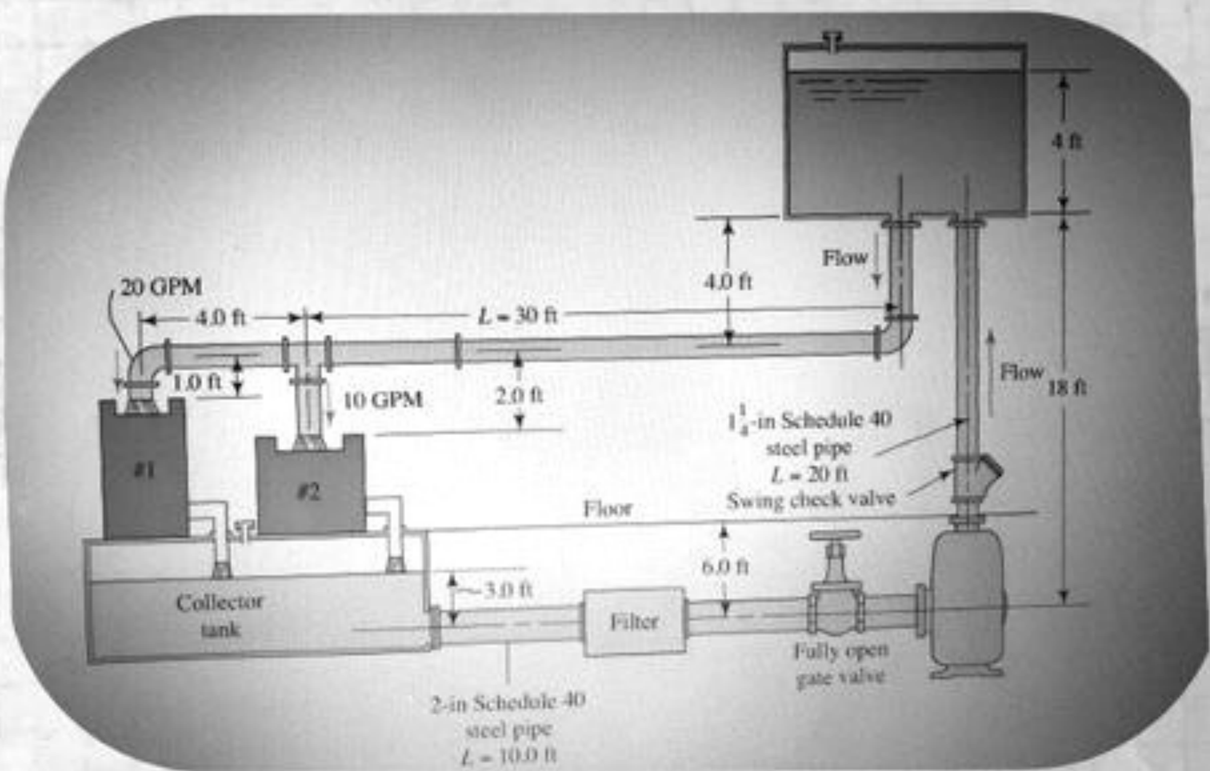
11.23 Given: For the system shown, compute the total head on the pump and the power delivered by the pump to the coolant.



SOLUTION:

$$\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 + h_A = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + Z_2 + h_L$$

$\boxed{\text{TABLE F.1}}$

Suction

$Q = vA \qquad v = \frac{Q}{A}$

$A = 0.02333\ ft^2$

$D_{in} = 0.1723\ ft$

$\boxed{\text{TABLE A2}}$

$N_R = \frac{vD\rho}{\mu} \qquad \rho_w = 1.94\ \frac{slugs}{ft^3}$

10+20

$Q = 30 \frac{gal}{min} = 0.0668403\ \frac{ft^3}{s}$

$\mu = 3.66 \times 10^{-5}\ \#/ft^2$

$0.92\left(1.94 \frac{slugs}{ft^3}\right) = 1.7848 \frac{slugs}{ft^3}$

$N_R = \frac{2.8650 \frac{ft}{s}(0.1723 ft)\left(1.7848 \frac{slugs}{ft^3}\right)}{3.66 \times 10^{-5}\ \# s/ft^2}$

