Colby Watts

MET 330 HW 3.2

4/14/24

Professor Ayala

HW 3.2

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11.26 For the system in **Fig. P11.24**, specify the size of Schedule 40 steel pipe required to return the fluid to the machines. Machine 1 requires 20 gal/min and Machine 2 requires 10 gal/min. The fluid leaves the pipes at the machines at 0 psig.

$Q_1 = 20 \text{ gpm} \qquad Q_2 = 10 \text{ gpm}$

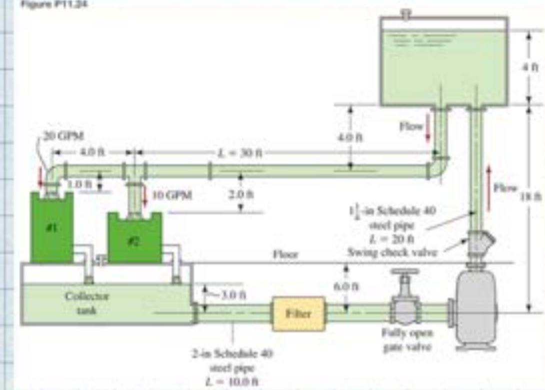
$Q_{tot} = 30 \text{ gpm} = 0.0668 \text{ ft}^3/\text{s}$

$V = QA = \dfrac{0.0668 \text{ ft}^3/\text{s}}{\frac{\pi}{2}(0.115)^2} = 3.22 \text{ ft}^2/\text{s}$

$\dfrac{P_2}{62.4} = 0.02\left(\dfrac{(20 + 2\times 30)}{0.115}\right)\left(\dfrac{3.22}{2(32.2)}\right)$

$\rightarrow P_2 = 44.66 \text{ psig}$

Figure P11.24



12.3 In the branched pipe system shown in **Fig. P12.3**, 850 L/min of water at 10°C is flowing in a DN 100 Schedule 40 pipe at A. The flow splits into two DN 50 Schedule 40 pipes as shown and then rejoins at B. Calculate (a) the flow rate in each of the branches and (b) the pressure difference $p_A - p_B$ Include the effect of the minor losses in the lower branch of the system. The total length of pipe in the lower branch is 60 m. The elbows are standard.

$Q_1 = 850 \text{ L/min} = 0.014 \text{ m}^3/\text{s}$
$D_1 = 102.3 \text{ mm} = 0.102 \text{ m}$
$D_2 = 52.5 \text{ mm} = 0.053 \text{ m}$

Density $= 1000 \text{ kg/m}^3$
Viscosity $= 1.30 \times 10^{-3}$

$A_b = \frac{\pi}{4}(0.053)^2 = 0.0022$

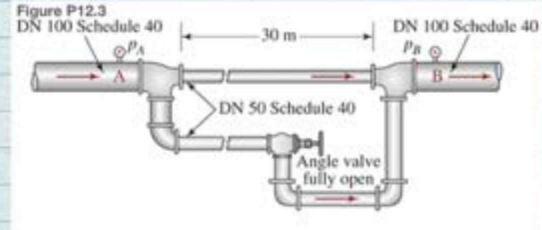
$V_b = \dfrac{Q_A}{2.55 A_b} = \dfrac{(0.014)(850)}{(2.55)(0.0022)(60)} = 2.56 \text{ m/s}$

$N_{R_a} = \dfrac{(3.97)(0.053)}{1.3\times10^{-3}} = 1.6 \times 10^5$

$N_{R_b} = \dfrac{(32.56)(0.053)}{1.3\times10^{-3}} = 1.03 \times 10^5$

$V_b = \dfrac{Q_A}{2.56 A_b} = \dfrac{850\times10^{-3}}{(2.56)(2.16\times10^{3})(60)} = 2.55 \text{ m/s}$

Figure P12.3



Branched pipe for **Problems 12.3** and **12.8**

$$V_a = 1.56\,V_b = 3.98\ \text{m/s}$$

$$Q_A = A_a V_a = (2.168\times10^{-8})(3.98) = 8.628\times10^{-3}\ \text{m}^3/\text{s} = 518\ \text{L/min}$$

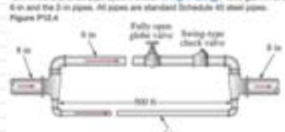
$$Q_B = A_b V_b = (2.168\times10^{-3})(2.55) = 332\ \text{L/min}$$

$$\Delta P = \frac{9.81\ \text{kN}}{\text{m}^3}\left[(571)(0.21)\left(\frac{3.98^2}{2(9.81)}\right)\right] = 95.0\ \text{kPa}$$

12.4 In the branched-pipe system shown in **Fig. P12.4**, 1350 gal/min of benzene ($sg = 0.87$) at $140\ ^\circ\text{F}$ is flowing in the 8-in pipe. Calculate the volume flow rate in the 6-in and the 2-in pipes. All pipes are standard Schedule 40 steel pipes.

