Homework #2.1

Ch 10 Minor Losses

Ch 11 Series Pipeline Systems

MET 330 Virginia Beach Distance Learning WC2 and Campus

Nathanael Yapnayon - Aaron Jackson - Zach Hollifield

Zach Hollifield

Homework 2.1

From the problems in chapter 10 minor losses and chapter 11 series pipeline systems I learned there will always be energy losses due to friction in a pipe were a fluids flows. We use Darcy-Weisbach equation to solve for major energy losses due to friction. To find friction factor we must calculate Reynolds number. The resistance coefficient K is found in the book. Sometimes problems must be iterated in order to determine the required pipe diameter.

Chapter 10: 20, 37, 39, 43, 46, 48

20) Determine the energy loss for a sudden contraction from a DN 125 schedule 80 steel pipe to a DN 50 schedule 80 pipe for a flow rate of 500 L/min.

DN 125 $Out_D = 141.3\text{ mm}$ $Wall_T = 9.5\text{ mm}$ $In_D = 128.2\text{ mm}$

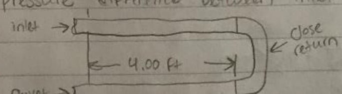
$h_L = K \times \left(\frac{V_2^2}{2g}\right)$ DN 50 $Out_D = 60.3\text{ mm}$ $Wall_T = 5.54\text{ mm}$ $In_D = 52.5\text{ mm}$

$Q = AV$ $V = \frac{Q}{A}$ $\frac{D_1}{D_2} = \frac{128.2}{52.5} = 2.44$ $A_2 = \frac{\pi}{4}(0.0525)^2 = 2.165\times10^{-3}\text{ m}^2$

$V_2 = \frac{500\text{ L/min}}{2.165\times10^{-3}\text{ m}^2} \times \frac{1\text{ m}^3/\text{s}}{60000\text{ L/min}} = 3.85\text{ m/s}$ From table $K = 0.39$

$h_L = K \times \left(\frac{V_2^2}{2g}\right) = (0.39)\frac{(3.85\text{ m/s})^2}{(2\times9.81\text{ m/s}^2)} = \boxed{0.295\text{ m}}$

37) A heat exchanger is made of two 1/2 in schedule 40 steel pipes. Compute the pressure difference between inlet and outlet. Flow rate = 12.5 gal/min ethylene glycol 77°F



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

$P_1 - P_2 = \gamma(h_L + h_f)$

$h_L = K\left(\frac{v^2}{2g}\right)$ $h_f = f \times \frac{L}{D} \times \frac{v^2}{2g}$

$Q = 12.5\,\frac{\text{gal}}{\text{min}} \cdot \frac{0.1337\text{ ft}^3}{1\text{ gal}} \cdot \frac{1\text{ min}}{60\text{ s}} = 0.0278\text{ ft}^3/\text{s}$

$D_{inner} = 0.0518\text{ ft}$ $A = 0.002\text{ ft}^2$

$v = \frac{Q}{A} = \frac{0.0278}{0.002} = 13.9\text{ ft/s}$ Closed loop coefficient $= K = f_T\left(\frac{L_e}{D}\right)$ $\frac{L_e}{D} = 50$

$D/\varepsilon = \frac{0.0518}{1.5\times10^{-4}} = 345.33$ $K = (0.026)(50) = 1.3$

$h_L = 1.3 \times \frac{(13.9)^2}{2\times32.2} = 3.9\text{ ft}$ $N_R = \frac{vD}{\nu} = \frac{13.9\times0.0518}{1.59\times10^{-4}} = 4528.4$

$h_f = 0.038 \times \frac{8}{0.0518} \times \frac{13.9}{2\times32.2} = 17.6\text{ ft}$

$P_1 - P_2 = \gamma(h_L + h_f)$

$= 68.47(3.9 + 17.6) \times \frac{1}{144} = \boxed{10.2\text{ psi}}$

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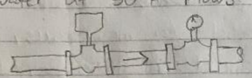
39) A pipe system for a pump contains a tee to permit the pressure at the outlet of the pump to be measured. Compute energy loss as 0.40 ft^3/s of water at 50°F flows through the tee

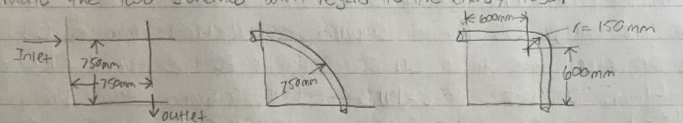


3 in schedule 40 $\quad A = 0.05132\ ft^2$

$V = \frac{Q}{A} = \frac{0.40\ ft^3/s}{0.05132\ ft^2} = 7.794\ ft/s$

$\frac{L_e}{D} = 20 \quad f = 0.017 \quad h_L = f \cdot \frac{L_e}{D} \cdot \frac{v^2}{2g} = (0.017) \cdot (20) \cdot \frac{(7.794^2)}{2 \cdot 32.2} \boxed{= 0.32\ ft}$

43) The inlet and outlet are to be connected with a 50mm OD x 2.0mm wall copper tube to carry 750 L/min of propyl alcohol at 25°C. Evaluate the two schemes with regard to the energy loss.



