meng 263 – Fluids & Heat Transfer

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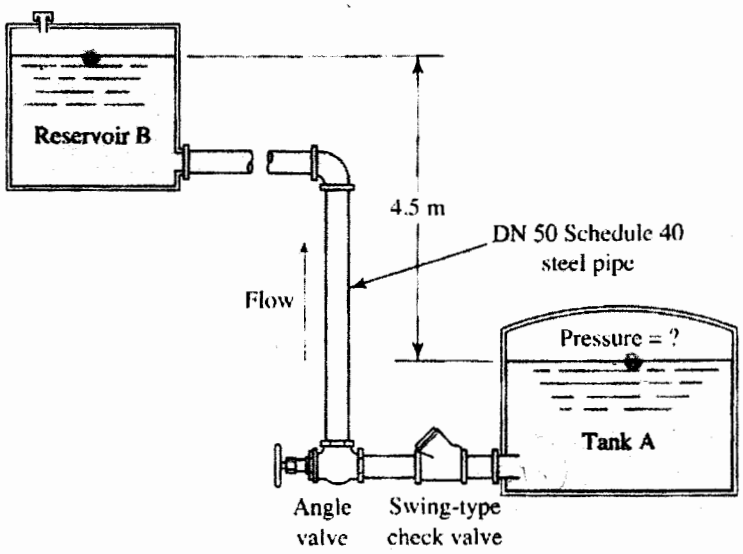
10/10

Assignment 1

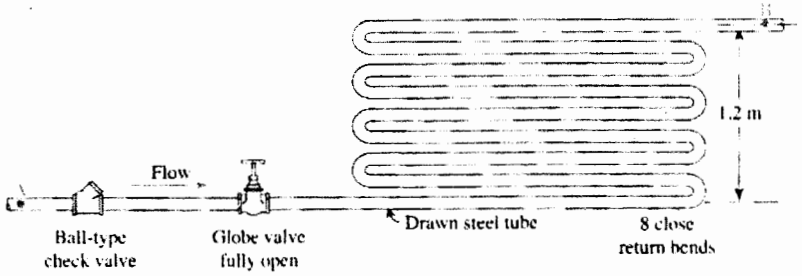
Question 1

11.2 For the system shown in Fig. 11.14, kerosene (sg = 0.82) at 20°C is to be forced from tank A to reservoir B by increasing the pressure in the sealed tank A above the kerosene. The total length of DN 50 Schedule 40 steel pipe is 38 m. The elbow is standard. Calculate the required pressure in tank A to cause a flow rate of 435 L/min.



Question 2

11.7 A liquid refrigerant flows through the system, shown in Fig. 11.19, at the rate of 1.70 L/min. The refrigerant has a specific gravity of 1.25 and a dynamic viscosity of 3×10^{-4} Pa·s. Calculate the pressure difference between points A and B. The hydraulic tube is drawn steel, with an outside diameter (OD) of 15 mm, a wall thickness of 1.5 mm, and a total length of 30 m.



MEng 263 Homework 1 Sept 12/16

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Question 1

- kerosene (S.g 0.82) @ 20°C
- 38m of DN 50 schedule 40 steel pipe (ID = 52.501mm)
- standard elbow
- required pressure for flowrate of 435 L/min ?

$$Q = \frac{435\ L/min}{60\ s/min} = 7.25\ L/s$$

$$\gamma_k = (0.82)(9.81 m/s^2)(1000 kg/m^3)$$

$$\boxed{\gamma_k = 8.0442 \times 10^3\ N/m^3}$$

$$\frac{P_1}{\gamma} + \cancel{z_1}^{0} + \cancel{\frac{V_1^2}{2g}}^{0} + \cancel{h_A}^{0} - h_L - \cancel{h_R}^{0} = \cancel{\frac{P_2}{\gamma}}^{0} + z_2 + \cancel{\frac{V_2^2}{2g}}^{0}$$

$$\frac{P_1}{\gamma} - h_L = z_2$$

$$P_1 = (z_2 + h_L)\gamma$$

Want P_1, Need h_L

Head Losses

① H_L Entrance
② H_L Exit
③ H_L Swing type check valve
④ H_L Angle valve
⑤ H_L Standard elbow
⑥ H_L 38m pipe section

