Homework #2.2

Ch 11 Series Pipeline Systems

Ch 12 Parallel and Branching Pipeline Systems

MET 330 Virginia Beach Distance Learning WC2 and Campus

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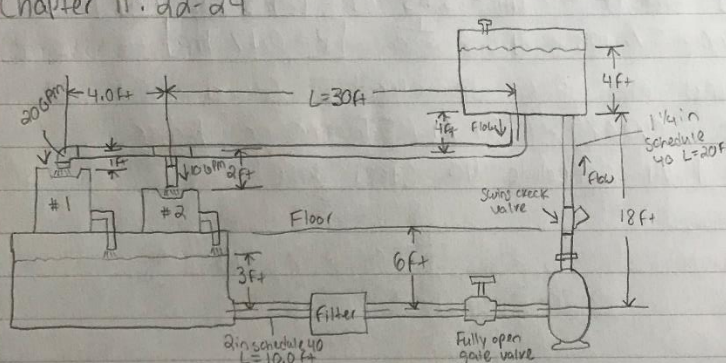
Homework 2.2

In chapter 11 and 12 series / parallel pipelines, I learned there will always energy losses due to friction in a pipe were a fluids flows. To find friction factor we must calculate Reynolds number. All of the problems regardless of what it is asking for are solved in a similiar fashion. We must recognize all the sources of energy losses in the system. It is important to label all of the terms because of the nature of these problem, the equation may be long and you do not want to get confused.

Chapter 11: 22-24



Pump delivers 30 gal/min

coolant sg = 0.92

dynamic viscocity = 3.6×10^{-5} lb·s/ft²

30 gal/min = 0.06684 ft³/s

22) Compute the pressure at the inlet to the pump. The filter has a resistance coefficient of 1.85 based on the velocity head in the suction line.

$\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + h_L \rightarrow P_2 = P_1 + \gamma\left[(z_1 - z_2) + \frac{(v_1^2 - v_2^2)}{2g} - h_L\right]$ $\quad v = \frac{0.6684}{0.02333} = 2.864$

$P_2 = \gamma\left[(z_1 - z_2) - \frac{v_2^2}{2g} - h_L\right] \rightarrow P_2 = (0.92 \times 62.4\ \text{lb/ft}^3) \times \left[3 - \frac{2.864^2}{2 \times 32.2} - h_L\right]$

$N_R = \frac{vDP}{\eta} \rightarrow N_R = \frac{2.864 \times 0.1723 \times (0.92 \times 1.94)}{3.6 \times 10^{-5}} = 2.44 \times 10^4$ $\quad \frac{D}{\epsilon} = \frac{0.1723}{1.5 \times 10^{-4}} = 1148.67$ $\quad f = 0.026$

$h_L = h_1 + h_2 + h_3 + h_4 \rightarrow h_L = \left(K\left(\frac{v^2}{2g}\right)\right) + \left(f \times \frac{L}{D} \times \frac{v^2}{2g}\right) + \left(f \times \frac{L}{D} \times \frac{v^2}{2g}\right) + \left(f \times \frac{L}{D} \times \frac{v^2}{2g}\right)$

$h_L = (0.5 \times 0.127) + \left(0.026 \times \frac{10}{0.1723} \times 0.127\right) + (1.85 \times 0.127) + (0.019 \times 8 \times 0.127) = 0.512\ \text{ft}$

$P_2 = (0.92 \times 62.4) \times \left[3 - \frac{2.864^2}{2 \times 32.2} - 0.512\right] \times \frac{1}{144} = \boxed{P_2 = 0.91\ \text{psig}}$

23) Compute the total head on the pump and the power delivered by the pump to the coolant.

$h_A = h_L + (z_2 - z_1)$ $\quad P = Q \gamma h_A$ $\quad \nu = 0.127$

1 1/4 schedule 40 steel pipe is D = 0.115 ft

$V_D = \frac{0.06684}{0.01039} = 6.43$ ft/s $\quad \frac{6.43^2}{2 \times 32.2} = 0.642$

$h_L = h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7$

$h_L = \left(K \times \frac{V_S^2}{2g}\right) + \left(f \times \frac{L}{D} \times \frac{V_S^2}{2g}\right) + \left(f \times \frac{L}{D} \times \frac{V_S^2}{2g}\right) + \left(f \times \frac{L}{D} \times \frac{V^2}{2g}\right) + \left(f \times \frac{L}{D} \times \frac{V^2}{2g}\right) + \left(f \times \frac{L}{D} \times \frac{V^2}{2g}\right) + \left(1.0 \times \frac{V_D^2}{2g}\right)$

$h_L = (0.5 \times 0.127) + \left(0.0265 \times \frac{10}{0.1723} \times 0.127\right) + (1.85 \times 0.127) + (0.019 \times 8 \times 0.127) + (0.022 \times 100 \times 0.642)$
$+ \left(0.0265 \times \frac{18}{0.115} \times 0.642\right) = 5.23$ ft $\qquad h_A = 5.23 + 19 = \boxed{24.3 \text{ ft} = h_A}$

$P = Q \gamma h_A \rightarrow P = 0.0668 \times 57.408 \times 24.3 \times \frac{1}{550}$ $\quad \boxed{P = 0.17 \text{ hp}}$

24) Using Excel to find the pipe diameter I found that the diameter must be 0.087952 ft / 1.055 in or larger

Pipe be atleast 1 1/4 schedule 40 steel pipe

C6 = 20

Input Data		
Specific Weight=	62.4	lb/ft^3
Kinematic Viscosity=	1.50E-04	ft^2/s
Pressure A=	20	psig
Pressrue B=	0	psig
Z_B=	19	ft
Tube Length=	34	ft
Flow rate=	0.0668	ft^3/s
Wall Roughness=	0.00015	ft