$d = 50 - 2 \times 2 = 46\ mm \qquad A = \frac{\pi d^2}{4} = \frac{\pi (0.046m)^2}{4} = 1.662 \times 10^{-3}\ m$

$V = \frac{Q}{A} \qquad 750\ L/min \cdot \frac{\frac{1}{1000}\ m^3/s}{1\ L/min} = 0.0125\ m^3/s \qquad V = \frac{0.0125\ m^3/s}{1.662 \times 10^{3}\ m} = 7.52\ m/s$

$\frac{L}{D} = \frac{750}{46} = 16.3m \qquad \frac{L_e}{D} = 43 \qquad \epsilon = 1.5 \times 10^{-6} m \qquad \eta = 1.92 \times 10^{-3}\ Pa \cdot s \qquad \rho = 802\ kg/m^3$

$N_R = \frac{vD\rho}{\eta} = \frac{7.52 \times 0.046 \times 802}{1.92 \times 10^{-3}} = 144493.67 \qquad \frac{D}{\epsilon} = \frac{0.046}{1.5 \times 10^{-6}} = 30666.67$

Moody chart $\quad f_T = 0.0095 \quad f = 0.0162 \quad K = f_T\left(\frac{L_e}{D}\right) = 0.0095(43) = 0.4085$

$h_L = 0.4085 \times \frac{(7.52)^2}{(2)(9.81)} \boxed{= 1.177m}$

$\frac{r}{D} = \frac{150}{46} = 3.261 \qquad \frac{L_e}{D} = 13 \qquad h_L = 0.0095 \times 13 \times \frac{(7.52)^2}{2 \times 9.81} = 0.356m$

$h_{L2} = f \cdot \frac{L}{D} \cdot \frac{v^2}{2g} \qquad h_{L2} = 0.0162 \times \frac{1.2}{0.046} \times \frac{(7.52)^2}{2 \times 9.81} = 1.218m$

$h_L = h_{L1} + h_{L2} \rightarrow h_L = 0.356 + 1.218 = \boxed{1.574m}$

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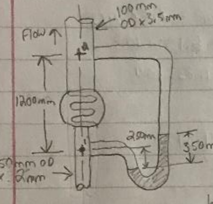
46) Figure shows a test setup for determining the energy loss due to a heat exchanger. Water at 50°C is flowing vertically upward at $6.0 \times 10^{-3}\ m^3/s$. Calculate the energy loss between points 1 and 2. Determine the resistance coefficient for the heat exchanger based on the velocity in the inlet tube.



$d_1 = D_1 - 2t_1 \rightarrow d_1 = 50 - 2 \times 2 = 46\ mm$

$A_1 = \frac{\pi}{4} d_1^2 \rightarrow A = \frac{\pi}{4}(0.046m)^2 = 1.662 \times 10^{-3}\ m^2$

$d_2 = D_2 - 2t_2 \rightarrow d_2 = 100 - 2 \times 3.5 = 93\ mm$

$A_2 = \frac{\pi}{4} d_2^2 \rightarrow A = \frac{\pi}{4}(0.093m)^2 = 6.8 \times 10^{-3}\ m^2$

$V_1 = \frac{Q}{A_1} = \frac{6.0 \times 10^{-3}\ m^3/s}{1.662 \times 10^{-3}\ m^2} = 3.61\ m/s$ $\quad V_2 = \frac{Q}{A_2} = \frac{6.0 \times 10^{-3}\ m^3/s}{6.8 \times 10^{-3}\ m^2} = 0.8823\ m/s$

$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L \rightarrow h_L = \frac{p_1 - p_2}{\gamma} + (z_1 - z_2) + \frac{V_1^2 - V_2^2}{2g}$

$h_L = \frac{132.8(0.35)}{9.69} + \frac{9.69(0.85)}{9.69} + (0 + 1.2m) + \frac{3.61^2 - 0.8823^2}{2 \times 9.81} = \boxed{5.07m}$

$h_L = K\left(\frac{V^2}{2g}\right) \rightarrow 5.07 = K\left(\frac{3.61^2}{2 \times 9.81}\right)$ $\boxed{K = 7.64}$

48) Compute the energy loss in a 90° bend in a steel tube used for a fluid power system. The tube has a 1 1/4 OD and a wall thickness of 0.083 in. The mean bend radius is 3.25 in. The flow rate of hydraulic oil is 27.5 gal/min.

$h_L = K\left(\frac{V^2}{2g}\right)$ $\quad A = 6.0 \times 10^{-3}\ ft^2$ $\quad D = 0.0874\ ft$

$\frac{r}{D} = \frac{3.25\ in\left(\frac{1 ft}{12 in}\right)}{0.0874\ ft} = 3.099$ $\quad \frac{L_e}{D} = 12.5$ $\quad \epsilon = 1.5 \times 10^{-4}\ ft$

$\frac{D}{\epsilon} = \frac{0.0874}{1.5 \times 10^{-4}} = 602.2$ $\quad f_T = 0.0222$ $\quad K = f_T\left(\frac{L_e}{D}\right) \rightarrow K = (0.0222)(12.5) = 0.2775$

$V = 2.75\ \frac{gal}{min} \cdot \frac{0.1337\ ft^3}{1 gal} \cdot \frac{1 min}{60 sec} = 0.06127\ ft^3/s$

$V = \frac{Q}{A} = \frac{0.06127}{6.409 \times 10^{-3}} = \boxed{9.7\ ft/s}$

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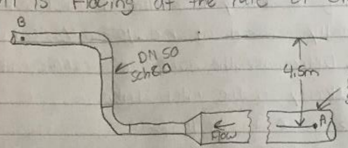
Chapter 11 5, 13, 20

5) Oil is Flowing at the rate of $0.015\ m^3/s$ in the system



$A_a = \frac{\pi \times 0.1463^2}{4} = 1.682 \times 10^{-2}\ m^2$

$A_b = \frac{\pi \times 0.0493^2}{4} = 1.905 \times 10^{-3}\ m^2$

$V_a = \frac{0.015}{1.682 \times 10^{-2}} = 0.892\ m/s$

$V_b = \frac{0.015}{1.905 \times 10^{-3}\ m^2} = 7.87\ m/s$

$N_{Ra} = \frac{0.892 \times 0.1463}{2.12 \times 10^{-5}} = 6.15 \times 10^3$

$\frac{D_a}{\epsilon} = \frac{0.1463}{4.6 \times 10^{-5}} = 3180$ $f_{sa} = 0.035$ $f_T = 0.019$

$N_{Rb} = \frac{7.87 \times 0.0493}{2.12 \times 10^{-5}} = 1.83 \times 10^4$

$\frac{D_b}{\epsilon} = \frac{0.0493}{4.6 \times 10^{-5}} = 1072$ $f_{sb} = 0.028$ $f_T = 0.019$

