

Gating Design (Contn.)

- In the figure, pressure at points 1 and 3 is equal ($p_1 = p_3$)
- Level 1 is maintained constant. Thus the velocity, $v_1 = 0$
- Frictional losses are neglected

The energy balance equation between points 1 and 3 gives:

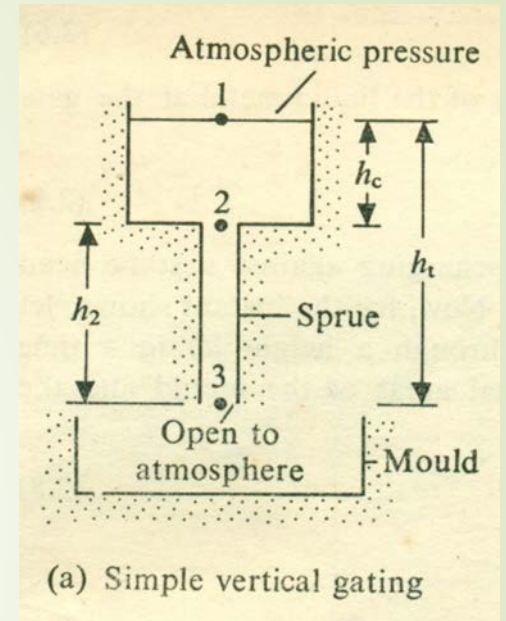
$$h_t = \frac{v_3^2}{2g}; \text{ or, } v_3 = \sqrt{2gh_t}$$

Where, g is the acceleration due to gravity and v_3 is the velocity of the liquid metal at the gate.

Time taken to fill up the mould is obtained as:

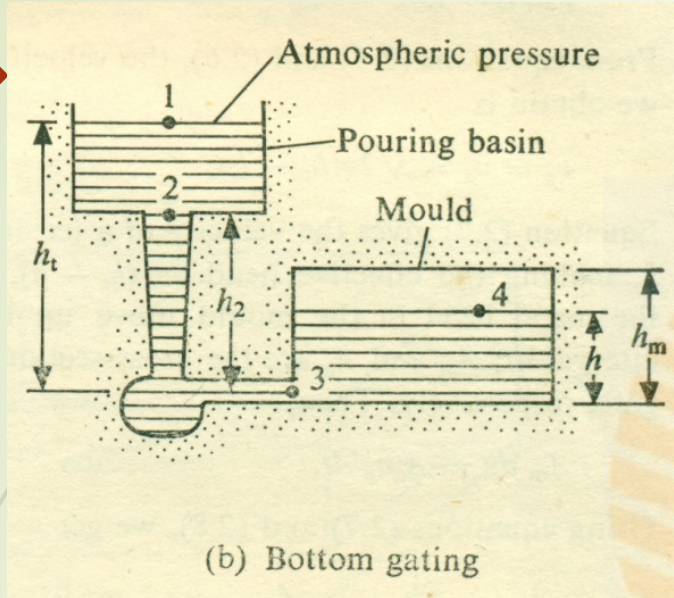
$$t_f = \frac{V}{A_g v_3}$$

Where, A_g and V are the cross-sectional area of the gate and the volume of the mould respectively.



Gating Design (Contn.)

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For the bottom gating system, applying Bernoulli's equation between points 1 and 3, we get

In time dt , the head increases dh , and the volume of metal in the cavity increases $A_m dh$, wherein A_m is the horizontal cross-sectional area of the casting

- Also, the liquid delivered to the gate in time dt will be $A_g v dt$, where A_g and v are the area and instantaneous velocity at the gate; $v = \sqrt{2g(h_t - h)}$
- Equating the increase in casting volume in time dt to the flow through the gate in dt :

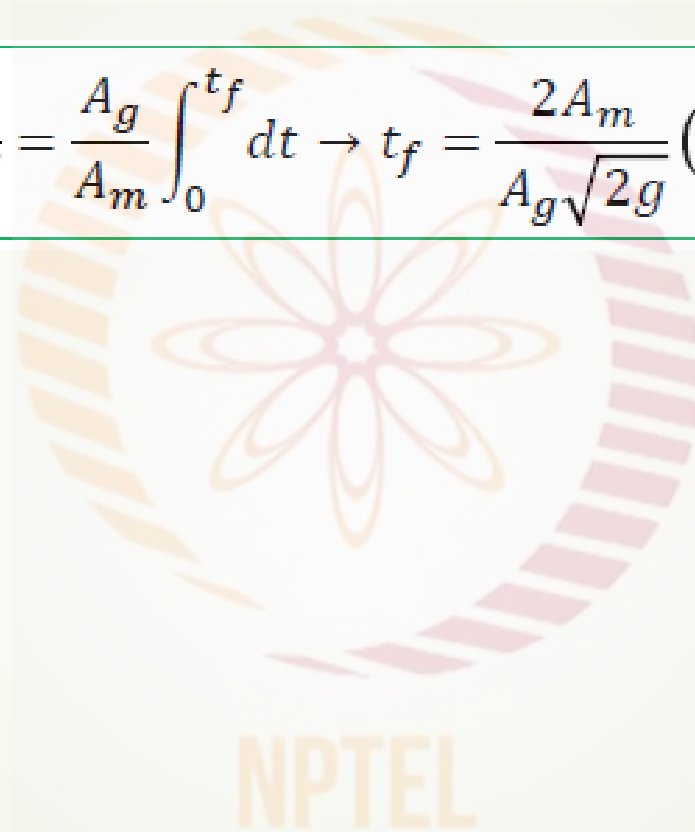
$$A_m dh = A_g \sqrt{2g(h_t - h)} dt \rightarrow \frac{dh}{\sqrt{2g(h_t - h)}} = \frac{A_g}{A_m} dt$$

