Chapter 11and 12 overviewed the concepts of series, parallel and branching pipelines systems. With parallel and branching pipelines, we were introduced into more class 4 and 5 problems. Being able to identify in both pipelines how the fluids travel within different branches and how each brand can vary. Each branch effects the system in different ways and must be addressed separately, unless they are both identical. There are many factors that must be account for when fluid is traveling from a single point of origins into another through various branches and pipelines. Friction factors of the pipe, energy losses of each sub component such as elbows and valves must be accounted for. Depending on the unknown to solve for also requires the ability to identify when to use "iterations / guessing" vs when to work / manipulate equations for the required variable being solved for. Also, fluid velocity can vary within each branch due to different pipe sizes. Nodes must also be accounted for and identified and the flow of fluid going into a node must be equal to the flow exiting each of the same node. Circuit law must also be accounted for and reviewed and flow in a clockwise motion it is assumed to be positive, with counter clockwise being viewed as negative. Identifying and utilizing when to use the "Hardy Cross" method is also key when approaching situation when branches equal three or more. Overall, the homework assignments and the problems worked within class definitely were robust. It was mutinied to really slow down and take a look at what's going on and identify what's being see. Labeling is also important and is encouraged as problems can become complicated with various equations for Bernoulli's throughout. Patience and organization is important for problems with such complexity.

HWK 3.2 | Met 330 | Carroll, Shaunmark | 1

11.23) For the system in Fig 11.26, compute total head on the pump and the power delivered by the pump to the coolant

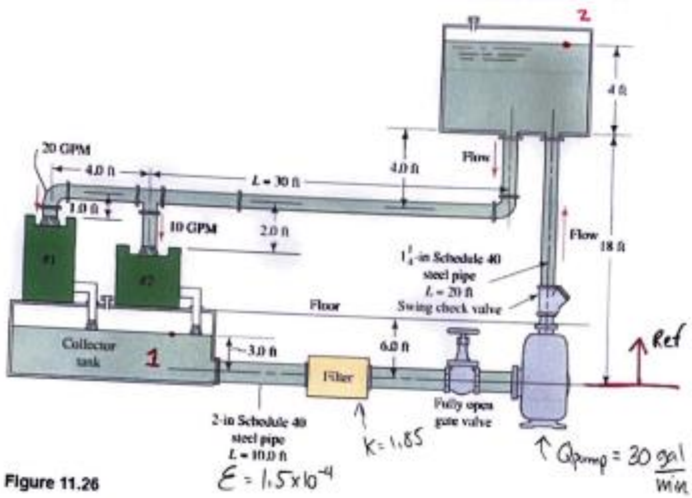


Figure 11.26

Inlet Pipe L = 10 ft

2 in schedule 40

Ø = .1723 ft

A = 0.02333 ft²

Outlet Pipe L = 20 ft

1 1/4 in schedule 40

Ø = 0.1150 ft

A = 0.01039 ft²

Coolant

Sg = 0.92

$\eta = 3.6\times10^{-5}\ \frac{lb\cdot s}{ft^2}$

$\gamma_c = .92(62.4) \rightarrow 57.408\ \frac{lb}{ft^3}$

P = 0 ; open to atmosphere   V = 0 ; large tanks

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

$Q_{series} \rightarrow Q_1 = Q_2$

$h_a = h_L + (z_b - z_1)$; $h_L = h_{entrance} + h_{inlet} + h_{filter} + h_{g.valve} + h_{s.valve} + h_{outlet} + h_{exit}$

inlet

$$Q_{1\text{-}pump} = U_1 A_1 \rightarrow 30\ \frac{gal}{min}\left(\frac{0.1336805556\ ft^3}{1\ gal}\right)\left(\frac{1\ min}{60\ sec}\right) = U_1(.02333\ ft^2)$$

$$U_1 = 2.865\ \frac{ft^2}{s}$$

outlet

$$Q_{out} = U_2 A_2 \rightarrow 30\ \frac{gal}{min}\left(\frac{0.1336805556\ ft^3}{1\ gal}\right)\left(\frac{1\ min}{60\ sec}\right) = U_2(.01039\ ft^2)$$

$$U_2 = 6.433\ \frac{ft^2}{s}$$

$$\rho_{coolant} = \rho_{water} \times Sg \rightarrow \rho_{coolant} = 1.94\ \frac{slugs}{ft3}(.92) \rightarrow \rho_c = 1.785\ \frac{slugs}{ft^3}$$

inlet

$$N_R = \frac{V_1 D_1 \rho_c}{\eta} \rightarrow \frac{2.865(.1723)(1.785)}{3.6\times10^{-5}}$$

$$N_R = 24476.3$$

outlet

$$N_R = \frac{V_2 D_2 \rho_c}{\eta} \rightarrow \frac{6.433(.1150)(1.785)}{3.6\times10^{-5}}$$

$$N_R = 36681.5$$

2

HWK 3.2 Met 330 Carroll, Shaunmark K

Inlet

$f_{T_1} = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{.1723}{1.5\times10^{-4}}\right)}\right)\right)^2} \rightarrow f_{T_1} = .019$

