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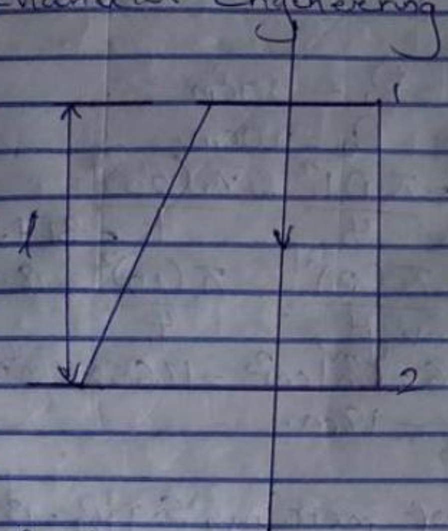
18/Eng06/046
Mechanical Engineering

1)



length, $L = 2.0m$
Velocity flow of Smaller end $= V_1 = 5m/s$
Velocity flow of lower end $= V_2 = 2m/s$
let the Pressure of the Smaller end $= P_s =$ 2.5m of liquid

loss of head $= H_2 = \frac{0.35(V1 - V2)^2}{2g}$

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

Pressure head at the lower end $= P_2 = ?$
Applying Bernoulli's Equation
$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V2^2}{2g} + Z_2 + H$

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

$Z_1 = 2.0$ and $Z_2 = 0$.

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

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

$5.774 - 0.365 = P_r$

$P_r = 5.409m$ of fluid.

2) let Inlet diameter $= D_1 = 20cm$

let throat diameter $= D_2 = 10cm$.

let Inlet Area $= A_1 = \frac{\pi D_1^2}{4} = \frac{\pi (20)^2}{4} = 314.16 cm^2$

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

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

pressure at Inlet $= 17.658 N/cm^3 = 17.658 \times 10^4 N/m^2$

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

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

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

$= -4.08m$.

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

$= 18 - (-4.08)$

$18 + 4.08 = 22.08m \times 100$

$H_1 = 2208cm$

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

$= \frac{0.98 \times \sqrt{2 \times 9.81 \times 2208} \times 314.16 \times 78.54}{\sqrt{(314.16)^2 - (78.54)^2}} = 165455.3 cm^3/s$

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

3) Diameter of pipe $d_1 = 30cm$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (30)^2}{4} = 706.8 cm$

Diameter of orifice $d_2 = \frac{\pi d_2^2}{4} = \frac{\pi (15)^2}{4} = 176.72$

Specific gravity of oil = 0.9

Specific gravity of mercury $S_{hg} = 13.6$.

Differential manometer reading, x = 50cm of mercury

Coefficient of discharge, $C_d = 0.64$.

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

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

$h = ~~705.56~~$ 705.56 of oil.

$\therefore Q = 0.64 \times \frac{\sqrt{2 \times 9.81 \times 705.56} \times 706.86 \times 176.72}{\sqrt{(706.86)^2 - (176.72)^2}}$

$Q = 137443.29 \text{ cm}^2/s$

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

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

The Specific gravity of mercury $S_{hg} = 13.6$

The Specific gravity of Sea water, $S_o = 1.026$

The Speed $V = ?$

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

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

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

In Km/hr

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

5) $Q = 0.05 m^3/mm = 50 dm^3/mm$

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

Speed = 1700 per/min.

$T = 15$ Nm, $ND = 10 cm^2/Sec.$

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

Ideal flow rate = Nominal flow rate × speed.

$= 10 cm^3/sec \times 1700$ per 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 $= \frac{0.05}{0.017} = 2.94\% = 2.94\%$

ii) fluid power = P × Q

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

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

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 $= \frac{2\pi N T}{60} = \frac{2\pi \times 1700 \times 15}{60}$

Shaft power = 2670.35 watts

iv) Overall efficiency = $\frac{\text{fluid power}}{\text{Shaft power}}$

$= \frac{1249.5}{2670.35} = 0.468$

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

46.8%