University of Technology
Materials Engineering Department

Casting Technology I

Fourth Class

Lecture No 2:Heating & Pouring

Heating and Pouring

Heating furnaces of various kinds are used to heat the metal to a molten temperature sufficient for casting. The heat energy required is the sum of

1. The heat to raise the temperature to the melting point,
2. The heat of fusion to convert it from solid to liquid,
3. The heat to raise the molten metal to the desired temperature for pouring.

This can be expressed:

$$H= \rho V\{Cs[T_m - T_o] + H_f + C_l(Tp-Tm)\}$$

- Where
- H= total heat required to raise the temperature of the metal to the pouring temperature, J
- ρ=Density g/cm^3
- V= Volume of metal Heated cm^3
- H_f= Heat of Fusion J/g
- Cs= weight specific heat for the solid metal, J/g°C
- Cl= weight specific heat of the liquid metal, J/g°C
- Tp= Pouring Temperature °C
- Tm=Melting Temperature of metal °C
- T_o= starting temperature-usually ambient-°C

Heating and Pouring

The above equation is of conceptual value, but its computational value is limited, notwithstanding our example calculation. Use of Eq. (1) is complicated by the following factors:

1. Specific heat and other thermal properties of a solid metal vary with temperature, especially if the metal undergoes a change of phase during heating.
2. A metal's specific heat may be different in the solid and liquid states.
3. Most casting metals are alloys, and most alloys melt over a temperature range between a solidus and liquidus rather than at a single melting point; thus, the heat of fusion cannot be applied so simply as indicated above.
4. The property values required in the equation for a particular alloy are not readily available inmost cases.
5. There are significant heat losses to the environment during heating.

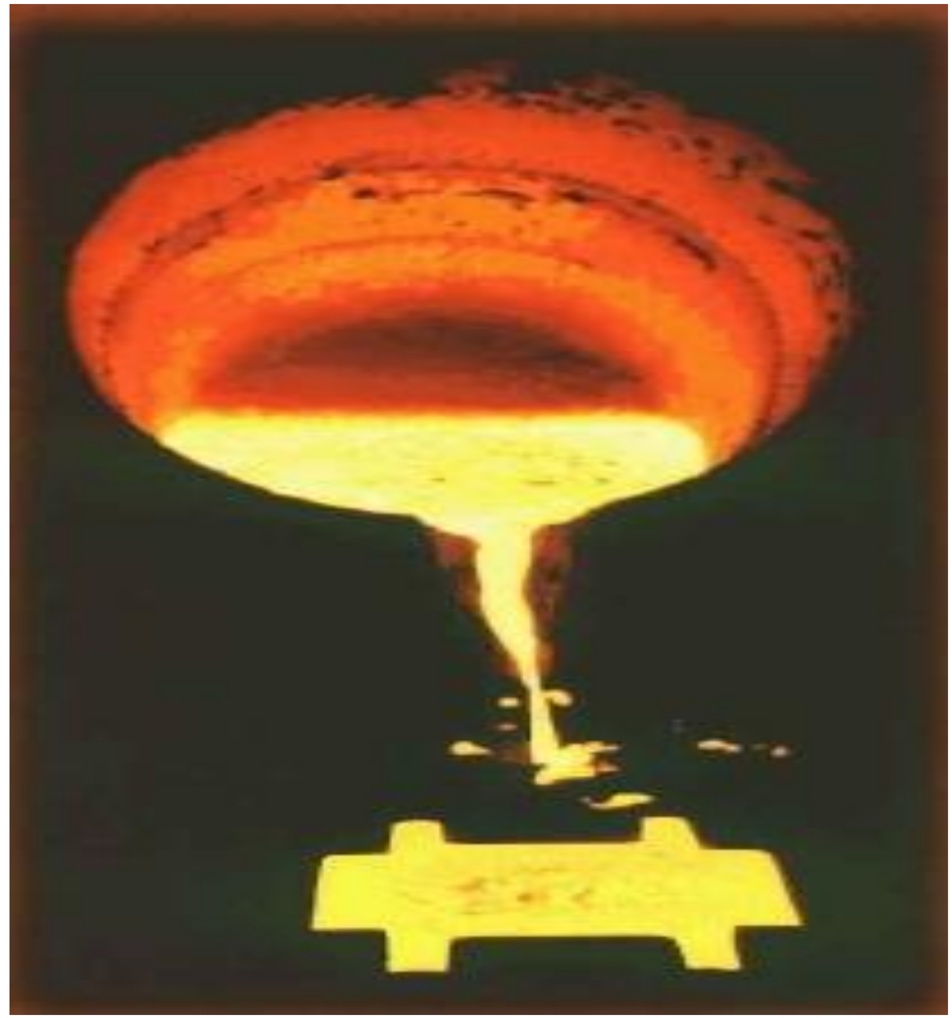
Example

- *EX1* One cubic meter of a certain eutectic alloy is heated in a crucible from room temperature to 100°C above its melting point for casting. The alloy's density = 7.5 g/cm3, melting point = 800°C, specific heat=0.33 J/g°C in the solid state and 0.29 J/g°C in the liquid state; and heat of fusion= 160 J/g. How much heat energy must be added to accomplish the heating, assuming no losses?