Q1 =	1350 gpm		0.08517 m3/s	
sg =	0.87			
γ =	54.35 lb/ft^3			
Specific Weight =	8.59 kN/m^3			
L2 = L3	500 ft		152.4 m	
viscosity =	7.42E-06 ft^2/s		6.89E-07 m^2/s	
Roughness =	0.00015 ft			
1 8in Di =	0.6651 ft		0.202722 m	
2 6in Di =	0.5054 ft		0.15404 m	
3 2in Di =	0.1723 ft		0.052517 m	
g =	9.81 m/s^2			
2 Ts at 2 =	K=	60 fT		
2 elbows 1 =	K =	20 fT		
globe valve 2 =	K =	340 fT		
swing-type 2=	K =	100 fT		
2 elbows 3	K =	20 fT		
D2/ε =	3369.33			
D3/ε =	1148.67			

12.4 In the branched-pipe system shown in Fig. P12.4, 1350 gal/min of benzene (sg = 0.87) at 140 °F is flowing in the 8-in pipe. Calculate the volume flow rate in the 6-in and the 2-in pipes. All pipes are standard Schedule 40 steel pipes.
Figure P12.4

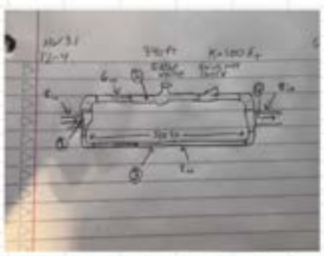


For Q2

Iteration	f1	Q2 (m3/s)	V1 (m/s)	Re
1	0.01000	0.03103479	2.63873028	1.90E+05
2	0.01918	0.02240969	0.69429536	1.55E+05
3	0.01983	0.02203937	0.68282196	1.53E+05
4	0.01998	0.02195648	0.68025408	1.52E+05

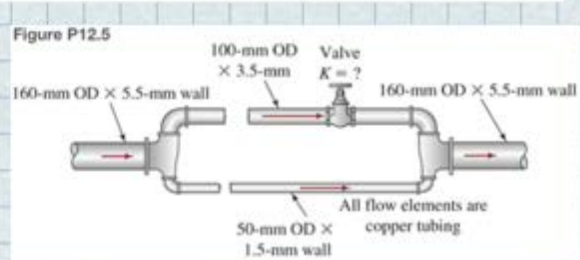
For Q3

Iteration	f1	Q2 (m3/s)	V1 (m/s)	Re
1	0.01000	0.00297581	0.09219625	2.06E+04
2	0.01918	0.00296333	0.09180877	2.05E+04
3	0.01983	0.00296246	0.09178259	2.05E+04
4	0.01998	0.00296225	0.09177632	2.05E+04



12.5 A 160-mm pipe branches into a 100-mm and a 50-mm pipe as shown in **Fig. P12.5**. Both pipes are hydraulic copper tubing and 30 m long. (The fluid is water at $10\ ^\circ\text{C}$.) Determine what the resistance coefficient K of the valve must be to obtain equal volume flow rates of 500 L/min in each branch.

Figure P12.5



$$\frac{\Delta P}{\gamma} = h_{L_{A-B}}$$

$$d_A = 50 - (2\times1.5) = 47\ \text{mm}$$

$$V_A = \frac{Q}{\frac{\pi}{4}d_A^2} = \frac{500\times10^{-3}/60}{\frac{\pi}{4}(47\times10^{-3})^2} = 4.801\ \text{m/s}$$

$$\rho = 999.7\ \text{kg/m}^3$$
$$\mu = 1.3059\times10^{-3}$$

$$Re_A = \frac{\rho V_A d_A}{\mu} = \frac{(999.7)(4.8)(47\times10^{-3})}{1.306\times10^{-3}}$$

