Tai Booker

MET 330

HW 2.3

Chapter 15

4. A sharp-edged orifice is placed in a 10-in-diameter pipe carrying ammonia. If the volume flow rate is 25 gal/min, calculate the deflection of a water manometer (a) if the orifice diameter is 1.0 in and (b) if the orifice diameter is 7.0 in. The ammonia has a specific gravity of 0.83 & a dynamic viscosity of 2.5×10^{-6} lb·/ft²

1 in = 0.083 ft

velocity of flow through a section

$$v_1 = C\sqrt{\frac{2gh[(\gamma_m/\gamma_A)-1]}{(A_1/A_2)^2-1}}$$

deflection of manometer

$$h = \left(\frac{v_1}{C}\right)^2 \frac{(A_1/A_2)^2-1}{2g[(\gamma_m/\gamma_A)-1]}$$

$$v_1 = \frac{Q}{A_1} = \frac{0.056}{0.541}$$

$$v_1 = 0.1035 \frac{ft}{s}$$

$\gamma_A = sg \times 62.4$ lb/ft³

$\gamma_A = (0.83)\times(62.4)$

$\gamma_A = 51.79$ lb/ft³

$$\nu = \frac{\mu}{\rho} \Rightarrow \rho_A = sg_A \times \rho_{H_2O}$$

$\rho_A = (0.83)\times(1.94)$

$\rho_A = 1.6102$ slugs/ft³

$$\Downarrow$$

$$\nu = \frac{2.5\times10^{-6}}{1.6102}$$

$\nu = 1.55\times10^{-6}$ ft²/s

a) $A_1 = \frac{\pi D^2}{4} = \frac{\pi(0.83)^2}{4} = 0.541\ ft^2$

$A_2 = \frac{\pi D_1^2}{4} = \frac{\pi(0.083)^2}{4} = 5.41\times10^{-3}\ ft^2$

$N_R = \frac{v_1 D}{\nu} = \frac{(0.1035)(0.83)}{1.55\times10^{-6}} = 5.54\times10^4$

C = 0.594

$d_o = 1$ in

$d_p = 10$ in

$\beta = \frac{d_o}{d_p} = \frac{1}{10} = 0.1$

$$h = \left(\frac{0.1035}{0.594}\right)^2 \frac{(0.541/6.41\times10^{-3})^2-1}{2(32.2)[(62.4/51.79)-1]}$$

$$h = 0.0303\left(\frac{9999}{13.193}\right) = \boxed{h = 23\ ft}$$

b) $d_{o_2} = 7$ in $= 0.58$ ft

$A_2 = \frac{\pi d_{o_2}^2}{4} = \frac{\pi(0.58)^2}{4} = 0.264\ ft^2$

C = 0.618

$\beta = \frac{d_{o_2}}{d_p} = \frac{7.0}{10} = 0.7$

$$h = \left(\frac{0.1035}{0.618}\right)^2 \frac{(0.541/0.264)^2-1}{2(32.2)[(62.4/51.79)-1]}$$

