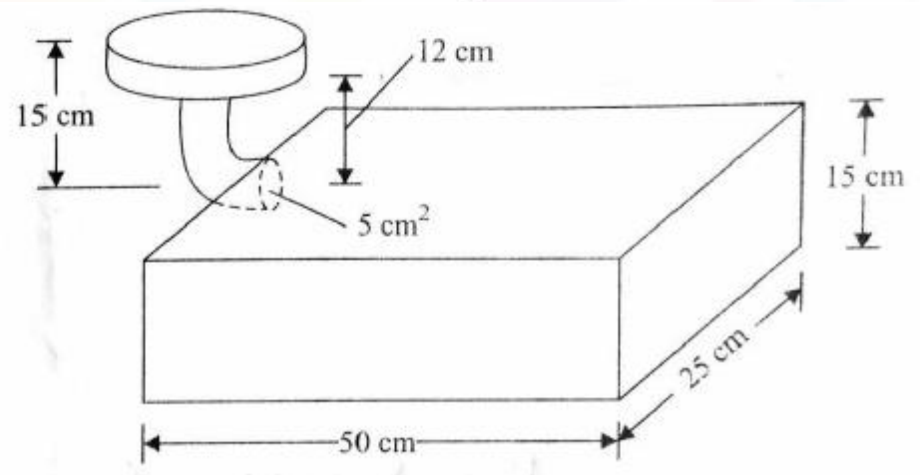
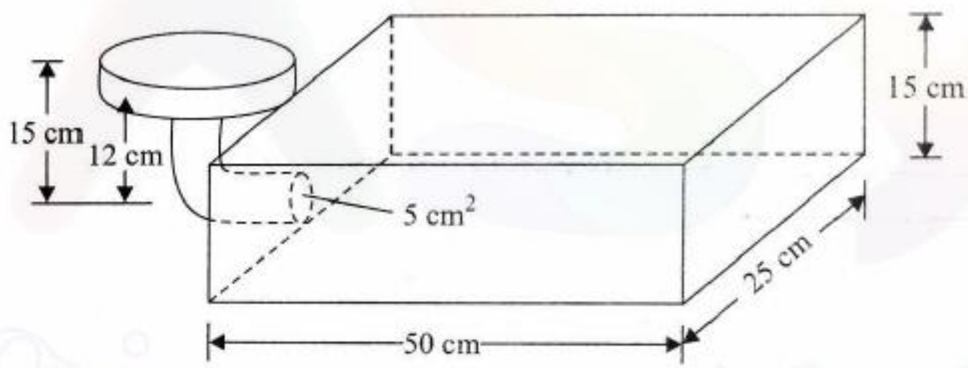
NUMERICAL PROBLEMS ON CASTING

EXAMPLE 2.1 Two gating designs for a mould of 50 cm × 25 cm × 15 cm are shown in Fig. 2.7. The cross-sectional area of the gate is 5 cm^2. Determine the filling time for both the designs.



(a) Top gating



(b) Bottom gating

SOLUTION Figure 2.7a. Since h_t = 15 cm, from equation (2.3), we have

$$v_3 = \sqrt{2 \times 981 \times 15} \text{ cm/sec} = 171.6 \text{ cm/sec.}$$

The volume of the mould is $V = 50 \times 25 \times 15$ cm^3 and the cross-sectional area of the gate is $A_g = 5$ cm^2. So, from equation (2.4), we get

$$t_f = \frac{50 \times 25 \times 15}{5 \times 171.6} \text{ sec} = 21.86 \text{ sec.}$$

Figure 2.7b. Here, $h_t = 15$ cm, $h_m = 15$ cm, $A_m = 50 \times 25$ cm^2, and $A_g = 5$ cm^2. Using equation (2.10), we have

$$t_f = \frac{50 \times 25}{5} \frac{\sqrt{2}}{\sqrt{981}} \sqrt{15} \text{ sec} = 43.71 \text{ sec.}$$

It should be noted that in Fig. 2.7b the time taken is double of that in Fig. 2.7a. We can easily verify that this will always be so if $h_m = h_t$.

EXAMPLE 2.5 Determine the solidification time of the following iron casting when poured, with no superheats, into sand moulds at the initial temperature 28°C: A slab-shaped casting 10 cm thick.

