

Aspiration Effect

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Let, in the limiting case, $p_2 = 0$. In that case,

$$\frac{v_3^2}{2} = gh_2 + \frac{v_2^2}{2}$$

From the principle of continuity of flow,

Or,
$$v_2 = \frac{A_3}{A_2} v_3 = R v_3$$

Or, from the above equation,

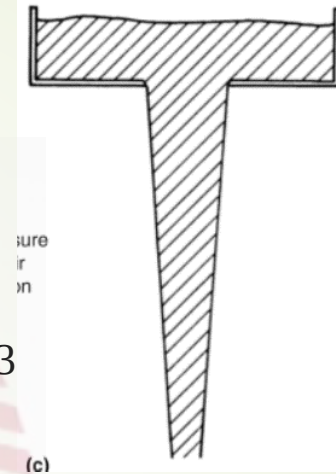
Or,
$$R^2 = 1 - \frac{2gh_2}{v_3^2}$$

$$\frac{v_3^2}{2g} = h_2 + \frac{R^2 v_3^2}{2g}$$

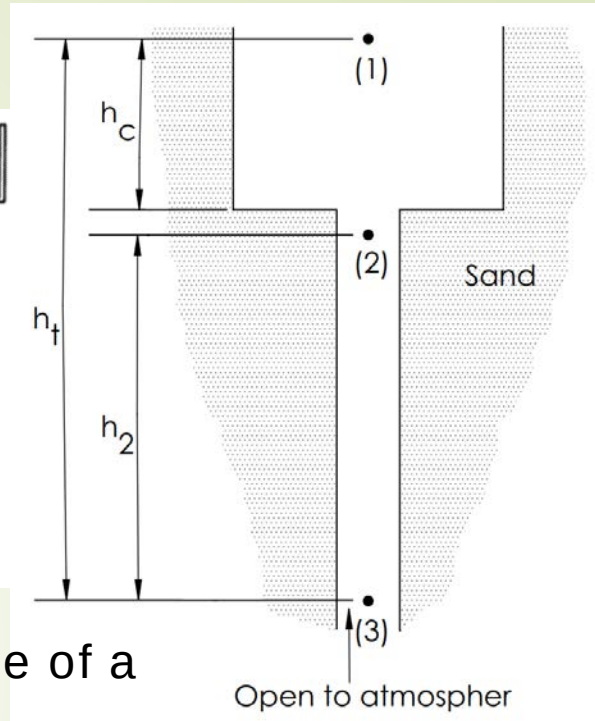
Again, Applying Bernoulli's equation between 1 and 3, we get, $v_3^2 = 2gh_t$ ($p_1 = p_3 = 0$ $v_1 = 0$)

Therefore,

$$R^2 = 1 - \frac{h_2}{h_t} = \frac{h_c}{h_t}, \text{ or, } R = \frac{A_3}{A_2} = \sqrt{\frac{h_c}{h_t}}$$



Ideal shape of a sprue



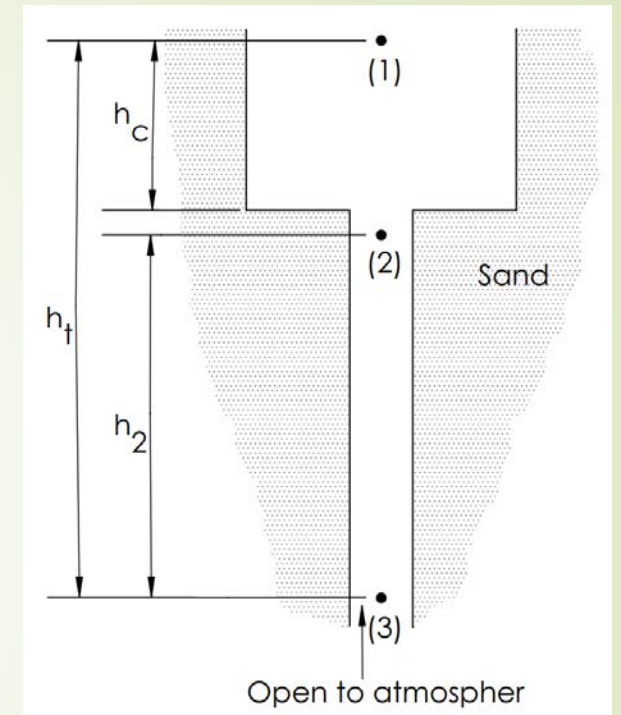
Vertical gating: aspiration effects (permeable mold)