$h_1 = 0.035 \times \frac{185}{0.1463} \times \frac{0.892^2}{2 \times 9.81} = 1.75\ m$ $h_2 = 0.028 \times \frac{2}{0.0493} \times \frac{7.87^2}{2 \times 9.81} = 14.34\ m$

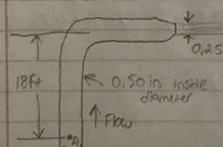
$h_3 = 2 \times 20 \times 0.019 \times \frac{7.87^2}{2 \times 9.81} = 2.39\ m$ $h_4 = 0.37 \times \frac{7.87^2}{2 \times 9.81} = 1.17\ m$

$h_L = 1.75 + 14.34 + 2.39 + 1.17 = 19.65\ m$

$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{P_B^2}{2g} + z_B - h_L \rightarrow P_A = \gamma\left[h_L + \frac{P_B}{\gamma} + (z_B - z_A) + \left(\frac{V_B^2}{2g} - \frac{V_A^2}{2g}\right)\right]$

$P_A = 8.80\left[19.65 + \frac{12.5 \times 10^6}{8.80} + 4.5 + \left(\frac{0.897^2}{2 \times 9.81} - \frac{7.87^2}{2 \times 9.81}\right)\right] = \boxed{12.7\ MPa}$

13) Determine the velocity of flow from the nozzle if the pressure at the bottom is a) 20 psig and 80 psig. The nozzle has a loss coefficient K of 0.15 based on the outlet velocity head. The tube ID of 0.50 in. The 90° bend has a radius of 6.0 in. The total length of straight tube is 20.0 ft. Water at 100°F



$A = \frac{\pi \times D^2}{4} = \frac{\pi \times \left(\frac{0.5}{12}\right)^2}{4} = 0.0013635\ ft^2$

$\frac{D}{\epsilon} = \frac{0.5}{1.5 \times 12 \times 10^{-4}} = 277.8$

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

$h_L = \left(\frac{P_A - P_B}{\gamma} + \left(\frac{V_A^2 + V_B^2}{2g}\right) + z_A - z_B\right) = \left(\frac{2880}{62.4} + (0 - 18)\right) = 28.15\ ft$

$Q = -2.22 \times D^2 \sqrt{\frac{g \cdot D \cdot h_L}{L}} \log\left(\frac{1}{3.7 D/\epsilon} + \frac{1.784 \nu}{D\sqrt{\frac{g \cdot D \cdot h_L}{L}}}\right)$

$Q = -2.22 \times 0.041667^2 \sqrt{\frac{32.2 \times 0.041667 \times 28.15}{20}} \log\left(\frac{1}{3.7 \times 277.8} + \frac{1.784 \times 7.37 \times 10^{-6}}{0.041667\sqrt{\frac{32.2 \times 0.041667 \times 28.15}{20}}}\right) = 0.0425\ ft^3/s$

$V = \frac{Q}{A} = \frac{0.0425}{0.0013635} = \boxed{31.2\ ft/s}$

$h_L = \left(\frac{11520}{62.4} + \left(0 - \frac{0}{2g}\right) + z_A - z_B\right) = 166.615\ ft$

$Q = -2.22 \times 0.041667^2 \sqrt{\frac{32.2 \times 0.041667 \times 166.615}{20}} \log\left(\frac{1}{3.7 \times 277.78} + \frac{1.784 \times 7.37 \times 10^{-6}}{0.041667\sqrt{\frac{32.2 \times 0.041667 \times 166.61}{20}}}\right)$

$Q = 0.088\ ft^3/s$

$V = \frac{Q}{A} = \frac{0.088}{0.0013635} = \boxed{64.5\ ft/s}$

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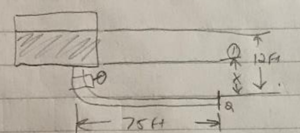
20) The tank is to be drained to a sewer. Determine the size of new schedule 40 steel pipe that will carry at least 400 gal/min of water at 80°F through the system shown. The total length of pipe is 75 ft



$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + H_{L_{1-2}}$$

$$\frac{P_A - P_B}{\gamma} - z_B = f\,\frac{L}{D}\cdot\frac{V^2}{2g} + K_{valve}\,\frac{V^2}{2g}$$

$$\frac{P_A - P_B}{\gamma} - z_B = f\,\frac{8LQ^2}{g\pi^2}\,\frac{1}{D^5} + K_{valve}\,\frac{8Q^2}{g\pi^2}\,\frac{1}{D^4}$$

$$h_1 + z_1 - h_L = h_2 + z_2 \rightarrow (12-x) + x - h_L = 0 + 0 = 12\,ft$$

$\epsilon = 1.5\times10^{-4}$ ft water at 80°F $\nu = 9.15\times10^{-6}$ ft²/s

$$D = 0.66\left[(1.5\times10^{-4})^{1.25}\left(\frac{75\,ft\times\left(\frac{400\,gal/min\times 1\,ft^3/s}{449\,gal/min}\right)^2}{32.2\,\frac{ft}{s^2}\times 12\,ft}\right)^{4.75} + (9.15\times10^{-6}\,\frac{ft^2}{s})\left(\frac{400\,\frac{gal}{min}\times 1\,\frac{ft^3}{s}}{499\,gal/min}\right)^{9.4}\right.$$

$$\left.\times\left(\frac{75\,ft}{32.2\,ft/s^2\times 12\,ft}\right)^{5.2}\right] \boxed{= 0.26\,ft}$$

Hw 2.1

Chapter 10: 20, 37, 39, 43, 46, 48

Chapter 11: 5, 13, 20

1 We learned about series Pipeline systems and the different types of classes for them. Class I determines energy losses Class II determines flow rate, and class III determines pipe diameter. From chapter 10, we learned that there will always be energy losses due to Friction in a pipe. We must calculate reynolds number to find friction factor.

