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Course: Fluid Mechanics  
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1) 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  $= P_s = 2.5\text{m of liquid}$

Let the loss of head  $= H_2 = \frac{0.35(V_1 - V_2)^2}{2g}$

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

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

Applying Bernoulli's Equation

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

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

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

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

Inputting Values into the equation

$$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = \frac{P_L}{19.62} + \frac{2^2}{2 \times 9.81} + 0 + 0.161$$

$$2.5 + \frac{25}{19.62} + 2 = \frac{P_L}{19.62} + \frac{4}{19.62} + 0 + 0.161$$

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

$$5.774 - 0.365 = P_L$$

$$P_2 = 5.409\text{m of fluid.}$$

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

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

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

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

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

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

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

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

$\frac{P_2}{\rho g}$

$= -4.08\text{m}$

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

$= 18 - (-4.08)$

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

$H = 2208\text{cm}$

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

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

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

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

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

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

$1000$

3) Diameter of pipe = 30cm  

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

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,  $S_{og} S_o = 0.9$

Specific gravity of mercury,  $S_{ug} = 13.6$

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

Coefficient of discharge,  $C_d = 0.64$

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

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

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

∴ The rate of flow of oil is;

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

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

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

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

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

The Specific gravity of mercury,  $S_g = 13.6$

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

The Speed,  $V = ?$

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

$$h = X \left[ \frac{S_g - 1}{S_o} \right] = 0.17 \left[ \frac{13.6 - 1}{1.026} \right] = 2.0834 \text{ m}$$

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

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

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

$$P_0 = 15 \text{ bar} = 15 \times 100000 = 15 \times 10^5 \text{ N/m}^2$$

$$\text{Speed} = 1700 \text{ rev/min}$$

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

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

$$\text{Ideal flow rate} = \text{Nominal flow rate} \times \text{Speed}$$

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

$$= 17000 \text{ cm}^3/\text{min}$$

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

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

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

$$\text{ii) Fluid Power} = P \times Q \quad \because P = 15 \times 10^5 \text{ N/m}^2, \quad Q = 0.05 \text{ m}^3/\text{min} = \frac{0.05}{60} = 8.33 \times 10^{-4} \text{ m}^3/\text{s}$$

$$\text{Fluid Power} = 15 \times 10^5 \times 8.33 \times 10^{-4}$$

$$= 15 \times 10^5 \times 83.3 \times 10^{-5}$$

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

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

$$\text{iii) Shaft Power} = \frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60} = 2670.35 \text{ watts}$$

$$\text{iv) Overall Efficiency} = \frac{\text{Fluid Power}}{\text{Shaft Power}} = \frac{1249.5}{2670.35} = 0.468$$

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