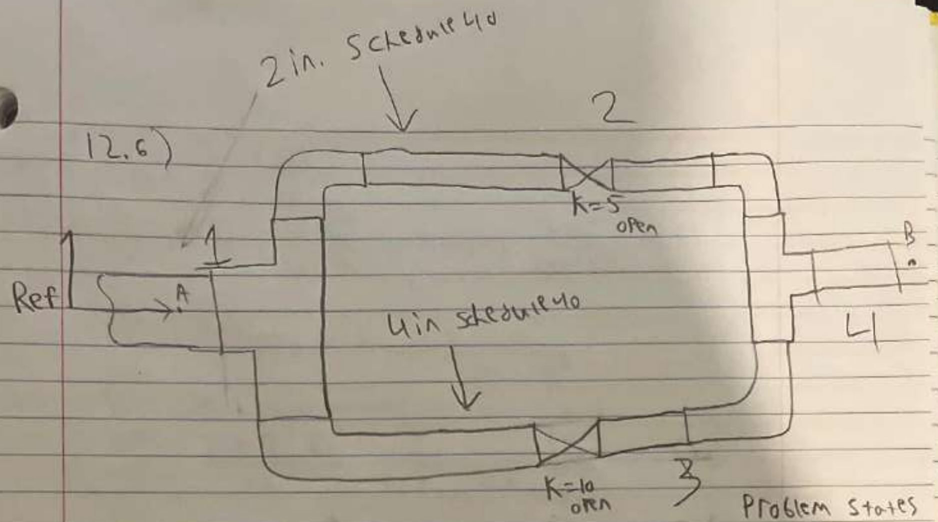
HW3.2

REFLECTION PARAGRAPH

Throughout the last two weeks, we started working on Parallel Pipeline Systems. We have learned that in these problems, we still have to use Bernoulli's equation, but the difference is that we might need to apply it several times as several branches are involved. When doing so to different branches, the energy loss term has to be adjusted to the selected branch. We also learned that we could increase the flow rate of a single pipeline system by adding a parallel branch to the single pipe. The increase can be controlled by the new branch pipe diameter and/or its length. For certain problems, if a flow in a given pipe of a circuit is clockwise, Q and h are positive. If the flow is counterclockwise, Q and h are negative.

12.6)



Problem states neglect $h_{L\,Tee}$

$h_{L\,friction}$

$P_A = 20$ psi $\qquad K_{el6} = 0.9$

find: $Q_{\text{[illegible]}}$ @ both valves open

Valve at 2 only open

Valve at 3 only open

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

$$\frac{\Delta P}{\gamma} = h_{LAB}$$

$$\frac{\Delta P}{\gamma} = h_{L_{A-B_2}} \qquad \frac{\Delta P}{\gamma} = h_{L\,A-B_3}$$

$$\frac{\Delta P}{\gamma} = 2h_{L\,el6_2} + h_{L_{Valve2}} \qquad \frac{\Delta P}{\gamma} = 2h_{Lel6_3} + h_{L\,Valve3}$$

$$= 2K_{el6}\frac{16Q_2^2}{2g\pi^2 D_2^4} + K_{Valve_2}\frac{16Q_2^2}{2g\pi^2 D_2^4} \qquad 2K_{el6}\frac{16Q_3^2}{2g\pi^2 D_3^4} + K_{Valve_3}\frac{16Q_3^2}{2g\pi^2 D_3^4}$$

$$Q_1 = Q_2 + Q_3$$

$$\frac{\Delta P}{\gamma} = 2K_{el45_2}\frac{16Q_2^2}{2g\pi^2 D_2^4} + K_{valve_2}\frac{16Q_2^2}{2g\pi^2 D_2^4}$$

$$\frac{\Delta P}{\gamma} = (2K_{el45_2} + K_{valve_2})\frac{16Q_2^2}{2g\pi^2 D_2^4}$$

$$\sqrt{\frac{\Delta P}{\gamma}\cdot\frac{2g\pi^2 D_2^4}{16}\cdot\frac{1}{(2K_{el45_2}+K_{valve_2})}} = Q_2^{\cancel{2}}$$

$$Q_2 = \sqrt{\frac{\Delta P \cdot 2g\pi^2 D_2^4}{\gamma \cdot 16 \cdot (2K_{el45_2}+K_{valve_2})}}$$