$V_1 = 2.865\ ft^2/s$

$N_R = 24476.3 \rightarrow 2.4\times10^4$

$\frac{D_1}{\varepsilon} \rightarrow \frac{.1723}{1.5\times10^{-4}} \rightarrow 1148.66$

$f_{inlet} = .026$ (moody chart)

Outlet

$f_{T_O} = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{.1150}{1.5\times10^{-4}}\right)}\right)\right)^2}$

$f_{T_O} = .021$

$V_2 = 6.433\ ft^2/s$

$N_R = 36681.5 \rightarrow 3.7\times10^4$

$\frac{D_2}{\varepsilon} \rightarrow \frac{.1150}{1.5\times10^{-4}} \rightarrow 766.66$

$f_{outlet} = .025$ (moody chart)

major:

$h_{L\,inlet} = f\frac{L_1}{D_1}\frac{V_1^2}{2g} \rightarrow .026\left(\frac{10}{.1723}\right)\left(\frac{2.865^2}{64.4}\right) \rightarrow h_{L\,inlet} = .1923\ ft$

$h_{L\,outlet} = f\frac{L_2}{D_2}\frac{V_2^2}{2g} \rightarrow .025\left(\frac{20}{.1150}\right)\left(\frac{6.433^2}{64.4}\right) \rightarrow h_{outlet} = 2.794\ ft$

minor:

$h_{L\,entrance\ square} = 0.5\left(\frac{V_1^2}{2g}\right) \rightarrow 0.5\left(\frac{2.865^2}{64.4}\right) \rightarrow h_{L\,entrance} = .0635\ ft$

$h_{filter} = 1.85\left(\frac{V_1^2}{2g}\right) \rightarrow 1.85\left(\frac{2.865^2}{64.4}\right) \rightarrow h_{L\,filter} = .2358\ ft$

$h_{g.valve} = 8 f_{T_1}\frac{V_1^2}{2g} \rightarrow 8(.019)\left(\frac{2.865^2}{64.4}\right) \rightarrow h_{g.valve} = .01937\ ft$

$h_{s.valve} = 100 f_{T_O}\frac{V_2^2}{2g} \rightarrow 100(.021)\left(\frac{6.433^2}{64.4}\right) \rightarrow h_{s.valve} = 1.3495\ ft$

$h_{exit} = 1.0\frac{V_2^2}{2g} \rightarrow 1.0\left(\frac{6.433^2}{64.4}\right) \rightarrow h_{exit} = .6426\ ft$

$h_a = h_L + (z_b - z_a) \rightarrow h_a = (.1923 + 2.794 + .0635 + .2358 + .01937 + 1.3495 + .6426) + (22 - 3)$

$h_a = 5.297\ ft + 19\ ft \rightarrow h_a = 24.3\ ft$

$P = \gamma Q h_a \rightarrow 57.408\left(30\frac{gal}{min}\left(\frac{.1336805556}{60}\right)\right)24.3$

$\rightarrow 92.58\ \frac{lb\cdot ft}{s}\left(1\,hp / 550\ \frac{lb\cdot ft}{s}\right) \rightarrow .168\ hp$

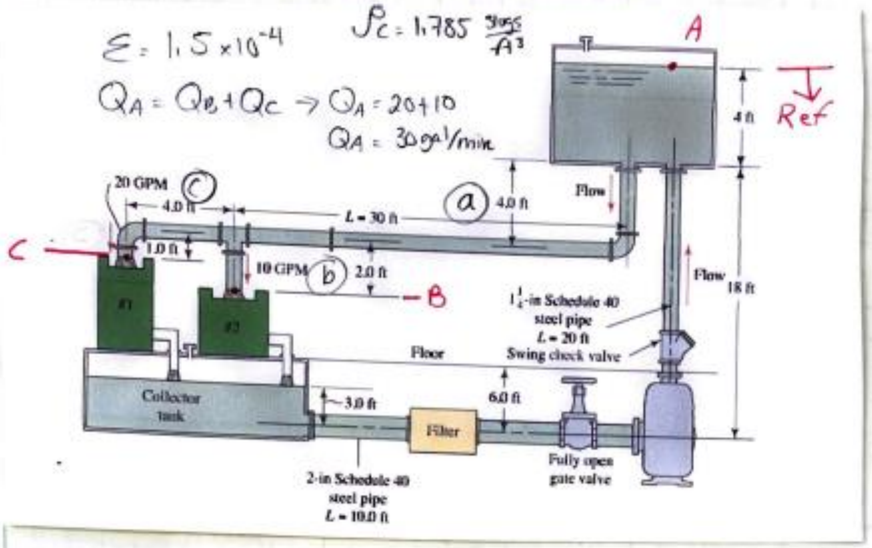
HWK 3.2 | Met 330 | Carroll, Shaunmark K | 3

