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COURSE : ENG 214 (FLUID MECHANICS)

1) length = 2.0m
$V_1 = 5m/s$; $V_2 = 2m/s$
$\frac{P_1}{w} = 2.5m$ of liquid

Loss of head, $h_L = \frac{0.35(V_1 - V_2)^2}{2g} = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161m$

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

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

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

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

Pressure head at lower end is larger end is 5.4m

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

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

Inlet Area (A_1) = $\frac{\pi \times 0.2^2}{4}$ = 0.0314m²

Throat diameter (D_2) = 10cm = 0.1m

Throat Area (A_2) = $\frac{\pi \times 0.1^2}{4}$ = 0.0079m²

P_1 = 17.658 N/cm² = 176580 N/m² = 176.580 kPa

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

Throat pressure head = $\frac{P_2}{w}$ = −30cm of mercury

= −0.3 × 13.6 = −4.08m

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

Cd = 0.98

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

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

Q = 0.166 m³/s

8) Orifice diameter = 15cm = 0.15m = D_o

Area of orifice = $\frac{\pi \times 0.15^2}{4}$ = 0.0176m² = A_o

Pipe diameter = 30cm = 0.30m = D_1

pipe Area = $\frac{\pi \times 0.3^2}{4}$ = 0.071m² = A_1

Manometer reading = 50cm of mercury = 0.5m of mercury

$C_d = 0.64$

Sp gravity of oil = 0.9

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

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

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

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

$$Q = 0.137\,m^3/s$$

4) axis = 15m below surface

$y = 170mm = 0.17m$ of mercury

Sp gravity of Hg = 13.6

Sp. gravity of water = 1.026

$$h = y\left(\frac{S_{hl}}{S_l} - 1\right) = 0.17\left(\frac{13.6}{1.026} - 1\right)$$

$h = 2.08m$

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

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

$= 6.38 m/s$

5) Rate of pump delivery = 0.05 m³/min = 8.33 × 10⁻⁴ m³/s

Pressure change = 15 bar = 15 × 10⁵ N/m²

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

normal displacement = 10 cm³/rev = 1 × 10⁻⁵ m³/rev

Torque input = 15 Nm

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

Ideal flow rate = normal displacement × speed

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

$= 2.833 \times 10^{-4}$ m³/s

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

$= 295.03\%$

ii) Fluid power = Actual flow rate × pressure

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

$= 1249.5$ W

$= 1.2495$ kW

iii) Shaft power = Torque input × Angular speed

Torque input = 15Nm

Angular speed = ω = $\frac{2\pi N}{60}$ = $2 \times \frac{22}{7} \times 28.33$

= 178.07W

iv) Overall Efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}} \times 100$

= $\frac{1249.5}{178.07} \times 100$

= 702%