☆ for Q_3 it would look the same

$$Q_3 = \sqrt{\frac{\Delta P \cdot 2g\pi^2 D_3^4}{\gamma \cdot 16 \cdot (2K_{el45_3}+K_{valve_3})}}$$

assume Q_1

☆ Remaining steps in excel

a) Open valve: 1.509 ft^3/s

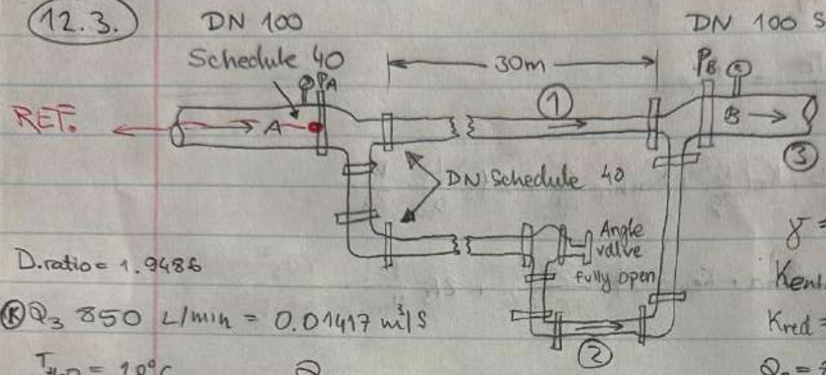
b) Branch 2 open: 0.356813 ft^3/s

c) Branch 3 open: 1.15284 ft^3/s

MET330-HW 3.2 03/27/2024

Angela Sicaja

(12.3.)



$\gamma = 9.81\ kN/m^3$

$K_{enlarg} = 0.446$

$K_{red} = 0.04$

$Q_3 = 850\ L/min$

D.ratio = 1.9486

Q_3 850 L/min = $0.01417\ m^3/s$

$T_{H_2O} = 10°C$

$L_2 = 60m$

$L_1 = 30m$

$D_1 = D_2 = 52.5\ mm$, $D_3 = 102.3\ mm$

$\frac{Le}{D_{valve}} = 150$ $\frac{Le}{D_{tee\text{-}run}} = 20$ $\frac{Le}{D_{tee\text{-}branch}} = 60$

Assume angle is 30°

$\epsilon = 4.6 \cdot 10^{-5} m$

Procedure:

1) Guess Q, plug into equation ① to get pressure drop
2) By using pressure difference, guess f_2 and find Q_2
3) Calculate Re using Q_2
4) Calculate f_2 (new) using Re
5) Find % difference
6) Calculate Q using $Q_3 = Q_1 + Q_2$, once f% is zero
7) Resume from step ①, if Q % difference is not zero

$$\boxed{Q_3 = Q_1 + Q_2}$$

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

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

①

$$\frac{\Delta P}{\gamma} = f_1 \frac{L_1}{D_1}\frac{V_1^2}{2g} + K_{red}\frac{V_1^2}{2g} + K_{enlarge}\frac{V_1^2}{2g} + 2 f_3 \frac{Le}{D_{tee}}\frac{V_3^2}{2g}$$

$$\frac{\Delta P}{\gamma} = \left(f_1 \frac{L_1}{D_1} + K_{red} + K_{enlarge}\right)\cdot \frac{8Q_1^2}{g\pi^2 D_1^4} + 2f_3 \frac{Le}{D_{tee\text{-}run}}\cdot\frac{8Q_3^2}{g\pi^2 D_3^4}$$