Gating Design (Contn.)

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If t_f is the time required to fill the cavity with height h_m , we can write:

$$\frac{1}{\sqrt{2g}} \int_0^{h_m} \frac{dh}{\sqrt{(h_t - h)}} = \frac{A_g}{A_m} \int_0^{t_f} dt \rightarrow t_f = \frac{2A_m}{A_g \sqrt{2g}} (\sqrt{h_t} - \sqrt{h_t - h_m})$$



Vertical gating: aspiration effects (permeable mold)

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First, for the case of a **straight downsprue**, for an **impermeable mold**, Bernoulli's equation for points 1 and 3 is:

$$h_t + 0 + \frac{p_1}{\rho_1} = 0 + \frac{v_3^2}{2g} + \frac{p_3}{\rho_3} \rightarrow v_3 = \sqrt{2gh_t}$$

The stream issues from 3 with v_3 at atmospheric pressure

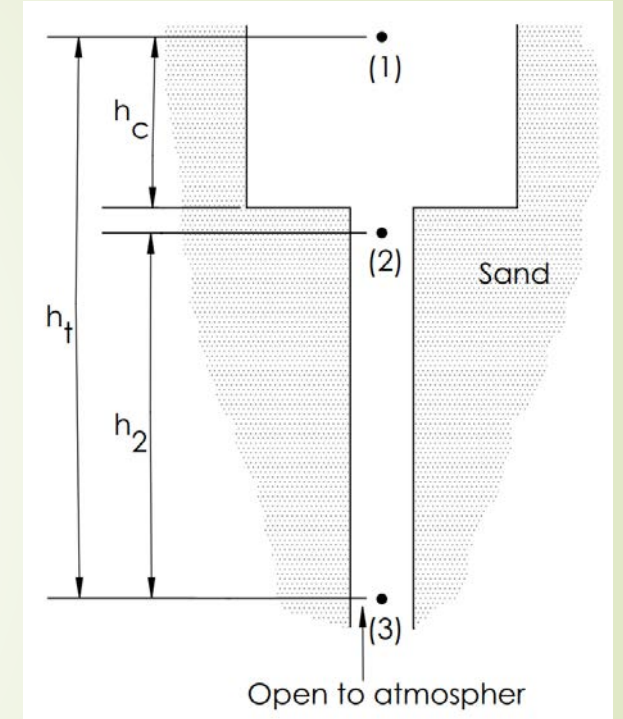
- However, by law of continuity, $v_2 = v_3$. This seems to disprove the principle of conservation of energy, since 2 is higher than 3, and has greater PE
- The inequality arises from the pressure term:

$$h_2 + \frac{v_2^2}{2g} + \frac{p_2}{\rho_2} = 0 + \frac{v_3^2}{2g} + \frac{p_3}{\rho_3}$$

Since $\rho_2 = \rho_3 = \rho$,
and since $v_2 = v_3$

$$p_2 = p_3 - h_2\rho$$

i.e. the pressure at 2 is less than atmospheric (p_3), by the factor $h_2\rho$



Aspiration Effect

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For an impermeable mould,

$$p_2 = p_3 - h_2\rho$$

If the pressure at point 3 is atmospheric, i.e, $p_3 = 0$, then $p_2 = -h_2\rho$ as $v_2 = v_3$

Hence the design as given in the figure is not acceptable.

For sand mould, care should be taken to ensure that the pressure anywhere in the liquid metal stream does not fall below the atmospheric pressure. Otherwise, the gases originating from baking of the organic compounds in the mould will enter the molten metal stream, producing porous castings. This is known as the aspiration effect.

Let us see what should be the best design for the sprue.

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,

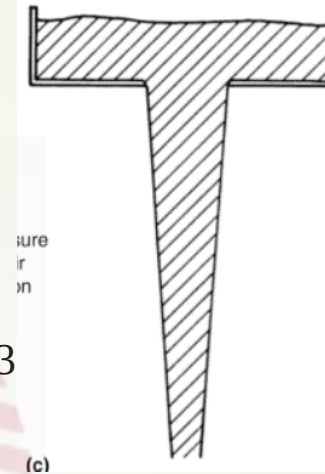
Or,
$$R^2 = 1 - \frac{2gh_2}{v_3^2}$$

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

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