1) H_L of Pipe entrance (inward projecting pipe)

$K = 0.78$

$V = Q/A = 7.25 \times 10^{-3}\ m^3/s \,/\, \frac{(0.052501)^2 \pi}{4} = 3.348\ m/s$ ✓

$h_L = K(V_1^2/2g) = 0.78\,((3.348\ m/s)^2/2(9.81))$

$\boxed{h_L = 445.8836 \times 10^{-3}\ m}$

2) H_L of Pipe exit (Square edged inlet)

$K = 1.0$ $\quad h_L = 1.0(V^2/2g)$

$V = 3.348\ m/s$ $\quad h_L = 1.0((3.348)^2/2(9.81))$

$\boxed{h_L = 571.31009 \times 10^{-3}\ m}$

3) H_L Swing type check valve

$Le/D = 100$ $\quad h_L = \left[f\left(\Sigma \frac{L_E}{D}\right)\right]\frac{V^2}{2g}$

Find f

$\mu = 0.00164\ Pa \cdot s$ $\quad \gamma = 8.0442 \times 10^3\ N/m^3$

$P = 850\ kg/m^3$

$N_R = \frac{VDP}{\mu} = \frac{(3.348\ m/s)(0.05250\ m)(850\ kg/m^3)}{0.00164\ Pa \cdot s}$

$\boxed{N_R = 91102.04012}$ ok

$\epsilon = 4.6 \times 10^{-5}\ (m)$ $\quad \therefore \frac{D}{\epsilon} = \frac{0.05250\ m}{4.6 \times 10^{-5}} = 1141.326$

$\therefore \boxed{f = 0.022}$ ✓

$h_L = f\left(\frac{L_E}{D}\right)\frac{V^2}{2g} = (0.022)(100)(571.31 \times 10^{-3})$

$\boxed{h_L = 1.2568\ m}$

Homework 1 cont.

4) H_L of Angle valve

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

$$h_L = f\left(\frac{L_E}{D}\right)\frac{V^2}{2g}$$

$$= (0.022)(150)(571.31009 \times 10^{-3}\,m)$$

$$\boxed{h_L = 1.88532\ m}$$

5) H_L of standard elbow

$$h_L = f\left(\frac{L_E}{D}\right) V^2/2g$$

$$\frac{L_E}{D} = 30$$

$$h_L = (0.022)(30)(571.31009 \times 10^{-3})$$

$$\boxed{h_L = 377.0646 \times 10^{-3}\,m}$$

6) H_L of pipe section

$$h_L = f(L/D)(V^2/2g)$$

$$h_L = (0.022)(38m/0.052501m)(571.31009 \times 10^{-3})$$

$$\boxed{h_L = 9.183m}$$

Total head: $h_L1 + h_L2 + h_L3 + h_L4 + h_L5 + h_L6$

→ $445.8836 \times 10^{-3} + 571.31009 \times 10^{-3} + 1.2568 + 1.88532 + 377.0646 \times 10^{-3} + 9.183$

Total Head = 13.7193m ✓

→ $P_1 = (z_2 + h_L)\,\gamma_k$

→ $P_1 = (4.5\,m + 13.7193\,m)\ 8.0442 \times 10^3 \frac{N}{m^3}$

→ $P_1 = 146.56032 \times 10^3 \frac{N}{m^2} =$ **146.56 kPa** ✓

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Homework 1

Question 2

$z_2 = 1.2m$

$Q = 1.70 L/min = 28.3\bar{3} \times 10^{-3} L/s$

$S.g = 1.25$

$\gamma = (S.g)(g)(\rho_{water}) = (1.25)(9.81 m/s^2)(1000 kg/m^3) = 12.262 \times 10^3$

