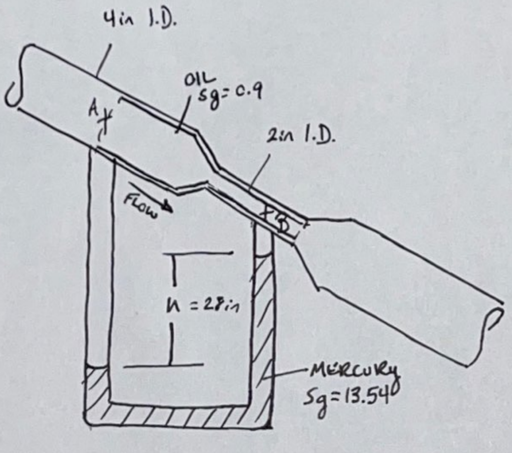
MET 330 HW-1.3 AUSTIN GOODMAN

6.79) OIL W/ A 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.



GIVEN: $Sg_{oil} = 0.9$ $\quad h = 28\,in \cdot \frac{1\,ft}{12\,in} = 2.\bar{3}\,ft$ $\quad D_A = 4\,in$

$Sg_{Hg} = 13.54$ $\quad Q = A \cdot V \ (\frac{ft^3}{s})$ $\quad D_B = 2\,in$

$A_1V_1 = A_2V_2$ $\quad \gamma = \rho g$

SOLUTION:

1. $D_A = 4\,in \cdot \frac{1\,ft}{12\,in} = 0.333\,ft$

$D_B = 2\,in \cdot \frac{1\,ft}{12\,in} = 0.167\,ft$

2. $A_A = \frac{\pi}{4} D_A^2 \rightarrow \frac{\pi}{4}(0.333\,ft)^2 = 0.087\,ft^2$

$A_B = \frac{\pi}{4} D_B^2 \rightarrow \frac{\pi}{4}(0.167\,ft)^2 = 0.022\,ft^2$

$A_A = 0.087\,ft^2$

$A_B = 0.022\,ft^2$

3. FROM BERNOULLI'S, $H = \left(\left(\frac{P_A}{\rho g}\right) + z_A\right) - \left(\left(\frac{P_B}{\rho g}\right) + z_B\right)$ ①

$\rightarrow H = h\left(\frac{Sg_{Hg}}{Sg_{oil}} - 1\right) = 2.333\,ft\left(\frac{13.54}{0.9} - 1\right)$

$\rightarrow H = 32.7657\,ft$

$$\frac{P_A}{\rho g} + z_A + \frac{V_A^2}{2g} = \frac{P_B}{\rho g} + z_B + \frac{V_B^2}{2g}$$

$$\rightarrow \underbrace{\frac{P_A}{\rho g} + z_A - \frac{P_B}{\rho g} + z_B}_{H} = \frac{V_B^2}{2g} - \frac{V_A^2}{2g}$$

$\rightarrow H = \frac{V_B^2}{2g} - \frac{V_A^2}{2g}$

$H = \frac{V_B^2 - V_A^2}{2g}$

$\rightarrow H2g = V_B^2 - V_A^2$

$\rightarrow (32.7657\,ft)(2)(32.2\,ft/s^2) = V_B^2 - V_A^2$

$2110.11\,\frac{ft^2}{s^2}\ V_B^2 - V_A^2$

4. USING CONTINUITY EQ., $A_AV_A = A_BV_B$

$\rightarrow V_A = \frac{A_B}{A_A} \cdot V_B \rightarrow \frac{(0.022\,ft^2)}{(0.087\,ft^2)} \cdot V_B$