► For an impermeable mould,

$$p_2 = p_3 - h_2\rho$$

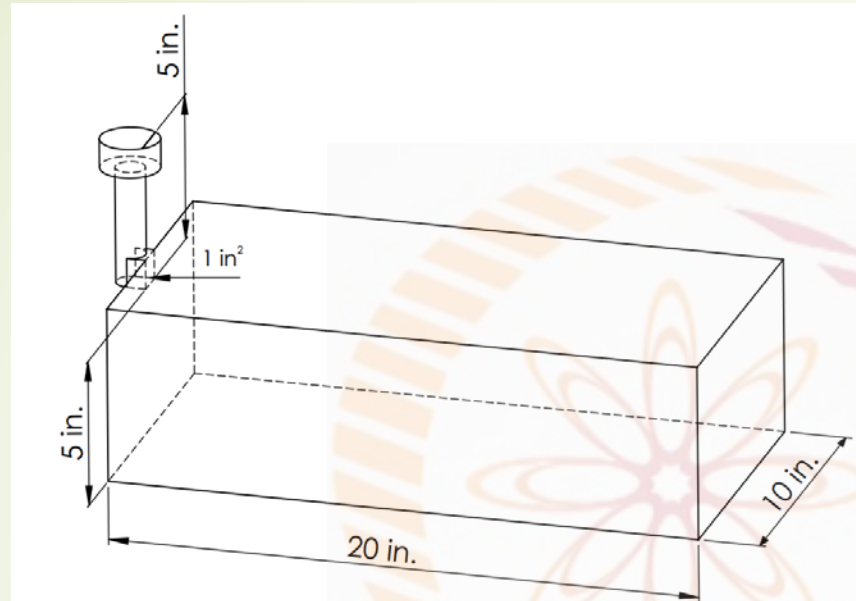
- In a permeable mold however, the air or mold gas at the sand-metal interface is at least at atmospheric pressure, or usually just higher (since mold gases are generated by the action of the hot metal, which tends to increase pressure)
- Gas will, therefore, be aspirated into the metal stream at 2, and
- The quantity of gas aspirated will depend on: $h_2\rho$, the permeability of the mold, and the pressure of the mold gas

The mold gas may react with the metal to form oxides; dissolve in the metal to precipitate later; or remain trapped as bubbles. All these are not desirable outcomes.



Filling times with vertical and bottom gatings

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Vertical gating

$$t = \frac{V}{Q} = \frac{V}{Av}$$

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

$$t = \frac{\text{total volume}}{1 \text{ in}^2 \times v} = 16.1 \text{ sec}$$

Bottom gating

$$t_f = \frac{2A_m}{A_g\sqrt{2g}} (\sqrt{h_t} - \sqrt{h_t - h_m})$$

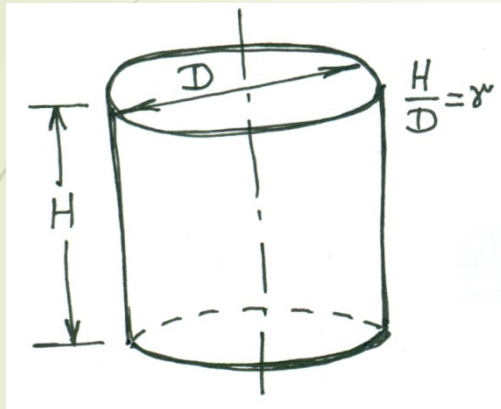
$$t_f = \frac{2 \times 200}{1\sqrt{2g}} (\sqrt{5 - 0}) = 32.2 \text{ sec}$$

Optimum Riser Design

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The volume of the cylinder,

$$V_R = \frac{\pi}{4} D^2 H = \frac{\pi}{4} D^3 r$$



The surface area of the riser is:

$$A_R = \pi D H + 2 \cdot \frac{\pi D^2}{4}$$

Therefore,

$$\frac{V_R}{A_R} = \frac{D^2 H}{4 D H + 2 D^2} = \frac{\frac{D H}{4 H}}{\frac{4 H + 2 D}{4 H}} = \frac{\frac{1}{4} D}{1 + \frac{1 D}{2 H}} = \frac{\frac{1}{4} D}{1 + \frac{1}{2 r}}$$

or,

$$D = 4 \cdot \left(\frac{V}{A} \right)_R \left(1 + \frac{1}{2 r} \right)$$

Therefore,

$$V_R = \frac{\pi}{4} D^3 r = \frac{\pi}{4} \left[\left(\frac{V}{A} \right)_R \left(1 + \frac{1}{2 r} \right) \right]^3 r = 16 \pi \left(\frac{V}{A} \right)_R^3 r \left(1 + \frac{1}{2 r} \right)^3$$

