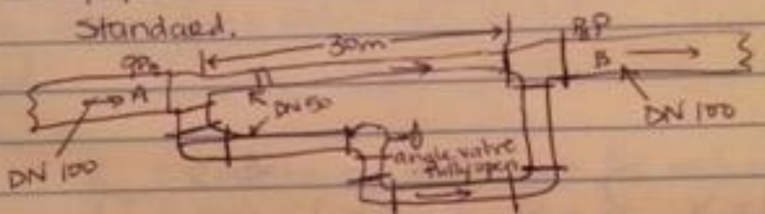
12.3 In the branched pipe system shown in the figure, 850 L/min of water at 10°C is flowing in a DN 100 Schedule 40 pipe at A. The flow splits into two DN 50 Schedule 40 pipes as shown & then rejoins at B. Calculate a) the flow rate in each of the branches & b) the pressure difference $P_A - P_B$. Include the effect of the minor losses in the lower branch of the system. The total length of pipe in the lower branch is 60 m. The elbows are standard.



$Q_a = A_a v_a \quad Q_b = A_b v_b$ $\qquad h_L = K\left(\frac{v^2}{2g}\right)$

$Q_1 = A_a v_a + A_b v_b \qquad Q_1 = 850 \text{ L/min}$

DN 100 $f_T = 0.016$

DN 50 $f_T = 0.019$

$\frac{L_e}{D}$ angle valve = 150

$\varepsilon = 4.6 \times 10^{-5}$ m

$$Q_1 = 850 \text{ L/min} \times \frac{1 \text{ m}^3/\text{s}}{60000 \text{ L/min}} = \boxed{0.0142 \text{ m}^3/\text{s}}$$

$$0.0142 = 0.00393 v_a + 0.00393 v_b$$

A_a & A_b = each other = 0.00393 m^2

$h_a = K_1\left(\frac{v_a^2}{2g}\right) + \cancel{K_2\left(\frac{v_2^2}{2g}\right)}$

$K_4 = f_{aT}\left(\frac{L_e}{D}\right)$ = Resistance coefficient for valve

~~K_2~~ $f_{aT} = 0.019$ — DN 50 $\frac{L_e}{D} = 150$ for angle valve

$\boxed{K_4 = (0.019)(150) = 2.85}$

$\Delta p = \gamma h_L$

$h_a = (2.85)\left(\frac{v_a^2}{2(9.81)}\right)$

$h_b = 3K_3\left(\frac{v_b^2}{2g}\right) + K_4\left(\frac{v_b^2}{2g}\right) + K_5\left(\frac{v_b^2}{2g}\right)$

straightforward → h_a

b/c no elbows or valves?

K_3 = Resistance coefficient for each elbow

$K_3 = f_{bT}\left(\frac{L_e}{D}\right)$ $f_{bT} = 0.019$ $\frac{L_e}{D} = 30$ $K_3 = 0.57$

K_4 = Resistance coefficient for angle valve

$\frac{L_e}{D} = 150$

$K_5 = f_b\left(\frac{L_b}{D}\right)$ = friction loss in the pipe of branch b for a pipe length of L_b =

$K_1 = f_a\left(\frac{L_a}{D}\right)$ = friction loss in pipe of branch a for a pipe length of La =

$K_1 = (0.019)\left(\frac{30m}{0.005m}\right) = 114$

there's no K_2 here.

$h_a = K_1\left(\frac{v_a^2}{2(9.81)}\right) = 114\left(\frac{v_a^2}{19.62}\right)$

$K_5 = (0.019)\left(\frac{60m}{0.005m}\right)$

$K_5 = 228$

$h_b = \underbrace{3(K_3)\left(\frac{v_b^2}{19.62}\right)} + \overset{K_4}{2.85}\left(\frac{v_b^2}{19.62}\right) + K_5\left(\frac{v_b^2}{19.62}\right)$

$= 3(0.57)\left(\frac{v_b^2}{19.62}\right) + 2.85\left(\frac{v_b^2}{19.62}\right) + 228\left(\frac{v_b^2}{19.62}\right)$

$= 0.0872\, v_b^2 + 0.145\, v_b^2 + 11.621\, v_b^2 = \boxed{11.8532\, v_b^2} = h_b$

$$h_b = 11.8532\, v_b^2$$

$$0.0142 = 0.00393 v_a + 0.00393 v_b$$

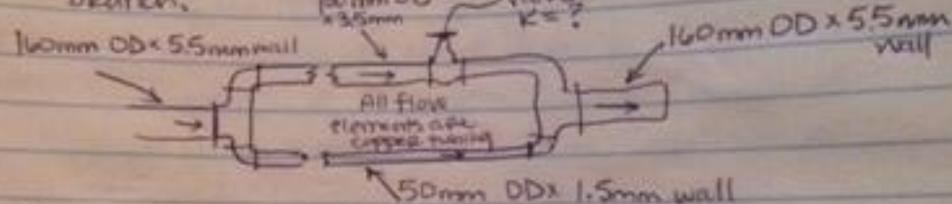
$$v_b = \frac{0.0142 - 0.00393 v_a}{0.00393}$$

$$h_b = 11.8532 \left(3.613 - v_a\right)^2$$

$$h_b = 11.8532 \left(13.054 - 7.226 + v_a^2\right)$$

$$h_b = 154.732 - 85.651 + 11.8532\, v_a^2$$

12.5 A 160 mm pipe branches into a 100 mm & a 50 mm pipe as shown in the figure. Both pipes are hydraulic copper tubing & 30 m long. (The fluid is water at 10°C.) Determine what the resistance coefficient K of the valve must be to obtain equal volume flow rates of 500 L/min in each branch.



2 elbows each

1 valve

$Q = Av$

$$\frac{p_A}{\gamma} + z_A + \frac{v_A^2}{2g} - h_L = \frac{p_B}{\gamma} + z_B + \frac{v_B^2}{2g}$$

$h_{\text{elbow}} = 2K\left(\frac{v_1^2}{2g}\right) + K_2\left(\frac{v_2^2}{2g}\right)$

$K_1 = f_T\left(\frac{L_e}{D}\right)$

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

30

$= 2$

OD – 100 mm

wall thickness – 3.5 mm

ID – 93.0 mm

flow area $A = 6.793 \times 10^{-3}$