problem 12.3 Branched pipe system

Given: $Q = 850 L/min = 850/1000 m^3/min = 0.850 m^3/min$
$= 0.850/60 m^3 = 0.014167 m^3/s$

Length of lower branch 60m, Temp 10 °C, length between A and B

Step 1 Flow rate of each branch

$Q_{branch} = \frac{Q}{2} \Rightarrow \frac{0.014167}{2} \Rightarrow 0.007835 m^3/s$

Step 2 velocity in each branch

$A_{branch} = \pi\left(\frac{D}{2}\right)^2 \Rightarrow \pi\left(\frac{0.0535}{2}\right)^2 = 0.00225 m^2$

$V_{branch} = \frac{Q_{branch}}{A_{branch}} = \frac{0.007085}{0.00225} = 3.15 m/s$

Step 3 Head losses in lower branch

$h_f = f\frac{L}{D}\frac{V^2}{2g} \Rightarrow 0.022\frac{60}{0.0535}\times\frac{3.15^2}{2\times9.81} = 1.14 m$

Minor head loses

for standard elbow $= 0.9$
for fully open valve $= 2.2$

$h_m = (4\times0.9+2.2)\times\frac{V^2}{2g} \Rightarrow (3.6+2.2)\times\frac{3.15^2}{2\times9.81} \Rightarrow 2.93 m$

$h_{total} = h_f + h_m = 1.14 + 2.93 = 4.07$

Step 4 pressure difference

$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B + h_{total}$

Assuming $Z_A = Z_B$ and $V_A = V_B$

$\frac{P_A}{\rho g} = \frac{P_B}{\rho g} + h_{total}$, $P_A - P_B = \rho g h_{total} \Rightarrow 1000\times9.81\times4.07 \Rightarrow 39,926.7 pa = 39.9 kpa$

problem 12.4 Branched pipe system

Given: $Q = 1350$ gal/min, $SG = 0.87$, Temp $= 140^\circ F$, Pipe dimensions (8 inch, 6 inch, 2 inch)

step 1 convert flow rate to cubic feet per second

$Q = 1350 \text{ gal/min} \times 0.13368 \text{ ft}^3/\text{min} \Rightarrow 180.46935 \text{ ft}^3/\text{min}$

$\frac{180.46935}{60} = 3.0078 \text{ ft}^3/s$

step 2 Determine flow rates in the branches

Let Q_6 = 6 inch pipe and Q_2 be in 2 inch pipe

$Q = Q_6 + Q_2$

Step 3 Crosssectional Areas

8 inch pipe

$D_8 = 8 \text{ in} = 0.66 \text{ ft} \Rightarrow \pi \frac{D_8}{2}^2 \Rightarrow \pi\left(\frac{0.666}{2}\right)^2 = 0.348 \text{ ft}^2$

6 inch pipe

$D_6 = 6 \text{ in} = 0.5 \text{ ft}$

$A_6 = \pi\left(\frac{D_6}{2}\right)^2 \Rightarrow \pi\left(\frac{0.5}{2}\right)^2 \Rightarrow 0.196 \text{ ft}^2$

2 inch pipe

$D_2 = 2 \text{ in} = 0.166 \text{ ft} \Rightarrow \pi\left(\frac{0.166}{2}\right)^2 = 0.0217 \text{ ft}^2$

Step 4 Bernoulli equation

8 inch pipe

$V_8 = \frac{Q}{A_8} = \frac{3.0078}{0.348} = 8.64 \text{ ft/s}$

6 inch pipe

$V_6 = \frac{Q_6}{A_6}$

2 inch $\Rightarrow V_2 = \frac{Q_2}{A_2}$

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