$Re_A = 172,702.59$

$f_A = \frac{0.316}{(Re)^{1/4}} = 0.015501$

$h_A = \frac{f_A L V_A^2}{d_A 2g}$ where $L = 30m$
$g = 9.8 m/s^2$

$\rightarrow h_A = \frac{(0.015501)(30)(4.8)^2}{(0.097)(2)(9.8)} = 11.63$

$d_B = 100 - (2 \times 3.5) = 93\,mm$

$Re_B = \frac{\rho V_B d_B}{\mu}$

$V_B = \frac{Q}{\frac{\pi}{4} d_B^2} = 7.357\ m/s$

$Re_B = \frac{(999.7)(7.357)(93 \times 10^{-3})}{1.3059 \times 10^{-3}} = 523,773.4$

$f_B = \frac{0.316}{(Re_B)^{1/4}} = 0.0117$

$h_A = \frac{f_B L V_B^2}{d_B 2g} = 10.42\ m$

$h_{valve} = K \frac{V_B^2}{2g} = K \times 0.0647$

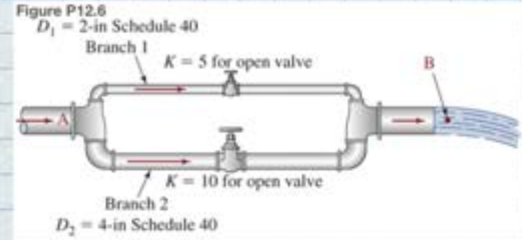
$h_B = h_{f_B} + h_{v_B} = 10.42 + (K \times 0.0647)$

$\rightarrow 11.619 = 10.42 + (K \times 0.0647)$

$\rightarrow K = 177.59$

12.6 For the system shown in **Fig. P12.6**, the pressure at A is maintained constant at 20 psig. The total volume flow rate exiting from the pipe at B depends on which valves are open or closed. Use $K = 0.9$ for each elbow, but neglect the energy losses in the tees. Also, because the length of each branch is short, neglect pipe friction losses. The steel pipe in branch 1 is 2-in Schedule 40, and branch 2 is 4-in Schedule 40. Calculate the volume flow rate of water for each of the following conditions:

Figure P12.6



$K = 0.9$

$\gamma_{H_2O} = 62.4\ lb/ft^3 = 0.0361\ lb/in^3$

$g = 32.2\ ft/s^2 = 386.4\ in/s^2$

$$\frac{V^2}{2g} = \frac{8Q^2}{g\pi^2 D^4}$$

$A_1 = 3.356\ in^2$

$A_2 = 12.730\ in^2$

$$\frac{P_A}{\gamma} + \cancel{\frac{V_A^2}{2g}} + \cancel{z_A} = \frac{P_B}{\gamma} + \cancel{\frac{V_B^2}{2g}} + \cancel{z_B} + h_L \rightarrow \frac{P_A - P_B}{\gamma} = h_{L_{A-B}}$$

① $$\frac{P_A - P_B}{\gamma} = [(2)(0.9)(5)]\frac{V^2}{2g} \rightarrow \frac{20\ lb/in^2 - P_B}{0.0361\ lb/in^3} = (9)\frac{8Q_1^2}{g\pi D^4} \rightarrow \text{Assuming } P_B = 20,\ Q_1 = \frac{14.6\ in^3/s}{3.35\ in^2}$$

$\rightarrow V_1 = 4.35\ in/s$ (branch 1)

② $$\frac{P_A - P_B}{\gamma} = [(2)(0.9)(10)]\frac{V^2}{2g} \rightarrow \frac{20\ lb/in^2 - P_B}{0.0361\ lb/in^3} = (18)\frac{8Q_2^2}{g\pi D_2^4} \rightarrow Q_2 = \frac{39.157\ in^3/s}{12.72} = 3.076\ in/s$$

$\rightarrow V_2 = 3.076\ in/s$ (branch 2)

Branch 2   Branch 1

$$\sqrt{\frac{\Delta P}{\gamma}\left(\frac{g\pi D_2^4}{144}\right)} + \sqrt{\frac{\Delta P}{\gamma}\left(\frac{g\pi D_1^4}{72}\right)}$$

$Q = 53.75\ in^3/s$

$V_{Tot} = 3.34\ in/s$

Weekly Reflection

In our class, we studied parallel pipeline systems that enable fluids to flow through different paths. We learned how to calculate energy losses and determine multiple flow rates. We also learned the equation to find different flow rates and used Excel for different iterations. We made assumptions by considering Q1, f2, and f3 to find the actual Q1, Q2, and Q3. When comparing the assumed Q1 to the actual Q1, find the differences. Also, find the difference between assumed f2 and f3 and the actual values of both.