	OD	thick	ID
10.20 DN 125 sch 80	– 141.3 mm	9.5	122.3 mm – 0.1223
DN 50 sch 80	– 60.3 mm	5.54	49.3 mm – 0.0493

$Q = 500\ L/min - 0.0083\ m^3/s$

$$h_L = k(V_2^2/2g)$$

$$\frac{D_1}{D_2} = \frac{0.1223}{0.0493} = 2.480$$

$$V_2 = \frac{Q}{A_2} \quad \frac{0.0083 m^3/s}{1.905 \times 10^{-3} m^2} = 4.35 m/s$$

$K = 0.38$

$$h_L = 0.38\left(4.35^2/2(9.81)\right) = 0.366 m$$

10.37 $\frac{1}{2}$ SCH 40 pipe — ID 0.0518 ft A 0.00211

Ethylene glycol at 77° F — $\rho = 2.13$ $\eta = 3.38 \times 10^{-4}$ $\gamma = 68.47$

$Q = 12.5$ gal/min — 0.0278 ft^3/s

$L = 4ft \times 2$

50 L/D

$V = \frac{Q}{A} = \frac{0.0278}{0.00211} = 13.175$ ft/s

$N_R = \frac{\rho V D}{\eta} = \frac{2.13 \cdot 13.175 \cdot 0.0518}{3.38 \times 10^{-4}} = 4300.74$

$F = 0.0429$ - Excel $D = 0.0518$ $\varepsilon = 0.00015$ $N_R = 4300.74$

$K = 50 \cdot 0.0429 = 2.145$

$h_{L\ bend} = K\left(\frac{V^2}{2g}\right) = 2.145 \cdot \frac{13.175^2}{64.4} = 5.78$ ft

$h_{L}pipe = 0.0429\left(\frac{4}{0.0518}\right)\left(\frac{13.175^2}{64.4}\right) = 17.86$ Ft

h_L total $5.76 + 17.86 = 23.46$ ft $\frac{P_1}{\gamma} + z_1 + \cancel{\frac{v_1^2}{2g}} = \frac{P_2}{\gamma} + z_2 +$

$P_1 - P_2 = 23.64 \cdot 68.47 = 1618.63 \frac{lb}{ft^2} = \boxed{11.24 \text{ psi}}$

10.39 $Q = 0.40\ ft^3/s$

H_2O @ $50°F$ = $\gamma = 62.4$ $\nu = 1.40 \times 10^{-5}$

3 in SCH 40 ID = 0.2557 A = 0.05132 ft^2

$$V = \frac{Q}{A} = \frac{0.40\ ft^3/s}{0.05132\ ft^2} = 7.79\ ft/s$$

$$N_R = \frac{vD}{\nu} = \frac{7.79 \cdot 0.2557}{1.40 \times 10^{-5}} = 142{,}279$$

$f = 0.020$ - Excel $D = 0.2557$ $\varepsilon = 1.5 \times 10^{-4}$ $N_R = 142{,}279$

$K = 20$ for tee

$K = 20 \cdot .020 = 0.4$

$$h_L = K\frac{v^2}{2g} = 0.4\left(\frac{7.79^2}{64.4}\right) = 0.377\ ft$$

10.43 Copper Tube 50mm OD 2mm wt

$1.5 \times 10^{-6} = \varepsilon$ ID = 46mm

$Q = 250\ L/min = 0.0125\ m^3/s$

Propyl alcohol @ $25°C$

$\gamma = 7.87$

$\rho = 802$

$\eta = 1.92 \times 10^{-3}$

$$h_{L_{total}} = f \frac{L}{D} \frac{V^2}{2g} + V_{elbow} \frac{V^2}{2g}$$

$$h_{L_{total}} = \left[0.0164 \cdot \left(\frac{1.2}{0.046} \right) \cdot \frac{7.52^2}{2g} \right] + \left\{ 0.1235 \left(\frac{7.52^2}{19.62} \right) \right.$$

$$= 1.619 \text{ m}$$

10.46 Water @ 50°C – $\gamma = 9.69$

$\gamma_{hg} = 132.8$

$Q = 6.0 \times 10^{-3}\ m^3/s$

	ID	A
P_1 = 50 mm OD w/ 2mm wall	46 mm	$1.662 \times 10^{-3}\ m^2$
P_2 = 100 mm OD w/ 3.5 mm wall	93 mm	$6.793 \times 10^{-3}\ m^2$

$$V_1 = \frac{Q}{A_1} = \frac{6 \times 10^{-3}}{1.662 \times 10^{-3}} = 3.61 \text{ m/s}$$

$$V_2 = \frac{Q}{A_2} = \frac{6.0 \times 10^{-3}}{6.793 \times 10^{-3}}$$

$$= 0.888 \text{ m/s}$$

10.43 cont

$V = \frac{Q}{A} = \frac{0.0175}{1.662 \times 10^{-3}} = 7.52\ m/s$

$N_R = \frac{\rho v D}{\eta} = \frac{802 \cdot 7.52 \cdot .046}{1.92 \times 10^{-3}} = 144,494$

$f = 0.0168$

Scheme I

$\frac{r}{D} = \frac{0.750}{0.046} = 16.30$

$\frac{D}{\epsilon} = \frac{0.046}{1.5 \times 10^{-6}} = 30,666.7$

f from diagram 8.7 $= 0.0095$

$\frac{L_e}{D}$ from 10.8 $= 43$

$K = 43 \cdot 0.0095 = 0.4085$

$h = \frac{KV^2}{2g}$ $h = 0.4085 \cdot \frac{7.52^2}{19.62} = 1.177\ m$

Scheme II

$\frac{r}{D} = \frac{0.150}{0.046} = 3.26$

$\frac{L}{D}$ from 10.8 $= 13$ $K = 13 \cdot 0.0095 = 0.1235$

10.48 $Q = 27.5$ gal/min $- 0.0613$ ft^3/s
$r = 3.25$

90° Bend steel tube with OD of $1\frac{1}{4}$ and Wt of 0.083in

ID
0.0903 ft $-$ 1.084 in

A
6.41×10^{-3}

$$V = \frac{Q}{A} = \frac{0.0613}{6.4 \times 10^{-3}} = 9.56\ ft/s$$

$$\frac{r}{D} = \frac{3.25}{1.084} = 3.0$$

From figure 10.24 $\frac{L}{D} = 13$

$$\frac{D}{\varepsilon} = \frac{0.0903}{1.5 \times 10^{-4}} = 602$$ From Diagram $f = 0.0225$

