Problem 11.23

Given:

pipe = 2 in Schedule 40 steel

length = 10 ft

length of delivery pipe = 20 ft

$\eta = 3.6 \times 10^{-5}\ lb.s/ft^2$

$sg = 0.92$

$Q = 30 gal/min = 0.0668 gal/min$

Diff in head = 19 ft

Equations

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} - h_L + h_A = \frac{p_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

$$h_A = h_L + (z_2 - z_1)$$

$$P = Q\gamma h_A$$

first v

$$v_s = \frac{0.0668}{0.02333}$$

$$= 2.864 ft/s$$

$$\frac{v_s^2}{2g} = \frac{2.864^2}{2 \times 32.2} = 0.127$$

Reynolds number $N_R = \frac{vD\rho}{\eta}$

$$\rho = 0.92(1.94 slug/ft^3)$$

$$= 1.784 slug/ft^3$$

$$N_R = \frac{2.864 \times 0.1723 \times 1.784}{3.6 \times 10^{-5}}$$

$$= 2.44 \times 10^4$$

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

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

1148.64 Corresponds to $f = 0.0265$ on the moody's chart

Velocity in discharge line

$V_D = \frac{0.6668}{0.01039}$

$= 6.433\ ft/s$

$\frac{V_D^2}{2g} = \frac{6.433^2}{2 \times 32.2}$

$= 0.642$

Reynold #

$N_R = \frac{6.433 \times 0.115 \times 1.784}{3.6 \times 10^{-5}}$

$= 3.67 \times 10^4$

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

3.67×10^4 corresponds to $f = 0.0265$ on moody's chart.

Calculating losses in System.

h_1 = Entrance loss

h_2 = friction loss in pipe

h_3 = Energy loss in filter

h_4 = Energy loss in fully open gate valve

h_5 = Energy loss in swing type check valve

h_6 = friction loss in delivery pipeline

h_7 = exit loss

$h_1 = 0.5 \times 0.127$

$= 0.0635\ ft$

$h_2 = f \times \frac{L}{D} \times \frac{V_s^2}{2g}$

$= 0.0265 \times \frac{10}{0.172} \times 0.127$

$= 0.195\ ft$

$h_3 = f_T \times \frac{L_e}{D} \times \frac{V_1^2}{2g}$

$h_3 = 1.85 \times 0.127$

$= 0.235\ ft$

$h_4 = 0.019 \times 8 \times 0.127$

$= 0.0193\ ft$

$h_5 = f_{dt} \times \frac{L_e}{D} \times \frac{V_D^2}{2g}$

$= 0.022 \times 100 \times 0.642$

$= 1.412\ ft$

$h_6 = 0.0265 \times \frac{15}{0.115} \times 0.642$

$= 2.66\ ft$

$h_7 = 1.0 \left(\frac{V_D^2}{2g}\right) = 1.0 \times 0.642$

$= 0.642\ ft$

Total Energy loss

$$h_L = 0.0685 + 0.195 + 0.235 + 0.0193 + 1.412 + 2.66 + 0.642$$

$$= 5.23\ ft$$

$$\gamma = sg \times 62.4\ lb/ft^3$$

$$\gamma = 0.92 \times 62.4\ lb/ft^3$$

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

Energy Supplied

$$h_A = 5.23 + 19$$

$$= 24.23\ ft$$

Power Calculations

$$P = 0.0665 \times 57.408 \times 24.23 \times \frac{1}{550}$$

$$= 0.169\ hp$$

$\therefore$ power delivered $= P = 0.169\ hp.$

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Problem 11.24

Given;

Length of pipe = 10 ft

$\eta = 3.6 \times 10^{-5}$ lb.s/ft²

Schedule 40 2 in steel pipe

$Sg = 0.92$

$Q = 0.0668$ gal/min

Equation

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

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

$$\text{Velocity} = \frac{0.06684}{0.0233} = 2.864 \text{ ft/s}$$

$$\frac{v^2}{2g} = \frac{2.864^2}{2 \times 32.2} = 0.127$$

$$\rho = 0.92 \times 1.94) = 1.784 \text{ slug/ft}^3$$

$$N_R = \frac{2.864 \times 0.172 \times 1.784}{36 \times 10^{-5}} = 2.44 \times 10^4$$

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

Total head Loss in the System

$h_L = h_1 + h_2 + h_3 + h_4$

h_1 = Entrance loss

h_2 = friction loss

h_3 = Energy loss in filters

h_4 = Energy loss in fully open valve gate

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$$h_a = \left(\left(f\frac{L}{D}\right) + \underbrace{\left(f_{dt}\frac{L_e}{d}\right)}_{\text{globe valve}} + \underbrace{\left(f_{dt}\frac{L_e}{d}\right)}_{\text{Swing valve}} + 2\left(f_{dt}\frac{L_e}{d}\right)\right)\left(\frac{V_a^2}{2g}\right)$$