11.24) Specify the size of the Schedule 40 steelpipe required to return the fluids to the machines

$\varepsilon = 1.5\times10^{-4}$ $\rho_C = 1.785\ \frac{slugs}{ft^3}$

$Q_A = Q_B + Q_C \rightarrow Q_A = 20+10$

$Q_A = 30\ gal/min$



Coolant

$Sg = 0.92$

$\eta = 3.6\times10^{-5}\ lb\cdot s/ft^2$

$\gamma = 57.408\ lb/ft^3$

$Q_C = 20\ gal/min$

$Q_B = 10\ gal/min$

$P_C = 0\ psig$

$P_B = 0\ psig$

$Q_A = 30\frac{gal}{min}\left(\frac{.1336805556}{60}\right) \rightarrow .06684\ \frac{ft^3}{s}$

$Q_B = 20\frac{gal}{min}\left(\frac{.1336805556}{60}\right) \rightarrow .0446\ \frac{ft^3}{s}$

$Q_C = 10\ gal/min\left(\frac{.1336805556}{60}\right) \rightarrow .0223\ \frac{ft^3}{s}$

$f_{Ta} = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{D_a}{1.5\times10^{-4}}\right)}\right)\right)^2}$

$f_{Tb} = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{D_b}{1.5\times10^{-4}}\right)}\right)\right)^2}$

$f_{Tc} = \frac{0.25}{\left(\log\left(\frac{1}{3.7\left(\frac{D_c}{1.5\times10^{-4}}\right)}\right)\right)^2}$

Bernoulli's A-B

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B + h_{L(A-B)}$$

$$-Z_B = \frac{V_B^2}{2g} + h_{L(A-B)} \rightarrow -Z_B = \frac{V_B^2}{2g} + \left(h_{L pipe_a} + h_{L pipe_b} + h_{elbow} + h_{T,Br} + h_{exit}\right)$$

$$h_{L(AB)} = f_a\frac{L_a}{D_a}\frac{V_a^2}{2g} + f_b\frac{L_b}{D_b}\frac{V_b^2}{2g} + 30 f_{Ta}\frac{V_a^2}{2g} + 60 f_{Ta}\frac{V_a^2}{2g} + 1.0\frac{V_b^2}{2g}$$

A-C

$$h_{L(A-C)} = f_a\frac{L_a}{D_a}\frac{V_a^2}{2g} + f_c\frac{L_c}{D_c}\frac{V_c^2}{2g} + 30 f_{Ta}\frac{V_a^2}{2g} + 20 f_T\frac{V_a^2}{2g} + 1.0\frac{V_c^2}{2g}$$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_C}{\gamma} + \frac{V_C^2}{2g} + Z_C + h_{L(AC)}$$

$$-Z_C = \frac{V_C^2}{2g} + h_{L(A-C)}$$

HWK 3.2 Met 330 Carroll, Shaunmark 4

$Q_A = .06684 \frac{ft^3}{s}$ $\quad f_{Ta} = 0.25 / \log(1/3.7(Da/1.5\times10^{-4}))^2$ $\quad V_a = \frac{4Q_a}{\pi D_a^2}$

$Q_B = .0446\ ft^3/s$ $\quad f_{Tb} = 0.25/\log(1/3.7(Db/1.5\times10^{-4}))^2$ $\quad V_b = \frac{4Q_b}{\pi D_b^2}$

$Q_C = .0223\ ft^3/s$ $\quad f_{Tc} = 0.25/\log(1/3.7(Dc/1.5\times10^{-4}))^2$ $\quad V_c = \frac{4Q_c}{\pi D_c^2}$

$$N_{Ra} = \frac{\rho V_a D_a}{\mu} \rightarrow \frac{1.785(4Qa/\pi Da^2)\,Da}{3.6\times10^{-5}}$$

$$N_{Rb} = 1.785(4Qb/\pi Db^2)\,Db$$

$$N_{Rc} = 1.785(4Qc/\pi Dc^2)\,Dc$$

$$f_a = 0.25/(\log(1/3.7(Da/1.5\times10^{-4}) + 5.74/N_{Ra}^{0.9})^2$$

$$f_b = 0.25/(\log(1/3.7(Db/1.5\times10^{-4}) + 5.74/N_{Rb}^{0.9})^2$$

$$f_c = 0.25/(\log(1/3.7(Dc/1.5\times10^{-4}) + 5.74/N_{Rc}^{0.9})^2$$

Bernoulli's A-B

$$Z_B = \left(f_a \frac{La}{Da}\frac{8Qa^2}{\pi g Da^4} + f_b \frac{Lb}{Db}\frac{8Qb^2}{\pi g Db^4} + 30 f_{Ta}\frac{8Qa^2}{\pi g Da^4} + 60 f_{Ta}\frac{8Qa^2}{\pi g Da^4} + \frac{8Qb^2}{\pi g Db^4}\right) - \frac{8Qb^2}{\pi g Db^4}$$

