thermal contraction during cooling of solid metal (dimensional reductions are exaggerated for clarity).

Solidification Shrinkage

- Solidification shrinkage occurs in nearly all metals because the solid phase has a higher density than the liquid phase.
- The ***exception is cast iron containing high carbon content***, whose solidification during the final stages of freezing is complicated by a period of graphitization, which results in ***expansion*** that tends to counteract the volumetric decrease associated with the phase change.

A metallurgical change in the microstructure of joints in carbon and certain low-alloy steels subjected to long term service in the temperature range of 450 to 600°C . . Graphitization is a breakdown of carbides in the steel to small patches of graphite and Iron caused by heat.

Compensation for Solidification Shrinkage

- Compensation for solidification shrinkage is achieved in several ways depending on the casting operation.
- In ***sand casting***, liquid metal is supplied to the cavity by means of ***risers*** .
- In ***die casting***, the molten metal is applied under ***pressure***.

Shrinkage Allowance

- Patternmakers account for solidification shrinkage and thermal contraction by making ***mold cavity oversized***
- ***Amount*** by which mold is ***made larger relative to final casting*** size is called ***pattern shrinkage allowance***
- Casting dimensions are expressed linearly, so allowances are applied accordingly.

References

- M. P. Groover, Fundamentals Of Modern Manufacturing: Materials, Processes, and Systems, Wiley (2010), 4th edition.
- Degarmo, E. P., Kohser, Ronald A. and Black, J. T., Materials and Processes in Manufacturing, Prentice Hall of India (2008) 8th ed.
- Kalpakjian, S. and Schmid, S. R., Manufacturing Processes for Engineering Materials, Dorling Kingsley (2006) 4th ed.