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

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

$$h_b = h_5 + h_6$$

$$= \left(f_b \frac{L}{D}\frac{V_b^2}{2g}\right) + 2\left(f_{dt}\frac{L_e}{d}\frac{V_b^2}{2g}\right)$$

$$= \left(\left(f_b\frac{L}{D}\right) + 2\left(f_{dt}\frac{L_e}{d}\right)\right)\left(\frac{V_b^2}{2g}\right)$$

2in schedule 40 steel pipe

$D = 0.1723\,ft$

$A = 0.02333\,ft^2$

$\varepsilon = 1.5\times10^{-4}\,ft$

$\frac{L_e}{D}_{\text{elbow}} = 30$

$$\frac{D}{\varepsilon} = \frac{0.1723}{1.5\times10^{-4}}$$

$$\frac{D}{\varepsilon} = 1148.67$$

$$f_{dt} = 0.019$$

$$= \left(\left(f_b\left(\frac{500}{0.1723}\right)\right) + 2(0.019(30))\right)\left(\frac{V_b^2}{2g}\right)$$

$$h_b = (2901.91 f_b + 1.14)\left(\frac{V_b^2}{2g}\right) \quad \cdots \quad ③$$

$h_1 = 0.5 \times 0.127$

$= 0.0635 \, ft$

$h_2 = f \times \frac{L}{D} \times \frac{v^2}{2g}$

$= \frac{0.0265 \times 10}{0.1723} \times 0.127$

$= 0.195 \, ft$

$h_3 = 1.85 \times 0.127$

$= 0.235 \, ft$

$h_4 = 0.019 \times 8 \times 0.127$

$= 0.0193 \, ft$

total Loss of Energy

$h_L = 0.0635 + 0.195 + 0.235 + 0.0193$

$= 0.513 \, ft$

$\gamma = 0.92 \times 62.4 \, lb/ft^3$

$= 57.408 \, lb/ft^3$.

∴ Calculating Pressure

$P_2 = 57.408 \times (3 - 0.127 - 0.513)$

$= 135.48 \, lb/ft^2 \times \frac{1}{144}$

$= 0.94 \, psig$

∴ total pressure

$= \underline{0.94 \, psig}$

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$h_{L_{A-B}} = h_a = h_b$

$(989.35 f_a + 7.5)\frac{V_a^2}{\cancel{2g}} = (2901.91 f_b + 1.14)\frac{V_b^2}{\cancel{2g}}$