②

$$\frac{\Delta P}{\gamma} = f_2\frac{L_2}{D_2}\frac{V_2^2}{2g} + K_{red}\frac{V_2^2}{2g} + K_{enlarge}\frac{V_2^2}{2g} + f_2\cdot 3\frac{Le}{D_{elb}}\frac{V_2^2}{2g} + f_2\frac{Le}{D_{valve}}\frac{V_2^2}{2g} + 2f_3\frac{Le}{D_{tee}}\frac{V_3^2}{2g} \;?$$

$$\frac{\Delta P}{\gamma} = \left[f_2\left(3\left(\frac{Le}{D}\right)_{elb} + \left(\frac{2e}{D_{valve}}\right) + \frac{Le}{D_2}\right) + (K_{red}+K_{enlarge})\right]\frac{8Q_2^2}{g\pi^2 D_2^4} + 2f_3\left(\frac{Le}{D}\right)_{tee\ branch}\cdot\frac{8Q_3^2}{g\pi^2 D_3^4}$$

$$f_3 = \frac{0.25}{\left[\log\left(\frac{1}{3.7(D/\varepsilon)} + \frac{5.74}{Re^{0.9}}\right)\right]^2} \qquad \rightarrow Re = \frac{VD}{\nu} = \frac{1.724\ \frac{m}{s}\cdot(0.1023)\,m}{1.3\cdot 10^{-6}\ m^2/s}$$

$$Re = 1.36\cdot 10^{-5}$$

$$f_3 = \frac{0.25}{\left(\log\left[\frac{1}{3.7(2224)} + \frac{5.74}{(1.36\cdot 10^{-5})^{0.9}}\right]\right)^2} = 0.0095$$

① $$\frac{\Delta P}{9.81\,\frac{kN}{m^3}} = (f_1\cdot 573.61 + 0.486)\,10876.31\,Q_1^2 + 0.0576\,m$$

② $$\frac{\Delta P}{9.81\,\frac{kN}{m^3}} = \left[f_2(1382.86 + 0.486)\right]\cdot 10876.37\,Q_2^2 + 0.0576\,m$$

$$Q_2 = \sqrt{\frac{\left(\frac{\Delta P}{9.81\frac{kN}{m^3}} - 0.0576m\right)}{\left[f_2 \cdot (1382.86) + 0.486\right] \cdot 10876.37}}$$

(*) After 10 iterations

$Q_1 = 0.0082480 \frac{m^3}{s}$

a) $Q_2 = Q_3 - Q_1$

$Q_2 = 0.01417 \frac{m^3}{s} - 0.0082480 \frac{m^3}{s}$

$$\boxed{Q_2 = 0.005922 \frac{m^3}{s}}$$

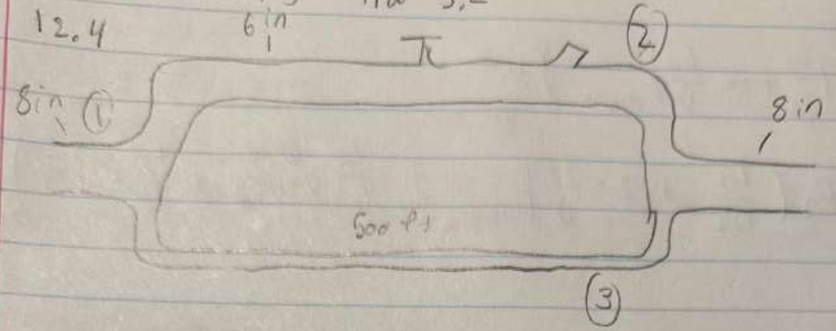
b) Plugged Q_1 and f_1 into the n. 1 equation

$$\Delta P = \left[9.81\frac{kN}{m^3}\left(0.03344 \cdot 573.61\right) + 0.486\right] \cdot 10876.37 \cdot (0.0082480)^2 + 0.0576m$$

