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18 |ENG03|015
CIVIL ENGINEERING
Fluid mechanics

1. Length, $L = 2.0m$

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

The velocity flow at larger end $= V_2 = 2m/s$

Let the pressure head at the smaller end $= P_1 = 2.5m$ of liquid

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

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

Let the pressure head at the larger end $= P_2 = ?$

Applying Bernoulli's equation

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + H_L$$

Where $P_1 = P_1/\rho g$ and $P_2 = \frac{P_2}{\rho g}$

$Z_1 = 2.0$ and $Z_2 = 0$ (datum line passes through section 2)

Input the values

$$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = P_2 + \frac{2^2}{2 \times 9.81} + 0 + 0.161$$

$$P_2 = 2.5 + \frac{25}{19.62} + 2 - \left(\frac{4}{19.62} + 0.161\right) = P_2$$

$= 5.774 - 0.365 = P_2$

$P_2 = 5.409m$ of fluid

2) Let inlet diameter $= D_1 = 20cm$

Let throat diameter $= D_2 = 10cm$

Let inlet area $= A_1 = \frac{\pi D_1^2}{4} = \frac{\pi(20)^2}{4} = 314.16cm^2$

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

Density of water $\rho = 1000 kg/m^3$

pressure at inlet $= 17.658 N/cm^2 = 17.658 \times 10^4 N/m^2$

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

$$\frac{P_2}{\rho g} = -30 cm \text{ of mercury}, \; S.g_{Hg} = 13.6$$

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

$$= -4.08 m$$

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

$$= \frac{0.98 \times \sqrt{2 \times 9.81 \times 2208} \times 314.16 \times 78.54}{\sqrt{314.16^2 - 78.54^2}}$$

$$= \frac{0.98 \times 2081.37 \times 24674.1264}{304.18412}$$

$$= 165455.3 cm^3/s$$

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

3. $d_1 = 30 cm$

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

diameter of orifice $d_2 = 15 cm$

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

Specific gravity of oil $S_o = 0.9$

Specific gravity mercury, $S_{Hg} = 13.6$

Differential manometer reading, $x = 60 cm$ of mercury

Coefficient of discharge, Cd = 0.64

Differential head, $h = x\left(\frac{S_m}{S_o} - 1\right)$

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

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

The rate of flow of oil = $Q = \frac{C_d \sqrt{2gh} \cdot A_1 \cdot A_2}{\sqrt{A_1^2 - A_2^2}}$

$$Q = \frac{0.64\sqrt{2 \times 9.81 \times 705.56} \times 706.56 \times 176.72}{\sqrt{(706.56)^2 - (176.72)}}$$

$$Q = 137443.29 \text{ cm}^3/s$$

$$Q = \frac{137443.29}{1000} = 137.443 \text{ lit/s}$$

4) The difference of mercury level, $x = 170 \text{mm} = 170 \times 10^{-3} = 0.17 \text{m}$

The specific gravity of mercury $S_g = 13.6$

The specific gravity of sea water, $S_o = 1.026$

Speed, $V = ?$

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

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

$$= 2.0834 \text{m}$$

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

In km/hr $V = \frac{6.393 \times 60^2}{1000} = 23.01 \text{ km/hr}$

5) $Q = 0.05 \text{m}^3/\text{min} = 50 \text{dm}^3/\text{min}$

$P_o = 15 \text{bar} = 15 \times 10^5 \text{N/m}^2$

speed = 1700 rev/min

$T = 15 \text{ Nm}$, $Mp = 10 \text{cm}^3/\text{rev}$

i. Volumetric efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flow rate = Nominal flow rate × speed

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

$= 17000\ cm^3/min$

Ideal flow rate $= \frac{17000}{1000000} = 0.017\ m^3/min$

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

Volumetric efficiency $= \frac{0.05}{0.017} = 2.94\%$

i) fluid power = $P \times Q$

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

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

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

$= 15 \times 10^5 \times 833 \times 10^{-5}$

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

Fluid power = 1249.5 Watts

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

Shaft power = 2670.35 Watts

iv) Overall efficiency $= \frac{\text{Fluid power}}{\text{Shaft power}} = \frac{1249.5}{2670.35}$

$= 0.468$

Overall efficiency $= 0.468 \times 100$

$= 46.8\%$

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Civil Engineering