$(989.35(0.016) + 7.5) V_a^2 = (2901.91(0.02) + 1.14) V_b^2$

$23.329 v_a^2 = 59.178 v_b^2$

$V_a = 1.592 v_b$

$Q = Q_A = Q_B = Q_a + Q_b$

$Q = V_a A_a + V_b A_b$

$3.01 = A_a(1.592 v_b) + V_b A_b$

$3.01 = (A_a(1.592) + A_b) V_b$

$3.01 = (0.2006(1.592) + 0.02333) v_b$

$V_b = 8.783$ ft/s

$V_a = 1.592 v_b$

$V_a = 1.592(8.783)$

$V_a = 13.98$ ft/s

$N_{R_a} = \frac{\rho V_a D_a}{\eta}$

$= \frac{1.6878(13.98)(0.5054)}{8 \times 10^{-6}}$

$N_{R_a} = 1490642.175$

$N_{R_b} = \frac{\rho V_a D_a}{\eta}$

$= \frac{1.6878(8.783)(0.1723)}{8 \times 10^{-6}}$

$N_{R_b} = 319270.76$

$f_a = 0.016$

$f_b = 0.02$

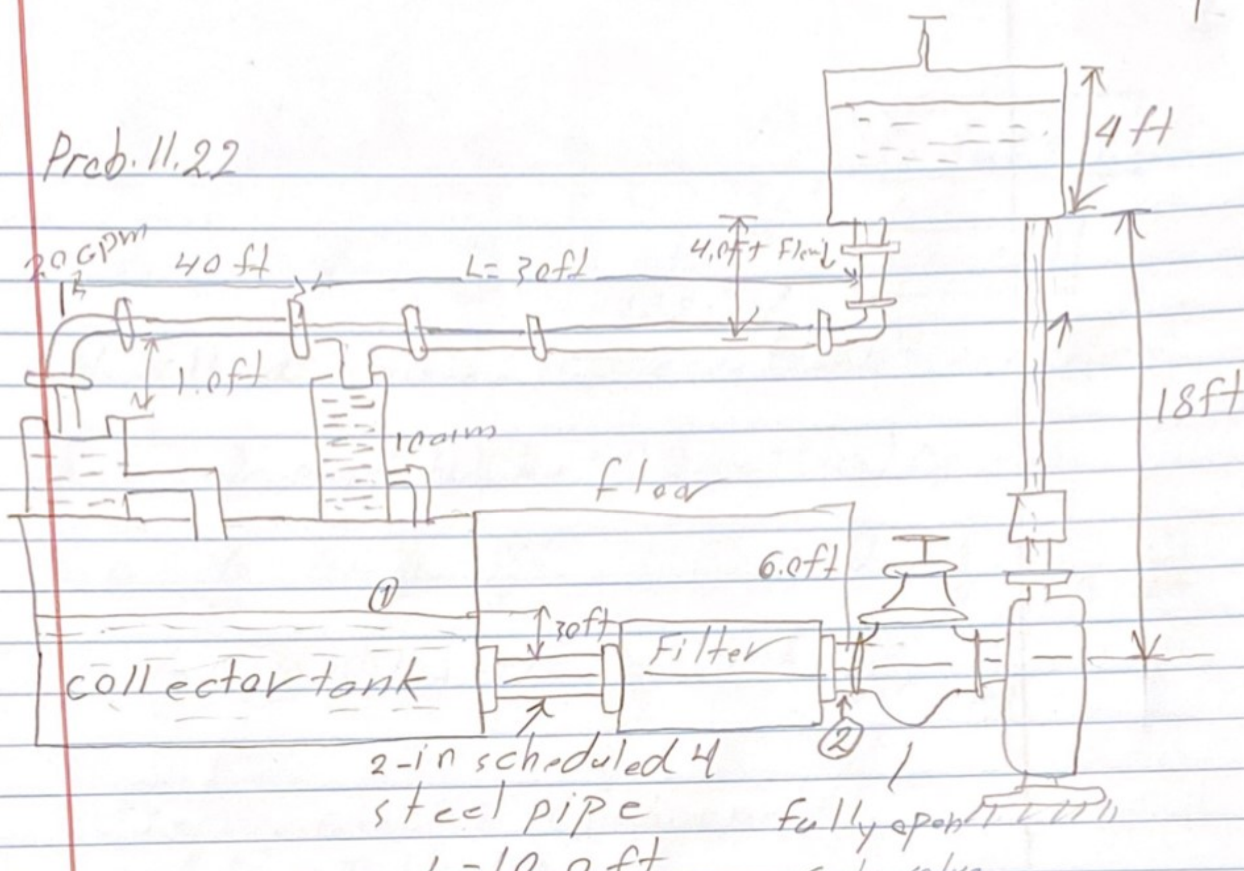
$Q_a = V_a A_a$
$= (13.98)(0.2006)$
$= 2.8043(449)$

$\boxed{Q_a = 1259.13 \text{ gal/min}}$

$Q_b = V_b A_b$
$= (8.783)(0.02333)$
$= 0.2049(449)$

$\boxed{Q_b = 92.0001 \text{ gal/min}}$

Prob. 11.22



Given: system as shown in figure with dimensions
· filter Resistance coefficient (k) filter = 1.85
· specific gravity (sG) = 0.92
Dynamic viscosity (μ) = $3.6\times10^{-5}\ \frac{lb\text{-}s}{ft^2}$

To find: Pressure at the inlet of pump

solution: Total Discharge of pump = $Q_1 + Q_2 = 20 + 10 = 30$ GPM

$\Rightarrow Q = 30\ gal/min \times \frac{1\ ft^3/s}{449\ gal/min} = 0.0668\ ft^3/s$

Velocity at pump inlet in 2 in pipe (V_2) = $\frac{Q}{A_2}$

From Table for 2-in pipe

$D_i = 0.1723\ ft$ & $A = 0.02333\ ft^2$

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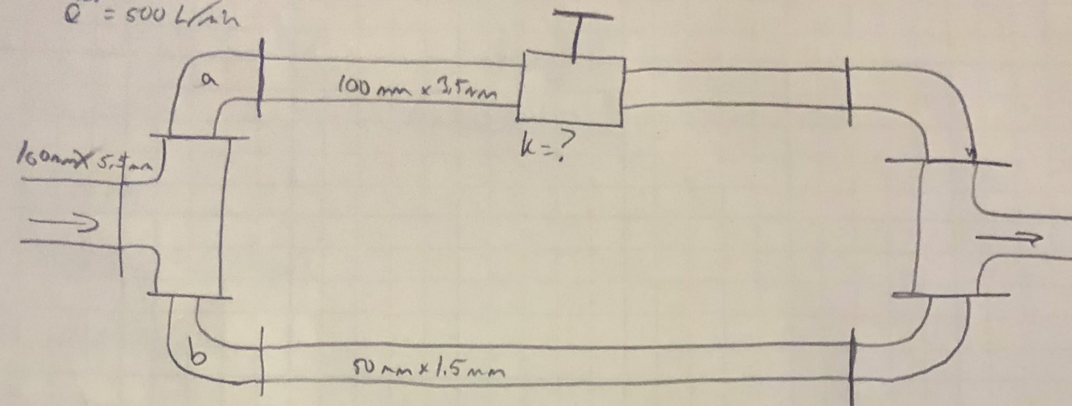
5) $L = 30m$
$T = 10°C$
$Q = 500\ L/min$



$$D_i = 100 - 2(3.5)$$
$$= 93mm\left(\frac{10^{-3}m}{1mm}\right)$$
$$D_i = 0.093m$$