- **Sol:**
- $H = \{7.5(10^6)\}(0:33)(800-25)+160+(0.29(100))$
- $=3335(10^6)$ J

POURING THE MOLTEN METAL

- ***The pouring temperature***
- ***Superheat*.**
- ***Pouring rate***
- ***Turbulence***
- ***Mold erosion***



ENGINEERING ANALYSIS OF POURING

Bernoulli's theorem,

- There are several relationships that govern the flow of liquid metal through the gating system and into the mold. An important relationship is which states
- *that the sum of the energies (head, pressure, kinetic, and friction) at any two points in a flowing liquid are equal. This can be written in the following form* :

$$h_1 + \frac{P_1}{\rho} = \frac{v_1^2}{2g} + F_1 = \frac{P_2}{\rho} + \frac{v_2^2}{2g} + F_2$$

ENGINEERING ANALYSIS OF POURING

- Bernoulli's equation can be simplified in several ways. If we ignore friction losses (to be sure, friction will affect the liquid flow through a sand mold), and assume that the system remains at atmospheric pressure throughout, then the equation can be reduced to

$$h_1 + \frac{v_1^2}{2g} = h_2 + \frac{v_2^2}{2g}$$

ENGINEERING ANALYSIS OF POURING

- This can be used to determine the velocity of the molten metal at the base of the sprue.
- Let us define point 1 at the top of the sprue and point 2 at its base.
- If point 2 is used as the reference plane,
- then the head at that point is zero ($h_2 = 0$) and h_1 is the height (length) of the sprue.
- When the metal is poured into the pouring cup and overflows down the sprue, its initial velocity at the top is zero (v1 = 0). Hence, Eq. (3) further simplifies to

$$h_1 = \frac{v_2^2}{2g}$$

ENGINEERING ANALYSIS OF POURING

- which can be solved for the flow velocity
- $$v = \sqrt[2]{2gh}$$
- where
- v=the velocity of the liquid metal at the base of the sprue, cm/s;
- g=981 cm/s/s
- h = the height of the sprue, cm

Continuity Law

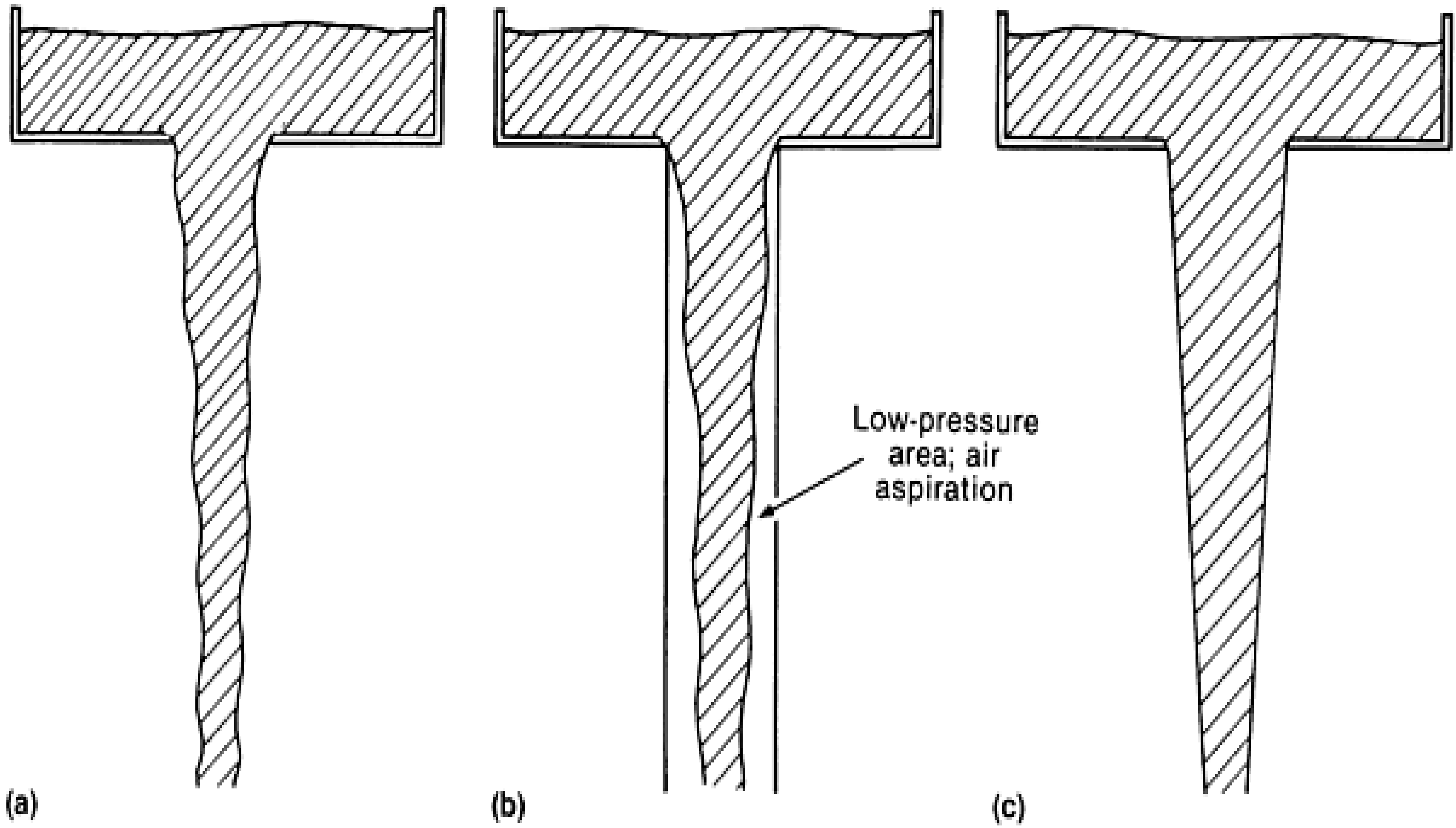
- Another relationship of importance during pouring is the continuity law, which states that the volume rate of flow remains constant throughout the liquid. The volume flow rate is equal to the velocity multiplied by the cross-sectional area of the flowing liquid