Bernoulli's A-C

$$Z_C = \left(f_a \frac{La}{Da}\frac{8Qa^2}{\pi g Da^4} + f_c \frac{Lc}{Dc}\frac{8Qc^2}{\pi g Dc^4} + 30 f_{Ta}\frac{8Qa^2}{\pi g Da^4} + 20 f_{Ta}\frac{8Qa^2}{\pi g Da^4} + \frac{8Qc^2}{\pi g Dc^4}\right) - \frac{8Qc^2}{\pi g Dc^4}$$

now to use excel, there is so much that can go wrong here. so I hope I can set this up correctly.

Data				
sg	0.92			
ρ	1.7848	slugs/ ft^3	0.0010329	slugs/in^3
D. Viscosity	0.000036	lb*s/ft^2	2.5E-07	lb*s/in^2
Gamma	57.408	lb/ft^3	0.0332222	lb/ in^3
Qc	10	gal/min	38.500576	in^3/sec
Qb	20	gal/min	77.001152	ft^3/sec
Qa	30	gal/min	115.50173	ft^3/sec
Zb	10	ft	120	in
Zc	9	ft	108	in
La	34	ft	408	in
Lb	2	ft	24	in
Lc	5	ft	60	in
gravity	32.2	ft/s^2	386.4	in/s^2
Roughness	0.00015	ft	0.0018	in

	Pipe a	Pipe b	elbow	T. Branch	exit
1	21.57265	12.84622	0.31554	0.677087	7.718491
2	2.575782	2.826559	0.056672	0.124658	2.442179
3	2.575782	4511.799	0.056672	0.179476	625.1978

Iteration	Diameter a	Diameter b	Nra	NRb	fa	fb	fT a	fT b	New Zb	old Zb	
1	2	1.5	4860650.55	1367058	0.019245	0.020804	0.001914	0.002054	35.41149	120	3441%
2	3	2	16404695.6	3240433.7	0.017449	0.01929	0.00174	0.001914	5.583671	120	458%
3	3	0.5	16404695.6	50631.777	0.017449	0.030069	0.00174	0.002756	4514.611	120	451361%
4										120	
5										120	
6										120	

Iteration	Diameter a	Diameter b	fa	fc	fT a	fT c	New Zc	old Zc
1	2	1.5						108
2								108
3								108
4								108
5								108
6								108

Kevin Smith ①
MET 330
HW 3.2 12.3

12.3) Given

$Q_1 = 850$ l/min $= 0.85$ m³/min
$Q_1 = 0.0142$ m³/s
$T = 10°C$
DN 100 in + out
DN 50 intermediary piping
$L_{AB_b} = 60$ m
$L_{AB_a} = 30$ m

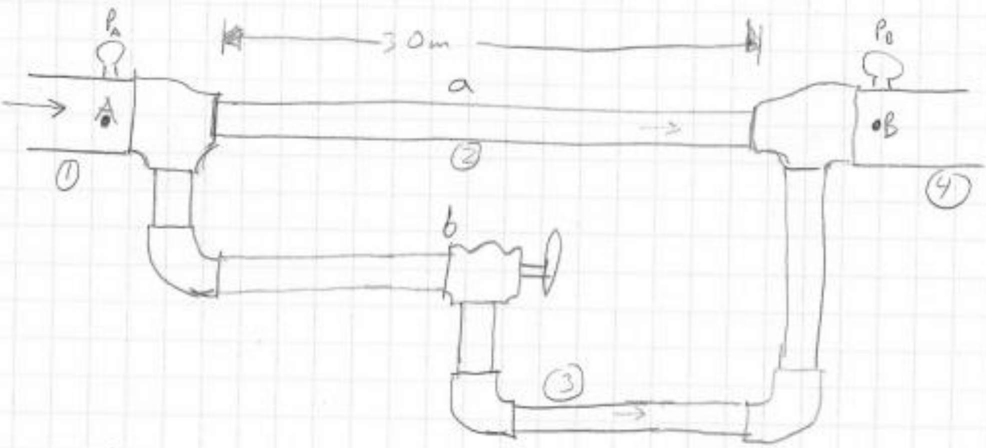
Variables

$\gamma = 9.81$ kN/m³
$\rho = 1000$ kg/m³
$\nu = 1.3 \times 10^{-6}$ m²/s
$\epsilon = 4.6 \times 10^{-5}$
$K_{valve} = 150 f_T$
$K_{Elbow} = 30 f_T$
$K_{Tee_{90}} = 60 f_T$
$K_{Tee_0} = 20 f_T$