2880 lb/ft^2
0 lb/ft^2

g= 32.2 ft/s^2

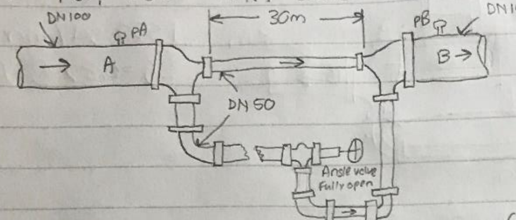
Iteration	f	D (ft)	V (ft/s)	Re	D/e	NEW f	%diff
1	0.01000	0.06755	18.63943	8.39E+03	450.335	0.03586	########
2	0.03586	0.087204	11.18435	6.50E+03	581.3621	0.03736	-4.191%
3	0.03736	0.087923	11.00216	6.45E+03	586.1559	0.03742	-0.155%
4	0.03742	0.087951	10.99535	6.45E+03	586.3373	0.03742	-0.006%
5	0.03742	0.087952	10.99509	6.45E+03	586.3442	0.03742	0.000%

Iterative process | Sheet3

Zach Hollifield

Chapter 12: 3, 4, 5, 6

3) Calculate the flow rate in each branch and the pressure different $p_A - p_B$, 850 L/min water 10°C DN 100 schedule 40 Total length = 60 m



value diameter = 0.0525 m Table F.1

$\frac{D}{\epsilon} = \frac{0.0525}{4.6\times10^{-5}} = 1.141\times10^{3}$

moody diagram = 0.02

$(h_L)_b = h_{friction} + h_{valve} + 3(h_{elb})$

$= f_b\left(\frac{L}{D}\right)\frac{V_b^2}{2g} + f_{bt}\left(\frac{L_e}{D}\right)_v\frac{V_b^2}{2g} + 3f_{bt}\left(\frac{L_e}{D}\right)_e\frac{V_b^2}{2g}$

$= f_b\left(\frac{60}{0.0525}\right)\frac{V_b^2}{2g} + 0.019\times(150)\frac{V_b^2}{2g} + 3\times0.019\times30\frac{V_b^2}{2g}$

$= 571 f_a \frac{V_a^2}{2g} = [1142\times0.02+4.56]\frac{V_b^2}{2g} \rightarrow 571\times0.02\times\frac{V_a^2}{2g} = [1142\times0.02+4.56]\frac{V_b^2}{2g}$

$V_a = 1.55 V_b$ 2 in schedule 40 steel pipe = $A = 2.168\times10^{-3}\ m^2$

$Q_{total} = A_aV_a + A_bV_b \rightarrow 0.01411 = A_a(1.15V_b) + A_bV_b \rightarrow \frac{0.01411}{1.55\times(2.168\times10^{-3}) + (2.168\times10^{-3})} = 2.5$

$V_a = 1.55(2.55) = 3.97$ m/sec $N_R = \frac{V_bD_b}{\nu} = \frac{2.55\times0.0525}{1.3\times10^{-6}} = 1.3\times10^{5}$ $f_A = 0.0215$ moody

$N_R = \frac{3.97\times0.0525}{1.3\times10^{-6}} = 1.6\times10^{-6}$ $f_b = 0.0215$ moody diagram

$Q_a = A_aV_a \rightarrow (2.168\times10^{-3})\times3.98 =$ **0.0141 m³/s = Q upper**

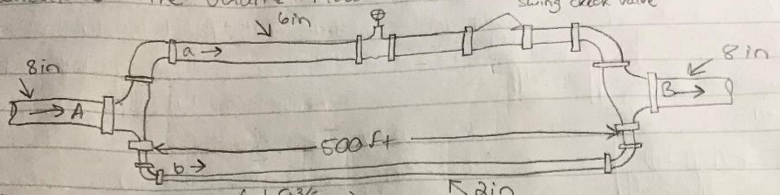
$Q_b = A_bV_b \rightarrow (2.168\times10^{-3})\times2.55 =$ **0.00553 m³/s = Q lower**

$h_L = 571 f_a \frac{V_a^2}{2g} \rightarrow 571\times0.021\times\frac{3.98^2}{2\times9.81} = 9.68$ m

$\Delta P = \gamma h_L \rightarrow (9.81)(9.68\text{m}) =$ **95 kN/m²**

Zach Hollifield

4) Calculate the volume flow rate in 6-in and the 2-in pipes.



1350 gal/min
Sg = 0.87 @ 140°F

$Q = 1350 \text{ gal/min} \left(\frac{1 \text{ ft}^3/s}{449 \text{ gal/min}}\right)$

$Q = 3.01 \text{ ft}^3/s$ $\quad h_A = h_1 + h_2 + h_3 + h_4$

$h_A = \left(f \frac{L}{D} \frac{V_a^2}{2g}\right) + \left(\left(f \frac{L}{D}\right)_{globe} \times \frac{V_a^2}{2g}\right) + \left(\left(f \frac{L}{D}\right)_{swing} \times \frac{V_a^2}{2g}\right) + \left[2\left(f \frac{L}{D}\right)_{elbows} \frac{V_a^2}{2g}\right]$

6in Schedule 40 $\quad D = 0.5054$ ft $\quad A = 0.2006$ ft^2 $\quad \epsilon = 1.5 \times 10^{-4}$ ft

$\frac{D}{\epsilon} = \frac{0.5054}{1.5 \times 10^{-4}} = 3369.33$ $\quad f = 0.015$ new, clean pipe

$\left(\frac{Le}{D}\right)_{globe} = 340$ $\quad \left(\frac{Le}{D}\right)_{swing} = 100$ $\quad \left(\frac{Le}{D}\right)_{elbow} = 30$

$h_A = \left[f \times \frac{500}{0.5054} + 0.015 \times 340 + 0.015 \times 100 + 2(0.015 \times 30)\right] \frac{V_a^2}{2g}$

$h_A = (989.315 f_a + 7.5) \frac{V_a^2}{2g}$

$h_B = \left[f_B \times \frac{500}{0.1723} + 2(0.019 \times 30)\right]\left(\frac{V_b^2}{2g}\right) \rightarrow h_B = [2901.91 f_B + 1.14] \frac{V_b^2}{2g}$

$h_{LA-B} = (989.315 f_a + 7.5) V_a^2 = (2901.91 f_B + 1.14) V_B^2$

$= 23.33 V_a^2 = 59.2 V_B^2$ $\quad V_A = 1.592 V_B$

$Q = A_a V_a + A_B V_B \rightarrow 3.01 = (0.2006 \times 1.592 + 0.02333) V_B$ $\quad V_B = 8.783$ ft/s

