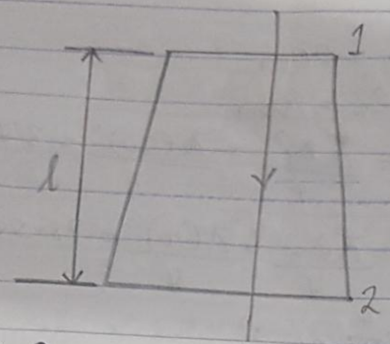
TEJERE EFETOBORE
COMPUTER ENG. 18/ENG02/093
FLUID MECHANICS

1.



Length = 2.0m
The velocity flow at smaller end = v_1 = 5m/s
The velocity flow at lower end = v_2 = 2m/s
Let the pressure head at the smaller end = P_s = 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 pressure head at the lower end = P_2 = ?
Applying Bernoulli's Equation

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

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

$Z_1 = 2.0$ and $Z_2 = 0$ (datum line passes through)
Substituting values

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

$$2.5 + \frac{25}{19.62} + 2 = P_2 + \frac{4}{19.62} + 0.161$$

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

$$5.774 - 0.365 = P_2$$

$P_2 = 5.409$m 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 $= A_2 = \frac{\pi D_2}{4} = \frac{\pi (10)^2}{4} = 78.54 cm^2$

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

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

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

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

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

$= -4.08m$

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

$= 18 - (-4.08)$

$= 18 + 4.08 = 22.08m \times 100$

$H = 2208cm$

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

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

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

$= 165455.3 cm^3/s$

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

3 Diameter of pipe $d_1 = 30cm$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (30)^2}{4} = 1706 \cdot 86 cm^2$$

Diameter of orifice, $d_2 = 15cm$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi (15)^2}{4} = 176 \cdot 72 cm$$

Specific gravity of oil, $SO = 0 \cdot 9$

Specific gravity of mercury, $SG = 13 \cdot 6$

Differential manometer reading, $x = 50cm$ of mercury

Coefficient of discharge, $Cd = 0 \cdot 64$

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

$$h = 50\left(\frac{13 \cdot 6}{0 \cdot 9} - 1\right)$$

$$h = 705 \cdot 56 cm \text{ of oil}$$

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

$$Q = \frac{0 \cdot 64 \times \sqrt{2 \times 981 \times 705 \cdot 56} \times 706 \cdot 86 \times 176 \cdot 72}{\sqrt{(706 \cdot 86)^2 - (176 \cdot 72)}}$$

$$Q = 13743 \cdot 29 \, cm^3/s$$

$$Q = \frac{137443 \cdot 29}{1000} = 137 \cdot 44 \text{ lit/s}$$

The difference of mercury level, $x = 170mm = 170 \times 10^{-3} = 0 \cdot 17m$

The Specific gravity of mercury $Sg = 13 \cdot 6$

The Specific gravity of Sea water, $SO = 1 \cdot 026$

The speed $v = ?$

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

$$h = x\left(\frac{Sg}{SO} - 1\right) = 0 \cdot 17\left[\frac{13 \cdot 6}{1 \cdot 026} - 1\right] = 2 \cdot 0834m$$

$$\therefore v = \sqrt{2 \times 9 \cdot 81 \times 2 \cdot 0834} = 6 \cdot 393 m/s$$

In Km/hr $v = \frac{6 \cdot 393 \times 60^2}{1000} = 23 \cdot 01$ Km/hr

5.

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

$P_2 = 15 bar = 15 \times 100000 = 15 \times 10^5 N/m^2$

Speed = 1700 rev/min

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

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 $= \frac{0.05}{0.017} = 2.94\% = 294\%$

i Fluid power = $P \times Q$

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

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

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

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

Shaft power = 2670.35 watts

Overall Efficiency $= \frac{\text{fluid power}}{\text{Shaft power}} = \frac{1249.5}{2670.35} = 0.468$

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