$$K = \left(\frac{L}{D}\right) f_T = K = 13 \cdot 0.0225 = 0.2925$$

$$h_L = K\frac{v^2}{2g} = h_L = 0.2925 \cdot \frac{7.52^2}{64.4} = 0.415\ ft$$

manometer

$$P_1 + ((0.25)(9.69)) - ((0.350)(132.8)) - ((1.1)(9.79)) = P_2$$

$$P_1 - P_2 = ((0.35 \cdot 132.8) + (0.85 \cdot 9.69))$$

$$P_1 - P_2 = 54.7165$$

$$\frac{P_1 - P_2}{\gamma} = 5.647\text{ m}$$

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

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

$$h_L = 5.647 - 1.2 + 3.61^2 - 0.483^2$$

$$h_L = 5.07\text{ m}$$

$$h_L = K\frac{V^2}{2g} = 5.07 = K\frac{3.61^2}{19.61}$$

$$K = 7.63$$

$$h_{L\,\text{elbow}} = 2\,k\,\frac{V^2}{2g} = 2\left(0.39 \cdot \frac{7.874^2}{19.62}\right) = 2.46\text{ m}$$

$$h_{L\,\text{pipe}} = f \cdot \frac{L}{D} \cdot \frac{v^2}{2g}$$

$$N_R = \frac{VD}{\gamma} = \frac{0.892 \cdot 0.1463}{2.12 \times 10^{-5}} = 6155.64$$

$f = 0.0360$ excel

$$h_L = 0.0360 \cdot \left(\frac{150}{0.1463}\right) \cdot \left(\frac{0.892^2}{19.62}\right) = 1.80\text{ m}$$

$$h_{L\,\text{pipe}_2} = f \cdot \frac{L}{D} \cdot \frac{v^2}{2g}$$

$$N_R = \frac{7.874 \cdot 0.0493}{2.12 \times 10^{-5}} = 18{,}310.74$$

$f = 0.0285$ excel

$$h_{L\,\text{pipe}\,2} = 0.0285\left(\frac{6}{0.0493}\right)\left(\frac{7.874^2}{19.62}\right) = 14.61\text{ m}$$

$$h_{L\,\text{total}} = 14.61 + 1.80 + 2.46 + 1.20 = 20.07$$

$$\frac{P_1}{\gamma} + \cancel{z_1} + \frac{v_1^2}{2g} = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g} + h_L$$

$$\frac{P_1}{9.8} + \frac{0.892^2}{19.62} = \frac{12.5 \times 10^3}{8.8} + 4.5 + \frac{7.874^2}{19.64} + 20.07$$

11.5 $Q_1 = 0.015\ m^3/s$

$\gamma = 8.80\ kN/m^3$

$\nu = 2.12 \times 10^{-5}\ m^2/s$

L of DN 150 pipe = 180 m

L of DN 50 pipe = 8 m

$P_B = 12.5\ MPa = 12.5 \times 10^3\ \frac{kN}{m^2}$

$$V_1 = \frac{Q}{A_1} = \frac{0.015}{1.682 \times 10^{-2}} = 0.892\ m/s$$

$$V_2 = \frac{Q}{A_2} = \frac{0.015}{1.905 \times 10^{-3}} = 7.874\ m/s$$

Contraction

$$\frac{D_1}{D_2} = \frac{0.1463}{0.0493} = 2.97$$

10.6, $K = 0.38$

$$h_L = K\frac{V^2}{2g} = 0.38 \cdot \frac{7.874^2}{19.68} = 1.20$$

2 90° Elbows

$$\frac{D}{\epsilon} = \frac{0.0493}{4.6 \times 10^{-5}} = 1071.74$$

f_T - figure 8.7 = 0.0195

$$K = \frac{L}{D} \cdot f_T = 0.0195 \times 20 = 0.39$$

$$\frac{P_1}{8.8} = 1448.14$$

$P_1 = 12743.63$ kPa

12.74 MPa

11.13 ID = 0.50 in

$$\frac{D}{\varepsilon} = \frac{0.5}{1.5 \cdot 12 \cdot 10^{-4}} = 277.777$$

$$h_L = \frac{P_1 - P_2}{\gamma} + \frac{V_A^2}{2g} - \frac{V_B^2}{2g} + z_A - z_B$$

$$\frac{2880}{62.4} \Rightarrow 18$$

$= 28.15$ ft

$$Q = -2.22 \cdot D^2 \sqrt{\frac{g \cdot D \cdot h_L}{L}} \log\left[\frac{1}{3.7\, D/\varepsilon} + \frac{1.784\, \nu}{D\sqrt{\frac{g \cdot D \cdot h_L}{L}}}\right)$$

$$= -2.22 \cdot 0.041667^2 \sqrt{\frac{32.2 \cdot 0.041667 \cdot 28.15}{20}} \log\left(\frac{1}{3.7 \cdot 277.777} + \frac{1.784 \cdot 7.5}{10^{?} \cdot 0.041667 \cdot \sqrt{\frac{32.2 \cdot 0.041667}{20}}}\right.$$

$= 0.0425\ ft^3/s$

$V = \frac{Q}{A} = \frac{0.088}{0.0013635}$

$= 64.53\ ft/s$

11.20 $\frac{P_1}{\gamma} + z_1 + \frac{V_1}{2g} - h_L = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$

$h_1 + z_1 - h_L = h_2 + z_2$

$12 - x + x - h_L = 0$

$h_L = 12\ ft$

$\varepsilon = 1.5 \times 10^{-4}\ ft$ from table

$V = 9.15 \times 10^{-6}\ ft^2/s$ @ $80°F$

$D = 0.66 \left\{ \varepsilon^{1.25} \left[\frac{LQ^2}{g h_L} \right]^{4.75} + \nu Q^{9.4} \left[\frac{L}{g h_L} \right]^{5.2} \right\}^{0.04}$

