ENATORU PROSPER SEROMU
CHEMICAL ENGINEERING
19/ENG01/018
ENG 214

Assignment

1) 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 at higher end, P_2/w

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

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

$$2.5 + \frac{5^2}{2 \times 9.8} + 2 = \frac{P_2}{w} + \frac{2^2}{2 \times 9.8} + 0.016$$

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

$$\frac{P_2}{w} = 5.775 - 0.304 = 5.411m \text{ of liquid}$$

pressure head at higher end = 5.411m

2) Inlet diameter = 20cm = 0.2m
throat at diameter = 10cm = 0.1m
pressure at inlet = $17.658N/cm^2$ = $176.58kN/m$
30cm of mercury
discharge coefficient = 0.98

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

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

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

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

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

$= \frac{0.0002416}{0.0304} \times 20.82$

$Q = 0.165 m^3/s$

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

3) Orifice diameter A_0 = 15cm = 0.15m^2
Pipe diameter = 30cm = 0.3m^2
Manometer reading = 0.5m of mecury
Sog of oil = 0.9 Cd = 0.64

Solution

Area of ~~Pipe~~ Orifice, $\frac{\pi}{4} \times 0.15^2 = 0.0177m^2$

Area of pipe, $\frac{\pi}{4} \times 0.30^2 = 0.707m^2 = A_1$

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

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

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

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

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

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

4) Reading of manometry y = 170 mm = 0.17m mecury
Sp. gravity of mecury, S_{hL} = 13.6
Sp gravity of ~~Sio~~ water, S_1 = 1.026
To find the head, (h) using the relation:

$h = y\left[\frac{S_{L}}{S_1} - 1\right]$

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

∴ Speed of the submarine
$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.08} = 6.38m/s$

5) Actual flow rate = 0.05 m^3/min = 0.05/60 = 8.3×10^{-4} m^3/s

pressure charge = 15×10^5 N/m^2

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

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

Torque input = 15 Nm

Ideal flow rate = normal x speed displacement

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

= 2.83×10^{-4} m^3/sec

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

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

= 296 %

ii) fluid Power = Q.dp

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

= 1245 watts

iii) Shaft power = T.ω

T = torque input

ω = angular speed

T = 15 Nm

ω = 2πN for rps

ω = $\frac{2\pi N}{60}$

ω = $2 \times \frac{22}{7} \times 28.3$ = 177.89 rad/s

Shaft power = 15 x 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%