DIN 50 Sch 40:
$D_2 = D_3 = 0.0525$ m
$A_2 = A_3 = 2.168 \times 10^{-3}$ m²

DIN 100 Sch 40:
$D_1 = D_4 = 0.1023$ m
$A_1 = A_4 = 8.213 \times 10^{-3}$ m²

Drawings



Find: a) flow rate in each of the branches $Q_{AB_A} =$
$Q_{AB_B} =$
b) pressure difference $P_A - P_B$

Variables

$V_4 = V_1 = 1.73$ m/s
$Re_1 = 3847 = Re_4$
$f_1 = 0.017$
$D/\epsilon = 2224$

No answer...
bad equations?
Excel sheet doesn't like
my written equations.

(2)

Equations

For section AB_a:

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

$$\frac{P_A}{\gamma} - \frac{P_B}{\gamma} = h_{L_{AB}}$$

$$Q_1 = Q_4 = Q_2 + Q_3$$

$$Q_1 = A_1 V_1$$

$$0.0142\ m^3/s = 8.213 \times 10^{-3}\ m^2\ V_1$$

$$1.73\ m/s = V_1$$

$$h_L = f\,\frac{L}{D}\,\frac{V^2}{2g}$$

$$R_e = \frac{\rho V D}{\mu} = \frac{VD}{\nu}$$

$$\text{Relative Roughness} = \frac{D}{\varepsilon}$$

$$R_e = \frac{~~1000~~ \cdot 1.73 \cdot 0.1023}{4.6 \times 10^{-5}}$$

$$R_e = 3847$$

(3)

(2) $$\frac{P_A}{\gamma} - \frac{P_B}{\gamma} = f_1 \underbrace{\left(\frac{L_e}{D}\right)_{Tee_o}}_{} \cdot \frac{V_1^2}{2g} + f_2 \frac{L_2}{D_2} \cdot \frac{V_2^2}{2g} + f_4 \left(\frac{L_e}{D}\right)_{Tee_o} \cdot \frac{V_4^2}{2g}$$

(Tee$_o$, Pipe, Tee)

(2) $$\frac{P_A}{\gamma} - \frac{P_B}{\gamma} = f_1 \left(\frac{L_e}{D}\right)_{Tee_o} \cdot .5 \frac{16 Q_1^2}{g \pi^2 D_1^4} + f_2 \frac{L_2}{D_2} \cdot .5 \frac{16 Q_2^2}{g \pi^2 D_2^4} + f_4 \left(\frac{L_e}{D}\right)_{Tee_o} \cdot .5 \frac{16 Q_4^2}{g \pi^2 D_4^4}$$

$$\frac{\Delta P_{AB}}{\gamma} = f_1 (20) \cdot 754.43 Q_1^2 + f_2\, 571.43 \cdot 754.43 Q_2^2 + f_4 (20) \cdot 754.43 Q_4^2$$

$$= f_1\, 15{,}088.6\, Q_1^2 + f_2\, 431{,}104\, Q_2^2 + f_4\, 15{,}088.6\, Q_4^2$$

$$= f_1\, 3.04 + f_2\, 431{,}104\, Q_2^2 + f_4\, 3.04$$

$$f_1 = f_4 \;\therefore$$

$$\frac{\Delta P_{AB}}{\gamma} = f_1\, 6.08 + f_2\, 431104\, Q_2^2$$

$$\frac{\Delta P_{AB}}{9.81} = 0.017 \cdot 6.08 + f_2\, 431104\, Q_2^2$$

$$\Delta P_{AB} = \left(0.101 + f_2\, 431104\, Q_2^2\right) 9.81$$

$$\Delta P_{AB} = 0.99227 + f_2\, 4229130\, Q_2^2$$

(2) $$\sqrt{\frac{\Delta P_{AB} - 0.99227}{f_2\, 4229130}} = Q_2$$

(9)

Equations for section AB_b:

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{P_4}{\gamma} + z_4 + \frac{V_4^2}{2g} + h_L$$

$$\frac{P_1}{\gamma} - \frac{P_4}{\gamma} = h_L$$

$$Q_1 = Q_4 = Q_2 + Q_3$$

$$Q_1 = A_1 V_1$$

(3) $$\frac{P_1}{\gamma} - \frac{P_4}{\gamma} = \left(K_{Tee_{90}} \cdot .5 \frac{16 Q_1^2}{g \pi^2 D_1^4}\right) + 3\left(K_{elbow} \cdot .5 \frac{16 Q_3^2}{g \pi^2 D_3^4}\right) + \left(K_{valve} \cdot .5 \frac{16 Q_3^2}{g \pi^2 D_3^4}\right) + \left(K_{Tee_{90}} \cdot .5 \frac{16 Q_4^2}{g \pi^2 D_4^4}\right)$$

$$\frac{\Delta P_{AB}}{9.81} = 60 \cdot 754.43 Q_1^2 + 3 \cdot 30 \cdot 754.43 Q_3^2 + 150 \cdot 754.43 Q_3^2 + 60 \cdot 754.43 Q_4^2$$

$$\frac{\Delta P_{AB}}{9.81} = 45265.8 Q_1^2 + 67898.7 Q_3^2 + 113164.5 Q_3^2 + 45265.8 Q_4^2$$

$Q_1 = Q_4 \therefore$

$$\frac{\Delta P_{AB}}{9.81} = 90531.6 Q_1^2 + 181063.2 Q_3^2$$

$$\Delta P_{AB} = \frac{18.255 + 181063.2 Q_3^2}{9.81}$$

$$\Delta P_{AB} = 1.86 + 18457 Q_3^2$$

(3) $$\sqrt{\frac{\Delta P_{AB} - 1.86}{18457}} = Q_3$$

Input Data		
Specific Weight=	9.81	kN/m^3
Kinematic Viscosity=	1.30E-06	m^2/s
Pressure A=	0	kPa
Pressrue B=	0	kPa
Pipe length = L2 = L3=	60	m
Pipe length = L1 = L4=	30	m
D1=	0.1023	m
D2=	0.0525	m
D3=	0.0525	m
Wall Roughness=	4.60E-05	m
Le/D valve=	150	
Le/D tee90=	60	
Le/D tee0=	20	
Le/D elbow=	30	

D1/e=	2223.91
D2/e=	1141.30
D3/e=	1141.30
g=	9.81 m/s^2

Q1= 0.0142 m3/s

Iteration 1

Guess Q2 (m3/s)	V2 (m/s)	Re2	f2	deltaP /gamma (m)
0.007100	3.279818873	132454	0.02134	5.54159597

f3	Q3 (m3/s)	V3 (m/s)	Re3	f3	%diff
0.01	0.01412334303	6.524226339	2.63E+05	0.02035	103.5%
0.02035	0.01412334303	6.524226339	2.63E+05	0.02035	0.0%
0.02035	0.01412334303	6.524226339	2.63E+05	0.02035	0.0%
0.02035	0.01412334303	6.524226339	2.63E+05	0.02035	0.0%

HW 3.2

Tuesday, November 16, 2021 5:20 PM

12.5 A 160-mm pipe branches into a 100-mm and a 50-mm pipe as shown in Fig. 12.10. Both pipes are hydraulic copper tubing and 30 m long. The fluid is water at 10°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.

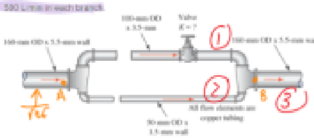


Figure 12.10
Problem 12.5

4. CLASS IV: Determine K of a valve (valve opening)

Conservation of Mass

$Q_3 = Q_1 + Q_2$

$Q = V \cdot A$

$K_{valve} = \frac{V_A^2}{2g}$

	O.D.	Wall Thickness	I.D.
A	160 mm = .16 m	5.5 mm = .0051 m	= .1498 m
B	100 mm = .10 m	3.5 mm = .0035 m	= .093 m
C	50 mm = .05 m	1.5 mm = .0015 m	= .047 m