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

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

$$V_a = Q/A_a$$
$$= 8.33\times10^{-3}/6.79\times10^{-3}$$
$$V_a = 1.22\ m/s$$

$$N_R = \frac{V_a D_i}{\nu} \leftarrow \text{Table A.1}$$
$$= \frac{1.22(0.093)}{1.30\times10^{-6}}$$
$$N_R = 87276.923$$

$$\frac{\varepsilon}{D} = \frac{1.5\times10^{-6}}{0.093}$$
$$= 1.61\times10^{-5}$$
$$f_a = 0.0185$$
$$f_T = 0.010$$

$\Rightarrow$ Velocity (1/2) $= \frac{Q}{A_{2_2}} = \frac{0.0668\ ft^3/s}{0.02333\ ft^2} = \boxed{2.86\ ft/s}$

Velocity Head $\frac{V_2^2}{2g} = \frac{(2.86 ft/s)^2}{2 \times 32.2\ ft/s^2} = \boxed{0.127\ ft}$

Now. Head losses in 2-in pipe are (tank to pump inlet)

$h_L = (h_L)_{entranc} + (h_L)_{filter} + (h_L)_{valve} + (h_L)_{friction}$

$= 0.5 \cdot \frac{V_2^2}{2g} + (k)_{filter} \cdot \frac{V_2^2}{2g} + f_T \left(\frac{L_e}{D}\right)_{valve} \cdot \frac{V_2^2}{2g} + f \cdot \frac{L}{D} \cdot \frac{V_2^2}{2g}$

$h_L = \left(0.5 + (k)_{filter} + f_T \left(\frac{L_e}{D}\right)_{valve} + f \cdot \frac{L}{D}\right) \cdot \frac{V_2^2}{2g}$

from Table
$(L_e/D)_{gate\ valve} = 8$ (fully opend)
and from Table 10.5
f_T for 2-in sket pipe $= 0.019$

$\Rightarrow h_L = \left[0.5 + 1.85 + 0.019 \times 8 + f \left(\frac{10 ft}{0.1723 ft}\right)\right] \times (0.127 ft)$

$\approx \{2.50 + 58.0 f\} \frac{V_2^2}{2g} = (2.50 + 58.0 f) \cdot \frac{V_2^2}{2g}$

Reynold number $R_e = \frac{V_2 \cdot D}{\nu} = \frac{2.86 \times 0.1723 \times 0.92 \times 1.94}{3.6 \times 10^{-5}}$

$R_e = \boxed{2.45 \times 10^4}$

& $D/\epsilon = \frac{0.1723 ft}{1.5 \times 10^{-4} ft} = \boxed{1149}$

$\Rightarrow$ from Moody's diagram $f = 0.0265$

$\rightarrow h_L\ (2.50 + 58.0 \times 0.0265)(0.127 ft) = \boxed{0.513 ft}$

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$d_i = 50 - 2(1.5)$

$= 47mm \left(\frac{10^{-3}m}{1mm}\right)$

$\underline{d_i = 0.047m}$

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

$= \frac{\pi (0.047)^2}{4}$

$\underline{A_b = 1.73\times10^{-3} m^2}$

$V_b = Q/A_b$

$= 8.33\times10^{-3}/1.73\times10^{-3}$

$\underline{V_b = 4.815 \ m/sec}$

$N_R = \frac{V_b d_i}{\nu}$

$= \frac{4.815(0.047)}{1.30\times10^{-6}}$

$N_R = 174080$

$\frac{\varepsilon}{d_i} = \frac{1.5\times10^{-6}}{0.047}$

$\approx 3.2\times10^{-5}$

$f_b = 0.016$

$f_T = 0.010$

$h_{La} = h_{fric} + h_{valve} + 2h_{elbow}$

$= \left(f_a \frac{L}{D}\frac{V_a^2}{2g}\right) + \left(k\frac{V_a^2}{2g}\right) + \left(2f_T \frac{L_e}{D}\frac{V_a^2}{2g}\right)$

$= 0.0185\left(\frac{30}{0.043}\right)\frac{V_a^2}{2g} + k\frac{V_a^2}{2g} + 2(0.010)(30)\frac{V_a^2}{2g}$

$\underline{h_{La} = (6.56 + k)\frac{V_a^2}{2g}}$

$h_{Lb} = h_{fric} + \cancel{h_{valve}} + 2h_{elbow}$

$= f_b \frac{L}{d_i}\frac{V_b^2}{2g} + 2f_T\frac{L_e}{D}\frac{V_b^2}{2g}$

$= 0.016\left(\frac{30}{0.047}\right)\frac{V_b^2}{2g} + 2(0.01)(30)\frac{V_b^2}{2g}$

$\underline{h_{Lb} = 10.812\frac{V_b^2}{2g}}$

Now applying Bernoulies eq from point 1 to 2

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

$$\Rightarrow 0 + 0 + 3ft = \frac{P_2}{\gamma} + (0.127\ ft) + 0 + (0.513ft)$$

$$\Rightarrow \frac{P_2}{\gamma} = (3 - 0.127 - 0.513)ft = 2.36ft$$

$$P_2 = (0.92) \times (62.4 lb/ft^2) \times (2.36ft) \times \left(\frac{1ft^2}{144in^2}\right) = 0.94 \frac{lb}{in^2}$$