$\rightarrow V_A = 0.253\,V_B$

$\rightarrow V_B^2 - (0.253\,V_B)^2 = 2110.11\,\frac{ft^2}{s^2}$

$\rightarrow 1V_B^2 - 0.0625\,V_B^2 = 2110.11$

$\rightarrow 0.9375\,V_B^2 = 2110.11$

$\rightarrow V_B^2 = 2251.1$

$\rightarrow V_B = \sqrt{2251.1\,\frac{ft^2}{s^2}}$

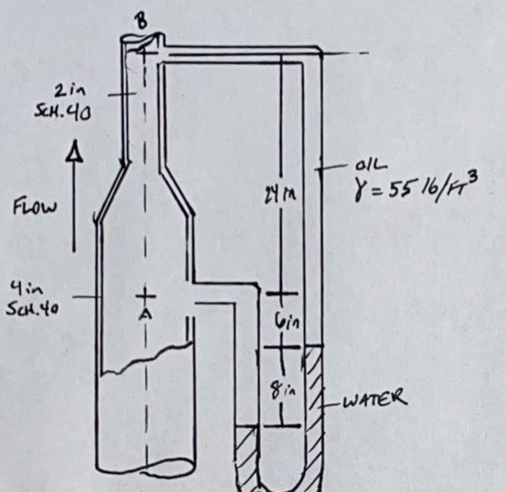
$V_B = 47.446\,\frac{ft}{s}$

5. USING VOLUME FLOW RATE, $Q = AV$

$\rightarrow Q_{oil} = A_B \cdot V_B \rightarrow (0.022\,ft^2)(47.446\,\frac{ft}{s})$

$$\boxed{Q_{oil} = 1.044\,\frac{ft^3}{s}}$$

6.82) OIL WITH A SPECIFIC WEIGHT OF 55 lb/FT^3 FLOWS FROM A TO B THROUGH THE SYSTEM. CALCULATE THE VOLUME FLOW RATE OF THE OIL.



GIVEN: $\gamma_{OIL} = 55$ lb/FT^3

$h = 8\text{ in} \cdot \frac{1\text{FT}}{12\text{in}} = 0.667$ FT

$\gamma_{WATER} = 62.4$ lb/FT^3

$Z_A - Z_B = 24\text{ in} \cdot \frac{1\text{FT}}{12\text{in}} = -2$ FT

$y = 6\text{in} \cdot \frac{1\text{FT}}{12\text{in}} = 0.5$ FT

$D_A = 0.3355$ FT
$D_B = 0.1723$ FT
App. F (F.1) FOR SCH.40

$A_B = 0.02333$ FT^2
$A_A = 0.08840$ FT^2

SOLUTION: START W/ BERNOULLI'S,

1. $$\frac{P_A}{\gamma} + Z_A + \frac{V_A^2}{2g} = \frac{P_B}{\gamma} + Z_B + \frac{V_B^2}{2g}$$

$$\rightarrow \frac{P_A - P_B}{\gamma} + Z_A - Z_B = \frac{V_B^2 - V_A^2}{2g} \quad (1)$$

2. FOR MANOMETER...

$$\rightarrow P_A + \gamma_{OIL}(0.5\text{ FT}) + \gamma_{OIL}(0.667\text{ FT}) - \gamma_w(0.667\text{ FT}) - \gamma_{OIL}(0.5\text{ FT}) - \gamma_{OIL}(2\text{ FT}) = P_B$$

$$\rightarrow P_A - P_B = \gamma_{OIL}(2\text{ FT} - 0.667\text{ FT}) + \gamma_w(0.667\text{ FT})$$

$$P_A - P_B = \gamma_{OIL}(1.333\text{ FT}) + \gamma_w(0.667\text{ FT})$$ *DIVIDE BY γ_{OIL}*

$$\rightarrow \frac{P_A - P_B}{\gamma_{OIL}} = 1.333\text{ FT} + \frac{\gamma_w(0.667\text{ FT})}{\gamma_{OIL}}$$

$$= 1.333\text{ FT} + \frac{62.4\frac{\text{lb}}{\text{FT}^3}(0.667\text{ FT})}{55\frac{\text{lb}}{\text{FT}^3}}$$

$$= 1.333\text{ FT} + 0.756742\text{ FT}$$

$$\frac{P_A - P_B}{\gamma_{OIL}} = 2.08974\text{ FT}$$

3. SOLVE CONTINUITY EQ. FOR ONE VARIABLE...

$$\rightarrow A_A V_A = A_B V_B \rightarrow V_B = V_A\left(\frac{A_A}{A_B}\right) \rightarrow V_A\left(\frac{0.08840\text{ FT}^2}{0.02333\text{ FT}^2}\right)$$