$V_a = 1.592 V_B \rightarrow 1.592 \times 8.783$ $\quad V_a = 13.98$ ft/s

$N_{R\,upper} = \frac{1.6878 \times 13.98 \times 0.5054}{8 \times 10^{-6}} = 1490642.175$ $\quad \frac{D}{\epsilon} = 3369.33$ $\quad f_a = 0.016$ moody

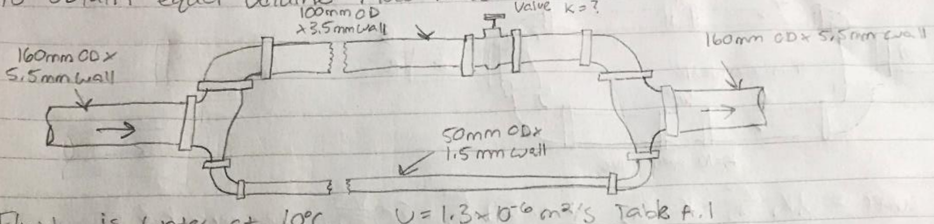
$N_{R\,lower} = \frac{1.6878 \times 8.783 \times 0.1723}{8 \times 10^{-6}} = 319270.76$ $\quad \frac{D}{\epsilon} = 1148.67$ $\quad f_b = 0.02$ moody

$Q_a = V_a A_a \rightarrow 13.98 \times 0.2006$ $\quad$ **$Q_a = 2.8$ ft^3/s or 1259 gal/min**

$Q_b = V_b A_b \rightarrow 8.783 \times 0.02333$ $\quad$ **$Q_b = 0.205$ ft^3/s or 92 gal/min**

Zach Hollifield

5) Determine what the resistance coefficient K of the valve must be to obtain equal volume flow rates of 500 L/min in each branch.



Fluid is water at 10°C $\nu = 1.3\times10^{-6}\ m^2/s$ Table A.1

100 mm pipe   inner diameter $= 100 - 2(3.5)\left(\frac{1\times10^{-3} m}{1mm}\right) = 0.093m$

$A = \frac{\pi D^2}{4} = \frac{\pi(0.093)^2}{4} = 6.79\times10^{-3} m^2$

$Q = 500\ L/min \times \frac{1.666\times10^{-5} m^3/sec}{1\ L/min} = 8.33\times10^{-3} m^3/sec$

$V_{upper} = \frac{8.33\times10^{-3}}{6.79\times10^{-3}} = 1.22\ m/s$ $N_R = \frac{1.22\times0.0933}{1.3\times10^{-6}} = 87276.923$

$R_{r\,upper} = \frac{1.5\times10^{-6}}{0.093} = 1.61\times10^{-5}$ $f_a = 0.0185$ $f_T = 0.01$ moody diagram

50 mm pipe   inner diameter $= 50 - 2(1.5)\left(\frac{1\times10^{-3} m}{1mm}\right) = 0.047m$

$A = \frac{\pi D^2}{4} = \frac{\pi(0.047)^2}{4} = 1.73\times10^{-3} m^2$

$V_{lower} = \frac{Q}{A_b}$ $N_R = \frac{V_b d}{\nu}$ $N_R = \frac{4.815\times0.047}{1.3\times10^{-6}} = 174080$

$R_{r\,lower} = \frac{1.5\times10^{-6}}{0.047} = 3.2\times10^{-5}$ $f_b = 0.016$ $f_T = 0.01$ moody diagram

$h_{L\,upper} = h_{fric} + h_{valve} + 2h_{elb} = f_a\left(\frac{L}{D}\right)\frac{V_a^2}{2g} + K\frac{V_a^2}{2g} + 2f_T\left(\frac{L_e}{D}\right)_e\frac{V_a^2}{2g}$

$h_{L\,upper} = 0.0185\left(\frac{30}{0.093}\right)\frac{V_a^2}{2g} + K\frac{V_a^2}{2g} + 2\times0.01\times(30)\frac{V_a^2}{2g} \rightarrow h_{L\,lower} = [6.56 + K]\frac{V_a^2}{2g}$

$h_{L\,lower} = f_b\left(\frac{L}{d}\right)\frac{V_b^2}{2g} + K\frac{V_b^2}{2g} + 2f_T\left(\frac{L_e}{D}\right)_e\frac{V_b^2}{2g}$

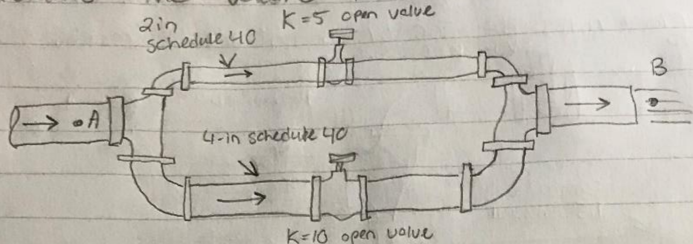
$h_{L\,lower} = 0.016\left(\frac{30}{0.047}\right)\frac{V_b^2}{2g} + 2\times0.01\times30\left(\frac{V_b^2}{2g}\right) \rightarrow [10.812]\frac{V_b^2}{2g}$

$[6.56 + K]\frac{V_a^2}{2g} = [10.812]\frac{V_b^2}{2g}$

$[6.56 + K]\frac{1.22^2}{2\times9.81} = [10.812]\frac{4.815^2}{2\times9.81}$ **K = 160**

Zach Hollifield

6) Calculate the volume flow rate of water for each condition



loss in upper $= 2K_1 \frac{Va^2}{2g} + K_2 \frac{Va^2}{2g} \rightarrow 2 \times 0.9 \frac{Va^2}{2g} + 5 \times \frac{Va^2}{2g}$ $\quad h_{Lupper} = 6.8 \frac{Va^2}{2g}$

loss in lower $= 2K_1 \frac{Vb^2}{2g} + K_3 \frac{Vb^2}{2g} \rightarrow 2 \times 0.9 \frac{Vb^2}{2g} + 10 \frac{Vb^2}{2g}$ $\quad h_{Llower} = 11.8 \frac{Vb^2}{2g}$

2in area $= \frac{\pi(2 \times \frac{1}{12})^2}{4} = 0.0218\ ft^2$ $\quad$ 4in area $= \frac{\pi(4 \times \frac{1}{12})^2}{4} = 0.0873\ ft^2$

$Q = (0.0218)(20) = 0.436$ $\quad Q = (0.0873)(15.87) = 1.385\ ft^3/s$

$Q = Q_a + Q_b = (0.436) + (1.385) =$ **1.821 ft^3/s both valves open**

$Q_{lower} = (0.0873) \times 15.87 =$ **1.39 ft^3/s lower valve open**

$Q_{upper} = (0.0218) \times 20 =$ **0.436 ft^3/s upper valve open**

Nathaniel Yuprayoon
11/4
HW22

What I learn in class

We used excel in some of our problems. this will help solve some iterations that would take longer than write the equation down. We were taught techniques to solve for the pipe. Design flowrate or finding a diameter of pipe can be found using excel. Recongnize all the sources of energy losses in the system. Last, We must label the terms. Being organize withthese long problems really helps.