$$\boxed{\Delta P = 139.65\ kPa}$$

Fluid mechanics   Hw 3,2

12.4   Pg 309



$Q_1 = 1350$ gal/min of benzene   Schedule 40 Pipe

$sg = 0.87$ @ 140°F $D_1(8) = 200$ mm $D_3(2) = 60.3$ mm

D_2 (6 in) = 150 mm

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

$sg = 0.87$

$\gamma = 8.59$ kN/m³

$\nu = 6.88 \cdot 10^{-7}$

Globe valve = 340 $\frac{Le}{D}$

Check valve = 100 $\frac{Le}{D}$

elbow = 30 $\frac{Le}{D}$

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

$$\frac{\Delta p}{\gamma} = h_L\ AB$$

$$\frac{\Delta p}{\gamma} = f_1 \left(\frac{L_1 + 2 \cdot Le\ elbow_1}{D_1}\right) \frac{V_1^2}{2g}$$

$$\frac{\Delta P}{\gamma} = f_3\left(\frac{L_1}{D_1} + 2\cdot \frac{Le}{D}\bigg|_{elbow_1}\right)\frac{V_1^2}{2g}$$

$$\frac{\Delta P}{\gamma} = F_2\left(\frac{L_2}{D_2} + 2\cdot\frac{Le}{D}\bigg|_{elbow_2} + \frac{Le}{D}\,\text{globe valve}_2 + \frac{Le}{D}\,\text{check}\right)\frac{1}{2g}\,\frac{16\,Q_2^2}{\pi^2 D^4}$$

$Q_1 = Q_2 + Q_3$

$$Q_1 = \sqrt{\frac{\Delta P/\gamma}{f_2\left(\frac{L_2}{D_2} + 2\cdot\frac{Le}{D}\,\text{elbow} + \frac{Le}{D}\,\text{globe valve} + \frac{Le}{D}\,\text{check}\right)\frac{8}{g\pi^2 D_2^4}}}$$

$$+\sqrt{\frac{\Delta P/\gamma}{f_3\left(\frac{L_3}{D_3} + 2\cdot\frac{Le}{D}\,\text{elbow}\right)\frac{8}{g\pi^2 D_3^4}}}$$

dont have pressure So solve

$$\frac{\Delta P}{\gamma} = f_1\,\frac{L_1}{D_1}\,\frac{V_1^2}{2g} + f_1\left(\frac{le}{D}\right)_{tee}\frac{V_1^2}{2g}$$

guess f_1

$$\frac{\Delta P}{\gamma} = 0.01\,\frac{192.4\,m}{0.2\,m}\,\frac{1}{2\cdot 9.81}\cdot\frac{16\,(Q_1 = 0.08517)}{\pi^2\,0.2^4} + 0.01(30).$$

$$\frac{\Delta P}{\gamma} = 59.4 = 6.91$$

Fluids 12.4

plug equation in

guess f value

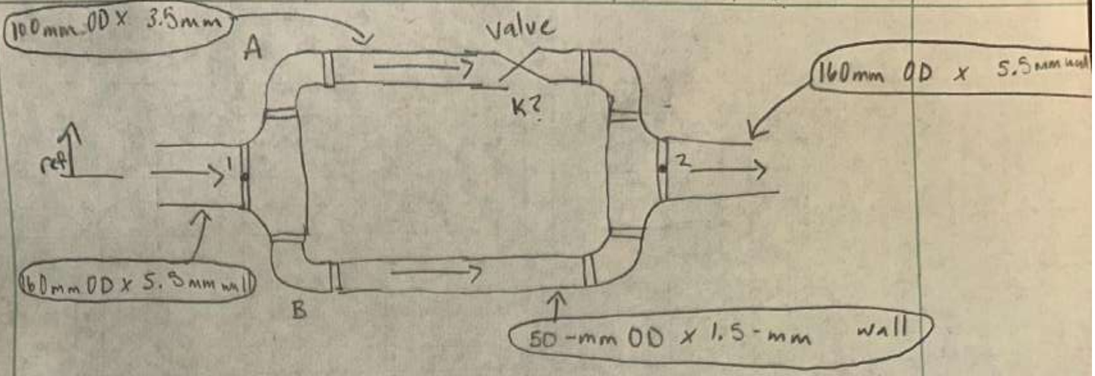
$Q_1 = Q_2 + Q_3$

% difference

$Q_2 = 0.033$

$Q_3 = 0.047$

% difference = 8%



$Q_A = Q_B = 500\ L/min$ $D_{160} = 149mm$ $Q_2 = Q_1 = Q_A + Q_B$ $Q = V \cdot A$

