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Assignment

Question 1

Solution

pressure head at smaller end = 2.5m P_1/w
Length of tube = 2.0m
velocity of flow at lower end = 5ms⁻¹ V_1
velocity of flow at higher end = 2ms⁻¹ V_2
loss of head = $\frac{0.35(V_1 - V_2)^2}{2g}$ h_L

loss of head = $\frac{0.35(5-2)^2}{2 \times 9.81} = 0.16m$

Pressure head head at higher end, $\frac{P_2}{w}$

$$\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + z_2 + h_L$$

$z_2 = 0$, $z_1 = 2.0m$

$$2.5 + \frac{5^2}{2 \times 9.8} + 2 = \frac{P_2}{w} + \frac{2^2}{2 \times 9.8} + 0.0.16$$

$$5.775 = \frac{P_2}{w} + 0.364$$

$$\frac{P_2}{w} = 5.775 - 0.364 = 5.411m \text{ of liquid}$$

Pressure head at higher end = 5.411m

3. Orifice diameter A_0 = 15cm = 0.15m²
pipe diameter = 30cm = 0.3m²
Manometer reading = 0.5m of mercury
S.g of oil = 0.9 Cd = 0.64

Solution

Area of ~~pip~~ orifice, $\frac{\pi}{4} \times 0.15^2 = 0.0177m^2 = A_0$

Area of pipe, $\frac{\pi}{4} \times 0.3^2 = 0.707m^2 = A_1$

Differential head, $h = y\left[\frac{S_{hr}}{S_0} - 1\right]$

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

Discharge Q:
Using the relation, $Q = Cd \times \frac{A_0 . A_1 . \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$

$Q = \frac{0.64 \times 0.707 \times 0.0177 \times \sqrt{2 \times 9.8 \times 7.06}}{\sqrt{(0.707)^2 - (0.0177)^2}}$

$= \frac{0.0942}{0.707} = 0.133 m^3/s$

Rate of oil discharge = $0.133 m^3/s$

2. Inlet diameter = 20cm = 0.2 m

throat diameter = 10cm = 0.1m

Pressure at inlet = 17.658N/cm² = 176.58 KN/m²

30cm of mercury

~~Cd = 0.98~~ coefficient of discharge = 0.98

Solution

Area of inlet = $A_1 = \frac{\pi}{4} \times 0.2^2 = 0.0314 m^2$

Area of throat = $\frac{\pi}{4} \times 0.1^2 = 0.00785 m^2$

$\frac{P_1}{w} = \frac{176.58}{9.8} = 18.01m$

Vacuum pressure at the throat,

$\frac{P_2}{w} = -300mm = -0.3 \times 13.6 = -4.08m$ of water

Differential head, $h = \frac{P_1}{w} - \frac{P_2}{w} = 18.01 - (-4.08) = 22.09m$

Rate of flow, Q:

Using the relation, $Q = Cd \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

= ~~0.98~~

$Q = 0.98 \times \frac{0.0314 \times 0.00785}{\sqrt{(0.0314)^2 - (0.00785)^2}} \times \sqrt{2 \times 9.81 \times 22.09}$

$= \frac{0.000241}{0.0304} \times 20.82$

$Q = 0.165 m^3/s$

Discharge of water through venturimeter = $0.165 m^3/s$

4. Reading of manometer, $y = 170mm = 0.17m$ of mercury
Sp. gravity of mercury, $S_{hL} = 13.6$
Sp. gravity of sea water, $S_L = 1.026$

To find the head (h), using the relation;

$$h = y\left[\frac{S_{hL}}{S_L} - 1\right]$$ we have:

$$h = 0.17\left[\frac{13.6}{1.026} - 1\right] = 2.08$$

∴ ~~Velocit~~ Speed of the submarine,

$$v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.08} = 6.38 m/s$$

Solution

5. Actual flow rate = 0.05 m^3/min = 0.05/60 = ~~8.3~~ 8.3×10^{-4} m^3/sec

Pressure charge = 15 bar = 15×10^5 N/m^2

Speed of rotation = 1700 rev/min = 1700/60 = 28.3 rps

Normal displacement = 10 cm^3/rev = 1×10^{-5} m^3/rev

Torque input = 15 Nm

Ideal flow rate = normal × speed displacement

= $28.3 \times 1 \times 10^{-5}$

= 2.83×10^{-4} m^3/sec

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

= $\frac{8.3 \times 10^{-4}}{2.83 \times 10^{-4}} \times 100$

= ~~34.076~~ % 296 %

ii.) Fluid Power = Q.∂P

= $8.3 \times 10^{-4} \times 15 \times 10^5$

= 1245 Watts or Nm/Sec

iii.) Shaft power = T.ω

where T = Torque input

ω = angular speed =

T = 15 Nm

W = 2πN for rps

W = $\frac{2\pi N}{60}$ for rpm

W = $2 \times \frac{22}{7} \times 28.3$ = 177.89 rad/sec

~~Shaft po~~

Shaft power = 15 × 177.89

= 2668.35 Watts

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

$= \frac{1245}{2668.35} \times 100$

$= 46.66\%$