Ch. 12

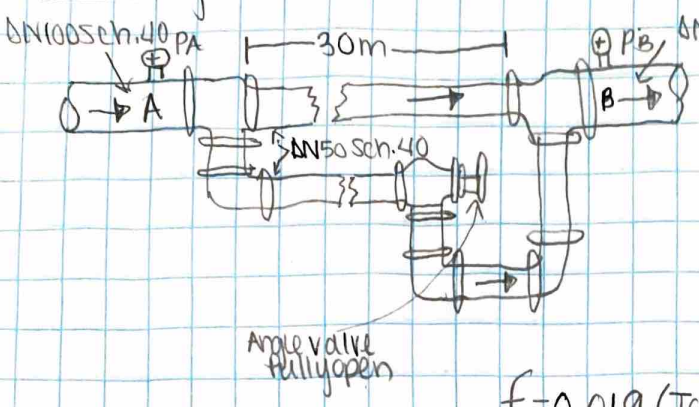
Amber Samm
MET 330
Homework #5

#12-3

Purpose: (a) calculate flow rate in each branch
(b) calculate the pressure difference between A+B

Drawing:

Materials: water



Data: $L_{upper} = 30m$, $L_{low} = 60m$

$SW_{water} = 9.81 kN/m^3$

$\nu_{water} = 1.30 \times 10^{-6} m^2/s$

Appendix F ↓

DN100: $D_L = 102.3mm = 0.1023m$

$A_F = 8.213 \times 10^{-3} m^2$

DN50: $D_L = 52.5mm = 0.0525m$

$A_F = 2.168 \times 10^{-3} m^2$

$f_1 = 0.019$ (Table 10.5)

$f_2 = 0.021$ $\quad \varepsilon = 4.6 \times 10^{-5} m$ (Table 8.2)

$Q = 850 L/min = 0.01417 m^3/s$

$\frac{Le}{D}_{elbow} = 30$ $\quad \frac{Le}{D}_{(open\ valve)} = 150$

Procedure/Calculations:

Continuity - Flow Rate

$Q_3 = Q_1 + Q_2$ $\quad h_{L1} = h_{L2}$ in parallel system

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

- elevations =
- velocity =

$h_L = \frac{P_A - P_B}{\gamma}$

$h_{L1} = f_1 \left(\frac{L_1}{D}\right) \frac{V_1^2}{2g}$ $\quad h_{L2} = \left(f_2 \left(\frac{L_2}{D}\right) + f \left(\sum \frac{Le}{D}\right)\right) \frac{V_2^2}{2g}$

$\sum \frac{Le}{D} = 3(30) + 150 = 240$

$f_2 \left(\frac{L_1}{D}\right) \frac{V_1^2}{2g} = f_2 \left(\frac{L_2}{D}\right) + f_1 \left(\sum \frac{Le}{D}\right) \frac{V_2^2}{2g}$

$\left[0.021 \left(\frac{30}{0.0525}\right)\right] V_1^2 = \left[0.021 \left(\frac{60}{0.0525}\right) + 0.019(240)\right] V_2^2$

$12 V_1^2 = (24 + 4.56) V_2^2$

$12 V_1^2 = 28.56 V_2^2$

$V_1 = \sqrt{\frac{28.56}{12}} V_2 = 1.5160 V_2$ $\quad Q = V \cdot A$ areas cancel

$(1.5160 \cdot Q_2) + Q_2 = 850 L/min$

$2.5160 \cdot Q_2 = 850 L/min$

Low $Q_2 = \frac{850}{2.5160} = \boxed{332.03 L/min}$

upp $Q_1 = 850 - 332 = \boxed{518 L/min}$ or $0.00865 m^3/s$

$V_1 = Q_1/A = 0.00865 m^3/s / 0.002169 m^2 = 3.99 m/s$

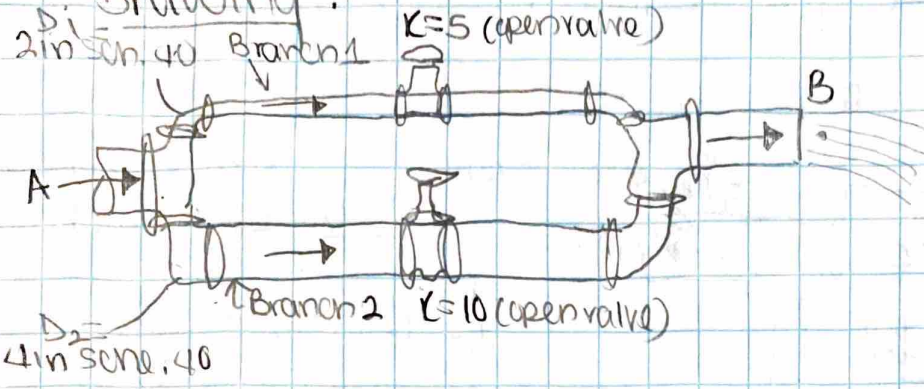
$h_L = 0.021 \left(\frac{30}{0.0525}\right) \frac{3.99^2}{2(9.81)} = 9.68m$

$P_B - P_A = \gamma \cdot h_L = 9.81 kN/m^3 \cdot 9.68m = \boxed{95 kPa}$

Summary: Q in lower pipe is 332 L/min, Q in upper pipe is 518 L/min. The pressure different between pt A + pt B is 95 kPa

#12-6 Purpose: Calculate the flow rate of water for (a) both valves open (b) valve in branch 2 only open (c) valve in branch 1 only open

Drawing:



Materials: water

Data:

$P_A = 20 psig$ $z_A = z_B$

$P_B = 0 psig$

$\gamma = 62.4 lb/ft^3$

$F_{A\,2in} = 0.02333 ft^2$

$F_{A\,4in} = 0.08840 ft^2$

$K_{elb.} = 0.9$ $K_{upper} = 5$ $K_{lower} = 10$ $g = 32.2 ft/s^2$

Calculations/Procedure:

Upper Branch (1):

$K_1 = 5 + 2(0.9) = 6.8$

$\Delta h = K_1 \frac{V^2}{2g} = 6.8\left(\frac{V^2}{2(32.2 ft/s^2)}\right)$

$V_1 = \sqrt{\frac{46.15 \times 64.4}{6.8}} = 20.91 ft/s$

$Q_1 = A_1 V_1 = 0.02333 ft^2 \cdot 20.91 ft/s = \boxed{0.488 ft^3/s}$ (B) Branch 1 open

Lower branch (2):

$K_2 = 10 + 2(0.9) = 11.8$

$46.15 = 11.8 \frac{V_2^2}{2(32.2)}$

$V_2 = \sqrt{\frac{46.15 \times 64.4}{11.8}} = 15.87 ft/s$

$Q_2 = A_2 V_2 = 0.0884 ft^2 \times 15.87 ft/s = \boxed{1.4 ft^3/s}$ (C) branch 2 open

$\Delta h_1 = \Delta h_2$ in parallel

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

- elevation cancel
- $P_B = 0$ · $V_1 = 0$

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

$h_L = \frac{20 lb/in^2 \times 144 in^2/ft^2}{62.4 lb/ft^3} = 46.15 ft$

(A) $Q_3 = Q_2 + Q_1 = 1.4 ft^3/s + 0.488 ft^3/s = \boxed{1.89 ft^3/s}$

Summary: when both valves are open the flow rate is $1.89 ft^3/s$. when only branch 1 is open the flow rate is $0.488 ft^3/s$. when only branch 2 is open the flow rate is $1.4 ft^3/s$.