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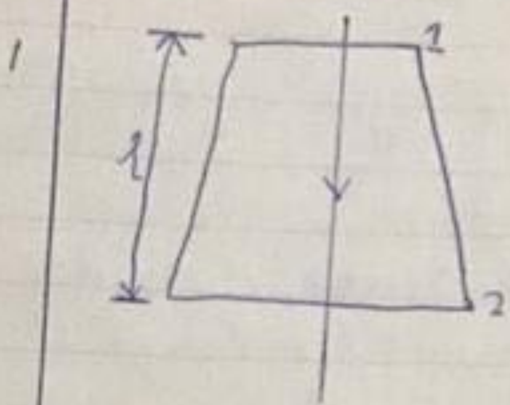
Biomedical Engineering
18/ENG05/1015
ENG 214 Assignment



length, $l = 2.0m$

velocity flow at smaller end $= V_1 = 5m/s$

velocity flow at lower end $= V_2 = 2m/s$

Pressure head at the smaller end $= P_s = 2.5m$ of liquid

loss of head $= H_L = \frac{0.35(V_1 - V_2)^2}{2g}$

$= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161m$

Pressure head at lower end $= P_L = ?$

Applying Bernoulli's Equation

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_f$$

where $P_s = \frac{P_1}{\rho g}$ and $P_L = \frac{P_2}{\rho g}$

$z_1 = 2.0$ and $z_2 = 0$ (datum line passes through section 2

Inputting values into the equation

$$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = P_L + \frac{2^2}{2g \times 9.81} + 0 + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 = P_L + \frac{4}{19.62} + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 - \left(\frac{4}{19.62} + 0.161\right) = P_L$$

$5.774 - 0.365 = P_L$

2. Let inlet diameter $= D_1 = 20\,cm$
Let throat diameter $= D_2 = 10\,cm$
Let inlet area $= A_1 = \frac{\pi D_2^2}{4} = \frac{\pi (20)^2}{4} = 314.16\,cm^2$

Let throat area $= A_2 = \frac{\pi D_2^2}{4} = \pi \frac{(10)^2}{4} = 78.54\,cm^2$

Density of water, $\rho = 1000\,kg/m^3$
Pressure at ~~metal~~ inlet $= 17.658\,N/cm^2 = 17.658 \times 10^4\,N/m^2$

$\therefore \frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18\,m$

$\frac{P_2}{\rho g} = 30\,cm$ of mercury, $S_{Hg} = 13.6$

$\frac{P_2}{\rho g} = -30 \times 10^{-2}\,m$ of mercury $\times 13.6$

$= -4.08\,m$

Let Differential Head $= H = \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

$= 18 - (-4.08)$
$= 18 + 4.08 = 22.08\,m \times 100$
$H = 2208\,cm$

Using, $Q = \frac{C_d \sqrt{2gh} \cdot A_1 A_2}{\sqrt{A_1^2 - A_2^2}}$

$= 0.98 \times \frac{\sqrt{2 \times 981 \times 2208} \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.54)^2}}$

$= \frac{0.98 \times 2081.37 \times 24674.1264}{304.184112}$

$= 165455.3\,cm^3/s$

$= \frac{165455.3}{1000} = 165.455\,lit/sec$

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3. Diameter of pipe $d_1 = 30cm$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (30)^2}{4} = 706.86 cm^2$$

Diameter of orifice, $d_2 = 15cm$

$$A_2 = \frac{\pi d_2^2}{4} = \pi \frac{(15)^2}{4} = 176.72 cm$$

specific gravity of oil, $S_0 = 0.9$
Specific gravity of mercury $S_{hg} = 13.6$
Differential manometer reading, $x = 50cm$ of mercury
Coefficient of discharge, $Cd = 0.64$
Differential head, $h = x\left(\frac{S_{hg}}{S_0} - 1\right)$

$$h = 50\left(\frac{13.6}{0.9} - 1\right)$$

$$h = 705.56 cm \text{ of oil}$$

∴ The rate of flow of oil is

$$Q = \frac{Cd \sqrt{2gh} \cdot A_1 \cdot A_2}{\sqrt{A_1^2 - A_2^2}}$$

$$Q = 0.64 \times \frac{\sqrt{2 \times 981 \times 705.56} \times 706.86 \times 176.72}{\sqrt{(706.86)^2 - (176.72)^2}}$$

$$Q = 137443.29 \ cm^3/s$$

$$Q = \frac{137443.29}{1000} = 137.44 \ lit/s$$

4. The difference of mercury level, $x = 170mm = 170 \times 10^{-3} = 0.17m$
The specific gravity of mercury, $S_g = 13.6$
The specific gravity of sea water, $S_0 = 1.026$
The speed, $V = ?$

$$V = \sqrt{2gh}, \ h = ?$$

$$h = x\left[\frac{S_g}{S_0} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right]$$

$$\therefore V = \sqrt{2 \times 9.81 \times 2.0834} = 6.393 \ m/s$$

In Km/hr

$$v = \frac{6.393 \times 60^2}{1000} = 23.01\ Km/hr$$

5. $Q = 0.05m^3/min = 50dm^3/min$

$P_0 = 15\ bar = 15 \times 100000 = 15 \times 10^5\ N/m^2$

Speed = 1700 rev/min

$T = 15Nm$, $ND = 10cm^3/rev$

i) Volumetric Efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flow rate = Nominal flow rate × speed

$= 10cm^3/rev \times 1700\ rev/min$

$= 17\,000\ cm^3/min$

Ideal flow rate $= \frac{17000}{1\,000\,000} = 0.017\ m^3/min$

Actual flow rate $= 0.05m^3/min$

∴ Volumetric Efficiency $= \frac{0.05}{0.017} = 2.94\% = 294\%$

ii) Fluid power $= P \times Q$

$P = 15 \times 10^5\ Ne/m^2$

$Q = 0.05m^3/min = \frac{0.05}{60} = 8.33 \times 10^{-4}\ m^3/s$

Fluid power $= 15 \times 10^5 \times 8.33 \times 10^{-4}$

$= 15 \times 10^5 \times 83.3 \times 10^{-5}$

$= 1249.5 \times 10^{5-5}$

Fluid Power = 1249.5 watts

iii) Shaft power $= \frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60}$

Shaft power = 2670.35 watts

iv) Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}}$

$\frac{\text{Fluid power}}{\text{Shaft power}} = \frac{1249.5}{2670.35} = 0.468$

Overall Efficiency $= 0.468 \times 100 = 46.8\%$