Continuity Law

- The continuity law can be expressed :

$$Q = v_1 A_1 = v_2 A_2$$

- where
- Q = volumetric flow rate, cm^3/s
- v = velocity as before cm/s
- A = cross sectional area of the liquid, cm^2
- Note *the subscripts refer to any two points in the flow system. Thus, an increase in area results in a decrease in velocity, and vice versa.*



Low-pressure
area; air
aspiration
(a)
(b)
(c)

ENGINEERING ANALYSIS OF POURING

- Accordingly, we can estimate the time required to fill a mold cavity of volume V as

$$MFT = \frac{V}{Q}$$

- Where TMF=mold filling time (sec)
- V=volume of mold cavity cm^3
- Q=volume flow rate, as before.

Example 2

- *A mold sprue is 20 cm long, and the cross-sectional area at its base is 2.5 cm^2. The sprue feeds a horizontal runner leading into a mold cavity whose volume is 1560 cm^3.*
- Determine:-
- Velocity of the molten metal at the base of the sprue
- Volume rate of flow
- Time to fill the mold.

Solution

- (a)The velocity of the flowing metal at the base of the Sprue is given by Eq. (4):

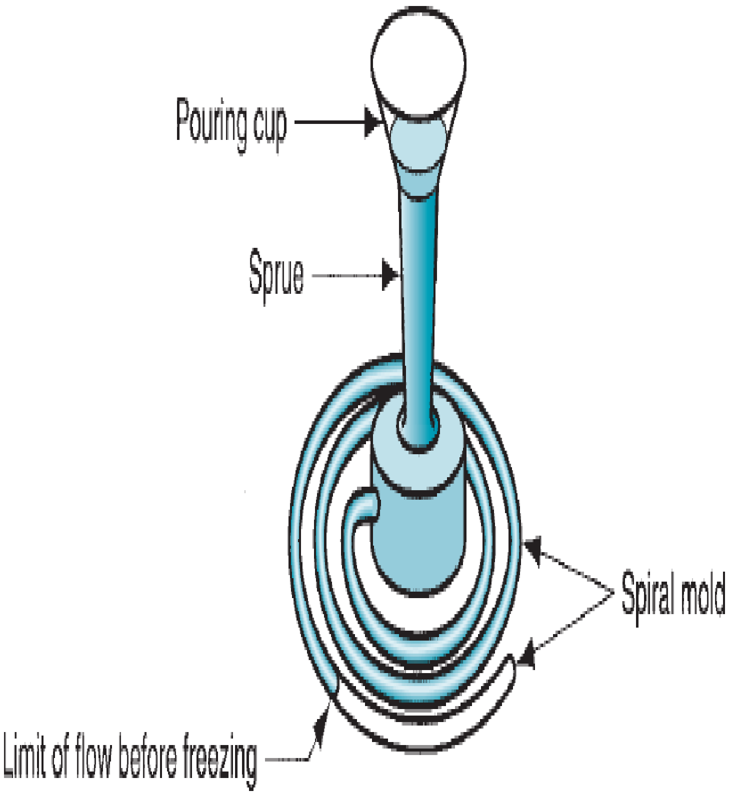
$$V = \sqrt[2]{2 \ * 981 * 20}$$

V= 198.1 cm/s

- (b) The volumetric flow rate is
  - Q =(2.5 cm^2)(198.1 cm/s)= 495 cm^2/s
- (c) Time required to fill a mold cavity of 100 in^3 at this flow rate is
  - TMF = 1560/495 = 3.2s