CH 11 : 22, 23, 24
CH 12 : 2, 4, 5, 6

Problem 22

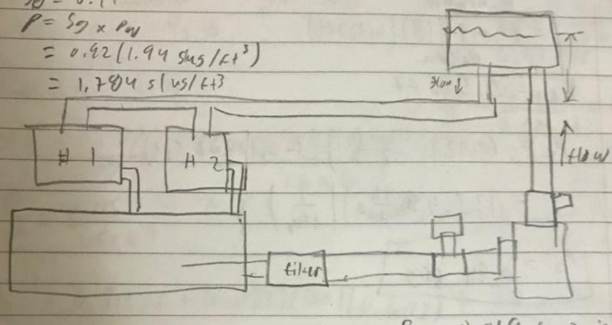
Based on fig 11.26, compute the pressure at the inlet to the pump. The filter has a resistance coefficient of 1.85 based on the velocity head in the suction line

$SG = 0.91$

$\rho = SG \times \rho_w$

$= 0.92(1.94\ slugs/ft^3)$

$= 1.784\ slugs/ft^3$



$f_T = 0.019$ for 2-in pipe

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

$P_1 = 0 \quad v_1 = 0$

Inlet $\quad P_2 = \gamma\left[(z_1 - z_2) - h_L - \frac{v_2^2}{2g}\right]$

$$Q = 30\ gal/min\left(\frac{1}{449\ gal/min}\right) = \underline{0.0668\ ft^3/s}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.0668\ ft^3/s}{0.02333\ ft^2} = 2.86\ ft/s$$

$$\frac{V_2^2}{2g} = \frac{(2.86)^2}{2(32.2)} = 0.127\ ft$$

$$N_R = \frac{VD\rho}{\eta} = \frac{(2.864)(0.1723)(1.784)}{3.6 \times 10^{-5}}$$

$N_R = 2.44 \times 10^4$

Relative roughness $\frac{D}{\varepsilon} = \frac{0.1723}{1.5 \times 10^{-4}} = 1148.67$

Moody's diagram $f = 0.0265$

$f_T \frac{L_e}{D} = 1.85$ $\frac{V^2}{2g} = \frac{0.127}{2(32.2)} = 0.127 ft$

$h_L = (f)\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$

3 1

$h_L = h_1 + h_2 + h_3 + h_4$

$h_L = 0.5\,(0.127 ft) + 1.85\,(0.127 ft) + (0.0265)\left(\frac{10 ft}{0.1723}\right)(0.127 ft)$

Entrance — filter — friction

$+ (0.019)(8)(0.127 ft)$

Valve

$h_L = 0.513 ft$

$P_2 = (0.92)\left(\frac{62.4 lb}{ft^3}\right)(3 - 0.127 - 0.513)$

$= \left(135.48 \frac{lb}{ft^2}\right)\left(\frac{1}{144}\right)$

$P_2 = 0.94$ psig

dynamic viscosity = 3.6 x 10^{-5} lb-s/ft²

Problem 23

Compute the total head on the pump and the power delivered by the pump to the coolant

$\frac{P_1}{\gamma} + z_1 + \frac{v_1^2}{2g} - h_L + h_A = \frac{P_3}{\gamma} + z_3 + \frac{v_3^2}{2g}$

$V_d = \frac{Q}{A_d} = \frac{0.0668 \text{ ft}^3}{0.01039 \text{ ft}^2}$

$P_1 = P_3 = 0, \; v_1 = v_3 = 0$

$V_d = 6.43$ ft/s

$h_A = (z_3 - z_1) + h_L$ (19 ft)

$\frac{V_d^2}{2g} = \frac{(6.43)^2}{2(32.2)} = 0.642$ ft

R.#

$N_R = \frac{V_d D \rho}{\eta} = \frac{(6.43)(0.115)(0.92)(1.94)}{3.6 \times 10^{-5}} = 3.67 \times 10^4$

friction

$\frac{D}{\varepsilon} = \frac{0.115}{1.5 \times 10^{-4}} = 767$

Moody diagram $f = 0.0265$

$f_{dt} = 0.022$

$h_L = 0.513$ ft $+ (0.022)(100)(0.642) + (0.0265)(157)(0.642)$

valve Friction

$+ 1(0.642) =$

$h_L = 5.24$ ft

$h_A = 19$ ft $+ 5.24$ ft $= 24.24$ ft

Power $P_A = h_A \gamma Q$

$= (24.24 \text{ ft})(0.92)\left(\frac{62.4 \text{ lb}}{\text{ft}^3}\right)(0.0668)\left(\frac{1}{550 \text{ ft-lb/s}}\right)$

$= \boxed{0.169 \text{ hp}}$

3

27. Based on my teammates excel sheet
Pipe diameter must be 0.087952 ft

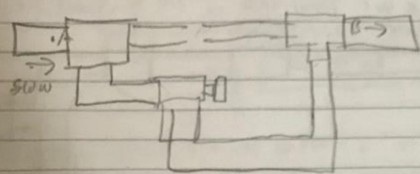
1 1/4 schedule 40 steel is recommended.

Ot 1?