$$h = 0.028\left(\frac{3.199}{13.193}\right)$$

$$\boxed{h = 0.00678\ ft}$$

Ch.15 #15 Team 7 Melanie Cruz Contee

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

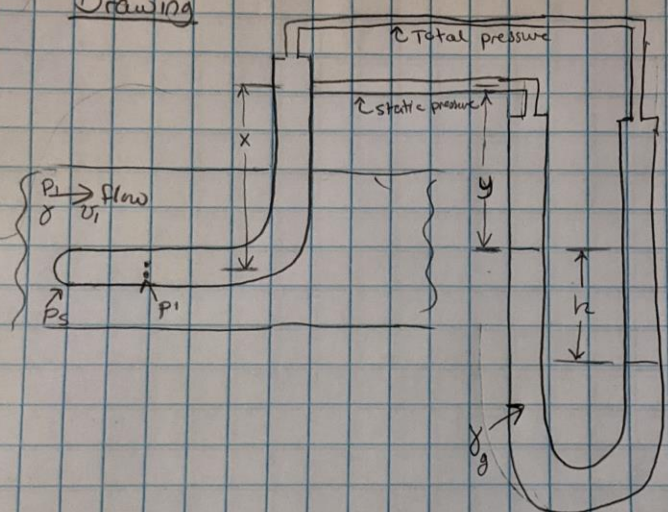
Data & Variables

$T = 50°C = 122°F$ $\gamma_g = 62.4\ lb/ft^3$

$h = 0.24in = 0.02ft$ $\gamma = 0.0764\ lb/ft^3$ Appendix E-2

$g = 32.2\ ft/s^2$

Drawing



Calculation

$0.24in \times \frac{0.083ft}{1in} \approx 0.02ft$

$F = (C \times 1.8) + 32$

$(50 \times 1.8) + 32$

$F = 122°F$

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

$= \sqrt{2(32.2)(0.02)(62.4 - 0.0764)/0.0764}$

$\boxed{v_1 = 32.41\ ft/s}$ Velocity of flow of air through the pipe

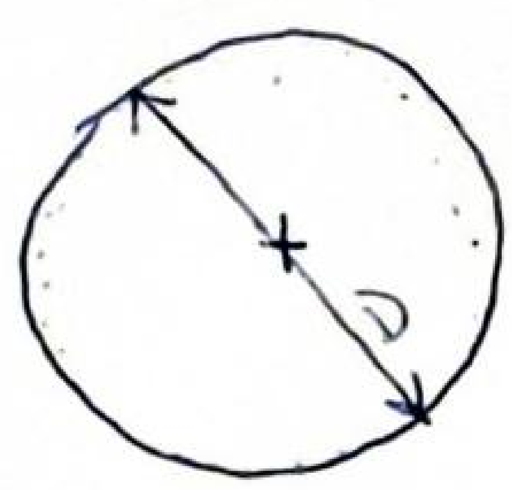
While reviewing the lecture notes and problems, I noticed that Bernoulli's equation is still being used. It can be manipulated to figure calculations for orifice meters, flow tubes and flow nozzles. I also noticed that the volume flow rate equation is used as well for measuring pressure differences.
If a differential manometer is used, the manometer deflection (h) can be related directly to the velocity.