Point 1 is on tank surfacr

$P_1 = 0$, $V_1 = 0$, $Z_1 = 3ft$

Point 2 is at inlet of pump

$V_2 = 2.86 ft/s$, $Z_2 = 0$

$$P_2 = (0.92) \times \left(62.4 \frac{lb}{ft^2}\right) \times (2.36ft) \times \left(\frac{1 ft^2}{144 in^2}\right) = 0.94 \frac{lb}{in^2}$$

$$\boxed{P_2 = 0.94\ Psig}$$

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$$(6.56+k)\frac{V_a^2}{\cancel{2g}} = 10{,}812\frac{V_b^2}{\cancel{2g}}$$

$$(6.56+k)V_a^2 = 10{,}812\,V_b^2$$

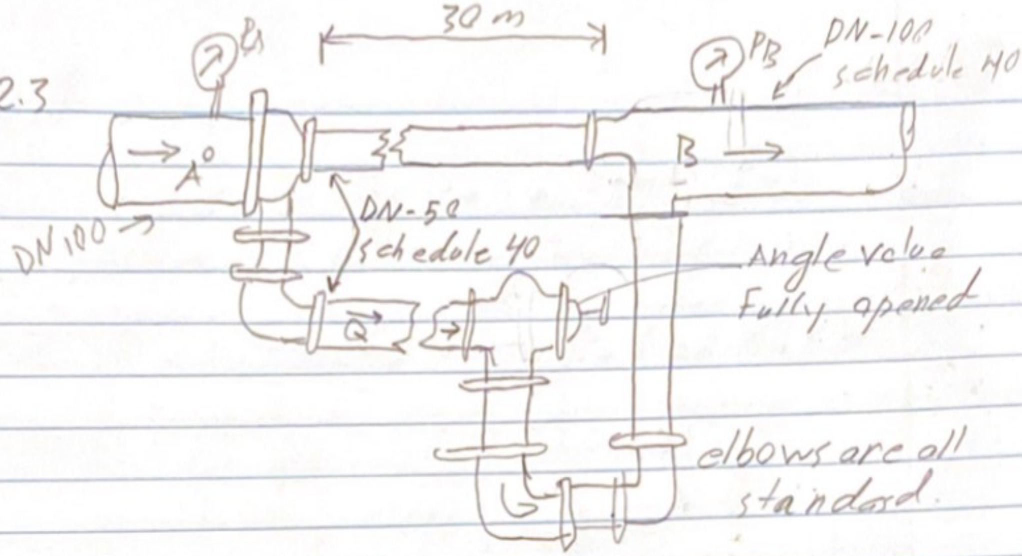
$$(6.56+k)(1.22)^2 = 10{,}812(4.815)^2$$

$$\boxed{K = 161{,}854}$$

Paragraph:

In this chapter we learned about parallel pipe systems and the effect they have on flow rate of a system. The flow rate at the beginning is the sum of the parallel pipes put together, and the larger a pipe diameter, the larger the flow rate will be chances are. We can find the flow rate of each pipe by first calculating the energy loses in each pipe and then using these to find the velocity of each pipe to use in the flow rate equation ($Q = VA$) to find said flow rate. The energy loses must also be the same in total for each pipe so that when they reconnect the same total flow rate is kept as when it starts.

Probl2.3



Given: system Diagram and Dimensions

$Q = Q_A = Q_B$ = flow rate = 850 L/min @ 10°C
= 0.0142 m^3/s

· Flowing fluid is water at 10°C

=> kinematic viscosity (ν) = 1.30×10^{-6} m^2/s

=> specific weight (γ_w) = 9810 N/m^3

$L_a = 80$ & $L_b = 60$ m

To find

a) Flow rate in each branch: $Q_a = ?$, $Q_b = ?$

b) Pressure difference ($P_A - P_B$) = ??

Solving

Resistance coeff. for valve $= (150)(f_T)_b$
Resistance coeff elbows $= (30)(f_T)_b$

For DN-50 pipe: $D_i = 52.5\ mm$ & $A = 2.168 \times 10^{-3}\ m^2$

For DN-50 pipe: $f_T = 0.019 = (f_T)_a = (f_T)_b$

For steel pipes: $\epsilon = 4.6 \times 10^{-5}\ m$

$$\Rightarrow \frac{D}{\epsilon} = \frac{0.0525\ m}{4.6 \times 10^{-5}\ m} = 1141$$

