Graded Tut-3

1.) $$\frac{P}{\rho} + 1\times\frac{\bar{v}^2}{2} - 9.81\times 10 = f\left(\frac{L}{D}\right)\frac{\bar{v}^2}{2} + 1.0\times\frac{\bar{v}^2}{2}$$

$$\Rightarrow P = 1000\times\left[98.1 + f\left(\frac{100}{75\times10^{-3}}\right)\frac{\bar{v}^2}{2}\right]$$

$$\bar{v} = \frac{0.01}{\frac{\pi}{4}\times(0.075)^2} = 2.2635\ ms^{-1}$$

$$Re = \frac{\rho\bar{v}D}{\mu} = \frac{1000\times 2.2635\times 0.075}{0.001}$$

$$= 169762.5$$

$$f(Re = 169762.5) = 0.0162$$

$$\therefore P = 1000\left[98.1 + 0.0162\times\frac{10^5}{75}\times\frac{(2.2635)^2}{2}\right]$$

$$\approx 153433\ Pa$$

$$= 153.433\ kPa$$

2.) $$gz = \alpha_1\frac{\bar{v}_{noz}^2}{2} + K_{nozz.}\frac{\bar{v}_{noz}^2}{2}$$

$$\Rightarrow \bar{v}_{noz} = \sqrt{\frac{2\times9.81\times1.5}{1+0.04}}\ ms^{-1} \approx 5.32\ ms^{-1}$$

Now with diffuser attached to nozzle,

$$gz = \underbrace{\alpha_2}_{\approx 1}\frac{\bar{v}_{diff}^2}{2} + (\underbrace{K_{nozz.}}_{=0.04} + \underbrace{K_{diff.}}_{0.3})\frac{\bar{v}_{nozz}^2}{2}$$

$$\bar{v}_{diff.} = \frac{\bar{v}_{nozz.}}{AR} = \frac{\bar{v}_{nozz.}}{2}\ ms^{-1}$$

So $9.81 \times 1.5 = \frac{\bar{v}_{nozz.}^2}{2}\left[0.25 + 0.04 + 0.3\right]$

$$\Rightarrow \bar{v}_{nozz.} = \sqrt{\frac{2 \times 9.81 \times 1.5}{0.59}} \ ms^{-1}$$

$$= 7.06 \ ms^{-1}$$

$$\Delta Q = \frac{\pi}{4} \times (0.025)^2 \ (7.06 - 5.32)$$

$$= 8.54 \times 10^{-4} \ m^3 s^{-1}$$

3.) $gh = \alpha \frac{\bar{v}^2}{2} + f \frac{L}{D} \frac{\bar{v}^2}{2} + K \frac{\bar{v}^2}{2}$

$$\Rightarrow K = \frac{2gh}{\bar{v}^2} - f \frac{L}{D} - \alpha_2$$

$$\bar{v} = \frac{0.016}{\frac{\pi}{4} \times (0.04)^2} = 12.7324 \ ms^{-1}$$

$$Re = \frac{10^3 \times 12.7324 \times 0.04}{0.001} = 509296$$

$$\frac{e}{D} = 3.81 \times 10^{-5}$$

Now, $\frac{1}{\sqrt{f}} = -2 \log\left(\frac{e/D}{3.7} + \frac{2.51}{Re\sqrt{f}}\right)$

$$\Rightarrow f = 0.01365$$

$$\therefore K = \frac{2 \times 9.81 \times 21.5}{(12.7324)^2} - \frac{0.01365 \times 3}{0.04} - 1$$

$$= 0.5783$$

5.) $$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + h_{loss}$$

$P_1 = 275$ kPa, $v_1 \approx v_2 \approx v_{avg}$, $z_1 = z_2$, $P_2 = 0$
($P_1, P_2 \rightarrow$ gauge pressure)

$$\therefore h_{loss} = \frac{275 \times 10^3}{10^3 \times 9.81} \text{ m} \approx 28.0326 \text{ m}$$

Now, $z_1 - z_2 = 15$ m, $v_1 \approx v_2 \approx v_{avg}$, $P_2 = 0$

$$P_1 = \rho g \left[h_{loss} + z_2 - z_1\right]$$

$$= 275 - 9.81 \times 15 = 127.85 \text{ kPa}$$

If $z_1 - z_2 = -15$ m,

$$P_1 = 275 + 9.81 \times 15 = 422.15 \text{ kPa}$$

Now, $P_1 = P_2 = 0$, $v_1 \approx v_2 \approx v_{avg}$

so $z_1 - z_2 = h_{loss} = 28.0326$ m

6.) $$R = \frac{\Delta P}{Q} = \frac{32 \mu v_{avg} \frac{L}{D^2}}{\frac{\pi}{4} D^2 v_{avg}}$$

$$= \frac{128 \mu L}{\pi D^4}$$

Now, $L = 250$ mm $= 0.25$ m
$D = 7.5$ mm $= 0.0075$ m

(a) $\mu_{kerosene} = 1.1 \times 10^{-3}$ Pas ($T = 40°C$)

$$R = \frac{128 \times 1.1 \times 10^{-3} \times 0.25}{\pi \times (7.5 \times 10^{-3})^4} \text{ Pas m}^{-3} = 3.54 \text{ MPas m}^{-3}$$

(b) $\mu_{\text{castor oil}} = 0.25 \text{ Pa s}$

$$R = \frac{128 \times 0.25 \times 0.25}{\pi \times (0.0075)^4} \text{ Pa s m}^{-3} = 0.805 \text{ GPa s m}^{-3}$$

4.) $$H_{Pump} = \frac{P_3}{\rho g} + \alpha_3 \frac{\bar{v}_3^2}{2g} + z_3 - \left(\frac{P_2}{\rho g} + \alpha_2 \frac{\bar{v}_2^2}{2g} + z_2 \right)$$

$(z_3 = z_2,\ \bar{v}_3 \approx \bar{v}_2,\ \alpha_3 = \alpha_2 = 1)$

$$= \frac{P_3 - P_2}{\rho g} = \frac{(450 - 150) \times 10^3}{10^3 \times 9.81} = 30.581 \text{ m}$$

$$H_{loss} = \frac{P_3}{\rho g} + \alpha_3 \frac{\bar{v}_3^2}{2g} + z_3 - \left(\frac{P_4}{\rho g} + \alpha_4 \frac{\bar{v}_4^2}{2g} + z_4 \right)$$

$(v_3 \approx v_4,\ \alpha_3 = \alpha_4 = 1)$

$$= \frac{P_3 - P_4}{\rho g} + z_3 - z_4$$

($P_4 = 0$ assuming discharge to atmosphere)

$$= \frac{450 \times 10^3}{10^3 \times 9.81} - 35 = 10.872 \text{ m}$$

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