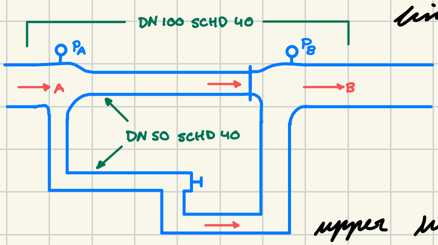
Homework #7

Problem 12-3

850 L/min, H_2O, 10°C, dimensions given in prob. statement, find pipe dim. from book



for energy losses use Darcy eq $h_L = f \frac{L}{D} \frac{v^2}{2g}$

upper branch: $h_L = f \frac{30}{.0525} \frac{v^2}{2g} \Rightarrow f(571)\frac{v^2}{2g}$

assume h_L in upper = h_L in lower

$f_a = f_b = .019$ from Moody's

lower branch: $h_L = h_f + h_{H_2O} + 3h_{elb} + f\frac{L}{D}\frac{v^2}{2g} + f\frac{L}{D}\frac{v^2}{2g} + 3f\frac{L}{D}\frac{v^2}{2g}$

$\rightarrow f \frac{60}{.0525}\frac{v^2}{2g} + .019 \cdot 150 \cdot \frac{v^2}{2g} \cdot 3 \cdot 19 \cdot 30 \frac{v^2}{2g}$

$\Rightarrow (1142f + 4.56)\frac{v^2}{2g}$

$571 f \frac{v_A^2}{2g} = (1142f + 4.86)\frac{v_B^2}{2g}$

$\hookrightarrow 11.4 v_A^2 = 27.4 v_B^2$

$v_A = \sqrt{27.4 / 11.4 v_B} - 1.55 v_B$

$Q_A = A_A v_A + A_B v_B - A_A(1.55 v_B) + A_B v_B = A_B(1.55 v_B) + A_B v_B = v_B(2.55 A_B)$

$Q_A = 850$ L/min or $.01416$ m³/s, $A_B = \frac{\pi(.0525^2)}{4} = 2.17E{-3}$ m²

$v_B = \frac{Q_A}{2.55 A_B} = \frac{.01416}{2.55(2.17E{-3})} \Rightarrow 2.56$ m/s & $v_A = 1.55 v_B \Rightarrow v_A = 3.97$ m/s

find Reynold's # w/ $N_R = VD/\nu$ where $\nu = 1.3E{-6}$

$N_{R_A} = \frac{3.97(.0525)}{1.3E{-6}} \Rightarrow 1.6E5$

$f = .021$

$N_{R_B} = \frac{2.56(.0525)}{1.3E{-6}} \Rightarrow 1.03E5$

$f = .022$

$\frac{D}{\varepsilon} = \frac{.0525}{4.6E{-5}}$

* use ~~to~~ find f values

must recompute w/ new values....

$571(.021)\frac{v^2}{2g} = (1142 \cdot .021 + 4.56)\frac{v^2}{2g} \Rightarrow 11.91 v_A^2 = 29.4 v_B^2$ so $v_A = \sqrt{29.11 / 11.91 v_B}$

then $v_A = 1.56 v_B$ so... $Q_A = A_B(1.56 v_B) + A_B v_B = v_B(2.56 A_B)$

$\rightarrow v_B = \frac{Q_A}{2.56 A_B} \rightarrow \frac{.01416}{2.56(2.17E{-3})} \Rightarrow 2.55$ m/s so $v_A = 3.98$ m/s

a) $Q_A = A_A v_A = 2.17E{-3}(3.98) \Rightarrow 8.63E{-3}\ m^3/s$ or **518 L/min**

$Q_B = A_B v_B = 2.17E{-3}(2.55) \Rightarrow 5.52E{-3}\ m^3/s$ or **332 L/min**

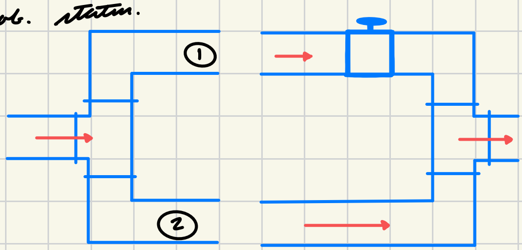
b) $\frac{P_A}{\gamma} + \frac{v_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{v_B^2}{2g} + z_B + h_{LAB} \rightarrow P_A - P_B = \gamma h_L - \gamma h_{LA}$

$-P_B$ & divide γ

$\rightarrow \frac{9.81\,kN}{m^3}\left(571(.021)\left(\frac{3.98^2}{2(9.81)}\right)\right) \Rightarrow$ **95 kPa**

Problem 12-5 | H_2O, 10°C — find K to achieve equal flow rates of 500 L/min

dimensions given in prob. statem.



$h_{L_1} = h_{L_2} \rightarrow f\frac{L}{D}\frac{v^2}{2g} + K\left(\frac{v^2}{2g}\right) = f\frac{L}{D}\frac{v^2}{2g}$

so only need to calculate for velocities in upper & lower

500 L/min = .00833 m^3/s

$V_1 = \frac{.00833}{\frac{\pi(.1)^2}{4}} \Rightarrow 1.06\ m/s$

$N_R = \frac{vD}{\nu} \rightarrow \frac{1.06(.1)}{1.39E{-6}} \Rightarrow 75{,}950$

f eq from turb flow

$f = .184 N_R^{-.2} \rightarrow .184(75950)^{-.2} \Rightarrow .019$

$V_2 = \frac{.00833}{\frac{\pi(.05)^2}{4}} \Rightarrow 4.24\ m/s$

$N_R = \frac{4.24(.05)}{1.39E{-6}} \Rightarrow 151{,}901$

$\rightarrow f = .184(151901)^{-.2} \Rightarrow .0169$

rearrange prev. equation to solve for K & get...

$K = \frac{30}{1.06^2}\left(\frac{.0169(4.24)^2}{.05} - \frac{.019(1.06)^2}{.1}\right) \Rightarrow$ **K = 156.6**

* can use this eq/strategy because when applying Bernoulli eq, most everything will cancel w/ this set-up leaving only head loss