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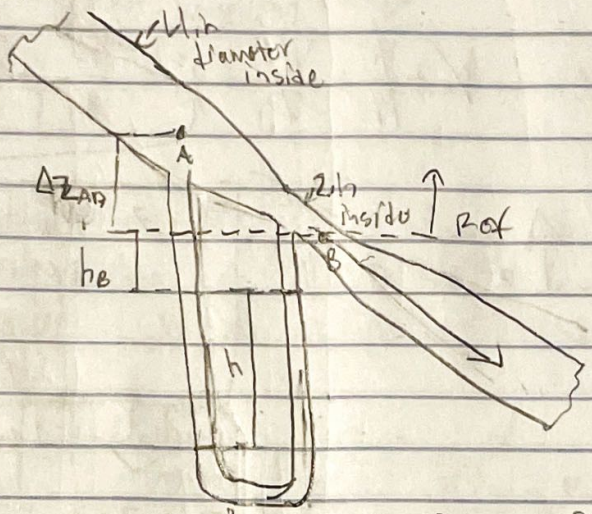
Fluidmechanics Homework 1.3

6.79 Oil w/ specific gravity of 0.90 is flowing downward through the venturi meter. If the manometer deflection h is 28 in calculate the volume flow rate of oil



$$\cancel{h_A} + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B + \cancel{h_R} + \cancel{h_L}$$

$$\frac{P_A - P_B}{\gamma} + (Z_A - Z_B) = \frac{V_A^2 - V_B^2}{2g} \qquad V = \frac{Q}{A}$$

$$= \frac{1}{2g}\left(\frac{Q^2}{A_B^2} - \frac{Q^2}{A_A^2}\right)$$

$$= \frac{1}{2g}\left(\frac{1}{A_B^2} - \frac{1}{A_A^2}\right)Q^2$$

$$Q = \frac{\sqrt{\frac{P_A - P_B}{\gamma} + \Delta Z_{AB}}}{\sqrt{\frac{1}{2g}\left(\frac{1}{A_B^2} - \frac{1}{A_A^2}\right)}}$$

$$P_A + \gamma_{oil}(\Delta Z_{AB} + \cancel{h_B} + h) - \gamma_{Hg} \cdot h - \cancel{\gamma_{oil} h_B} = P_B$$

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$$\frac{P_B - P_A}{\gamma_{Hg}} = (\Delta Z_{AB}) + \left(1 - \frac{\gamma_{H_2O}}{\gamma_{oil}}\right) h$$

$$\frac{P_B - P_A}{\gamma_{Hg}} = (\Delta Z_{AB}) + \left(1 - \frac{SG_{H_2O}}{SG_{oil}}\right) h$$

$$Q = \sqrt{\frac{2g\left(1 - \frac{SG_{H_2O}}{SG_{oil}}\right)}{\frac{1}{A_A^2} - \frac{1}{A_B^2}}}$$

$A_A = \pi \frac{d^2}{4}$

$d = 4\text{in} / 12\text{in} = 0.333\,ft$

$A_A = \pi \frac{0.333^2}{4}$

$A_A = 0.087\,ft^2$

$A_B = \pi \frac{d^2}{4}$

$d = 2\text{in} / 12\text{in} = 0.1667$

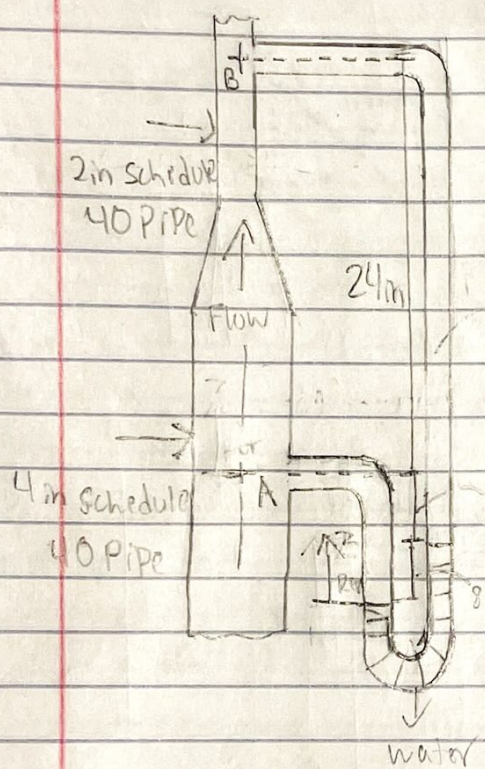
$A_B = \pi \frac{0.1667^2}{4}$

$A_B = 0.0218\,ft^2$

$$Q = \sqrt{\frac{(2)(32.2\,ft/s^2)\left(1 - \frac{13.54}{0.90}\right)\left(\frac{28\text{in}}{12\text{in}}\right)}{\frac{1}{(0.087\,ft^2)^2} - \frac{1}{(0.0218\,ft^2)^2}}}$$

$$\boxed{Q = 1.03\,ft^3/s}$$

6.82 Oil with a specific weight of 55.0 lb/ft³ flows from A to B through the system. Calculate the volume flow rate of the oil.