$D = 0.66 \left\{ (1.5 \times 10^{-4})^{1.25} \left[\left(\frac{75\ ft \cdot 400\ gal/min \cdot 1\ ft^3/s}{449\ gal/min} \right)^2 \right]^{4.75} \right.$

$\left. + \left[9.15 \cdot 10^{-6}\ \frac{ft^2}{s} \cdot \frac{400\ gal/min \cdot 1\ ft^3/s}{449\ gal/min} \right]^{9.4} \left[\frac{75\ ft}{32.2\ \frac{ft}{s^2} \cdot 12\ ft} \right]^2 \right\}$

$D = 0.66 \cdot \left\{ (2.295 \cdot 10^{-4}) + (6.12 \cdot 10^{-10}) \right\}^{0.04} = 0.3006\ ft$

$$V = \frac{Q}{A} = \frac{0.04250}{0.0013635}$$

$$= 31.17\ ft/s$$

B) $h_L = \frac{P_1 - P_2}{\gamma} + \frac{V_A^2}{2g} - \frac{V_B^2}{2g} + z_A - z_B$

$$\frac{11520}{62.4} +$$

$$= 166.615\ ft$$

$$Q = -2.22 \cdot 0.041667^2 \sqrt{\frac{32.2 \cdot 0.041667 \cdot 166.61}{20}} \log\left[\frac{1}{3.7 \cdot 277.778} + \frac{1.784.77 \times 10^{-5}}{0.041667\sqrt{\frac{32.2 \cdot 0.41666 \cdot 166.61}{20}}}\right]$$

$$= 0.086\ ft^3/s$$

Yaqinya

What we learn in class

1) We learned that series pipe line systems and how it worked in equations. We have different classes (I and II) to explain the flow rate and type of pipe diameter we use.
We use the Darcy-weisbach equation to help solve energy losses. We had to look for certain values like friction in the back of the book. Problems are sometimes iterated to find the pipe diameter.

Nathanael Yepiliyan

1

CH 10 20, 37, 39, 43, 46, 48 (11, 3, 13, 21)

20. Determine the energy loss for a sudden contraction from a DN 125 schedule 80 steel to a DN 50 schedule 80 pipe for a flow rate of 500 L/min

$K =$ use table (10.3)

Table F.9 = $D_1 = 122.3\text{ mm}$ $A_1 = 1.23 \times 10^{-3}\text{ m}^2$

$D_2 = 49.3\text{ mm}$ $A_2 = 1.905 \times 10^{-3}\text{ m}^2$

use A_2 for v_2

$$\frac{D_1}{D_2} = \frac{122.3\text{ mm}}{49.3\text{ mm}} = 2.48$$

convert

$Q = Av$

$$v_2 = \frac{Q}{A_2} = \frac{500\text{ L/min}}{1.905 \times 10^{-3}\text{ m}^2} = 262467.19\text{ gal/min}\left(\frac{1\text{ m}^3/\text{s}}{60000\text{ L/min}}\right)$$

$V = 4.374\text{ m/s}$

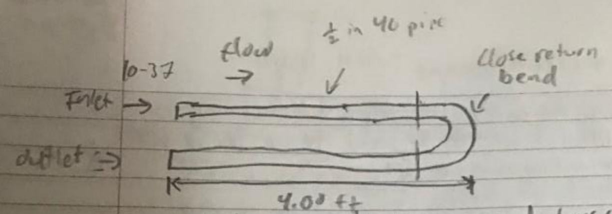
$K = 0.38$ (table 10.3)

Sudden contraction

$$h_L = K\left(\frac{v_2^2}{2g}\right) = 0.38\left(\frac{(4.371\text{ m/s})^2}{2(9.81\text{ m/s}^2)}\right)$$

$$\boxed{h_L \doteq 0.370\text{ m}}$$

2



compute pressure difference between the inlet and the outlet for a flow rate of 12.5 gal/min of ethylene glycol at 77°F

P_1 = Inlet $\quad$ P_2 = Outlet $\quad\quad$ $V_1 = V_2$

Burnolli's equation

$$\frac{P_1}{\cancel{\gamma}} + \cancel{z_1} + \cancel{\frac{v_1^2}{2g}} - h_{pipe} - h_{head} = \frac{P_2}{\gamma} + \cancel{z_2} + \cancel{\frac{v_2^2}{2g}}$$

$$\frac{P_1}{\gamma} - h_{pipe} - h_{head} = \frac{P_2}{\gamma}$$

$$\frac{P_1}{\gamma} - \frac{P_2}{\gamma} = h_p - h_h \qquad P_1 - P_2 = \gamma(h_p - h_h)$$

Flow

$Q = VA$

$$v = \frac{Q}{A} = \left(\frac{12.5\ \text{gal/min}}{0.002116\ ft^2}\right)\left(\frac{1\ ft^3/s}{449\ \text{gal/min}}\right) = 13.19\ ft/s$$

$$N_R = \frac{vD\rho}{\mu} = \frac{(13.19)(0.0518)(2.13)}{3.38 \times 10^{-4}} = 4.31 \times 10^3$$

$$\frac{D}{\varepsilon} = \frac{0.0518}{1.5 \times 10^{-4}} = 345 \qquad f = 0.041$$

Close return bend

Table 10.5

$$\frac{L_e}{D} = 50 \qquad f_T = 0.027 \qquad h_{L_{head}} = f_T \frac{L}{D}\frac{V^2}{2g}$$

$f = 0.044$

$$h_{L_{head}} = (0.027)(0.50)\left(\frac{(13.19)^2}{2(32.2)}\ ft\right) = 3.65\ ft$$

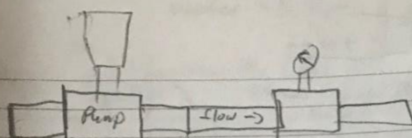
$$h_{pipe} = (0.041)\left(\frac{8.00}{0.0518}\right)\left(\frac{13.19^2}{2(32.2)}\right) = 17.12\ ft$$

$$P_1 - P_2 = (68.47)\frac{(17.12 + 3.65)}{144} = 9.87\ psi$$

ns

3

10.37



Compute the energy loss as 0.40 ft³/s of water at 50 °F flow through the tee

$$V = \frac{Q}{A} = \frac{0.40\ ft^3/s}{0.05132\ ft^2}$$

$$= 7.79\ ft/s$$

Tee flow $\frac{L}{D} = 20$

Table 10.5

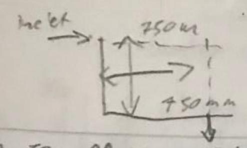
$f = \begin{pmatrix}\text{Table}\\ 10.5\end{pmatrix}$