$V = Q/A$

$L_{pipe_{A,B}} = 30m$ $D_{100} = 93mm$

Pipe

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

$\gamma_w = 9.81\ kN/m^3$ $D_{50} = 47mm$

$\varepsilon = 1.5 \times 10^{-6}\ m$ A

$Re = \frac{V D}{\nu}$ Relative Roughness $= D/\varepsilon$

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

$$\frac{P_1}{\gamma} + \cancel{\frac{V_1^2}{2g}}^{0} + \cancel{z_1}^{0} = \frac{P_2}{\gamma} + \cancel{\frac{V_2^2}{2g}}^{0} + \cancel{z_2}^{0} + h_{L1-2} \longrightarrow \frac{\Delta P}{\gamma} = h_{L1-2_A} = h_{L1-2_B}$$

$$h_{L1-2_A} = \overset{\times 2}{h_{L_{Tee}}} + h_{L_{reductor}} + \overset{\times 2}{h_{L_{elbow}}} + h_{L_{pipe}} + h_{L_{valve}} + h_{L_{expander}}$$

$$= 2\left(K_{Tee_A} \frac{V_1^2}{2g}\right) + K_{reductor_A} \frac{V_A^2}{2g} + 2\left(K_{elbow_A} \frac{V_A^2}{2g}\right) + f \frac{L}{D} \frac{V_A^2}{2g} + K_{valve} \frac{V_A^2}{2g} + K_{expander} \frac{V_A^2}{2g}$$

$$h_{L1-2_B} = \overset{\times 2}{h_{L_{Tee}}} + h_{L_{reductor}} + \overset{\times 2}{h_{L_{elbow}}} + h_{L_{pipe}} + h_{L_{expander}}$$

$$= 2\left(K_{Tee_B} \frac{V_B^2}{2g}\right) + K_{red_B} \frac{V_B^2}{2g} + 2\left(K_{elbo} \frac{V_B^2}{2g}\right) + f \frac{L}{D} \frac{V_B^2}{2g} + K_{exp} \frac{V_B^2}{2g}$$

$K_{elbow} = 30 f_T$ Diameter ratio

$K_{Tee} = 60 f_T$ A) = 1.60215

$K_{red_A} \approx 0.043$ } assume 30°   B) 3.17

$K_{exp_A} \approx 0.405$

$K_{red_B} = 0.05$ } assume 30°

$K_{exp_B} = 0.48$

Procedure

- I will first solve for $h_{L_{1-2_B}}$ because I have all the variables
- I will then solve for $h_{L_{1-2_A}}$ with variable K_{valve}.
- Finally I will set them equal to each other ($h_{L_{1-2_A}} = h_{L_{1-2_B}}$) and solve for K_{valve}.