Nathaniel Vaughan

Problem 3

Calculate (a) the flow rate in each of the branches (b) pressure difference $h_{La} = h_{Lb}$



$$h_{La} = f_a \frac{30}{0.0525} \frac{v_a^2}{2g}$$

h_L = sum

$$h_{Lb} = f_b \frac{60}{0.0525} \frac{v_b^2}{2g} + 3 f_{bT}(30) + f_{bT}(30) \frac{v_b^2}{2g} =$$

$$h_{Lb} = (1142 f_b + 4.56) \frac{v_b^2}{2g}$$

(1) Assume $f_a = f_b = 0.02$ $h_{La} = h_{Lb}$

From moody diagram

$$571(0.02) \frac{v_a^2}{2g} = (1142(0.02) + 4.56) \frac{v_b^2}{2g}$$

$V_a = 1.55 V_b$ $A = 2.160 \times 10^{-3} m^2$ (2 in Sch 40 steel)

$Q_{total} = A_a V_a + A_b V_b$

$= A_a (1.55 V_b) + A_b V_b = V_b (2.55 A_b)$

$$V_b = \frac{Q_A}{2.55 A_b} = \frac{850 \text{ L/min} \quad 1 m^3/s}{2.55(2.168 \times 10^{-3} m^2)(60000 \text{ L/min})}$$

$V_b = 2.56$ m/s

$$N_{Ra} = \frac{v_a D_a}{\nu} = \frac{(3.97)(0.0525)}{1.30 \times 10^{-6}} = 1.60 \times 10^5 \quad \frac{D}{\epsilon} = \frac{0.0525}{4.6 \times 10^{-5}} = 1141 \quad f_a = 0.021$$

$$N_{Rb} = \frac{V_b D_b}{\nu} = \frac{(2.56)(0.0525)}{1.30 \times 10^{-6}} = 1.03 \times 10^5 \quad \frac{D}{\epsilon} = \frac{0.0525}{4.6 \times 10^{-5}} = 1141 \quad f_b = 0.0215$$

{ Moody diagram

Q upper $Q_a = A_a v_a = (2.168 \times 10^{-3})(3.98) =$ **$0.0141 m^3/s$**

Q lower Q_b $A_b V_b = (2.168 \times 10^{-3})(2.55) =$ **$0.00558 m^3/s$**

$$h_L = 571 f_a \frac{v_a^2}{2g} = (571)(0.021)\left(\frac{3.98^2}{2 \times 9.81}\right) = 9.68 m$$

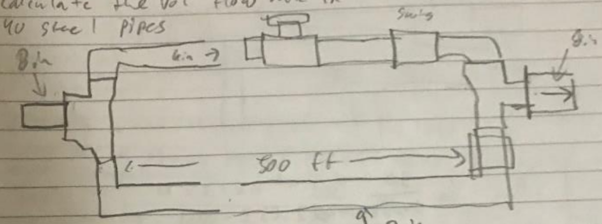
$\Delta P = \gamma h_L = (9.81)(9.68 m) =$ **$95 \text{ kN}/m^2$**

Problem 4

Fig 12.9 1350 gal/min of benzene ($sg = 0.87$) at 140°F flowing in the 8 in pipe

Calculate the vol flow rate in the 6 in and the 2 in pipes

Sch 40 steel pipes



$Q_{ain} = 1350 \text{ gal/min} \left(\frac{1}{449 \frac{gal}{min}} \right) = 3.01 \text{ ft}^3/s$ 6 in Sch 40

$\rho = 0.87(1.94) = 1.69 \text{ slugs/ft}^3$ (sg) $D = 0.5054$ ft $\epsilon = 1.5 \times 10^{-4}$ ft

B $A = 0.2006 \text{ ft}^2$

$h_a = h_1 + h_2 + h_3 + h_4$

$h_A = \left(f \frac{L}{D} \frac{V_a^2}{2g} \right) + \left(\left(f \frac{L}{D} \right)_g \left(\frac{V_a^2}{2g} \right) \right) + \left(\left(f \frac{L}{D} \right)_{swing} \frac{V_a^2}{2g} \right) + \left[2 \left(f \frac{L}{D} \right) \frac{V_b^2}{2g} \right]$

globe = 340   swing = 100   elbow = 30

$h_A = (989.315 f_t + 7.5) \frac{V_a^2}{2g}$

$h_B = (f_B) \left(\frac{500}{0.172} \right) + 2(0.019 \times 30)$ $h_B = (2901.91 f_B + 1.14) \frac{V_b^2}{2g}$

$h_{LA-B} = (989.315 f_a + 7.5) V_a^2 = (2901.91 f_B + 1.14) V_B^2$

$= 23.37 V_a^2 = 59.2 V_B^2$ $V_a = 1.592 V_B$

$Q = 3.01 = (0.2006 \times 1.592 + 0.02333) V_B$ $V_B = 8.783$ ft/s

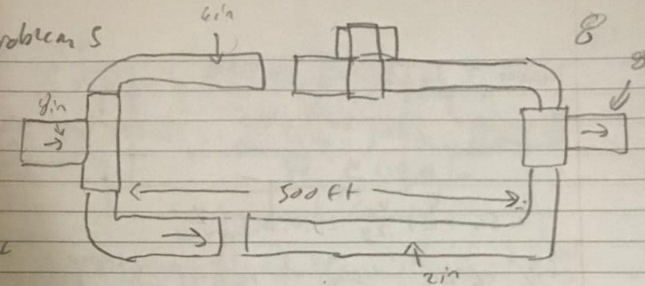
Upper $N_R = \frac{1.6878 \times 13.98 \times 0.5054}{8 \times 10^{-6}} = 1.49 \times 10^6$ $f_a = 0.016$ moody

Lower $N_R = \frac{1.6878 \times 8.783 \times 0.1723}{8 \times 10^{-6}} = 3.20 \times 10^5$ $f_b = 0.02$ moody

$Q_a = 13.98 \times 0.2006 = \boxed{2.8 \text{ ft}^3/s}$ (1255 gal/min)

$Q_b = 8.783 \times 0.02333 = \boxed{0.205 \text{ ft}^3/s}$ (92 gal/min)

Problem 5 8



water @ 10°C

Determine what the res coeff K of the valve must be to obtain equal vol. flow rates 500 L/min in each branch

Table A.1 $\nu = 1.3 \times 10^{-6}\ m^2/s$

inner diameter $= 100 - 2(3.5)\left(\frac{1 \times 10^{-3}\ m}{1\ mm}\right) = 0.093\ m$