$v = \frac{0.0668403 \frac{ft^3}{s}}{0.02333 ft^2} = 2.8650 \frac{ft}{s}$

$N_R = 24072.3437$

$\frac{D}{\varepsilon} = \frac{0.1723 ft}{1.5 \times 10^{-4} ft} = 1148.667$

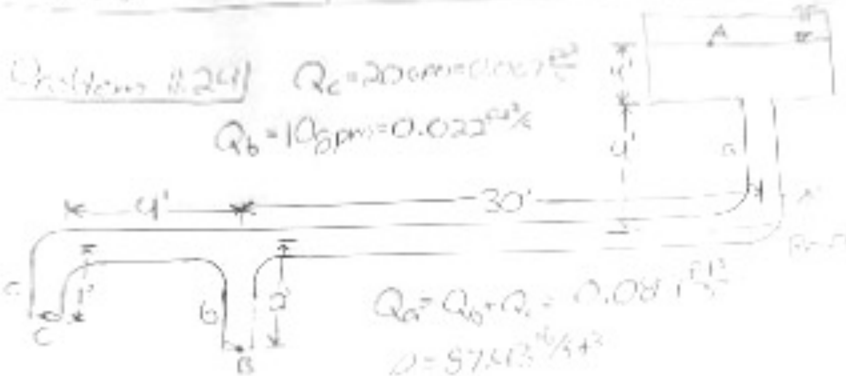
$\varepsilon = 1.5 \times 10^{-4}\ ft$

$f = 0.0265$

$\frac{\left(2.8650 \frac{ft}{s}\right)^2}{2(32.2)} = 0.1275$

Problem 8.24 $Q_c = 20\,gpm = 0.0?? \frac{ft^3}{s}$

$Q_b = 10\,gpm = 0.022\, ft^3/s$



$Q_a = Q_b + Q_c = 0.08\, \frac{ft^3}{s}$

$\rho = 57.43\, lb/ft^3$

Bernoulli's from A to B

$$\frac{p_A^{\,0}}{\gamma} + \cancel{\frac{V_A^2}{2g}} + z_A = \frac{p_B^{\,0}}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L \quad \therefore\ z_A - z_B = \frac{V_B^2}{2g} + h_{L\,A\to B}$$

Losses

$$h_{L\,PIPE\,a} = f_a \frac{L_a}{D_a}\frac{V_a^2}{2g} = f_a \frac{31'}{D_a}\frac{8Q_a^2}{g\pi^2 D_a^2} = \frac{0.218 f_a}{g D_a^3}$$

$$h_{L\,EL} = 30 f_a \frac{V^2}{2g} = \frac{0.193 f_a}{g D_a^2}$$

$$h_{L\,EN} = 0.5\frac{V_a^2}{2g} = \frac{0.003}{g D_a^2}$$

$$h_{L\,PIPE\,b} = f_b \frac{L_b}{D_b}\frac{V_b^2}{2g} = f_b \frac{2'}{D_b}\frac{8Q_b^2}{\pi^2 D_b^2 g} = \frac{0.00078 f_b}{g D_b^3}$$

$$h_{LT} = 60 f_b \frac{8Q_b^2}{\pi^2 D_b^2} = \frac{0.0235 f_b}{g D_b^2}$$

$$h_L = \frac{1}{32.2}\left(\frac{0.218 f_a}{D_a^3} + \frac{0.193 f_a}{D_a^2} + \frac{0.003}{D_a^2} + \frac{0.000789 f_b}{D_b^3} + \frac{0.0235 f_b}{D_b^2}\right)$$

$$\frac{V_B^2}{2g} = \frac{1}{g}\left(\frac{8Q_b^2}{\pi^2 D_b^2}\right) = \frac{0.0000122}{D_b^2} \qquad z_A - z_B = 10\,ft$$

Fluids	Homework 3.2	Andrew Bresnahan

$$10' = \frac{1}{32.2}\left(\frac{0.00080Q}{D_1^2} + \frac{0.219f_a}{D_a^2} + \frac{0.1935f_a}{D_a^2} + \frac{0.003}{D_a^2} + \frac{0.00078f_b}{D_b^2} + \frac{0.0235f_b}{D_b^2}\right)$$

Bernoulli's from A to C

$$\cancel{\frac{P_A}{\gamma}} + \cancel{\frac{V_A^2}{2g}} + z_A = \cancel{\frac{P_C}{\gamma}} + \frac{V_C^2}{2g} + z_C + h_{LA\to C} \quad z_A - z_C = \frac{V_C^2}{2g} + h_{LA\to C} = 9'$$