For parallel branching system: $\boxed{Q_A = Q_a + Q_b}$ and $\boxed{(h_L)_a = (h_L)_b}$

where $(h_L)_a = f_a \cdot \frac{L_a}{D_a} \cdot \frac{V_a^2}{2g} = f_a \left(\frac{30\ m}{0.0525\ m}\right) \cdot \frac{V_a^2}{2g} = \boxed{571\, f_a \frac{V_a^2}{2g}}$

and $(h_L)_a = (h_L)_{friction} + (h_L)_{valve} + 3 \times (h_L)_{bend/elbows}$

$$\Rightarrow (h_L)_b = f_b \cdot \frac{L_b}{D_b} \cdot \frac{V_b^2}{2g} + (f_T)_b \cdot (150) \cdot (150) \cdot \frac{V_b^2}{2g} + 3 \times (f_T)_b \cdot (30) \cdot \frac{V_b^2}{2g}$$

$$= \left[f_b \frac{60\ m}{0.0525\ m} + 0.019 \times 150 + 3 \times 0.019 \times 30\right] \frac{V_b^2}{2g}$$

$$\Rightarrow \boxed{(h_L)_b = [1142\, f_b + 4.56] \frac{V_b^2}{2g}}$$

and $Q_A = Q = Q_a + Q_b = A_a \cdot V_a + A_b \cdot V_b = \boxed{(2.168 \times 10^{-3}\ m^2)(V_a + V_b)}$

$$\Rightarrow 0.0142\ m^3/s = (2.168 \times 10^{-3}\ m^2)(V_a + V_b)$$

$$\Rightarrow \boxed{V_a + V_b = 6.55\ m/s}$$

Now we have $\frac{D}{e} = 1141$

$h_{La} = (571) \cdot f_a \cdot \frac{V_a^2}{2g} = (h_L)_b = [(1142) f_b + 4.56] \cdot \frac{V_b^2}{2g}$ &

$V_a + V_b = 6.55$ m/s

f_a & f_b are unknown. lets assume these valves and iterate.

1st iteration Assuming $f_a = f_b = 0.02$

$\Rightarrow (h_L)_a = 571 \times 0.02 \times \frac{V_a^2}{2g} = (h_L)_b = [1142 \times 0.02 + 4.56] \times \frac{V_b^2}{2g}$

$\Rightarrow \boxed{V_b = 1.55\, V_a}$ & since $V_a + V_b = 6.55 \Rightarrow (1.55 + 1) V_a = 6.55$ m/s

$\Rightarrow \boxed{V_a = 2.56 \text{ m/s}}$ $\quad V_b = 1.55 \times 2.56 = \boxed{3.97 \text{ m/s} = V_b}$

To verify assumed values validity.

Reynold no $(Re)_a = \frac{V_a \cdot D_a}{\nu} = \frac{2.56 \text{ m/s} \times 0.0525 \text{ m}}{1.30 \times 10^{-6} \text{ m}^2/\text{s}} = \boxed{1.60 \times 10^5}$

and $(Re)_b = \frac{V_b \cdot D_b}{\nu} = \frac{8.97 \text{ m/s} \times 0.0525 \text{ m}}{1.30 \times 10^{-6} \text{ m}^2/\text{s}} = \boxed{1.03 \times 10^5}$

& $D/\epsilon = 1142$

$\Rightarrow$ from Moody's Diagram.

$\Rightarrow f_a = 0.021$ & $f_b = 0.015$

Recomputing, calculatings are shown below

$(h_L)_a = 571 \times 0.021 \times \frac{V_a^2}{2g} = (h_L)_b = [1142 \times 0.0215 + 4.56] \frac{V_b^2}{2g}$

$\Rightarrow \boxed{V_a = 1.56\, V_b}$

$\Rightarrow (1.56 + 1) V_b = 6.55 \Rightarrow \boxed{V_b = 2.56 \text{ m/s}}$ & $\boxed{V_a = 3.99 \text{ m/s}}$

verifying: $(Re)_a = \frac{3.99 \text{ m/s} \times 0.0525 \text{ m}}{1.30 \times 10^{-6} \text{ m}^2/\text{s}} = 1.61 \times 10^5$

$(Re)_b = \frac{2.56 \text{ m/s} \times 0.0525 \text{ m}}{1.30 \times 10^{-6} \text{ m}^2/\text{s}} = \boxed{1.03 \times 10^5}$

& $D/\epsilon = 1142$

from moody Diagram, $f_a = 0.021$ & $f_b = 0.0215$

since No change in valves. Hence are precisely convrged.

$\Rightarrow$ $\boxed{V_a = 3.99\ m/s \ \ \&\ \ V_b = 2.56\ m/s}$ & $h_L = (h_L) = (h_L)_a = 571 \times 0.021$

$$\times \frac{(3.99 m/s)^2}{2 \times 9.81} = \boxed{9.713 m}$$

Now we computed.

