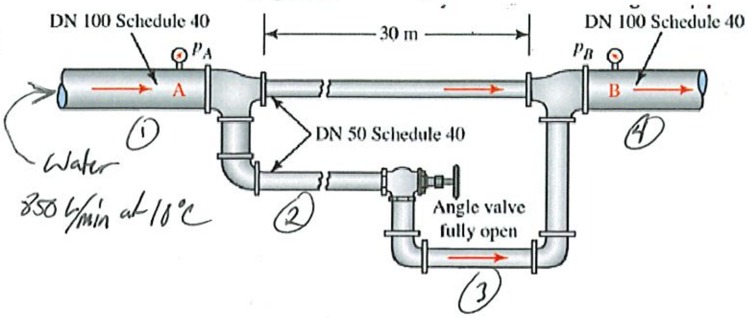
Purpose 12.3) Drawing Dario Baxter

a) Calculate the flow rate in each branch

b) the pressure difference $P_A - P_B$



$L_e/D_{valve} = 150 \times 0.037$

$L_e/D_{elbow} = 30$

$K = 4$

Design considerations
- incompressible fluids
- isothermal process
- steady state
- Include minor losses
- Total length of lower branch = 60m
- elbows are standard

Data

DN sch 40 = D = 0.0525m

DN sch 100 = D = 0.1023m

Flow rate = 850 L/min = 0.0141667 m³/s

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_{LA}$$

$$h_{L_a} = f\left(\frac{L}{D}\right)\frac{V^2}{2g}$$

$$= 0.03\left(\frac{30}{.0525}\right)\frac{V^2}{2g}$$

$$= 0.8736V^2$$

$$h_{L_b} = f\left(\frac{L}{D}\right)\frac{V^2}{2g} + 3\times K_{elbow}\left(\frac{V^2}{2g}\right) \times K_{valve}\left(\frac{V^2}{2g}\right)$$

$$= 42.29\frac{V^2}{2g} + 3.33\frac{V^2}{2g} + 5.55\frac{V^2}{2g}$$

$$= 2.6081V^2$$

$$A_a = \frac{\pi D^2}{4} = \frac{\pi(0.0525)^2}{4} = 0.002165\,m^2$$

$$0.8736V_a^2 = 2.6081V_b^2$$

$$V_a = 1.72V_b$$

$$Q = A_a(1.72V_b) + A_bV_b$$

$$V_b = \frac{Q}{(A_a \times 1.72) + A_b}$$

$V_b \approx 2.406$

$V_a = 1.72\,(2.406) = 4.138$

$$\frac{D_a}{\varepsilon} = \frac{(0.0525)}{4.6\times10^{-5}} = 114.13$$

$$V_a = \frac{Q}{A} = \frac{0.0141667}{0.02165} = 6.5435\,m/s$$

$$R_e = \frac{6.5435(0.0525)}{1.30\times10^{-6}} = 264256.73$$

$Q_a = 0.002165 \times 4.138$
$= 0.00895877\,m^3/s = $ **537.53 L/min**

$Q_b = 0.02165 \times 2.406$
$= 0.00520899 = $ **312.54 L/min**

f = 0.037 using friction factor equation

$$h_{L_A} + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_1 = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_2 + h_{L_B}$$

$$\frac{P_A - P_B}{\gamma} = h_{L_A}$$

$$P_A - P_B = \gamma\left(f\left(\frac{L}{D}\right)\left(\frac{V_A^2}{2g}\right)\right)$$

$$P_A - P_D = 9.81\ kN/m^3\left(0.037\left(\frac{30}{0.0505}\right)\left(\frac{4.138^2}{2 \cdot 9.81}\right)\right)$$

$$= 181.02\ kpa$$

Purpose (12.4)

Calculate the volume flow rate in the 6-in and 2in pipe

Design Considerations

- incompressible fluids
- isothermal process
- steady state
- pipes are standard sch 40 steel
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Data and Variables

Benzene

1350 gal/min = 3.007813 ft^3/s

$\nu = 7.41 \times 10^{-6}$

Sg = 0.87

D_1 = 6in ID = 0.5054 ft

D_2 = 2in ID = 0.1725 ft

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

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

$A = \frac{\pi D^2}{4}$

$= \frac{\pi (.5054)^2}{4}$

$= 0.201\ ft^2$

$\frac{D}{\varepsilon} = \frac{0.5054}{1.5\times10^{-4}}$

$= 3369.33$

$Re = \frac{15.346(0.5\ ft)}{0.0493\times10^{-4}}$

$= 1,534,037.65$

$v = \frac{Q}{A}$

$= \frac{3.007813\ ft^3/s}{0.201\ ft^2}$

$= 14.964\ ft/s$

$f = 0.015$

$A = \frac{\pi (0.1723)^2}{4}$

$= 0.023\ ft^2$

$\frac{D}{\varepsilon} = \frac{0.167}{1.5\times10^{-4}}$

$= 1148.67$

$V = \frac{Q}{A}$

$= \frac{3.007813\ ft^3/s}{.023\ ft^2}$

$= 130.77\ ft/s$

$Re = \frac{130.77(0.1723)}{0.0493\times10^{-4}}$

$= 4,570,318.66$

$f = 0.019$

$$h_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) + K_{globe\,valve}\left(\frac{V^2}{2g}\right) + K_{swing\,valve}\left(\frac{V^2}{2g}\right) + 2 \times K_{elbows}\left(\frac{V^2}{2g}\right)$$

$$= 14.840 \frac{V^2}{2g} + 5.1 \left(\frac{V^2}{2g}\right) + 1.5 \frac{V^2}{2g} + 0.9 \frac{V^2}{2g}$$

$$= 22.34 \frac{V^2}{2g} = 1.14 V_a^2$$

$\frac{L_e}{D}$ globe valve $= 340$

$\frac{L_e}{D}$ swing valve $= 100$

$\frac{L_e}{D}$ elbow $= 30 \times 0.019$

$$h_{L_b} = 55.14 \frac{V^2}{2g} + 1.14 \frac{V^2}{2g}$$

$$= 56.28 \frac{V^2}{2g} = 2.82 V_b^2$$

$$1.14 V_a^2 = 2.82 V_b^2$$

$$V_a = 1.57 V_b$$

$$Q = A_a(1.57 V_b) + A_b V_b$$

$$3.007813 = (0.201 \times 1.57 + 0.023) V_b$$

$$V_b = 8.88 \text{ ft/s}$$

$$V_a = 1.57 \times 8.88$$

$$= 13.92 \text{ ft/s}$$

$$Q_a = 0.201 \times 13.92$$

$$= 2.8 \text{ ft}^3/\text{s} = 1256.73 \text{ gal/min}$$

$$Q_B = 0.023 \times 8.88$$

$$= 0.20 \text{ ft}^3/\text{s} = 89.77 \text{ gal/min}$$