2in Schedule 40 Pipe → 0.1723 ft inside diameter → $A_B = 0.02333\ ft^2$

4in schedule 40 Pipe → 0.3355 ft inside diameter → $A_A = 0.08840\ ft^2$

Oil: $\gamma_{oil} = 55.0\ lb/ft^3$

$Q_A = Q_B \quad V_A A_A = V_B A_B$

$Q_A = V_A A_A \quad V = \frac{Q}{A}$

$$\cancel{h_A} + \frac{P_A}{\gamma_{oil}} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma_{oil}} + \frac{V_B^2}{2g} + Z_B + \cancel{h_R} + \cancel{h_L}$$

$$P_A + \left(\gamma_{oil} \cdot 14in \cdot \tfrac{1ft}{12in}\right) - \left(\gamma_{H_2O} \cdot 8in \cdot \tfrac{1ft}{12in}\right) - \left(\gamma_{oil} \cdot 24in \cdot \tfrac{1ft}{12in}\right) = P_B$$

$$P_B - P_A = 55.0\ lb/ft^3\left(\tfrac{14}{12}\right) - \left(62.4\ lb/ft^3\left(\tfrac{8}{12}\right)\right) - \left(55.0\ lb/ft^3\left(\tfrac{24}{12}\right)\right)$$

$$P_B - P_A = -87.43\ lb/ft^2$$

$$\frac{P_A - P_B}{\gamma_{oil}} + Z_A - Z_B = \frac{V_B^2 - V_A^2}{2g} \qquad V^2 = \frac{Q^2}{A^2}$$

$$\frac{P_A - P_B}{\gamma_{oil}} + (Z_A - Z_B) = \frac{1}{2g}\left(\frac{Q_B^2}{A_B^2} - \frac{Q_A^2}{A_A^2}\right)$$

$$\frac{P_A - P_B}{\gamma_{oil}} + (Z_A - Z_B) = \frac{Q^2}{2g}\left(\frac{1}{A_B^2} - \frac{1}{A_A^2}\right)$$

$$\left(\frac{\frac{P_A - P_B}{\gamma_{oil}} + (Z_A - Z_B)}{\frac{1}{A_B^2} - \frac{1}{A_A^2}}\right) = \frac{Q^2}{2g}$$

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$$Q^2 = \left(\frac{\frac{P_A - P_B}{\gamma_{oil}} + (Z_A - Z_B)}{\frac{1}{A_B^2} - \frac{1}{A_A^2}} \right) 2g$$

$$Q = \sqrt{\frac{\left(\frac{P_A - P_B}{\gamma_{oil}} + (Z_A - Z_B)\right) 2g}{\frac{1}{A_B^2} - \frac{1}{A_A^2}}}$$

$$P_B - P_A = -87.43 \text{ lb/ft}^2$$

$$P_A - P_B = 87.43 \text{ lb/ft}^3$$

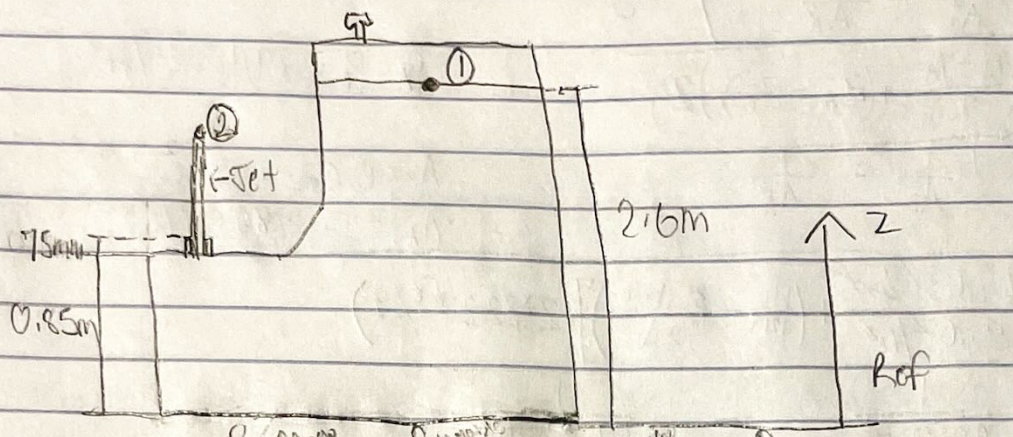
$$A_B = 0.02333 \text{ ft}^2$$

$$A_A = 0.08840 \text{ ft}^2$$

$$Q = \sqrt{\frac{\left[\frac{-87.43 \text{ lb/ft}^2}{55.0 \text{ lb/ft}^3} + \left(\frac{14}{12} - \frac{38.1 \text{ ft}}{12.10}\right)\right](2 \cdot 32.2 \text{ ft/s}^2)}{\frac{1}{0.02333 \text{ ft}^2} - \frac{1}{0.08840 \text{ ft}^2}}}$$

$$\boxed{Q = 0.368 \text{ ft}^3/\text{s}}$$

6.91 To what height will the jet of the fluid rise for the conditions



$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_R + h_L$$

($P_1 = 0$ gage; $V_1 = 0$ (large reservoir); $P_2 = 0$ gage; $V_2 \neq 0$; $h_A = 0$)

$$V_1 A_1 = V_2 A^2$$

$$0 \cdot A = V_2 \cdot A$$

$$0 = 0$$

$$z_1 = z_2$$

$$z_1 = 2.6\text{m}$$

$$z_2 = 2.6\text{m}$$