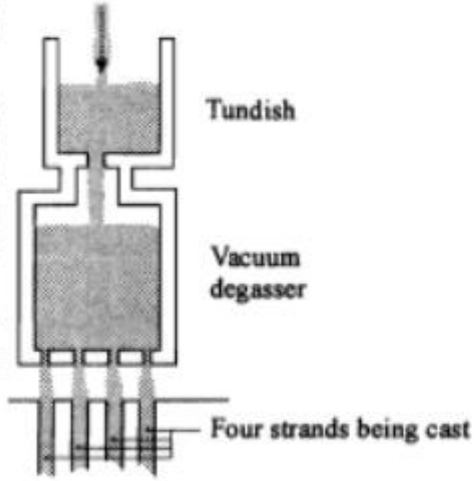
4.16 In planning continuous casting, we use fluid flow analysis. Consider the illustrated configuration of the equipment, which includes in-line vacuum degassing.

a) Determine the tundish and degasser nozzle sizes which are necessary to operate the system at a rate of 6.3 kg s^{-1} per strand. Suppose that for operational reasons it is desirable to maintain tundish and degasser bath depths of 0.76 and 1.83 m, respectively.

b) If only 13 mm diameter degasser nozzles are available, how would their use affect the casting operation?



Inside dimensions: tundish, 2.4 m × 2.4 m × 1.2 m; degasser, 1.2 m × 1.2 m × 2.4 m.

Liquid-steel density = 7530 kg m^{-3}.

Discharge coefficients for tundish and vacuum degasser nozzles: $C_D = 0.8$.

Vacuum pressure = 10^{-3} atm (101 N m^{-2}).

(a) $W := 4 \cdot 6.3 \cdot \frac{kg}{s}$ $\quad h := -0.76 \cdot m$ $\quad \rho := 7530 \cdot \frac{kg}{m^3}$ $\quad Cd := 0.8$ $\quad P_2 := 101 \cdot Pa$ $\quad \beta := 1$

$$v_2 := \sqrt[2]{2} \cdot Cd \cdot \left(-\frac{(P_2 - 1 \cdot atm)}{\rho} - g \cdot h\right)^{0.5} = 5.172 \frac{m}{s} \qquad d := \sqrt{\frac{W}{v_2 \cdot \pi \cdot \rho}} = 14.352\ mm$$

Check:

$$\frac{(P_2 - 1 \cdot atm)}{\rho} + \frac{v_2^{\ 2}}{2} \frac{1}{Cd^2} + g \cdot h = 0 \frac{m^2}{s^2}$$

(b) If d=13 mm Increase the head to 1.794 m to maintain the required flow rate.

$$W_{13} := W \cdot \left(\frac{13 \cdot mm}{d}\right)^2 = 20.676 \frac{kg}{s} \qquad v_{13} := v_2 \cdot \left(\frac{d}{13 \cdot mm}\right)^2 = 6.303 \frac{m}{s}$$

$$f(h) := \frac{(P_2 - 1 \cdot atm)}{\rho} + \frac{v_{13}^{\ 2}}{2} \frac{1}{Cd^2} + g \cdot h$$

$$h_0 := -1 \cdot m \qquad h_{13} := \mathbf{root}(f(h0), h0, -0.5 \cdot m, -2 \cdot m) = -1.794\ m$$

Or shut down one strand and adjust head the to 0.41 m

$$v_3 := 0.75 \cdot v_{13} = 4.727 \frac{m}{s} \qquad W_3 := 0.75 \cdot W = 18.9 \frac{kg}{s}$$

$$f_3(h) := \frac{(P_2 - 1 \cdot atm)}{\rho} + \frac{v_3^{\ 2}}{2} \frac{1}{Cd^2} + g \cdot h \qquad h_3 := -0.5 \cdot m$$

$$h_3 := \mathbf{root}(f_3(h3), h3, -0.3 \cdot m, -2 \cdot m) = -0.41\ m$$