$\mu = 3 \times 10^{-4} Pa \cdot s$

$ID = 15mm - 3m = 12mm = 12 \times 10^{-3} m$

$\ell = 30m$

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

$\rho = \gamma / g = 12.262 \times 10^3 / 9.81 m/s^2 = 1.24994 \times 10^3 kg/m^3$

$V = Q/A = 28.3\bar{3} \times 10^{-6} m^3/s \,/ \left(\frac{(12 \times 10^{-3} m)^2}{4}\right)\pi = 250.52 \times 10^{-3} m/s$ ✓

$N_R = \frac{VD\rho}{\mu} = \frac{(250.52 \times 10^{-3})(12 \times 10^{-3})(1.24994 \times 10^3)}{3 \times 10^{-4}}$

$N_R = 12.52539 \times 10^3$ ✓

$\frac{D}{\epsilon} = \frac{12 \times 10^{-3} m}{1.5 \times 10^{-6} m} = 8000$ ✓

$f = 0.25 \,/ \left[\log\left[(1/3.7)(8000)\right) + \left((5.74/(12.52539 \times 10^3)^{0.9}\right)\right]\right]^2$

$= \frac{0.25}{\left[\log\left[(33.7837 \times 10^{-6}) + (1.17733 \times 10^{-3})\right]\right]^2}$

$f = 0.029384$ ✓

Head Losses

1) Ball type valve
2) Globe Valve (open)
3) 8 close bends
4) Pipe section

3.19879×10^{-3}

1) H_L of Ball type valve

$h_L = f\left(\frac{L_E}{D}\right) V^2/2g$

$h_L = (0.029384)(150)\left((250.52 \times 10^{-3})^2/2(9.81)\right)$

$\boxed{h_L = 14.098 \times 10^{-3} m}$

2) H_L of globe valve (fully open)

$h_L = f\left(\frac{L_E}{D}\right) V^2/2g$

$= (0.029384)(340)\left((250.52 \times 10^{-3})^2/2(9.81)\right)$

$\boxed{h_L = 31.957 \times 10^{-3} m}$

3) H_L of 8 close bends

$\left(\frac{L_E}{D}\right) = 50 \therefore 50 \times 8 = 400$

$h_L = f\left(\frac{L_E}{D}\right) V^2/2g$

$h_L = (0.029384)(400)\left((250.52 \times 10^{-3})^2/2(9.81)\right)$

$\boxed{h_L = 37.597 \times 10^{-3} m}$

4) H_L of pipe section

$h_L = f\,(L/D)(V^2/2g)$

$h_L = (0.029384)(30m/12 \times 10^{-3} m)\left((250.52 \times 10^{-3})^2/2(9.81)\right)$

$\boxed{h_L = 234.983 \times 10^{-3} m}$

Homework 1
Question 2 cont.

Total Head

$h_{L1} + h_{L2} + h_{L3} + h_{L4}$

$14.098 \times 10^{-3} m + 31.957 \times 10^{-3} m + 37.597 \times 10^{-3} m + 234.983 \times 10^{-3}$

Total head = $318.6351 \times 10^{-3} m$

$$\frac{P_1}{\gamma} + \cancel{z_1}^{\,0} + \frac{\cancel{V_1^2}^{\,0}}{2g} - \cancel{h_A}^{\,0} - h_L - \cancel{h_R}^{\,0} = \frac{P_2}{\gamma} + z_2 + \frac{\cancel{V_2^2}^{\,0}}{2g}$$

$$\rightarrow \frac{P_1}{\gamma} - h_L = \frac{P_2}{\gamma} + z_2$$

$$\rightarrow \frac{P_1}{\gamma} - \frac{P_2}{\gamma} = z_2 + h_L$$

$$\rightarrow P_1 - P_2 = \gamma (z_2 + h_L)$$

$$\rightarrow = (12.262 \times 10^3 N/m^3)(1.2m + 318.6351 \times 10^{-3} m)$$

$$\rightarrow = 18.6215 \times 10^3 N/m^2$$

$P_1 - P_2$ **$= 18.6215 \times 10^3$ Pa**

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