$A = \frac{\pi D^2}{4} = \frac{\pi (0.093)^2}{4} = 6.79 \times 10^{-3}\ m^2$

$Q = 500\ L/min \left(\frac{1.66 \times 10^{-5}\ m^3/sec}{1\ L/min}\right) = 8.33 \times 10^{-3}\ m^3/sec$

$V_{upper} = \frac{8.33 \times 10^{-3}}{6.79 \times 10^{-3}} = 1.22\ m/s$ $N_R = \frac{1.22 \times 0.0933}{1.3 \times 10^{-6}} = 87276.9$

$R_{upper} = \frac{1.5 \times 10^{-6}}{0.093} = 1.61 \times 10^{-5}$ $f_a = 0.0185$ $f_T = 0.01$ moody

50 mm pipe inner diameter $= 50 - 2(1.5)\left(\frac{1 \times 10^{-3}\ m}{1\ mm}\right) = 0.047\ m$

$A = \frac{\pi D^2}{4} = \frac{\pi (0.047)^2}{4} = 1.73 \times 10^{-3}\ m^2$

$V_{lower} = \frac{Q}{A_b}$ $N_R = \frac{V_b d}{\nu}$ $N_R = \frac{4.815 \times 0.047}{1.3 \times 10^{-6}} = 174080$

$R_{lower} = \frac{1.5 \times 10^{-6}}{0.047} = 3.2 \times 10^{-5}$ $f_b = 0.016$ $f_T = 0.01$ moody diagram

$h_{L\,upper} = h_{friction} + h_{valve} + 2h_{elb} = f_a\left(\frac{L}{D}\right)\frac{V_a^2}{2g} + K\frac{V_a^2}{2g} + 2f_T\left(\frac{L}{D}\right)_e\frac{V_a^2}{2g}$

$h_{L\,upper} = 0.0185\left(\frac{30}{0.093}\right)\frac{V_a^2}{2g} + K\frac{V_a^2}{2g} + 2(0.01)(30)\frac{V_a^2}{2g}$

$h_{L\,lower} = (6.56 + K)\frac{V_a^2}{2g}$

$$h_{lower} = f_b\left(\frac{L}{D}\right)\frac{V_3^2}{2g} + k\frac{V_3^2}{2g} + 2F_T\left(\frac{Le}{D}\right)_e\frac{V_3^2}{2g}$$

$$h_{L\,lower} = 0.016\left(\frac{30}{0.047}\right)\frac{V_3^2}{2g} + 2(0.01)(30)\left(\frac{V_3^2}{2g}\right)$$

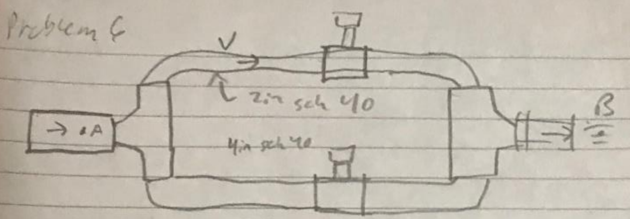
$$= 10.812\frac{V_3^2}{2g}$$

$$(6.56 + k)\frac{V_1^2}{2g} = 10.812\left(\frac{V_3^2}{2g}\right)$$

$$(6.56 + k)\frac{1.22^2}{2(9.81)} = 10.812\left(\frac{4.8152}{2(9.81)}\right)$$

$$\boxed{k = 160}$$

Problem 6 10



$\text{loss in upper} = 2K_1 \frac{V_a^2}{2g} + k_2 \frac{V_a^2}{2g}$ $\quad h_{upper} = 6.8 \frac{V_a^2}{2g}$

$= 2\left(0.9 \frac{V_a^2}{2g} + 5 \frac{V_a^2}{2g}\right)$

$h_{lower} = 11.8 \frac{V_a^2}{2g}$

$\text{loss in lower} = 2k_1 \frac{V_a^2}{2g} + k_2 \frac{V_a^2}{2g} = 2\left(0.9 \frac{V_a^2}{2g} + 10 \frac{V_a^2}{2g}\right)$

$2\text{in area} = \frac{\pi (2 \frac{1}{12})}{4} = 0.0218\ ft^2$

$4\text{in area} = \frac{\pi (4 \times \frac{1}{12})^2}{4} = 0.0873\ ft^2$

$Q = (0.0218)(20) = 0.436$ $\quad Q = (0.0873)(15.87) = 1.385\ ft^3/s$

Both valves open

$Q = Q_a + Q_b = 0.436 + 1.385 = \boxed{1.821\ ft^3/s}$

in Branch 2

$Q_{lower} = (0.0873)(15.87) = \boxed{1.39\ ft^3/s}$

in Branch 1

$Q_{upper} = (0.0218)(20) = \boxed{0.436\ ft^3/s}$

Hw 22 Chapter 11: 22 - 24
Chapter 12: 3,4,5,6

1 Energy will always be lost due to Friction in a pipe. we must use Reynolds number in order to find friction factor. All the terms must be labeled because alot of the problems are solved similarly and it is tricky to keep track.

11.22 $Q = 30 \frac{gal}{min} = 0.066 \frac{ft^3}{min}$

2 in sch 40 pipe = $D: 0.1723 ft$
$A = 0.0233 ft^2$
$sg = 0.92 = \gamma_c = 57.401, \rho_c = 1.7847$

$$\frac{p_1}{\gamma} + \frac{v^2}{2g} + z_1 = \frac{p_2}{2g} + \frac{v^2}{2g} + z_2 + h_L$$

$$V_2 = \frac{Q}{A} = V_2 = \frac{0.066}{0.0233} = 2.37 \frac{ft}{s}$$

$$h_L = f \frac{L}{D} \frac{v^2}{2g} + V - \frac{v^2}{2g} + \sqrt{\frac{v^2}{2g}}$$

pipe filter gate valve

$h_{L\,pipe}$ = $Re\ \frac{\rho V D}{\eta} = \frac{1.7846 \cdot 2.87 \cdot 0.1723}{3.6 \times 10^{-5}} = 24.516$

f using excel = 0.0288

$h_L\ pipe = 0.0288 \cdot \frac{10}{0.1723} \cdot \frac{2.872}{64.4} = 0.199\ ft$