Areas

$A_A = \frac{\pi d^2}{4} = \frac{\pi(.1498m)^2}{4} = .0176m^2$

$A_B = \frac{\pi d^2}{4} = \frac{\pi(.093m)^2}{4} = .0068m^2$

$A_C = \frac{\pi d^2}{4} = \frac{\pi(.047m)^2}{4} = .0017m^2$

Pipes

30m

Pipe Energy losses

$h_L = f\frac{L}{D}\frac{v^2}{2g}$ ⇒ * Moody Chart, Relative Roughness

$R_r = \frac{D}{\varepsilon}$

Friction Factor

$Re = \frac{\rho v D}{\mu} = \frac{vD}{\nu}$

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

*Path 1

$h_{L\,elbow} + h_{L\,pipe} + h_{L\,valve} + h_{L\,elbow}$

*Path 2

$h_{L\,elbow} + h_{L\,pipe} + h_{L\,elbow}$

*Flow Rate

$Q_A = Q_B$

$\frac{500L}{min} = \frac{500}{6000} = .00833\,m^3/s$

Velocity A & B

$V_1 = \frac{Q}{A_B} = \frac{.00833m/s}{.0068m^2} = 1.23\,m/s$

$V_2 = \frac{Q}{A_C} = \frac{.00833\,m/s}{.0017m^2} = 4.9\,m/s$

Areas

$A_A = \frac{\pi d^2}{4} = \frac{\pi(.1498m)^2}{4} = .0176m^2$

$A_B = \frac{\pi d^2}{4} = \frac{\pi(.093m)^2}{4} = .0068m^2$

$A_C = \frac{\pi d^2}{4} = \frac{\pi(.047m)^2}{4} = .0017m^2$

	O.D.	Wall Thickness	I.D.
A	160 mm = .16 m	5.5 mm = .0051 m	= .1498 m
B	100 mm = .10 m	3.5 mm = .0035 m	= .093 m
C	50 mm = .05 m	1.5 mm = .0015 m	= .047 m

Branch 1

Pipe, Elbows, Valve

$h_{L\,elbow} + h_{L\,pipe} + h_{L\,valve} + h_{L\,elbow} \Rightarrow f_1\frac{L}{D}\frac{V_1^2}{2g} + 2\left(f_T 30\frac{V_1^2}{2g}\right) + \frac{K V_1^2}{2g}$

$= f_1\frac{30m}{.093m} + 2\left(f_T 30\frac{(1.23)^2}{2(9.8)}\right) + K\frac{V_1^2}{2g}$

$= (322.6 f_1 + 2.31 f_T + K)\frac{V_1^2}{2g}$

Branch 2

Pipe, Elbow

$h_{L\,elbow} + h_{L\,pipe} + h_{L\,elbow} \Rightarrow f_2\frac{L}{D}\frac{V_2^2}{2g} + 2\left(f_T 30\frac{V_2^2}{2g}\right)$

$= f_2\frac{30m}{.047m} + 2\left(f_T 30\left(\frac{(4.9m/s)^2}{2(9.8)}\right)\right)$

$= 638.3 f_2 + 1.23 f_T$

Flow of Branch 1 & 2

Water @ 10°C = $\nu = 1.30 \times 10^{-6}$

$N_{R_1} = \frac{V_1 D_B}{\nu} = \frac{(1.23)(.093)}{1.30 \times 10^{-6}} = 87992.3 \Rightarrow 8.7 \times 10^4$ & 62000

$N_{R_2} = \frac{V_2 D_C}{\nu} = \frac{(4.9)(.047)}{1.30 \times 10^{-6}} = 177153.8 \Rightarrow 1.7 \times 10^5$ & 31333

Relative Roughness

Pg 185 @ Copper Table 8.2

$\frac{D}{\varepsilon_1} = \frac{.093}{1.5 \times 10^{-6}} = 62000$ / $\frac{\varepsilon}{D} = \frac{1.5 \times 10^{-6}}{.093} = 1.6 \times 10^{-5}$

$\frac{D}{\varepsilon_2} = \frac{.047}{1.5 \times 10^{-6}} = 31333$ / $\frac{\varepsilon}{D} = \frac{1.5 \times 10^{-6}}{.047} = 3.19 \times 10^{-5}$

$= f_1 = .0185$

$= f_2 = .0163$

Complete Turbulence $= f_T = .010$

Branch 1

$h_{L\,elbow} + h_{L\,pipe} + h_{L\,valve} + h_{L\,elbow} \Rightarrow f_1 \frac{L}{D}\frac{V_1^2}{2g} + 2\left(f_T 30 \frac{V_1^2}{2g}\right) + \frac{K V_1^2}{2g}$ (Pipe, Elbows, Valve)

$= \left(f_1 \frac{L}{D} + 2 f_T 30 + K\right)\frac{V_1^2}{2g}$

$= f_1 \frac{30m}{.093m} + 2(.010)(30) + K\Big)\frac{1.23^2}{2(9.8)}$

$= ((.0185)(322.6) + .60 + K)\,.077$

$= (5.97 + .60 + K).077$

$= (6.57 + K).077$

Branch 2

$$f_2 = h_{L_{Elbow}} + h_{L_{Pipe}} + h_{L_{Elbow}}$$

$$= \left(2 f_T 30 + f \frac{L}{D}\right) \frac{V_2^2}{2g}$$

$$= \left(2(30)(.01) + .0163\left(\frac{30}{.047}\right)\right) \frac{4.9^2}{2(9.8)}$$

