Chapter 15.4

PROBLEM: A SHARP-EDGED ORIFICE IS PLACED IN A 10-IN-DIAMETER PIPE CARRYING AMMONIA. IF THE VOLUME FLOW RATE IS 25 $\frac{GAL}{MIN}$, CALCULATE THE DEFLECTION OF A WATER MANOMETER

(A) IF ORIFICE DIAMETER IS 1.0 IN

(B) IF THE ORIFICE DIAMETER IS 7.0 IN

THE AMMONIA HAS A SPECIFIC GRAVITY OF 0.83 AND A DYNAMIC VISCOSITY OF 2.5×10^{-6} lb/ft³

$d_2 = \frac{1.0''}{12} = 0.083\ ft \quad A_2 = \frac{\pi d_2^2}{4} = \frac{\pi}{4}(0.083 ft)^2 = 0.00541$

(A) $d_1 = \frac{10''}{12} = 0.83\ ft \quad A_1 = \frac{\pi d_1^2}{4} = \frac{\pi}{4}(0.83\ ft)^2$

$\gamma_{AMMONIA} = 0.83 \quad A_1 = .541\ ft^2$

$\gamma_w = (62.4\ lb/ft^3)1.0$

$\beta = \frac{d}{D} = \frac{1.0}{10} = 0.1$

$\gamma_{AMMONIA} = (0.84)(62.4\ \frac{lb}{ft^3}) = 52.416\ \frac{lb}{ft^3}$

$Q = \left(\frac{25\ gal}{min}\right)\left(\frac{1\ ft^3/s}{449\ \frac{gal}{min}}\right) = .0557\ \frac{ft^3}{s}$

$V_1 = \frac{Q}{A_1} = \frac{.0557\ \frac{ft^3}{s}}{.541\ ft^2} = .103\ \frac{ft}{s}$

$N_R = \frac{V_1 D}{\nu} = \frac{(.103\frac{ft}{s})(0.83)}{1.5\times10^{-6}\ \frac{ft}{s}} = 57491.3$

$v_1 = C\sqrt{\frac{2g\frac{(P_1-P_2)}{\gamma}}{\left(\frac{A_1}{A_2}\right)^2-1}}$

$= C\sqrt{\frac{2gh(\gamma_m/\gamma_f)-1}{\left(\frac{A_1}{A_2}\right)^2-1}}$

$\nu = \frac{\eta}{\rho} = \frac{(2.5\times10^{-6}\ \frac{lb}{ft^2})}{\left(\frac{52.416\ \frac{lb}{ft^3}}{32.2}\right)}$

$\nu = 1.5\times10^{-6}\ \frac{lb}{s}$

$.103 = (.592)\sqrt{\frac{2(32.2)h\left(\left(\frac{62.4}{52.416}\right)-1\right)}{\left(\frac{.541\ ft^2}{.00541\ ft^2}\right)^2-1}} \quad \sqrt{\frac{12.3h}{9999}} = (.103)/(.592)$

$h = \frac{(.174)^2}{.00123} = 24.6\ ft$

(B) $d_2 = \frac{7.0}{12} = .583\,ft$

$A_2 = \frac{\pi}{4}(.583\,ft)^2 = .267\,ft^2$

$A_1 = .541\,ft^2$

$\beta = \frac{7.0}{10.0} = .7$

$\gamma_{AMMONIA} = 52.416\,\frac{lb}{ft^3}$

$\gamma_w = 62.4\,\frac{lb}{ft^3}$

$N_R = 57491.3$

$C = .592$

$Q = .0557\,\frac{ft^3}{s}$

$V_1 = .103\,\frac{ft}{s}$

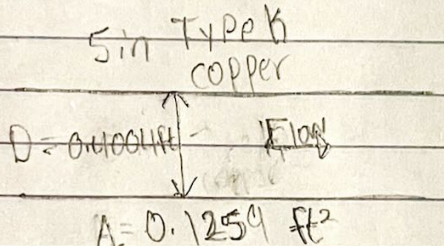
$$.103 = (.592)\sqrt{\frac{2(32.2)h\left(\frac{62.4}{52.416}\right)-1}{\left(\frac{.541\,ft^2}{.267\,ft^2}\right)^2-1}}$$

$$\sqrt{\frac{12.3h}{3.1}} = (.103)(.592)$$

$$h = (.174)^2/(3.97) = .0076\,ft$$

15.9 Problem:

A flow nozzle is to be installed in a 5in Type K copper tube carrying linseed oil at 77°F. A mercury manometer is used to measure the pressure difference accross the nozzle when expected range of flow rate is 700 gpm to 1000 gpm. The manometer scale ranges from 0 to 8.0 in of mercury. Determine the appropriate diameter of the nozzle.



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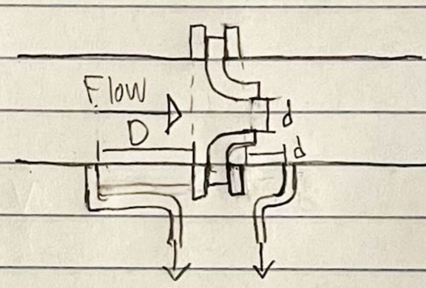

$$V_1 = C\sqrt{\frac{2gh(\gamma_m/\gamma_f)-1}{(A_1/A_2)^2-1}}$$

$700\ gpm - 1000\ gpm$

$449\ gpm$

$0 - 8\,in = 0 - 0.667\,ft$

$Q_{1-2} = 1.56\ ft^3/s - 2.23\ ft^3/s$

$$A_2 = \frac{A_1}{\sqrt{\frac{2gh(\gamma_m/\gamma_f)-1}{\left(\frac{Q}{A_1 C}\right)^2}+1}}$$

$A_1 = 0.1259\ ft^2$

$V_1 = \frac{Q}{A_1}$

$\gamma_m = 844.9\ lb/ft^3$

$\gamma_f = 58.0\ lb/ft^3$

$h = 0.667\ ft$

$C = 0.92$

$\frac{\pi d^2}{4} = 0.0768\ ft^2$

$C_{new} = 0.91$

$d = 0.313\ ft$

Within 1%

$N_R = \frac{vD}{\nu} = \frac{\left(\frac{2.23}{0.667}\right)(0.4004\ ft)}{3.84\times10^{-4}}$

$N_R = 3486.1$

$\boxed{d = 0.313\ ft \text{ or } 3.76\ in}$

15.15	HW 2.3	

A pitot-static tube is inserted into a duct carrying air at standard atmospheric pressure & a temperature of 50°C. A differential manometer reads 0.24 in of water. Calculate the velocity of the flow

temp: $50°C = 122°F$ $\quad g = 32.2\ ft/s$ $\quad \gamma_{aire_{122°F}} \approx 0.06846\ lb/ft^3$

$h_{H_2O}: 0.24 in = 0.024\ ft$ $\quad \gamma_g = 62.4\ lb/ft^3$

$$v_1 = \sqrt{2gh(\gamma_g - \gamma)/\gamma}$$

$$v_1 = \sqrt{2(32.2\ ft/s)(0.024\ ft)(62.4\ lb/ft^3 - 0.06846\ lb/ft^3)/0.06846\ lb/ft^3}$$

$$v_1 = \sqrt{64.4\ ft/s\ (0.024\ ft)(62.33154\ lb/ft^3)/0.06846\ lb/ft^3}$$

$$v_1 = \sqrt{96.34/0.06846\ lb/ft^3}$$

$$v_1 = \sqrt{1407.25}$$

$$\boxed{v_1 = 37.51\ ft/s}$$