$h_L\ filter = K\frac{V^2}{2g} = 1.85\left(\frac{2.81^2}{64.4}\right) = 0.237\ ft$

$h_{L\,valve}$ $K = \frac{L_e}{D} \cdot f_T$ $\frac{L_e}{D} = 8$ $\frac{D}{k} = \frac{0.1723}{0.00015} = 1149$ $f_T = 0.019$

$K_{valve} = 0.152$ $h_{L\,valve} = 0.152\left(\frac{2.872}{64.6}\right) = 0.019\ ft$

$h_L\ total = 0.199 + 0.237 + 0.237 + 0.019 = 0.455\ ft$

$z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + h_L = \frac{p_2}{\gamma} = z_1 - \frac{V^2}{2g} - h_L$

$\frac{p_2}{\gamma} = 3 - \frac{2.87^2}{64.4} - 0.455 = \frac{p_2}{\gamma} = 2.42\ ft$

$p_2 = 2.42 \cdot 57.408 = 138.93\ \frac{lb}{ft^2}$ or 0.96 psi

11.23 Values from 11.22

$\frac{P_1}{\gamma} = 2.42$

$Q = 0.0668 \frac{ft^3}{s}$

$1\frac{1}{4}$ in SCH 40 pipe — $D = 0.1150$ ft $A = 0.01032$ ft^2

$L = 20$

Point 1 - Pump inlet
Point 2 - Upper tank fluid surface

$$\frac{P_1}{\gamma} + \frac{v^2}{2g} + h_A = z_2 + h_L$$

$$v = \frac{Q}{A} = \frac{0.0668}{0.01032} = 6.47 \text{ ft/s}$$

$$Re = \frac{\rho v D}{\eta} = \frac{1.7848 \cdot 6.47 \cdot 0.1150}{3.6 \cdot 10^{-4}} = 36.843$$

$f = 0.0260$ - Excel

$$h_L = f\frac{L}{D}\frac{v^2}{2g} + k\frac{v^2}{2g}$$

$$h_{L\,pipe} = 0.0260 \cdot \frac{20}{0.1150} \cdot \frac{6.47^2}{64.4} = 2.94 \text{ ft}$$

h_L swing valve

$\frac{L_e}{D} = 100$ from chart

$\frac{D}{\epsilon} = \frac{0.1150}{1.5 \times 10^{-4}} = 767 \quad f_T = 0.021$

$h = \frac{L_e}{D} f_T \quad k = 100 \cdot 0.021 = 2.1$

$h_L \text{ valve} = 2.1 \cdot \frac{6.47^2}{64.4} = 1.37 \text{ ft}$

$h_L \text{ total} = 2.94 + 1.37 = 4.31 \text{ ft}$

$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + h_A = z_2 + h_L = 2.42 + \frac{2.87^2}{64.4} + h_A = 22 + 4.31$

$h_A = 23.76 \text{ ft}$

Power

$P = \gamma_L Q h_A$

$P = (57.408)(0.0668)(23.76)\left(\frac{1}{550}\right) = 0.166 \text{ hp}$

11.24 $Q_{machine_2} = 10\ GPM = 0.0223\ ft^3/s$

$Q_{machine_1} = 20\ GPM = 0.0446\ ft^3/s$

Excel

Diameter must be 0.087452 ft / 1.055 in

Pipe must be $1\frac{1}{4}$ SCH 40 steel pipe

12.5 Valve Diameter = 0.0525 m Table F.

$\frac{D}{\varepsilon} = \frac{0.0525}{4.6\times10^{-5}} = 1.141\times10^{3}$

Moody diagram = 0.02

$h_{v_b} = h_{Friction} + h_{valve} + 3h_{line}$

$F_D \cdot \frac{100}{0.0525} \cdot \frac{v^2}{2g} + 0.014 \cdot 1150\ \frac{v_0^2}{2g} + 3 \cdot 0.019 \times 30\ \frac{v_0^2}{2g}$

$= 571 \cdot f + \frac{v_g}{2g}^2 = (1142 + 0.02 + 4.56)\ \frac{v_b^2}{2g} \Rightarrow 571 \cdot 0.02\ \frac{v_A^2}{2g}$

$= 1142 + 0.02 + 4.5 \cdot \frac{v_0^2}{2g} = 571 \cdot 0.02 \cdot \frac{v_A^2}{2g} = [1142 \cdot 0.02 + 4.56)\ \frac{v_0^2}{2g}$

$v_A = 1.59\, v_b$

2 in SCH 40 steel pipe = $2.160\times10^{-3}\ m^2 = A$

$Q_{total} = A_1V_1 = A_2V_2 = 0.0411 = A_a \cdot V_a + A_b \cdot V_b = 0.0411$

$1.55 \cdot 2.166 \times 10^{-3}$ + [illegible]

$V_a = 1.55 \cdot 2.55 = 3.97 \text{ m/sec}$ $N_R = \frac{V_b D_b}{\nu} = \frac{2.55 \cdot 0.0525}{1.3 \times 10^{-6}} = 1.3 \times 10^{5}$

$f_a = 0.0215$

$N_R = \frac{3.97 \cdot 0.0525}{1.3 \times 10^{-6}} = 1.6 \times 10^{-4}$ $f_b = 0.0215$

$Q_a = 2.166 \times 10^{-3} \cdot 3.98 = 0.0141 \text{ m}^3/\text{s}$

$Q_b = 2.166 \times 10^{-3} \cdot 2.55 = 0.00553 \text{ m}^3/\text{s} = Q$ lower

$h_L = 571 \cdot f_a \frac{V_a^2}{2g} = 571 \cdot 0.021 \cdot \frac{3.98^2}{2 \cdot 9.81} = 9.68 \text{ m}$

$\Delta P = \gamma h_L \rightarrow 9.81 \cdot 9.68 = 95 \frac{kN}{m^2}$

12.4 $Q = 1350 \frac{gal}{min} = 3.01 \frac{ft^3}{s}$

$h_A = h_1 + h_2 + h_3 + h_4$

$h_A = F \frac{L}{D} \frac{V_a^2}{2g} + F \frac{L}{D}_{globe} \cdot \frac{V_a^2}{2g} + f \frac{L}{D}_{swing} \cdot \frac{V_a^2}{2g} + 2 \left\{ \frac{fL}{D} \right._{elbows}$