Energy Losses

$$h_{LT} = 20 f_a \frac{V_a^2}{2g} = \frac{0.0194 f_a}{D_a^2} \qquad h_{Lcb} = \frac{0.000093}{D_b^2}$$

$$h_{LPa} = f_a \frac{L_a}{D_a}\frac{V_a^2}{2g} = \frac{0.00068 f_a}{D_a^3}$$

$$h_{Lca} = \frac{0.006 f_a}{D_a^2}$$

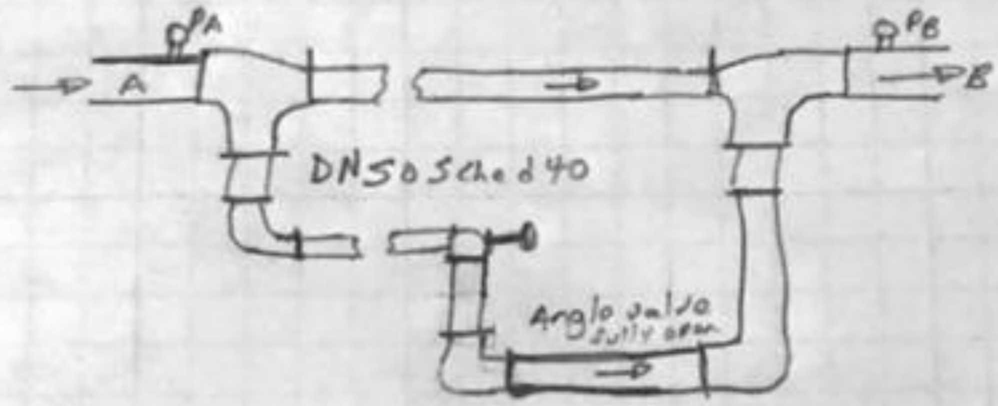
$$h_{LPc} = f_c \frac{5'}{D_c}\frac{8Q_c^2}{\pi^2 g D_c^4} = \frac{0.000565 f_c}{D_c^3}$$

$$h_{Lcc} = 30 f_c \frac{8Q_c^2}{\pi^2 D_c^4 g} = \frac{0.0034 f_c}{D_c^2}$$

$$\frac{V_c^2}{2g} = \frac{0.00011}{D_c^2}$$

$$9 = \frac{0.00011}{D_c^2} + \frac{0.0034 f_c}{D_c^2} + \frac{0.000565 f_c}{D_c^3} + \frac{0.006 f_a}{D_a^2} + \frac{0.00068 f_a}{D_a^3} + \frac{0.0194 f_a}{D_a^2} + \frac{0.000093}{D_b^2}$$

$$\boxed{\begin{aligned} D_a &= 0.1' = 1.2'' \\ D_b &= 0.0405' \cong 0.5'' \\ D_c &= 0.011 \cong 0.1'' \end{aligned}} \Bigg\} \text{ From Iteration}$$



SOLUTION:

UPPER BRANCH

$h_L = h_{friction} = f_a \left(\frac{L}{D}\right) \frac{v_a^2}{2g}$

90° Elbow $L/D = 30$
Fully open Angle $= L/D = 150$

DN50 = 2 in
TABLE F.1:

$h_L = f\,(30/0.0525\,m)\,\frac{v_a^2}{2g}$

$D_{in} = 52.5\,mm$

$D/\varepsilon = 0.0525\,m / 4.6\times10^{-5}\,m$

TABLE 8.2:

$1.141\times10^3 \quad f = 0.019$

$\varepsilon = 4.6\times10^{-5}\,m$

$h_L = f_b\,(60/0.0525)\,(v^2/2g) + 0.019\,(150)\,\frac{v^2}{2g} + 3\times0.019\times30\,\frac{v^2}{2g}$

$= (1142\,f + 4.56)\,v^2/2g$

$f_a = 0.02$
$f_b = 0.02$

$571\times0.02\times\frac{v^2}{2g} = (1142\times0.02 + 4.56)\,v^2/2g$

$v_a = 1.55\,v_b$

TABLE F.1
$A = 2.168\times10^{-3}\,m^2$

$850\,L/min = \frac{0.01411\,m^3/s}{1.55\times2.168\times10^{-3} + 2.168\times10^{-3}} = v_b = 2.55\,m/$