$$= \left(.6 + .0163(638.3)\right) 1.23$$

$$= (11) 1.23$$

$$= 13.5$$

Head Loss Equation for Parallel Systems

$$h_{L_{1-2}} = h_a = h_b$$

Branch 1 = Branch 2

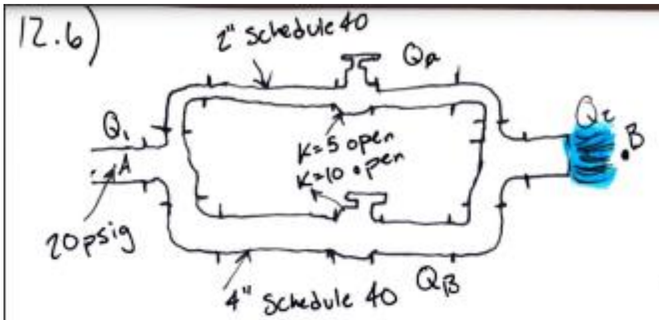
$$(6.57 + K).077 = 13.5$$

$$= .51 + .077K = 13.5$$

$$= .077k = 12.99$$

$$= K = 168.7$$

12.6)



Robert Krupp
MET 330
HW 3.2
Group 2

Given
$P_A = 20\,psig$
$K_{elbow} = 0.9$
$K_{small\,valve} = 5$
$K_{Large\,valve} = 10$
$D_1 = 2.067"$
$D_2 = 4.026"$
$A_1 = 3.36\,in^2$
$A_2 = 12.73\,in^2$
$P_B = 0\,psig$
$g = 32.2\,ft/s^2 = 386.4\,in/s^2$
$\gamma_w = 62.4\,lb/ft^3 = 0.036\,lb/in^3$

a) Both valves open $Q_2 = Q_1$

$$\frac{P_A}{\gamma} + \frac{v_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{v_B^2}{2g} + z_B + h_{LAB}$$

$$\frac{P_A}{\gamma} = H_{LAB}$$

$$\therefore \frac{P_A}{\gamma} = 2\left(0.9\frac{v^2}{2g}\right) + 2\left(0.9\frac{v^2}{2g}\right) + \left(5\frac{v^2}{2g}\right) + 10\frac{v^2}{2g}$$

$$\frac{P_A}{\gamma} = 2\left(0.9\left(\frac{16Q^2}{\pi^2(2.067)^4}\right)\right)\left(\tfrac{1}{2g}\right) + 2\left(0.9\left(\frac{16Q^2}{\pi^2(4.026)^4}\right)\right)\left(\tfrac{1}{2g}\right) + 5\left(\frac{16Q^2}{\pi^2(2.067)^4}\right)\left(\tfrac{1}{2g}\right) + 10\left(\frac{16Q^2}{\pi^2(2.067)^4}\right)\left(\frac{1}{2g}\right)$$

$$\frac{20}{0.036} = 2\left(0.9\left(\frac{16Q^2}{180.1275}\right)\frac{1}{2(386.4)}\right) + 2\left(0.9\left(\frac{16Q^2}{2{,}543.06}\right)\right)(0.0013) + 5\left(\frac{16Q^2}{180.1275}\right)(0.0013) + 10\left(\frac{16Q^2}{2{,}543.06}\right)(0.0013)$$

(0.0013)

$$\frac{20}{0.036} = Q^2\left(2(0.9(0.0888)(0.0013) + 2(0.9(0.0062)(0.0013) + 5(0.0888)(0.0013) + 10(0.0062)(0.0013)\right)$$

(.00021) (0.000015) (0.00058) (0.000081)

$$\therefore Q = \sqrt{\frac{555.56}{0.000886}} = 791.86\,in^3/s = \text{~~0.46 ft}^3\text{/s~~}$$

$Q_2 = Q_a + Q_B$

$\therefore Q_2 = 0.485 + 1.39$

$Q_2 = 1.875\,ft^3/s$

b) Valve in branch 2 open only

$$\frac{P_A}{\gamma} = 2\left(0.9\left(\frac{16Q^2}{\pi^2(4.026)^4}\right)\left(\frac{1}{2(386.4)}\right)\right) + 10\left(\frac{16Q^2}{\pi^2(4.026)^4}\right)\left(\frac{1}{2(386.4)}\right)$$

$$Q_b = \sqrt{\frac{555.56}{0.00096}} = 2{,}405.64\,in^3/s = 1.39\,ft^3/s$$

c) Valve in branch 1 open only

$$\frac{P_A}{\gamma} = 2\left(0.9\left(\frac{16Q^2}{\pi^2(2.067)^4}\right)\left(\frac{1}{2(386.4)}\right)\right) + 5\left(\frac{16Q^2}{\pi^2(2.067)^4}\right)\left(\frac{1}{2(386.4)}\right)$$

$$\therefore Q_a = \sqrt{\frac{555.56}{.00079}} = 838.59\,in^3/s = 0.485\,ft^3/s$$