$f = 0.018$

$$h_L = f_T \frac{L}{D}\frac{v^2}{2g} = (0.018)(20)\left(\frac{(7.79)^2}{2(32.2)}\right)$$

$$\boxed{h_L = 0.346\ ft}$$

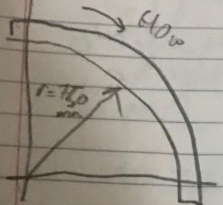
4.3

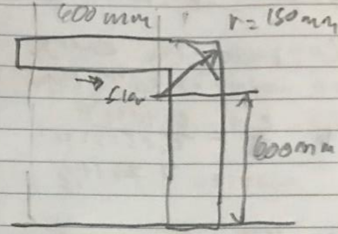


4 1)

Both 50 mm OD × 2.0 mm wall copper

$\rho = 802$





(b) Pipe Bend

$v = \frac{Q}{A} = \frac{750\,L/min}{1.945\times10^{-3}\,m^2}\left(\frac{1\,m^3/s}{60000\,L/min}\right) = 6.43\,m/s$

$N_R = \frac{vD\rho}{\mu} = \frac{(6.43)(0.0498)(802)}{1.92\times10^{-3}} = 1.34\times10^5$

Pipe bend $\frac{r}{D} = \frac{750\,mm}{49.9\,mm} = 15.1 \quad \frac{L_e}{D} = 40.5$

$\frac{D}{\varepsilon} = \frac{0.0498}{1.5\times10^{-6}} = 33200$ (Fig 2.3

Turbulence $f_T = 0.010$ $\quad f = 0.017$

$h_L = f_T\frac{L_e}{D}\frac{v^2}{2g}$

$= (0.010)(40.5)\left(\frac{(6.43)^2}{2(9.81)}\right) = \boxed{0.85\,m}$

(c) Bend tube

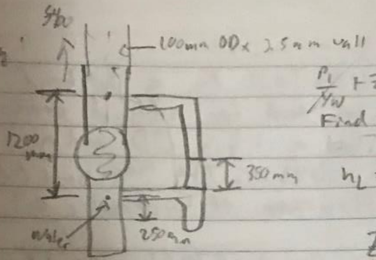
$h_{L} = f_T\frac{L_e}{D}\frac{v^2}{2g} = (0.010)(11.8)\left(\frac{(6.43)^2}{2(9.81)}\right) = 0.250\,m$

$\frac{L_e}{D} = 11.8$ $\quad \frac{r}{D} = \frac{150\,mm}{49.9\,mm} = 3.01\,mm$

$0.250\,m + 0.85\,m = \boxed{1.1\,m}$

water $= 50°C$ $\uparrow 6.0 \times 10^{-3}\ m^3/s$

Problem 4.6.



4

$$\frac{P_1}{\gamma_w} + z_1 + \frac{v_1^2}{2g} - h_L = \frac{P_2}{\gamma_w} + z_2 + \frac{v_2^2}{2g}$$

Find h_L

$$h_L = \frac{P_1 - P_2}{\gamma_w} + z_1 - z_2 + \frac{v_1^2 - v_2^2}{2g}$$

$$z_1 - z_2 = -1.20m$$

$$A_1 = \frac{\pi D_1^2}{4} = \frac{\pi (0.05m)^2}{4} = 0.001963m$$

$$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi (0.10m)^2}{4} = 0.0078$$

$$v_1 = \frac{Q}{A_1} = \frac{6.0 \times 10^{-3} m^3/s}{0.001963 m^2} = 3.056 m/s \quad v_2 = \frac{Q}{A_2} = \frac{6.0 \times 10^{-3}}{0.007854} = 0.764 m/s$$

$$\frac{v_1^2}{2g} = \frac{(3.056 m/s)}{2(9.81)} = 0.476m \quad \frac{v_2^2}{2g} = \frac{(0.764)^2}{2(9.81} = 0.0297m$$

Manometer follow based on manometer

$$P_1 + \gamma_w(0.250m) - \gamma_m(0.35m) - \gamma_w(1.10m) = P_2$$

$$\frac{P_1 - P_2}{\gamma_w} = \frac{\gamma_m(0.35)}{\gamma_w} + \frac{\gamma_w(0.85)}{\gamma_w} = \frac{132.8(0.35)}{9.69 kN/m^3} + \frac{9.69(0.85)}{9.69}$$

$$\frac{P_1 - P_2}{\gamma_w} = 4.796 + 0.85 = 5.65m$$

$$h_L = 5.65 - 1.20 + 476 - 0.0297$$

$$h_L = 4.90m$$

$$h_L = K\frac{v_1^2}{2g} = \text{Find } K$$

$$K = \frac{h_L}{\frac{v_1^2}{2g}} = \frac{4.90m}{0.476m}$$

$$\boxed{K = 10.3}$$

5

4.8. Compute the energy loss in a 90° bend in a steel tube used for a fluid powers system. The tube has a $1\frac{1}{4}$ in OD and a wall thickness of 0.083 in. The mean bend radius is 3.25 in. The flowrate of hydraulic oil 27.5 gal/min

$A = 6.0 \times 10^{-3}\ ft^2$ $\quad D = 0.0874\ ft$ $\quad \epsilon = 1.5 \times 10^{-4}\ ft$

$h_L = K\left(\frac{v^2}{2g}\right)$

$\frac{r}{D} = 3.25\,in\left(\frac{1\,ft}{12\,in}\right) = 3.099$ $\quad \frac{Le}{D} = 12.5$