FLUIDITY

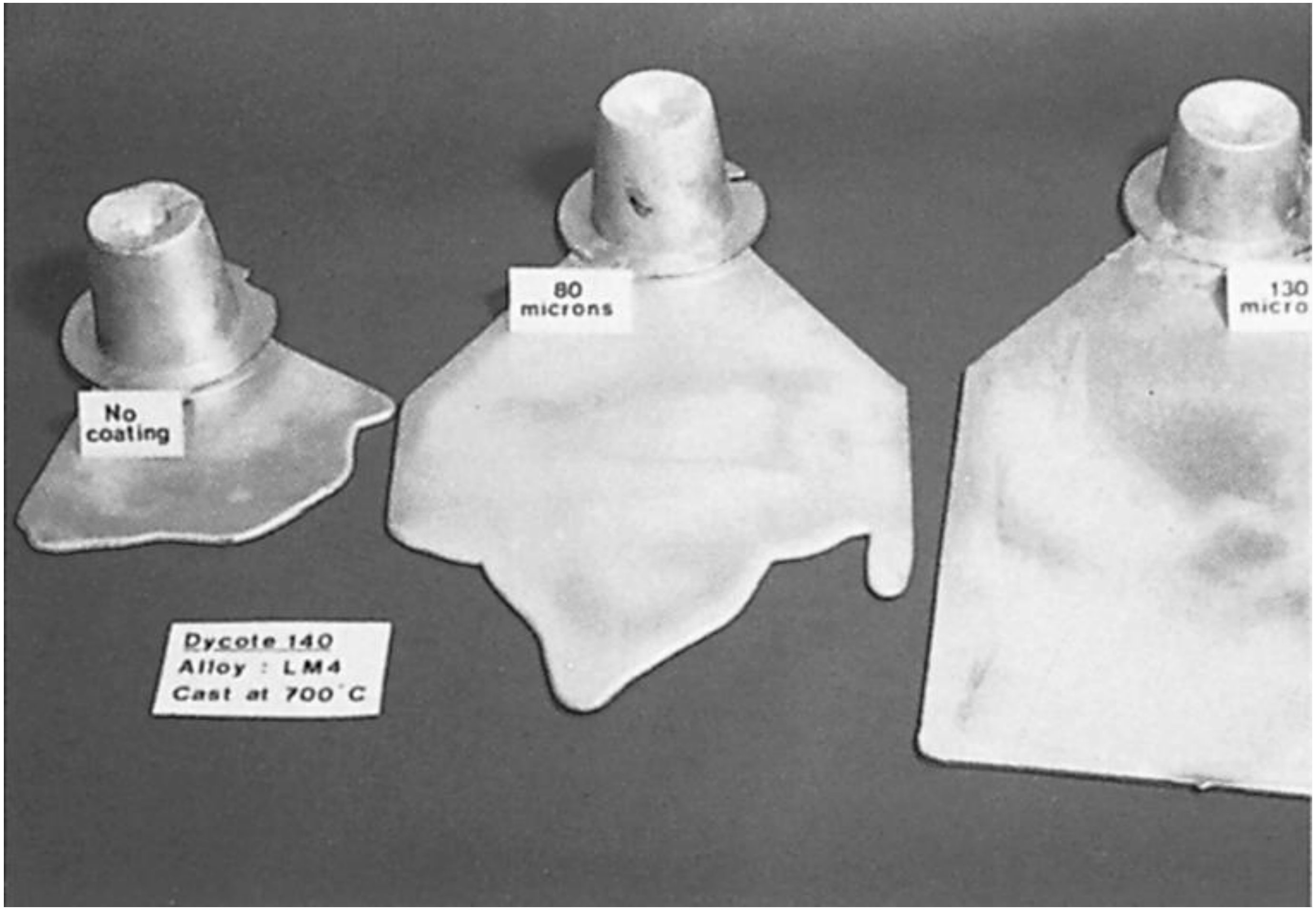
- **<u>Fluidity</u>**, a measure of the capability of a metal to flow into and fill the mold before freezing.
- Fluidity is the inverse of viscosity as viscosity increases, fluidity decreases.



Factors Affecting Fluidity

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

Fluidity Test



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