ENG 214 (Fluid mechanics)

Assignment

1) $z_1 = 0$

$z_2 = 2.0m$

$V_1 = 5m/s$

$V_2 = 2m/s$

Pressure; $\frac{P_1}{w} = 2.5m$

$\frac{P_2}{w} = ?$

$$h_L = \frac{0.35(V_1 - V_2)^2}{2g}$$

$$= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.1606m$$

Applying Bernoulli's Equation

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

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

$$= 2.5 + \frac{5^2}{2 \times 9.81} + 0 - \frac{2^2}{2 \times 9.81} - 2 - 0.1606$$

$$\frac{P_2}{w} = 2.5 + 1.274 - 0.204 - 0.1606 - 2.0$$

$= 1.4094m \approx 1.41m$

2) $d_1 = 20cm = 0.2m$

$d_2 = 10cm = 0.1m$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.2)^2}{4} = 0.0314 m^2$

$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi (0.1)^2}{4} = 0.00985 m^2$

$P_1 = 17.658 N/cm^2 = 176580 N/m^2$

$P_2 =$ 30cm of mecury = 0.3m of Hg

$0.3mmHg \times 13.6 = 4.08$

$h_2 = 4.08m$

$h_1 = \frac{P_1}{w} = \frac{176580}{1000 \times 9.81} = 18m$

$h = h_2 - h_1$

$h = 18 - (-4.08) = 22.08$

using $Q = \frac{C_d A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$Q = \frac{0.98 \times 0.0314 \times 0.00985}{\sqrt{(0.0314)^2 - (0.00985)^2}} \times \sqrt{2 \times 9.81 \times 22.08}$

$Q = \frac{0.00503}{0.0304}$

$Q = 0.1654 m^3/s$

3)

3) Orifice diameter ; $d_o = 15cm = 0.15m$

Pipe diameter $d_1 = 30cm = 0.3m$ $\quad C_d = 0.64$

$A_o = \frac{\pi d_o^2}{4} = \frac{\pi (0.15)^2}{4} = 0.01767 m^2$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.3)^2}{4} = 0.0706 m^2$

Differential head ; $y = 50cm \Rightarrow 0.5m$

$h = \frac{p}{\omega} = y\left(\frac{S.G \text{ of mercury}}{S.G \text{ of oil}} - 1\right)$

$= 0.5\left(\frac{13.6}{0.9} - 1\right)$

$= 0.5(14.11)$

$= 7.06m$

$\therefore h = 7.06m$

$\therefore Q = \frac{C_d \times A_1 \times A_o}{\sqrt{A_1^2 - A_o^2}} \times \sqrt{2gh}$

$Q = \frac{0.64 \times 0.01767 \times 0.0706}{\sqrt{(0.0706)^2 - (0.01767)^2}} \times \sqrt{2 \times 9.8 \times 7.06}$

$= \frac{0.009407}{0.06844}$

$= 0.137 m^3/s$

4) Differential head

$y = 170mm$

$y = 0.17m$

S.G of mercury = 13.6

S.G of sea water = 1.026

$\therefore h = y\left(\frac{S.G \text{ of mercury}}{S.G \text{ of sea water}} - 1\right)$

$= 0.17\left(\frac{13.6}{1.026} - 1\right) = 2.088$

Velocity $= \sqrt{2g\Delta h}$

$V = \sqrt{2 \times 9.8 \times 2.088}$

$V = 6.39 \, m/s$

5. i) Volumetric efficiency $= \frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$

Actual flow rate $= \frac{0.05 \, m^3/min}{60} = 0.000833 \, m^3/sec$

Ideal flowrate = Nominal displacement x speed

nominal displacement $= \frac{10 \, cm^3/rev}{1{,}000{,}000} = 0.00001 \, m^3/rev$

speed $= \frac{1700 \, rev/min}{60} = 28.33 \, rev/sec$

$\therefore$ Ideal flowrate $= 0.00001 \, m^3/rev \times 28.33 \, rev/sec$

$= 0.0002833 \, m^3/sec$

Volumetric efficiency $= \frac{0.000833}{0.0002833} \times 100$

$= 294.03\%$

ii) Fluid power; $P_F = Q \cdot dp$

$dp = 15 \, bar \times 10^5 = 1.5 \times 10^6 \, N/m^2$

$P_F = 0.000833 \times 1.5 \times 10^6$

$P_F = 1{,}249.5$ watts

iii) shaft

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$\therefore$

iv) Ou

(iii) shaft power = Torque × angular speed

Torque = 15Nm

angular speed = $2\pi N$ = $2 \times \frac{22}{7} \times 28.33$

= 178.07 rad/sec

∴ shaft power = 15 × 178.07

= 2,671.11 watts

(iv) Overall efficiency = $\frac{\text{Fluid power}}{\text{shaft power}} \times 100$

= $\frac{1,249.5}{2,671.11} \times 100$

= 46.77%