$\left(\frac{V}{A} \right)_R^3$ Is constant since,

$\left(\frac{V}{A} \right)_{\text{casting}}$ Is fixed

For optimum value of r, $\frac{\partial V_R}{\partial r} = 0$

Optimum Riser Design

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$$\text{Therefore, } \left(1 + \frac{1}{2r}\right)^3 \cdot 1 + r \cdot 3 \left(1 + \frac{1}{2r}\right)^2 \left(-\frac{1}{2r^2}\right) = 0$$

$$\text{or, } \left(1 + \frac{1}{2r}\right)^2 \left[1 + \frac{1}{2r} - \frac{3}{2r}\right] = 0$$

$$\text{or, } \left(1 + \frac{1}{2r}\right)^2 \left(\frac{r-1}{r}\right) = 0, \text{ or, } r = 1, \text{ or, } H = D$$

$$\text{Therefore, } (V_R)_{\text{optimum}} = \frac{\pi D^3}{4}$$



HEATING THE METAL

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The heat energy required = The heat to raise the temperature to the melting point + the heat of fusion to convert it from solid to liquid + the heat to raise the molten metal to the desired temperature for pouring.

This can be expressed as:

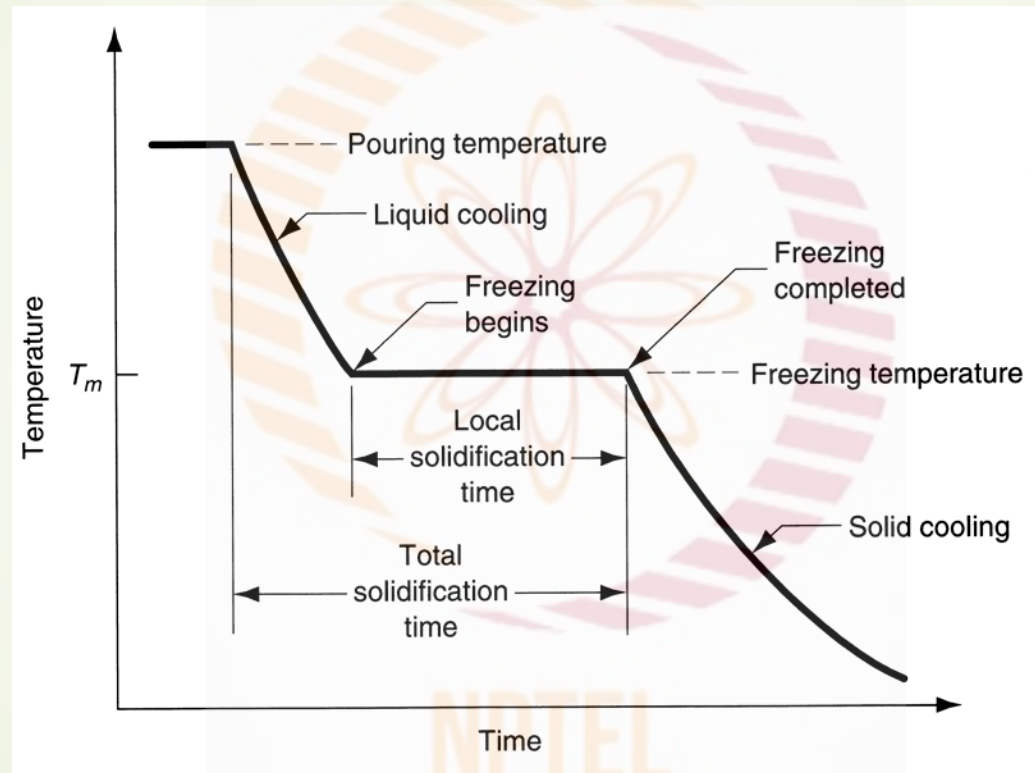
$$H = \rho V \{ C_s (T_m - T_o) + H_f + C_l (T_p - T_m) \}$$

Where, H is the total heat required to raise the temperature of the metal to the pouring temperature, J ; ρ is the density; g/cm³; C_s is the weight specific heat for the solid metal, J/g-C ; T_m is the melting temperature of the metal, C; T_o is starting temperature—usually ambient, C; H_f is the heat of fusion, J/g; C_l is the weight specific heat of the liquid metal, J/g-C ; T_p is the pouring temperature, C; and V is the volume of metal being heated, cm³.

Solidification



A pure metal solidifies at a constant temperature equal to its freezing point (same as melting point)



Cooling curve for a pure metal during casting