The data for iron is

$$\theta_f = 1540°\text{C}, \qquad L = 272 \text{ kJ/kg}, \qquad \rho_m = 7850 \text{ kg/m}^3;$$

and for sand is

$$c = 1.17 \text{ kJ/kg-K}, \qquad k = 0.8655 \text{ W/m-K}, \qquad \rho = 1600 \text{ kg/m}^3.$$

SOLUTION (i) Let l, b, and h be the length, breadth, and thickness, respectively, of the slab. So, the volume of the casting is

$$V = lbh$$

and the surface area of the casting is

$$A = 2(lb + bh + lh) \approx 2lb \qquad (\text{as both } l, b \gg h).$$

Hence,

$$\frac{V}{A} \approx \frac{h}{2} = 5 \times 10^{-2} \text{ m}.$$

$t_s = \gamma(\frac{V}{A})^2$ where the constant γ is given by $\gamma = \{\frac{\rho_m \sqrt{\pi\alpha}[L + c_m(\theta_p - \theta_f)]}{2k(\theta_f - \theta_0)}\}^2$

$$\alpha = \frac{k}{\rho c} = \frac{0.8655}{1600 \times 1.17 \times 10^3} = 4.6234 \times 10^{-7}\, m^2/s$$

$$\theta_p - \theta_f = 1540 \text{ °C}$$

$$\gamma = \left[\frac{7850 \times \sqrt{3.14 \times 4.6234 \times 10^{-7}} \times 272 \times 10^3}{2 \times 0.8655 \times (1540 - 28)}\right]^2 = 966{,}210.36$$

$$t_s = \gamma \times (V/A)^2 = 966{,}210.36 \times (5 \times 10^{-2})^2 = 2415.53\, s$$

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?

Solution: Assume ambient temperature in the foundry = 25°C and that the density of the liquid and solid states of the metal are the same. Noting that one m³ = 10^6 cm³, and substituting the property values into Equation (10.1),

$$H = (7.5)(10^6)\{0.33(800 - 25) + 160 + 0.29(100)\} = 3335(10^6) \text{ J}$$

A mold sprue is 20 cm long, and the cross-sectional area at its base is 2.5 cm². The sprue feeds a horizontal runner leading into a mold cavity whose volume is 1560 cm³. Determine: (a) velocity of the molten metal at the base of the sprue, (b) volume rate of flow, and (c) time to fill the mold.

Solution: (a) The velocity of the flowing metal at the base of the sprue is given by Equation (10.4):