$V_a = 3.99\ m/s$ $V_b = 2.56 m/s$ $(h_L) = (h_L)_a = (h_L)_b = 9.713\ m$

a) Flow Rates, are:

$$Q_a = A_a \times V_a = (2.168 \times 10^{-3} m^2) \times (3.99 m/s) \times \frac{60.000\ L/min}{1\ m^3/s} \boxed{519 L/min}$$

$$Q_b = A_b \cdot V_b = (2.168 \times 10^{-3} m^2) \times (2.56 m/s) \times \left(\frac{60{,}000\ L/min}{1\ m^3/s}\right) = 332 L/min$$

b. Applying Bernoulie's equation between Ⓐ & Ⓑ

$$\frac{P_A}{\gamma_w} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma_w} + \frac{V_B^2}{2g} + Z_B + h_L$$

(since, $D_A = D_B \Rightarrow V_A = V_B$ & $Z_A = Z_B$

$$\Rightarrow \frac{P_A - P_B}{\gamma_w} = h_L \Rightarrow P_A - P_B = \gamma_w (h_L)$$

$$= 9810\ N/m^3 \times 9.713\ m = 95.4 \frac{kN}{m^2}$$

$$\Rightarrow P_A - P_B = 95.4\ kPa$$

Results

$Q_a = 519 L/min$

$Q_b = 332 L/min$

$P_A - P_B = 95.4\ kPa$

Fluids HW. ch12. 6-7

6) $k = .9$

2in schedule 40   20psig

4in schedule 40

$(h_L) = 2 \times .9 \frac{v^2}{2g} + 5 \times \frac{v^2}{2g}$

$(h_L)_A = 6.8 \frac{v^2}{2g}$

$(h_L)_B = 2 \times 9 \frac{v^2}{2g} + 10 \frac{v^2}{2g}$

$11.8 \frac{v^2}{2g}$

A) $46.15 = 6.8 \times \frac{v^2}{2 \times 32.2}$

$V_a = 20.9\ ft/s$

$A = \frac{\pi \times \left(\frac{2}{12}\right)^2}{4} = .0218\ ft^2$

$Q_a = .0218 \times 20.8 = .456\ ft^3/sec$

$(h_L)_B = 11.8 \frac{v^2}{2g}$ $46.15 = 11.8 \frac{v^2}{2 \times 32.2}$

$V_B = 15.87\ ft/sec$

$A_a = \frac{\pi \times \left(\frac{4}{12}\right)^2}{4} = .0873\ ft^2$

$Q_b = (.0873) \times 15.87 = 1.385\ ft^3/sec$

$Q = Q_A + Q_B$ $.455 + 1.385 = \boxed{1.841\ ft^3/s}$

B) $Q_t = .0873 \times 15.87 = \boxed{1.385\ ft^3/s}$

C) $Q_a = A_a V_a$

$(.0218) \times 20.9 = \boxed{.456\ ft^3/s}$

7) 1350 gal/min   8 in pipe   sg = .87   40 steel pipe

$\epsilon = 1.5 \times 10^{-4}$

$\frac{D}{\epsilon} = \frac{.5054}{1.5\times10^{-4}} = 3369.33$

$\frac{L}{D}_{valve} = 340 \quad \frac{L}{D}_{swing valve} = 100 \quad \frac{L}{D}_{elbow} = 30$

$h_a \left(f \times \frac{500}{.5054} + .015 \times 340 + .015 \times 100 + 2(.015 \times 30)\right)\frac{v^2}{2g}$

$= (989.315f + 7.5)\frac{v^2}{2g}$

$= (989.315f + 7.5)\frac{Q^2}{2A^2g}$

$(989.315f + 7.5)\frac{Q^2}{2 \times .2006^2 \times 32.2}$

$\frac{D}{\epsilon} = 1.5\times10^{-4} \quad \frac{.1723}{1.5\times10^{-4}} = 1148.69 \quad \frac{L}{D}_{elbow} = 30$

$h_B = \left(f \times \frac{500}{.1723} + 2(.019 \times 30)\right)\frac{v^2}{2g}$

$h_B = (2901.91f + 1.14)\frac{Q^2}{2A^2}$

$= (2901.91f + 1.14)\frac{Q^2}{2 \times .0233 \times 32.2}$

$= (82790f + 32.52)Q^2$

$\rho = .87 \times 1.94 = 1.69$ slugs/ft³ $\quad n = 8\times10^{-6}$ lbs/ft²

$N_R = \frac{Q \times 1.69 \times .5054}{.2006 \times 8 \times 10^{-6}} = (5.3222 \times 10^{5})Q$

→

$$N_R = \frac{Q_B \times .1723 \times 1.69}{.233 \times 8 \times 10^{-6}} = (1.562 \times 10^5)Q$$