$Q_{tot} = A_a v_a + A_b v_b$

$v_a = 1.55\, v_b = 1.55 \times 2.55 = 3.97\ m/s$

TABLE A.1
$\nu = 1.30 \times 10^{-6}\ m^2/s$

$$N_R = \frac{v_b D_b}{\nu} = \frac{2.55 \times 0.0525}{1.30 \times 10^{-6}} = 1.30 \times 10^{5}$$

$f_b = 0.0215$

$$N_R = \frac{v_a D_a}{\nu} = \frac{3.97 \times 0.0525}{1.30 \times 10^{-6}} = 1.60 \times 10^{5}$$

$f_b = 0.0215$

$h_{L\,a} = h_{L\,B}$ $\quad 571\, f_a \frac{v_a^2}{2g} = 1142 f_b + 4.56 \frac{v_b^2}{2g}$

$$v_a = 1.56 v_b$$

$$0.01411 = A_a (1.15 v_b) + A_b v_b$$

$$v_b = \frac{0.01411}{1.56 \times 2.168 \times 10^{-3} + 2.168 \times 10^{-3}}$$

$$= 2.55\ m/s$$

$v_a = 1.56 \times 2.55 = 3.98\ m/s$

$Q_a = 2.168 \times 10^{-3} \times 3.98 = 0.008628\ m^3/s = \boxed{518\ L/min}$

$Q_b = 2.168 \times 10^{-3} \times 2.55 = 0.00552\ m^3/s = \boxed{332\ L/min}$

$$h_L = 571\, f_a \frac{v_a^2}{2g} = 571 \times 0.021 \times \frac{398^2}{2 \times 9.81} = 9.68\ m$$

$\Delta p = \gamma h_L = 9.81 \times 9.68\ m$

$= \boxed{94.961\ kPa}$

Tyler Ri
MET 33

Ch 12 #5.

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

$A_a = \dfrac{\pi D_i^2}{4} = \dfrac{\pi \times 0.093^2}{4} = 6.79 \times 10^{-3}\,m^2$

$Q = 500\,L/min \left|\dfrac{1.666 \times 10^{-5}\,m^3/sec}{1\,L/min}\right| = 8.33 \times 10^{-3}$

$V_a = \dfrac{Q}{A_a} = \dfrac{8.33 \times 10^{-3}}{6.79 \times 10^{-3}} = 1.22\,m/s$

$N_R = \dfrac{V_a D_i}{\nu} = \dfrac{1.22 \times 0.093}{1.30 \times 10^{-6}} = 87276.92$

$R_r = \dfrac{\epsilon}{D} = \dfrac{1.5 \times 10^{-6}}{0.0930} = 1.61 \times 10^{-5}$

$f_a = 0.0185 \qquad f_r = 0.010$

$d_i = 50 - 2(1.5) = 47\,mm \left|\dfrac{10^{-3}\,m}{1\,mm}\right| = 0.047\,m$

$A_b = \dfrac{\pi d_i^2}{4} = \dfrac{\pi \times 0.047^2}{4} = 1.73 \times 10^{-3}\,m^2$

$V_b = \dfrac{Q}{A_b} = \dfrac{8.33 \times 10^{-3}}{1.73 \times 10^{-3}} = 4.815$

$N_R = \dfrac{V_b d_i}{\nu} = \dfrac{4.815 \times 0.047}{1.30 \times 10^{-6}} = 174080$

$R_r = \dfrac{\epsilon}{d_i} = \dfrac{1.5 \times 10^{-6}}{0.047} = 3.2 \times 10^{-5}$

$f_b = 0.016 \qquad f_r = 0.010$

rest on next page

$$(h_L)_a = h_{friction} + h_{valve} + 2h_{elb}$$

$$= f_a\left(\frac{L}{D}\right)\frac{V_a^2}{2g} + K\frac{V_a^2}{2g} + 2f_r\left(\frac{L_e}{D}\right)_e\frac{V_a^2}{2g}$$

$$= 0.0185\left(\frac{30}{0.093}\right)\frac{V_a^2}{2g} + K\frac{V_a^2}{2g} + 2\times 0.016\times(30)\frac{V_a^2}{2g}$$

$$(h_L)_a = \left[6.56 + K\right]\frac{V_a^2}{2g}$$

$$(h_L)_b = f_b\left(\frac{L}{d_i}\right)\frac{V_b^2}{2g} + K\frac{V_b^2}{2g} + 2f_r\left(\frac{L_e}{D}\right)_e\frac{V_b^2}{2g}$$

