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COURSE: ENG 214 (FLUID MECHANICS)

MATRIC: 18/ENG05/057

DEPT: MECHATRONICS ENGINEERING

SUNDAY WINTER CHALLENGE
18/ENG05/057

ASSIGNMENT ENG 214 SOLUTIONS:

(1) length = 2.0m
 $v_1 = 5 \text{ m/s}$; $v_2 = 2 \text{ m/s}$
 $\frac{P_1}{w} = 2.5 \text{ m of liquid}$

$$\text{loss of head, } h_L = \frac{0.35(v_1 - v_2)^2}{2g} = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161 \text{ m}$$

Applying Bernoulli's equation at ends (1) and (2)

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

$$2.5 + \frac{25}{2 \times 9.81} + 2 = \frac{P_2}{w} + 4 + 0 + 0.161$$

$$\frac{P_2}{w} = 5.77 - 0.204 = 5.6 \text{ m} - 0.161 = 5.4 \text{ m}$$

Pressure head at lower end is larger end is 5.4m //

$$P_2 = 5.4 \times 9810 \times 10^{-5} = 0.53 \text{ bar}$$

(2) Inlet diameter (D_1) = 20cm = 0.2m

$$\text{Inlet Area } (A_1) = \frac{\pi \times 0.2^2}{4} = 0.0314 \text{ m}^2$$

Throat diameter (D_2) = 10cm = 0.1m

$$\text{throat Area } (A_2) = \frac{\pi \times 0.1^2}{4} = 0.0079 \text{ m}^2$$

$$P_1 = 17.658 \text{ N/cm}^2 = 176580 \text{ N/m}^2 = 176.580 \text{ kPa}$$

$$\text{Pressure head} = \frac{P_1}{w} = \frac{176.580}{9.81} = 18 \text{ m}$$

$$\text{throat pressure head} = \frac{P_2}{w} = -30 \text{ cm of mercury}$$

$$= -0.3 \times 13.6 = -4.08 \text{ m}$$

$$h = \frac{P_1}{w} - \frac{P_2}{w} = 18 - (-4.08) = 22.08 \text{ m}$$

$$C_d = 0.98$$

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

$$Q = 0.98 \times \frac{0.0314 \times 0.0079}{\sqrt{(0.0314)^2 - (0.0079)^2}} \times \sqrt{2 \times 9.81 \times 22.08}$$

$$Q = 0.166 \text{ m}^3/\text{s} //$$

(3) Orifice diameter = 15 cm = 0.15 m = D_0

$$\text{Area of Orifice} = \frac{\pi \times 0.15^2}{4} = 0.0176 \text{ m}^2 = A_0$$

Pipe diameter = 30 cm = 0.30 m = D_1

$$\text{Pipe Area} = \frac{\pi \times 0.3^2}{4} = 0.071 \text{ m}^2 = A_1$$

Manometer reading = 50 cm of mercury = 0.5 m of mercury
 $C_d = 0.64$

Sp. gravity of oil = 0.9

$$h = y \left[\frac{S_{rel}}{S_o} - 1 \right]$$

$$h = 0.5 \left(\frac{13.6}{0.9} - 1 \right); h = 7.06 \text{ m of oil}$$

$$Q = C_d \frac{A_0 \cdot A_1}{\sqrt{A_1^2 - A_0^2}} \times \sqrt{2gh}$$

$$Q = 0.64 \times \frac{0.0176 \times 0.071}{\sqrt{0.071^2 - 0.0176^2}} \times \sqrt{2 \times 9.81 \times 7.06}$$

$$Q = 0.64 \times \frac{0.0176 \times 0.071}{\sqrt{0.071^2 - 0.0176^2}} \times \sqrt{2 \times 9.81 \times 7.06}$$

$$Q = 0.137 \text{ m}^3/\text{s}$$

(4) axis = 15m below surface

$y = 170 \text{ mm} = 0.17 \text{ m}$ of mercury

Sp. gravity of Hg = 13.6

Sp. gravity of water = 1.026

$$h = y \left(\frac{S_H}{S_L} - 1 \right) = 0.17 \left(\frac{13.6}{1.026} - 1 \right)$$

$$h = 2.08 \text{ m}$$

Speed of sub-mantle = $\sqrt{2gh}$

$$= \sqrt{2 \times 9.81 \times 2.08}$$

$$= 6.38 \text{ m/s}$$

(5) Rate of pump delivery = $0.05 \text{ m}^3/\text{min} = 8.33 \times 10^{-4} \text{ m}^3/\text{s}$

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

Speed of rotation = 1700 rev/min = 28.33 rev/sec

Normal displacement = $10 \text{ cm}^3/\text{rev} = 1 \times 10^{-5} \text{ m}^3/\text{rev}$

Torque input = 15 Nm

(i) Volumetric efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100$

Ideal flow rate = normal displacement \times speed

$$= 1 \times 10^{-5} \times 28.33$$

$$= 2.833 \times 10^{-4} \text{ m}^3/\text{s}$$

$$\text{Volumetric efficiency} = \frac{8.33 \times 10^{-4}}{2.833 \times 10^{-4}} \times 100$$

$$= 294.03\%$$

$$\begin{aligned} \text{(ii) Fluid power} &= \text{Actual flow rate} \times \text{pressure} \\ &= 8.33 \times 10^{-4} \times 15 \times 10^5 \\ &= 1249.5 \text{ W} \\ &= 1.2495 \text{ kW} \end{aligned}$$

$$\begin{aligned} \text{(iii) shaft power} &= \text{Torque input} \times \text{angular speed} \\ \text{Torque input} &= 15 \text{ Nm} \\ \text{Angular speed} &= \omega = \frac{2\pi N}{60} = \frac{2 \times 22}{7} \times 28.33 \\ &= 178.07 \text{ W} \end{aligned}$$

$$\begin{aligned} \text{(iv) Overall efficiency} &= \frac{\text{Fluid power}}{\text{shaft power}} \times 100 \\ &= \frac{1249.5}{178.07} \times 100 \\ &= 702\% // \end{aligned}$$