$$V_B = 3.78911\,V_A$$

(NEED V_B^2) $\rightarrow V_B^2 = 14.3574\,V_A^2$

SUBSTITUTE $\rightarrow V_B^2 - V_A^2 \rightarrow 14.3574\,V_A^2 - V_A^2 = 13.3574\,V_A^2$

$$V_B^2 - V_A^2 = 13.3574\,V_A^2$$

4. SOLVE EQ. (1) (BERNOULLI'S EQ.)...

$$\rightarrow \frac{P_A - P_B}{\gamma_{OIL}} + Z_A - Z_B = \frac{V_B^2 - V_A^2}{2g}$$

$$\rightarrow (2.08974\text{ FT}) + (-2\text{ FT}) = \frac{13.3574\,V_A^2}{(2 \cdot 32.2\frac{\text{FT}}{\text{S}^2})}$$

$$\rightarrow V_A = \sqrt{\frac{2 \cdot 32.2\frac{\text{FT}}{\text{S}^2} \cdot 0.08974\text{ FT}}{13.3574}}$$

$$\rightarrow V_A = 0.657771\ \frac{\text{FT}}{\text{S}}$$

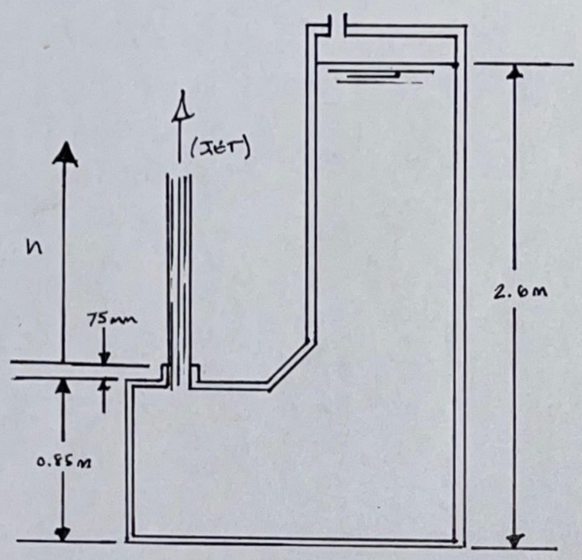
5. CALCULATE VOLUME FLOW RATE (Q)...

$$\rightarrow V_B = 3.78911\,V_A$$
$$= 3.78911(0.657771\tfrac{\text{FT}}{\text{S}})$$
$$= 2.49237\ \tfrac{\text{FT}}{\text{S}}$$

$$\rightarrow Q_{OIL} = A_B \cdot V_B = 0.02333\text{ FT}^2(2.49237\tfrac{\text{FT}}{\text{S}})$$
$$= 0.058147\ \frac{\text{FT}^3}{\text{S}}$$

$$\boxed{Q_{OIL} = 0.058\ \frac{\text{FT}^3}{\text{S}}}$$

6.91) TO WHAT HEIGHT WILL THE JET OF FLUID RISE FOR THE CONDITIONS SHOWN?



GIVEN: $Z_A = h + 0.075m + 0.85m$

$Z_B = 2.6m$

* WITHOUT ADDITIONAL PRESSURE APPLIED, THE JET SHOULD REACH A HEIGHT EQUAL TO THE ELEVATION OF THE FREE SURFACE OF THE FLUID IN TANK.

— CH. 6, Pg 139

SOLUTION: 1. USING BERNOULLI'S...

$$\rightarrow \cancel{\frac{P_A}{\rho g}} + Z_A + \cancel{\frac{V_A^2}{2g}} = \cancel{\frac{P_B}{\rho g}} + Z_B + \cancel{\frac{V_B^2}{2g}}$$

$$\rightarrow Z_A = Z_B$$

$$\rightarrow h + 0.075m + 0.85m = 2.6m$$

$$\boxed{h_{JET} = 1.675m}$$