$$= 0.016\left(\frac{30}{0.047}\right)\frac{V_b^2}{2g} + 2\times 0.0100\times(30)\frac{V_b^2}{2g}$$

$$(h_L)_b = \left[10.812\right]\frac{V_b^2}{2g}$$

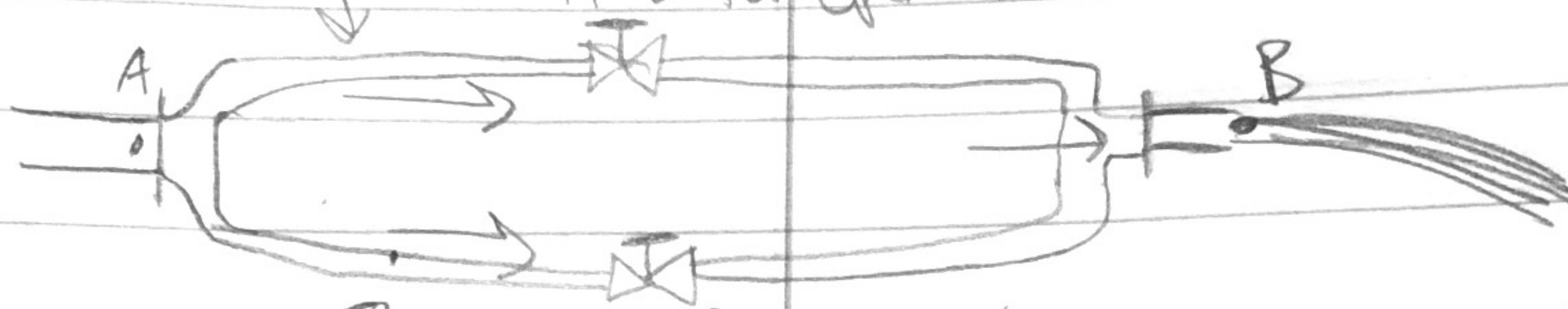
$$\left[6.56 + K\right]\frac{V_a^2}{2g} = \left[10.812\right]\frac{V_b^2}{2g}$$

$$\left[6.56 + K\right]\frac{1.22^2}{2\times 9.81} = \left[10.812\right]\frac{4.815^2}{2\times 9.81}$$

$$K = 161.854 = \boxed{162}$$

12.6 $D_1 = 2in$ Sch40

branch 1



$D_2 = 4in$ Sch40

$K_{elbow} = 0.9$

D_1 area $= 0.02333 ft^2$

D_2 area $= 0.08840 ft^2$

$D_1 = 0.1723 ft$

$D_2 = 0.3355 ft$

$\gamma_{water} = 62.4 lb/ft^3$

$20 lb/in^2 \cdot 144 = 2880 lb/ft^2$

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

$$V_1 = \sqrt{\frac{2gh_L}{h_1}} = \sqrt{\frac{2 \cdot 32.2 \cdot 46.15}{6.8}} = 20.91 ft/s \cdot 0.02333 ft^2 = 0.488 ft^3/s$$

$$V_2 = \sqrt{\frac{2gh_L}{h_2}} = \sqrt{\frac{2(32.2)(46.15)}{11.8}} = 15.87 ft/s \cdot 0.08840 ft^2 = 1.40 ft^3/s$$

$$\boxed{Q_{Total} = 1.89 ft^3/s}$$

$$\frac{P_1}{\gamma} = h_L \quad \frac{2880 lb/ft^2}{62.4 lb/ft^3} = 46.15 ft = h_L$$

$$h_1 = 2\left(0.9 \cdot \frac{V_1^2}{2g}\right) + 5\left(\frac{V_1^2}{2g}\right) = 6.8 \frac{V_1^2}{2g}$$

$$h_2 = 2\left(0.9 \cdot \frac{V_2^2}{2g}\right) + 10\left(\frac{V_2^2}{2g}\right) = 11.8 \frac{V_2^2}{2g}$$

$h_1 = k \frac{V_1^2}{2g}$

$h_2 = k \frac{V_2^2}{2g}$

$$\boxed{\begin{aligned} Q_1 &= 0.488 ft^3/s \\ Q_2 &= 1.4 ft^3/s \end{aligned}}$$