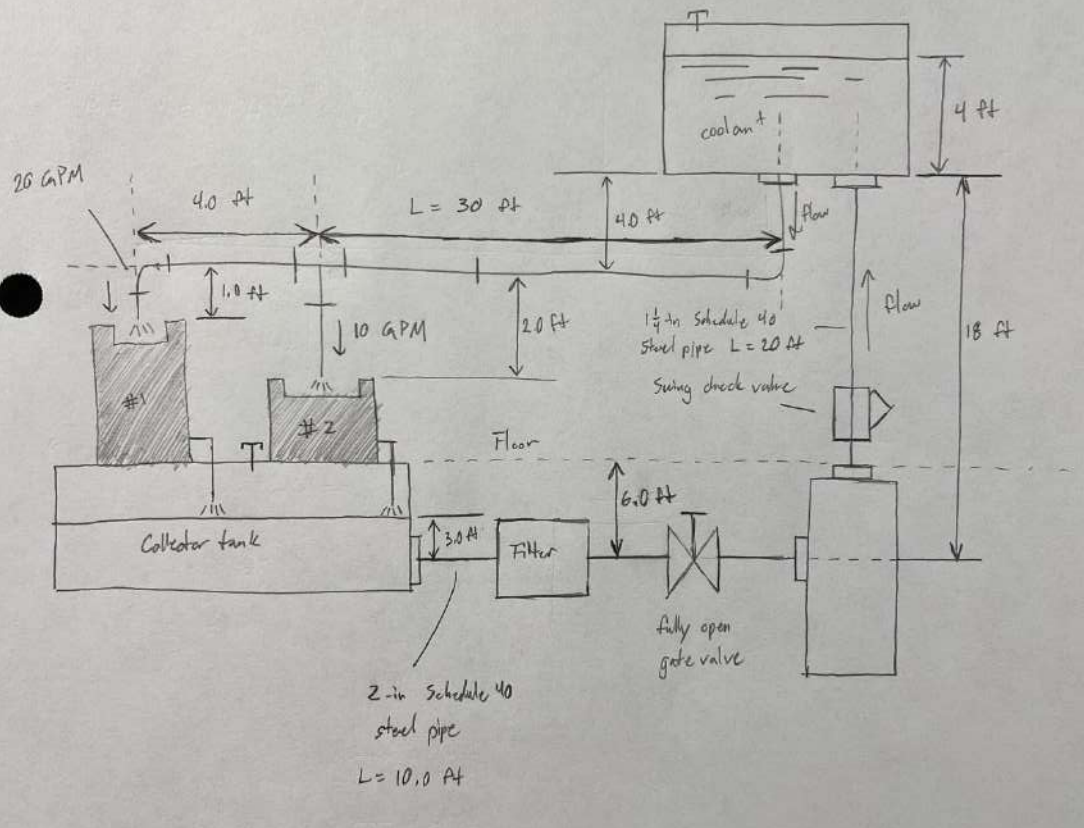
$$K_{valve} = \frac{\left[\left(2h_{L_{Tee}} + h_{L_{red_B}} + 2h_{L_{elb_B}} + h_{L_{pipe_B}} + h_{L_{exp_B}}\right) - \left(2h_{L_{Tee}} + h_{L_{red_A}} + 2h_{L_{elb_A}} + h_{L_{pipe_A}} + h_{L_{exp_A}}\right)\right]}{\left(\frac{V_A^2}{2g}\right)}$$

*Calculations done through excel

$K_{valve} = 174.39$

Problems 11.24 – 11.26

Figure P11.24 shows a system used to pump coolant from a collector tank to an elevated tank, where it is cooled. The pump delivers 30 $\frac{gal}{min}$. The coolant then flows back to the machines as needed, by gravity. The coolant has a specific gravity of 0.92 and a dynamic viscosity of 3.6E-5 $\frac{lb \cdot s}{ft^2}$.



Homework 3.2

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 $\frac{gal}{min}$ and Machine 2 requires 10 $\frac{gal}{min}$. The fluid leaves the pipes at the machines at 0 psig.

flow

$Q_B = 20\ \frac{gal}{min} = 0.04456\ ft^3/s$

flow

$Q_C = 10\ \frac{gal}{min} = 0.02228\ ft^3/s$

wall roughness

$\varepsilon = 1.5E{-4}\ ft$ (Table 8.2)

dynamic viscosity

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

pressure

$P_a - P_b = 0$ psig (open to atmosphere)