$$\frac{D}{\varepsilon} = \frac{.5054}{1.5 \times 10^{-4}} = 3369.33$$

$$\frac{D}{\varepsilon} = \frac{.1723}{1.5 \times 10^{-4}} = 1148.67$$

$$(989.315 f_a + 7.5)\frac{V^2}{2g} = (2901.918_B + 1.14)\frac{V^2}{2g}$$

$$23.329 V_a^2 = 59.178 V_B^2$$

$$V_a^2 = \frac{59.178 V_B^2}{23.329} = V_a = 1.592 V_B$$

$$3.01 = (.2006 \times 1.592 + .02333)V_B$$

$V_B = 8.783$ ft/s

$V_a = 1.592 \times 8.783 = 13.98$ ft/s

$Q_A = 13.98 \times .2006 = 2.5$ ft³/s

$Q_B = 3.01 - (8.783 \times .02333) = .51$ ft³/s

$N_R = (5.3222 \times 10^5)2.5 = 1.330 \times 10^6$

$R_k = (1.562 \times 10^5).51$ ft³/s $= 7.962 \times 10^5$

$h_a = (3.81.6 f + 2.894) Q_a^2 = 9 Q_a^2$

$h_B = (82791 f + 32.52) Q_B^2 = 1647 Q_B^2$

$N_R = (5.3322 \times 10^5)\ 2.805 = 1.49 \times 10^6$

$N_R = (1.562 \times 10^5) \div .205 = 3.202 \times 10^5$

$h_A = 9 \times 2.805^2 = 70.812$

$h_B = 1688 \times .205^2$

$h_B = 71$

$h = 71 - 70.812 = -.24$

$h_A = 2 \times 9 \times 2.805^2 = 50.5$

$h_B = 2 \times 1688 \times .205^2 = 692.65$

$h = 642.16$

$$\Delta Q = \frac{.24}{642.16} = -.00037$$

$A = 2.805\ ft^3/s$

$B = .205\ ft^3/s$

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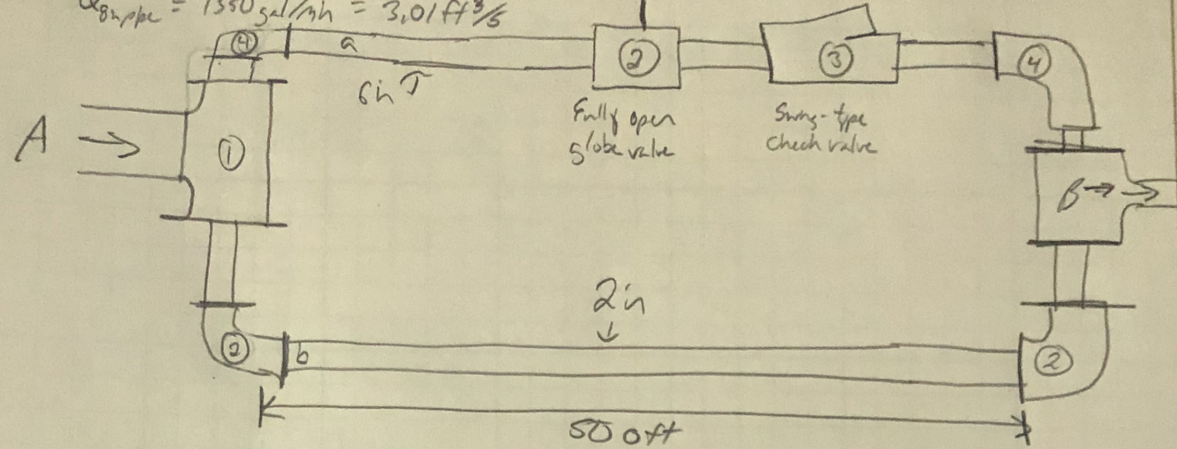
4) $L = 500 ft$
$sg = 0.87$
$T = 140°F$
$Q_{8 in\ pipe} = 1350\ gal/min = 3.01\ ft^3/s$



$Q = Q_A = Q_B = Q_a + Q_b$

$Q = V_a A_a + V_b A_b$

$h_{L A\text{-}B} = h_a = h_b$

$$h_a = h_1 + h_2 + h_3 + h_4$$
$$= \left(f \frac{L}{D} \frac{V_a^2}{2g}\right) + \underbrace{\left(f_{dt} \frac{L_e}{D} \frac{V_a^2}{2g}\right)}_{\text{globe valve}} + \underbrace{\left(f_{dt} \frac{L_e}{D} \frac{V_a^2}{2g}\right)}_{\text{Swing valve}} + 2\left(f_{dt} \frac{L_e}{D} \frac{V_a^2}{2g}\right)$$
$$= \left(\left(f \frac{L}{D}\right) + \underbrace{\left(f_{dt} \frac{L_e}{D}\right)}_{\text{globe valve}} + \underbrace{\left(f_{dt} \frac{L_e}{D}\right)}_{\text{Swing valve}} + \underbrace{2\left(f_{dt} \frac{L_e}{D}\right)}_{\text{elbows}}\right)\left(\frac{V_a^2}{2g}\right) \quad \text{---} \ ①$$

6 in schedule 40 steel pipe

$D = 0.5054\ ft$
$A = 0.2006\ ft^2$
$\varepsilon = 1.5 \times 10^{-4}\ ft$

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

$= 3369.33$

$f_{dt} = 0.015$

$\left(\frac{L_e}{D}\right)_{\text{globe valve}} = 340$

$\left(\frac{L_e}{D}\right)_{\text{Swing valve}} = 100$

$\left(\frac{L_e}{D}\right)_{\text{elbow}} = 30$