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MATRIC NO: 18/ENG09/006

DEPARTMENT: AERONAUTICAL ENGINEERING

COURSE: ENG214

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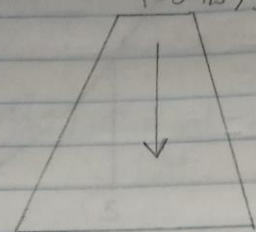
ASSIGNMENT

1.) $V_1 = 5m/s$, $\frac{P_1}{\rho g} = 2.5m$



Length (l) = 2m

$V_2 = 2m/s$

Velocity at smaller end $(V_1) = 5m/s$, head loss $(h_f) = \frac{0.35(V_1 - V_2)^2}{2g}$

Velocity at larger end $(V_2) = 2m/s$

Pressure head at smaller end $\left(\frac{P_1}{\rho g}\right) = 2.5m$ Liquid

Datum head $(Z_2 - Z_1) = 2m$

from Bernoulli's equation

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

$$2.5 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + (Z_2 - Z_1) + \frac{0.35(V_1 - V_2)^2}{2g}$$

$$2.5 + \frac{5^2}{2 \times 9.81} = \frac{P_2}{\rho g} + \frac{2^2}{2 \times 9.81} + 2 + \frac{0.35(5-2)^2}{2 \times 9.81}$$

$$3.774 = \frac{P_2}{\rho g} + 2.364$$

$$\frac{P_2}{\rho g} = 3.774 - 2.364$$

$$\frac{P_2}{\rho g} = 1.41m$$

$\therefore$ Pressure head at larger end $\left(\frac{P_2}{\rho g}\right) = 1.41m$

2) Inlet diameter (d_1) = 20 cm = 0.2 m

Area of inlet (A_1) = $\frac{\pi d_1^2}{4}$

$$A_1 = \frac{\pi \times 0.2^2}{4} = 3.14 \times 10^{-2} m^2$$

Throat diameter (d_2) = 10 cm = 0.1 m

Area of throat (A_2) = $\frac{\pi d_2^2}{4}$

$$A_2 = \frac{\pi \times 0.1^2}{4} = 7.85 \times 10^{-3} m^2$$

Pressure at inlet (P_1) = 17.658 N/cm² = $17.658 \times 10^4 N/m^2$

differential manometer reading (y) = 30 cm Hg = 0.3 m Hg

Pressure head at throat $\left(\frac{P_2}{\rho g}\right) = y\left[\frac{S.G_{Hg}}{S.G_{H_2O}} - 1\right]$

$S.G_{Hg} = 13.6$, $S.G_{H_2O} = 1$

$$\therefore \frac{P_2}{\rho g} = 0.3\left[\frac{13.6}{1} - 1\right] = 3.76 m$$

height of water (h) = $\frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

$$= \frac{17.658 \times 10^4}{1000 \times 9.81} - (3.76)$$

$$= 18 - 3.76$$

$$h = 14.24 m$$

$C_d = 0.98$

Discharge rate (Q) = $\frac{C_d A_2 A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$$= \frac{0.98 \times 3.14 \times 10^{-2} \times 7.85 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 14.24}}{\sqrt{(3.14 \times 10^{-2})^2 - (7.85 \times 10^{-3})^2}}$$

$$Q = 1.33 \times 10^{-1} m^3/s$$

$$Q = 0.133 m^3/s$$

3) Diameter of orifice (d_o) = 15cm = 0.15m

Area of Orifice (A_o) = $\frac{\pi \times d_o^2}{4}$

$$A_o = \frac{\pi \times 0.15^2}{4} = 0.0177 m^2$$

Diameter of pipe (d_1) = 30cm = 0.3m

Area of diameter (A_1) = $\frac{\pi \times d_1^2}{4}$

$$A_1 = 0.0707 m^2$$

Differential manometer reading (y) = 50cm Hg = 0.5m Hg

height of oil (h) = $y\left[\frac{S.G_{Hg}}{S.G_{oil}} - 1\right]$

$S.G_{Hg} = 13.6 \quad S.G_{oil} = 0.9$

$$h = 0.5\left[\frac{13.6}{0.9} - 1\right]$$

$$h = 7.056m$$

$Cd = 0.64$

$$\text{Discharge}(Q) = \frac{Cd A_o A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_o^2}}$$

$$= \frac{0.64 \times 0.0177 \times 0.0707 \times \sqrt{2 \times 9.81 \times 7.056}}{\sqrt{(0.0707)^2 - (0.0177)^2}}$$

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

4) Datum head $(Z_2 - Z_1) = 15\,m$

Differential manometer reading $(y) = 170\ mm\ Hg = 0.17\,m\ Hg$

height of sea water $(h) = y\left[\frac{S.G_{Hg}}{S.G_{seawater}} - 1\right]$

$S.G_{Hg} = 13.6 \quad S.G_{seawater} = 1.026$

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

$$h = 2.083\,m$$

From Bernoulli's equation

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

$V_2 = 0\ m/s$

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

$$\frac{V_1^2}{2g} = \frac{P_2 - P_1}{\rho g} + (Z_2 - Z_1)$$

$$\frac{V_1^2}{2g} = h + (Z_2 - Z_1) \quad \text{where } h = \frac{P_2 - P_1}{\rho g}$$

~~$\frac{V_1^2}{2g} = 2.083 + 15$~~

~~$\frac{V_1^2}{2 \times 9.81} =$~~

$$\frac{V_1^2}{2g} = h$$

$$V_1 = \sqrt{2gh}$$

$$V_1 = \sqrt{2 \times 9.81 \times 2.083}$$

$$V_1 = 6.39\ m/s$$

5:) Actual flow rate (Q) = 0.005 m^3/min
Pressure change (P) = 15 bar
P = 15×10^5 N/m^2
Speed of rotation (ω) = 1700 rev/min
Normal displacement = 10 cm^3/rev
Torque (τ) = 15 Nm

i) Nominal flow rate = Normal displacement × Speed of rotation
= 10 × 1700
= 17000 cm^3/min
$= \frac{17000 \times 10^{-6} m^3}{1 min}$
Nominal flow rate = 0.017 m^3/min

Volumetric efficiency $= \frac{Q}{\text{Nominal flow rate}} \times 100\%$
$= \frac{0.005}{0.017} \times 100\%$
Volumetric efficiency = 29.41%

ii) Fluid power = Q × P
= 0.005 × 15×10^5
= 7500 W

iii) Shaft power = τ × ω
τ = 15 Nm
ω = 1700 rev/min
1 rev = 2π rad, 1 min = 60 sec
∴ $ω = \frac{1700 \times 2\pi}{1 \times 60}$
ω = 178.02 rad/sec

Shaftpower = 15 × 178.02

Shaftpower = 2670.35W

iv.) Overall efficiency = $\frac{\text{Shaftpower}}{\text{Fluidpower}} \times 100\%$

$= \frac{2670.35}{7500} \times 100\%$

Overall efficiency = 35.6%