8 in SCH 40 $D = 0.5054$ ft $A = 0.2006$ ft^2

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

$\frac{D}{\varepsilon} = \frac{0.5054}{1.5 \times 10^{-4}} = 3369.33$ $f = 0.015$

$\left(\frac{L_e}{D}\right)_{globe} = 340$ $\left(\frac{L_e}{D}\right)_{sw.ch} = 100$ $\left(\frac{L_e}{D}\right)_{elbow} = 30$

$h_A = f \cdot \frac{500}{0.5054} + 0.015 \cdot 340 + 0.015 \cdot 100 + 2(0.015 \cdot 30) \frac{v_A^2}{2g}$

$h_A = [989.315 f_A + 7.5] \frac{v_A^2}{2g}$

$h_B = f_B \cdot \frac{500}{5.023} + 2(0.019 \cdot 30) \cdot \frac{v_B^2}{2g} = h_B = 2901.91 f_B + 1.14 \frac{v_B^2}{2g}$

$h_{A+B} = (989.315 f_A + 7.5) \cdot v_A^2 = 2901.91 f_B + 1.14 \cdot v_B^2$

$= 23.33 v_A^2 = 59.2 v_B^2$ $v_A = 1.592 v_B$

$Q = A_A v_A + A_B v_B \rightarrow 3.01 = 0.2006 + 1.592 + 0.02333 v_B$ $v_B = 8.783$ ft/s

$v_A = 1.592 v_B = 1.592 \cdot 8.783$ $v_A = 13.98$

$N_{R\,water} = \frac{1.6679 \cdot 13.98 \cdot 0.5054}{8 \times 10^{-6}} = 1490642.175$ $\frac{D}{\varepsilon} = 3369.33$

$F_a = 0.016$ moody

$N_{R_{lower}} = \frac{1.8870 \cdot 0.733 \cdot 0.1733}{8 \times 10^{-6}} = 317770.7$ [illegible]

$F_b = 0.02$

$Q_a = 1398 \times 0.20066 \quad Q_a = 2.8 \frac{Ft^3}{s} \to 1254 \ gal/min$

$Q_b = 8.753 \cdot 0.02333 \quad Q_b = 0.205 \frac{ft^3}{s}$ or $92 \frac{gal}{min}$

12.5 $Q = 500 \frac{L}{min} = 8.33 \times 10^{-3} \frac{m^3}{sec}$

$V_{upper} = \frac{8.33 \times 10^{-3}}{6.79 \times 10^{-3}} = 1.22 \ m/s$

$N_R = \frac{1.22 \times 0.0933}{1.3 \times 10^{-6}} = 87227.923$

$R_{upper} = \frac{1.5 \times 10^{-6}}{0.093} = 1.61 \times 10^{-5} \quad f_a = 0.018 \quad F_T = 0.01$

50 mm pipe inner diameter $= 50 - 2 \cdot 1.5 \quad 1 \cdot 10^{-3} m = 0.047 m$

$A = \frac{\pi D^2}{4} = \frac{\pi (0.047)^2}{4} = 1.73 \times 10^{-3} m^2$

$V_{lower} = \frac{Q}{A_b} \quad N_R = \frac{V_b d}{\nu} \quad N_R = \frac{4.815 \cdot 0.047}{1.3 \times 10^{-6}} = 174080$

$h_{L\,upper} = h_{entr} + h_{valve} + h_{elbow} = f_a \cdot \frac{L}{D} \cdot \frac{V_a^2}{2g} + k \frac{V_a^2}{2g} + 2 f_T \frac{L_e}{D} \cdot \frac{V_a^2}{2g}$

$h_{L\,upper} = 0.0185 \cdot \frac{20}{0.083} \frac{V_a^2}{2g} + k \frac{V_a^2}{2g} + 2 \cdot 0.017 \cdot \frac{30\,V_a^2}{2g}$

$h_{upper}\ [6.56 + k] \frac{V_a^2}{2g}$

$h_{L\,lower} = f_b \frac{L}{D} \cdot \frac{V_b^2}{2g} + k \frac{V_b^2}{2g} + 2 f_T \frac{L_e}{D} \cdot \frac{V_b^2}{2g}$

$h_{L\,lower} = 0.016 \frac{30}{0.083} \cdot \frac{V_b^2}{2g} + 2 \cdot 0.01 \cdot 30 \frac{V_b^2}{2g} = 10.812 \frac{V_b^2}{2g}$

$6.56 + k \frac{V_a^2}{2g} = 10.812 \frac{V_b^2}{2g}$

$6.56 + k \frac{1.75^2}{2 \cdot 9.81} = 10.612 \cdot \frac{9.615^2}{2 \cdot 9.81}$ $\quad k = 160$

12.6 Upper loss $= 2k_1 \frac{V_a^2}{2g} + k_2 \frac{V_a^2}{2g} = 2 \cdot 0.9 \frac{V_a^2}{2g} + 5 \cdot \frac{V_a^2}{2g}$ $\quad h_{L\,upper} = 6.8 \frac{V_a^2}{2g}$

lower loss $= 2k_1 \frac{V_b^2}{2g} + k_3 \frac{V_b^2}{2g} = 2 \cdot 0.9 \frac{V_b^2}{2g} + 10 \frac{V_b^2}{2g}$ $\quad h_{L\,lower} = 11.9 \frac{V_b^2}{2g}$

2 in area $= \frac{\pi \cdot 2^2 \cdot \frac{1}{144}}{4} = 0.0218\ ft^2$ $\quad$ 4 in area $= \frac{\pi\, 4^2 \frac{1}{144}}{4} = 0.0873\ ft^2$

$Q = 0.0218 \cdot 20 = 0.436$ $\quad Q = 0.0873 \cdot 15.87 = 1.385\ ft^3$

$Q = 0.436 + 1.385 = 1.821\ ft^3/s$ - both valves open

$Q_{lower} = 0.0873 \cdot 15.87 = 1.39\ ft^3/s$ lower valve open

$Q_{upper} = 0.0218 \cdot 20 = 0.436\ ft^3/s$ upper valve open