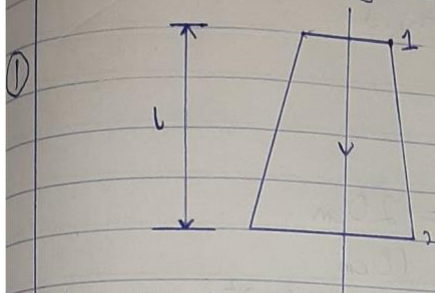


Fluid Mechanics  
 Barr Oghenetega Onireme  
 18/MTH501/107  
 Computer Engineering



Length,  $L = 2.0\text{m}$

The velocity flow at smaller end  $= v_1 = 5\text{m/s}$

The velocity flow at lower end  $= v_2 = 2\text{m/s}$

Let the pressure head at the smaller end  $= P_s =$

Let the loss of head  $= H_L = \frac{0.35 (v_1 - v_2)^2}{2g}$

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

Let the pressure head at the lower end  $= P_h = ?$

Applying Bernoulli's Equation

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + H$$

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

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

Inputting values into the equation

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

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

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

$$P_L = 5.774 - 0.365$$

$$P_L = 5.409 \text{ m of third}$$

①

② Let inlet diameter =  $D_1 = 20 \text{ cm}$

Let throat diameter =  $D_2 = 10 \text{ cm}$

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

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

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

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

$\therefore P_1 = -30 \text{ cm of mercury, } 5.9 \text{ Hg} = 13.6$

$P_g$

$$\frac{P_2}{P_g} = -30 \times 10^{-2} \text{ m of Mercury} \times 13.6$$

$$P_2 = -4.08$$

Let Differential Head =  $H_d = \frac{P_1}{P_g} - \frac{P_2}{P_g}$

$$= 18 - (-4.08)$$

$$= 18 + 4.08 = 22.08 \text{ m} \times 100$$

$$H_d = 2208 \text{ cm}$$

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

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

$$= 0.98 \times 2081.37 \times 24674.1264$$

$$304.18442$$

$$= 165455.3 \text{ cm}^3/\text{s}$$

$$= \frac{165455.3}{1000}$$

$$= 165.455 \text{ lit/s}$$

③ Diameter of pipe =  $d_1 = 30 \text{ cm}$

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

Diameter of orifice =  $d_2 = 15 \text{ cm}$

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

Specific gravity of oil =  $S_o = 0.9$

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

Differential manometer reading =  $X = 50 \text{ cm}$  of mercury

Coefficient of discharge =  $C_d = 0.6$

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

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

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

∴ The rate of flow of the oil is

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

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

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

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

④ The difference of mercury level =  $x = 170 \text{ mm} = 0.17 \text{ m}$

The specific gravity of mercury =  $S_g = 13.6$

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

The speed =  $v = ?$

$$v = \sqrt{2gh}$$

$$h = x \left( \frac{S_g}{S_o} - 1 \right) = 0.17 \left( \frac{13.6}{1.026} - 1 \right)$$
$$= 2.0834 \text{ m}$$

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

In km/hr

$$v = \frac{6.393 \times 60^2}{1000} = 23.07 \text{ km/hr}$$

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

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

Speed = 1700 rev/min

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

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

$$\text{Ideal flow rate} = \text{Normal flow rate} \times \text{Speed}$$
$$= 10 \text{ cm}^3/\text{rev} \times 1700 \text{ rev}/\text{min}$$

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

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

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

ii Fluid power =  $P \times Q$

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

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

$$\begin{aligned} \text{Fluid power} &= 15 \times 10^5 \times 8.33 \times 10^{-4} \\ &= 15 \times 10^5 \times 83.3 \times 10^{-5} \\ &= 1249.5 \times 10^{5-5} \end{aligned}$$

$$\text{Fluid power} = 1249.5 \text{ watts}$$

$$\text{ii) Shaft power} = \frac{2\pi N \tau}{60} = \frac{2\pi \times [700 \times 15]}{60}$$

$$\text{Shaft power} = 2670.35 \text{ watts}$$

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

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

$$\text{Overall efficiency} = 0.468 \times 100 = 46.8\%$$