$\frac{D}{\epsilon} = \frac{0.0874}{1.5 \times 10^{-4}} = 602.2$ $\quad f_t = 0.0222$

$K = (0.0222)(12.5) = 0.2775$

$v = 2.75\ \frac{gal}{min}\left(\frac{0.1337\ \cancel{ft^3}}{gal}\right)\left(\frac{1\,min}{60\,sec}\right)$

$Q = 0.06127\ ft^3/s$

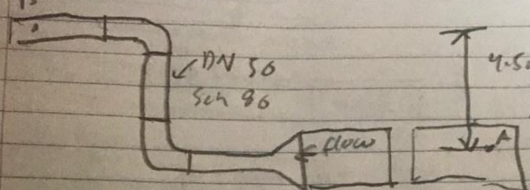
$V = \frac{Q}{A} = \frac{0.06127}{6.404 \times 10^{-3}} = \boxed{9.70\ ft/s}$

Nathaniel Yapuyon

Ch 11

7

5) Oil is flowing at the rate of 0.015 m^3/s



$$A_a = \frac{\pi(0.1463)^2}{4} = 1.682 \times 10^{-2}\ m^2 \qquad A_b = \frac{\pi \times 0.0493^2}{2} = 1.905 \times 10^{-3}\ m^2$$

$$V_a = \frac{0.015}{1.682 \times 10^{-2}} = 0.892\ m/s \qquad V_b = \frac{0.015}{1.905 \times 10^{-3}\ m^2} = 7.87\ m/s$$

$$N_{RA} = \frac{(0.892)(0.1463)}{2.12 \times 10^{-5}} = 6.15 \times 10^3 \qquad N_{RB} = \frac{7.87 \times 0.0493}{2.12 \times 10^{-5}} = 1.83 \times 10^4$$

$$\frac{D_A}{\varepsilon} = \frac{0.1463}{4.6 \times 10^{-5}} = 3180\ ;\ f_A = 0.035 \qquad \frac{D}{\varepsilon} = \frac{0.0493}{4.6 \times 10^{-5}} = 1072\ ;\ f_B = 0.028$$

$f_{TB} = 0.019$

$$h_1 = 0.035 \times \frac{186}{0.1463}\left(\frac{0.892^2}{2 \times 9.81}\right) = 1.73$$

$$h_2 = 0.028\left(\frac{a}{0.0493}\right)\left(\frac{7.87^2}{2(9.81)}\right) = 14.34\ m$$

$$h_3 = 2(20)(0.019)\left(\frac{7.87^2}{2 \times 9.81}\right) = 2.39\ m$$

$$h_4 = 0.37\left(\frac{7.87^2}{2(9.81)}\right) = 1.17\ m$$

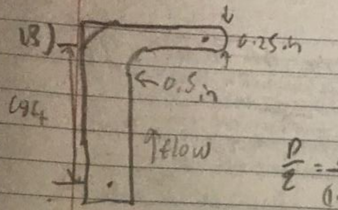
total $h_L = 19.65\ m$

$$\frac{P_A}{\gamma} + \frac{v_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{v_B^2}{2g} + z_B - h_L \qquad P_A = \gamma\left[h_L + \frac{P_B}{\gamma} + (z_B - z_A) + \left(\frac{v_B^2}{2g} -\right.\right.$$

$$P_A = 8.80\left[19.65 + \frac{12.5 \times 10^6}{8.80} + 4.5 + \left(\frac{0.892^2}{2(9.81)} - \frac{7.87^2}{2(9.81)}\right)\right]$$

$$\boxed{P_A = 12.7\ MPA}$$

8



$$A = \frac{\pi D^2}{4} = \frac{\pi\left(\frac{0.5}{12}\right)^2}{4} = 0.0013635 ft^2$$

$$\frac{D}{\varepsilon} = \frac{0.5}{(1.5)(2\times10^{-4})} = 277.8 \quad 99$$

$$h_L = \frac{P_1 - P_2}{\gamma} + \frac{v_A^2}{2g} - \frac{v_B^2}{2g} + z_A - z_B$$

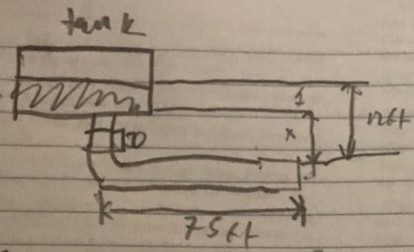
$h_L = 28.15 ft$ $g = 32.2$ $D = 0.041667$ $L = 20$

$$Q = -2.22 \cdot D^2 \sqrt{\frac{g \cdot D \cdot h_L}{L}} \log\left[\frac{1.784 \nu}{D\sqrt{\frac{g \cdot D \cdot h_L}{L}}}\right]$$

$Q = 0.0425 \ ft^2/s$

$$V = \frac{Q}{A} = \frac{0.099}{0.0013635} = \boxed{62.53 \ ft/s}$$

11.20



$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_{L_{1-2}}$$

$$\frac{P_A - P_D}{\gamma} - z_B = f\frac{8LQ^2}{g\pi^2}\frac{1}{D^5} + k_{valve}\frac{8Q^2}{g\pi^2}\frac{1}{D^4}$$

$$h_1 + z_1 - h_L = h_2 + z_2$$

$$(12 - x) + x - h_L = 0 + 0 = \underline{12\ ft}$$

ε 1.5×10^{-4} ft water at 80°F $\nu = 9.15\times10^{-6}\ ft^2/s$

$$D = 0.66\left((1.5\cdot10^{-4})^{1.25}\left(\frac{75\left(\frac{4000\frac{gal}{min}\cdot1\frac{ft^3}{s}}{449\ gal/min}\right)^2}{(32.2\frac{ft}{s^2})(12\ ft)}\right)\right.$$

$$\left.+\left(9.15\times10^{-6}\frac{ft^2}{s}\right)\left(\frac{(400\frac{gal}{min})(1\frac{ft^3}{s})}{449\ gal/min}\right)^{9.4}\left(\frac{75}{32.2\ ft/s^2}\right)^{5.2}\right)$$

$$\boxed{D = 0.26\ ft}$$