$$v = \sqrt{2(981)(20)} = 198.1 \text{ cm/s}$$

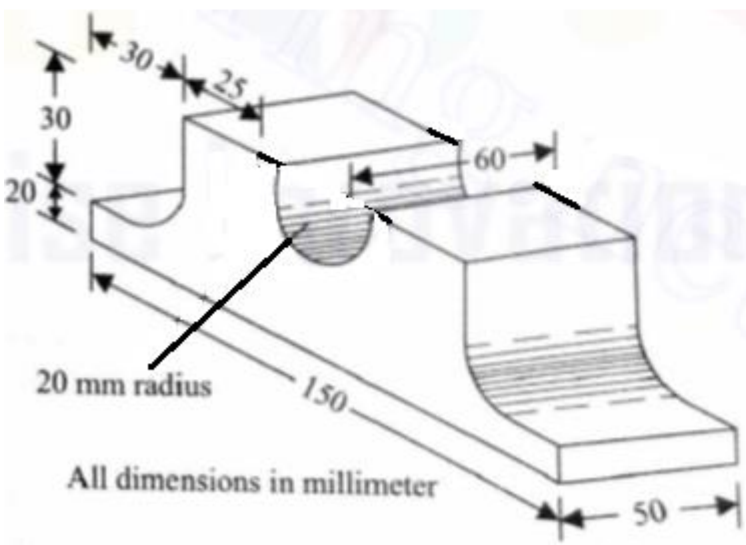
(b) The volumetric flow rate is

$$Q = (2.5 \text{ cm}^2)(198.1 \text{ cm/s}) = 495 \text{ cm}^3/\text{s}$$

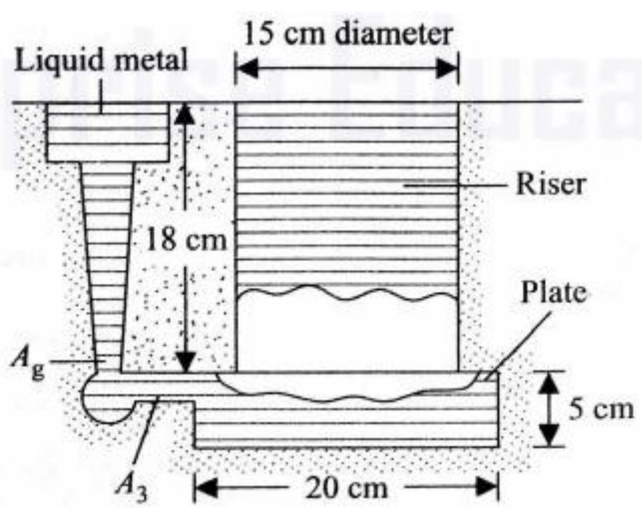
(c) Time required to fill a mold cavity of 1560 cm³ at this flow rate is

$$T_{MF} = 1560/495 = 3.2 \text{ s}$$

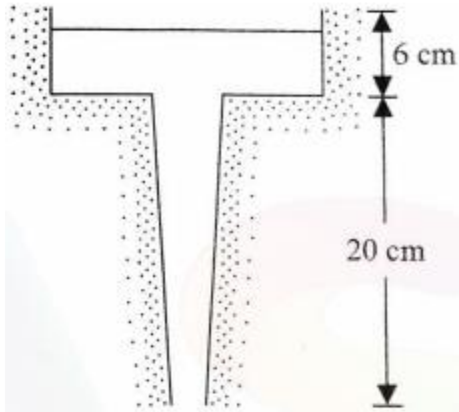
Q. Sketch the pattern of the cast iron bearing block shown below by considering shrinkage allowance of 20 mm/m and machining allowance of 3 mm on all surfaces.



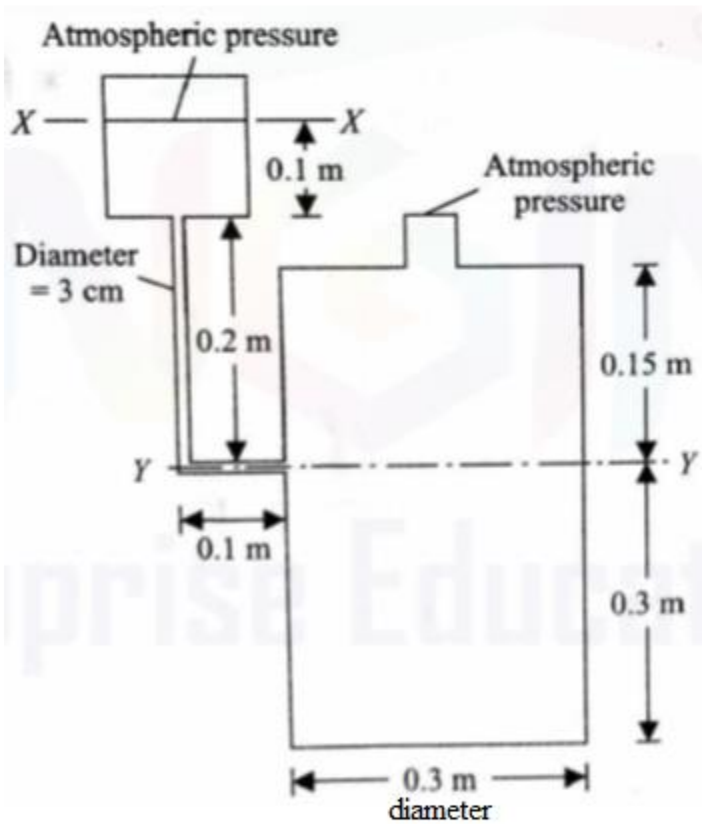
Q. The following Figure shows a mould along with the riser for casting a plate 20 cm x 20 cm x 5 cm. Determine the area A_g such that the mould and the riser get filled up within 10 sec after the downsprue has been filled. It should be noted that $A_3 >> A_g$ since below the downsprue a flat gate is attached to the casting.



Q. Design the downsprue, avoiding aspiration, as shown below to deliver liquid cast iron (density = 7800 kg/m3) at a rate of 10 kg/sec against no head at the base of the sprue.



Q. Estimate the time required to fill the mould as shown below. The liquid metal (density = 6000 kg/m^3) level at X –X is maintained constant and the time to fill the runner is negligible.



Q. Compare the solidification time of two optimum risers of the same volume when one has a cylindrical shape and the other is of the form of a rectangular parallelepiped.

Solve the Exercise problems of Chapter 10 from the book "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems" by M. P. Groover