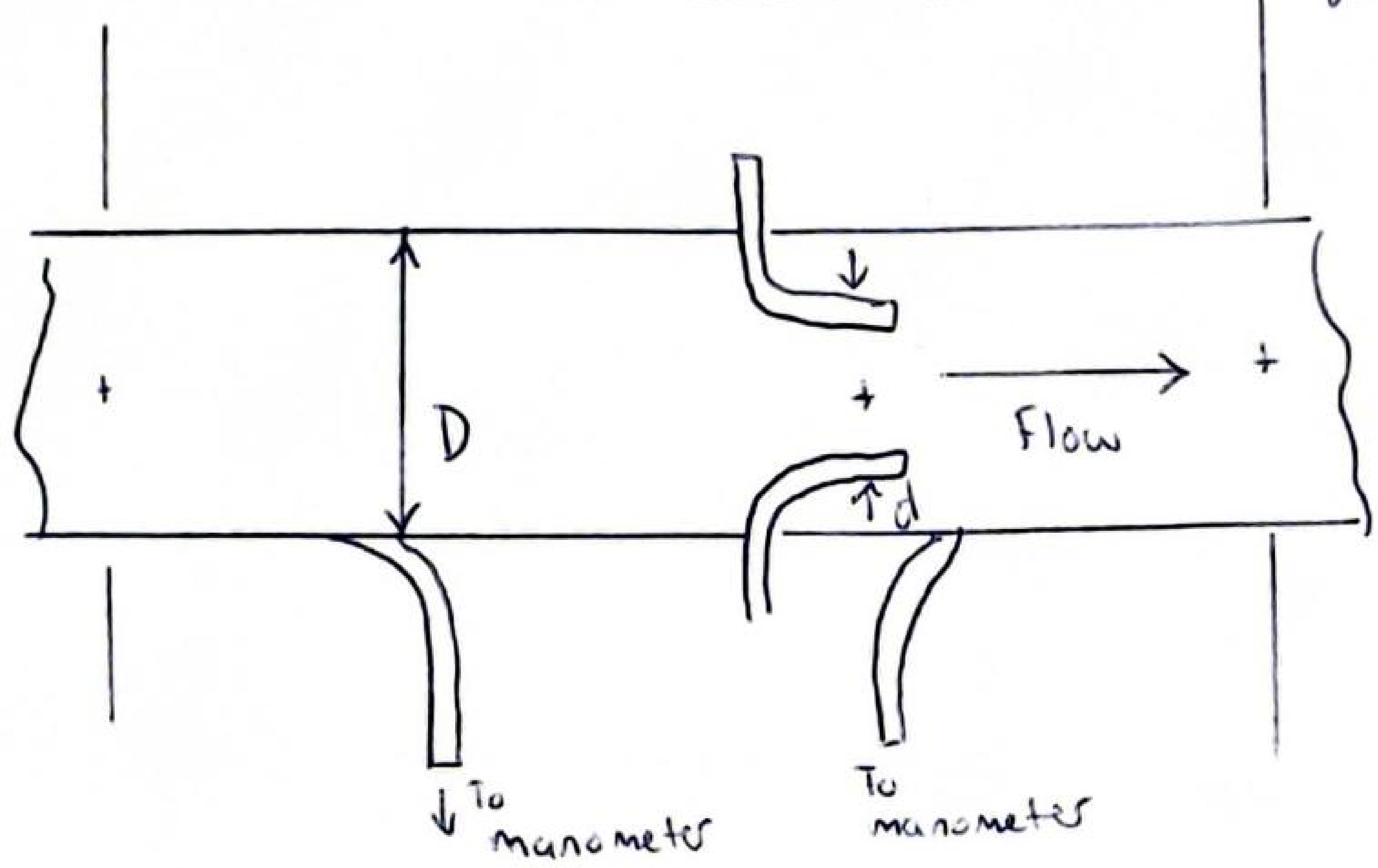
15.9 Chris Betton Team 7

Data & Variables

- Appendix H: 5in type K copper $\therefore$ Flow Area $= 1.259 \times 10^{-1}\,ft^2$
  Diameter$_{inside} = 0.4004\,ft$
- Range of flow rate $= 700\,gal/min \rightarrow 1000\,gal/min$
- Manometer Range $= 0 \rightarrow 8.0\,in\,Hg$
  $= 0 \rightarrow 0.6\overline{6}\,ft$
- Linseed oil @ 77°F $\gamma = 58.10\,\frac{lb}{ft^2}$ $\nu = 3.84 \times 10^{-4}\,\frac{ft^2}{sec}$
- $\gamma_{mercury} = 844.9\,\frac{lb}{ft^3}$
- gravity $= 32.2\,\frac{ft}{sec^2}$

Drawing





Calculations

$$\frac{700\,gal}{min}\cdot\frac{1\,min}{60\,sec}\cdot\frac{1\,ft^3}{7.48\,gal} = 1.559714795\,\frac{ft^3}{sec} \qquad \frac{1000\,gal}{min}\cdot\frac{1\,min}{60\,sec}\cdot\frac{1\,ft^3}{7.48\,gal} = 2.22816\,\frac{ft^3}{sec}$$

$$V_{max} = C_{max}\sqrt{\frac{2gh(\gamma_m/\gamma)-1}{(A/A_1)^2-1}} \;\therefore\; \frac{V_{max}}{C_{max}} = \sqrt{\frac{2gh(\frac{\gamma_m}{\gamma})-1}{(\frac{A}{A_1})^2-1}} \;\therefore\; \left(\frac{A}{A_1}\right)^2 - 1 = \frac{2gh(\frac{\gamma_m}{\gamma})-1}{(\frac{V_{max}}{C_{max}})^2}$$

$$\therefore\; \left(\frac{A}{A_1}\right) = \sqrt{\frac{2gh(\frac{\gamma_m}{\gamma})-1}{(\frac{V_{max}}{C_{max}})^2}+1} \;\therefore\; A_1 = \frac{A}{\sqrt{\frac{2gh(\frac{\gamma_m}{\gamma})-1}{(\frac{V_{max}}{C_{max}})^2 \cancel{-1}}+1}}$$ equation

$$V = \frac{Q}{A} = \frac{1.559714795\,ft^3}{sec}\cdot\frac{1}{1.259 \times 10^{-1}\,ft^2} = 12.70623348\,\frac{ft}{sec}$$

Loop

$$N_R = \frac{vD}{\nu} = \frac{12.70623348\,ft}{sec}\cdot\frac{.4004\,ft\;\;sec}{3.84 \times 10^{-4}\,ft^2} = 13248.89553$$

Fig 15.5 (Flow Nozzle Disch. Coeff) = $C = 0.955$

Max

$$V = \frac{Q}{A} = \frac{2.22816\ ft^3}{sec} \Big| \frac{}{1.259\times10^{-1}\ ft^2} = 17.69785544\ \frac{ft}{sec}$$

$$N_R = \frac{17.69785544\ ft}{sec} \Big| \frac{.4004\ ft}{} \Big| \frac{sec}{3.84\times10^{-4}\ ft^2} = 18453.70135\ \frac{ft}{sec}$$

Fig 15.5 (Flow Nozzle Disch coeff) → $C = .960$

(1) $$A_1 = \frac{A}{\sqrt{\frac{2gh\left(\frac{\gamma m}{\gamma}\right)(C_{max})^2}{V_{max}^2}+1}} = \frac{1.259\times10^{-1}\ ft^2}{\sqrt{\frac{2(32.2\frac{ft}{sec^2})(.605\ ft)\left(\frac{844.95}{58}\right)(.960)^2}{(17.69785544\ ft/sec)^2}+1}}$$

$$A_1 = 0.074704825\ ft^2$$

$$A_1 = \frac{\pi}{4}d^2 \quad \therefore \quad d = \sqrt{A_1 \cdot \frac{4}{\pi}} \quad \boxed{d = 0.308410663\ ft = 3.70092\ in}$$

After reviewing the lecture notes & example problems it is clear that the principles established earlier in this course still apply, but for a wide range of applications. For example, Bernoulli's equation can be rearranged for different types of differential pressure flow meters such as nozzles, orifice meters, & flow tubes. That being said, there are many ways of determing flow through a system. Flow rate can be measured directly or indirectly through average velocity.

Also, the type of differential pressure flow meter used in a system directly affects the pressure drop in the system. Since an orifice meter has a sudden contraction in area, there is a large pressure loss. On the other hand, a venturi meter has a gradual decrease in diameter, therefore there is less pressure loss.