total flow

$Q_T = 30\ \frac{gal}{min} = 0.06684\ ft^3/s$

specific gravity

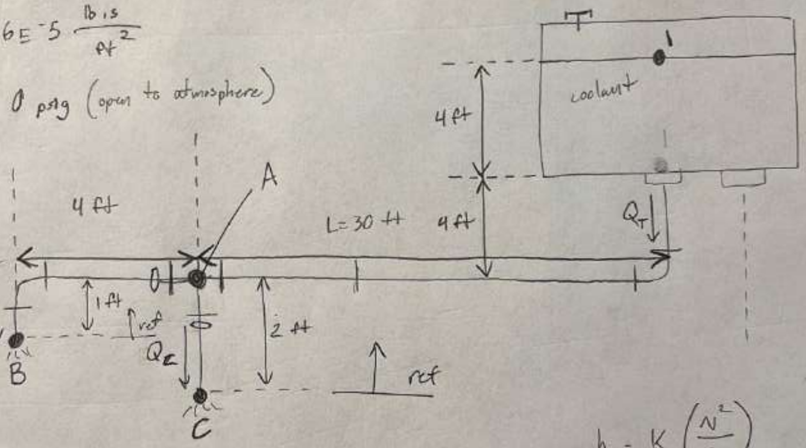
$sg = 0.92$

$g = 32.2\ ft/s^2$

$L_{1-A} = 34\ ft$

$L_{A-B} = 5\ ft$

$L_{A-C} = 2\ ft$



$h_L = K\left(\frac{v^2}{2g}\right)$

$K_{entrance} = 0.5\ f_T$

$K_{elbow} = 30\ f_T$

$K_{TEE-Through} = 20\ f_T$

$K_{TEE-Branch} = 60\ f_T$

$$Z_1 = \frac{N^2}{2g} + h_{L_{1-A}}$$

$$Z_1 = f\frac{8Q^2}{g\pi^2}\frac{L_{1-A}}{D^5_{1-A}} + \left(\frac{8Q^2}{g\pi^2}\cdot\frac{1}{D^4_{1-A}}\right)\left(K_{entrance} + K_{elbow} + 1\right)$$

$$sg = \frac{\rho_s}{\rho_{w @ 40F}}$$

$$sg = 0.92$$

$$(0.92)(\rho_{w @ 40F}) = \rho_s$$

$$(0.92)(1.94) = \rho_s$$

$$\rho_{coolant} = 1.7848 \frac{lb-s^2}{ft^4}$$

$$\text{Kinematic viscosity} = \frac{\eta}{\rho} \qquad \frac{\cancel{lb}-s}{\cancel{ft^2}}\cdot\frac{ft^4}{\cancel{lb}-s^2}$$

$$\nu = \frac{3.6E-5}{1.7848} \; ft^2/s$$

$$\nu = 2.02E-5 \; ft^2/s$$

$$\gamma = \rho g = 1.7848\left(32.2 \; ft/s^2\right)$$

$$\gamma_{coolant} = 57.47056 \; lb/ft^3$$

Excel Sheets

For Q_T (1-A):

$$z_1 = f\,\frac{8Q_T^2}{g\pi^2}\,\frac{L_{1-A}}{D_{1-A}^5} + \left(\frac{8Q_T^2}{g\pi^2}\,\frac{1}{D_{1-A}^4}\right)\left(K_{entrance} + K_{elbow} + 1\right)$$

$D_{1-A} = 0.1085$ ft

$1\frac{1}{4}$-inch Schedule 40 steel pipe

For Q_B (A-B):

$$z_1 = f\,\frac{8Q_B^2}{g\pi^2}\,\frac{L_{A-B}}{D_{A-B}^5} + \left(\frac{8Q_B^2}{g\pi^2}\,\frac{1}{D_{A-B}^4}\right)\left(K_{TEE\ Through} + K_{elbow} + 1\right)$$

$D_{A-B} = 0.0713$ ft

1-inch Schedule 40 steel pipe

For Q_c (A-C)

$$z_1 = f\,\frac{8Q_c^2}{g\pi^2}\,\frac{L_{A-C}}{D_{A-C}^5} + \left(\frac{8Q_c^2}{g\pi^2}\,\frac{1}{D_{A-C}^4}\right)\left(K_{TEE\ Branch} + 1\right)$$

$D_{A-C} = 0.04943$ ft

$\frac{1}{2}$-inch Schedule 40 steel pipe