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COURSE: FLUID MECHANICS (ENG 214)
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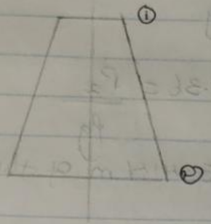
1).



$L = ~~20m~~\ 2.0m$

$V_1 = 5m/s$.

$\frac{P_1}{\rho g} = 2.5m$ of liquid.

$V_2 = 2m/s$.

Loss of head

$$h_L = \frac{0.35(V_1 - V_2)^2}{2g}$$

$$= \frac{0.35(5-2)^2}{2g} = \frac{0.35 \times 9}{2 \times 9.81}$$

$$= 0.16m.$$

Pressure head $\left(\frac{P_2}{\rho g}\right) = ?$

Applying Bernoulli's equation at sections (1) and (2), we get

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

Let the datum line passes through section (2). Then $z_2 = 0$, $z_1 = 2.0$.

$\therefore \; 2.5 + \frac{5^2}{2\times9.81} + 2.0 = \frac{P_2}{\rho g} + \frac{V_2^2}{2\times9.81} + 0 + 0.16$

$2.5 + 1.274 + 2.0 = \frac{P_2}{\rho g} + 0.20 + 0 + 0.16$

$5.774 = \frac{P_2}{\rho g} + 0.36$

$5.774 - 0.36 = \frac{P_2}{\rho g}$

$\frac{P_2}{\rho g} = 5.414$ m of fluid.

2). $d_1 = 20cm = 0.2m$.

$A_1 = \frac{\pi d^2}{4} = \frac{\pi(0.2)^2}{4} = 0.0314 \, m^2$.

$d_2 = 10cm = 0.1m$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi(0.1)^2}{4} = 7.85\times10^{-3} m^2$.

$P_1 = 17.658 \, N/cm^2 = 17.658 \times 10^4 \, N/m^2$.

$\frac{P_1}{\rho g} = \frac{17.658\times10^4}{9.81\times1000}$

$= 18m$ of water.

$\frac{P_2}{\rho g} = 30cm$ of mercury

$= -0.30m$ of mecury $= -0.30\times 13.6 = -4.08$ of water,

∴ Differential head

~~$h = \frac{P_1}{\rho g}$~~ .. $h = \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$.

$h = 18 - (-4.08)$

$h = 18 + 4.08$
$= 22.08m$ of water.

The discharge Q is given by.

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

$$Q = 0.98 \times \frac{0.0314 \times 7.85\times10^{-3}}{\sqrt{(0.0314)^2 - (7.85\times10^{-3})^2}} \times \sqrt{2\times9.81\times22.08}$$

$$Q = 0.98 \times \frac{2.4649\times10^{-4}}{\sqrt{9.8596\times10^{-4} - 6.16225\times10^{-5}}} \times \sqrt{433.2096}$$

$$Q = \frac{0.98 \times 2.4649\times10^{-4} \times 20.81}{\sqrt{9.243375\times10^{-4}}}$$

$$= \frac{5.026867762\times10^{-3}}{\sqrt{}}$$

$$Q = \frac{5.02687\times10^{-3}}{0.0304}$$

$Q = 0.165 m^3/s$
~~$= 165.55$~~ $Q = 165.5$ lit/s

3) $d_o = 0.15m$
$A_o = \frac{\pi d^2}{4} = \frac{\pi(0.15)^2}{4} = 0.01767 m^2$

$d_1 = 0.30m$
$A_1 = \frac{\pi d^2}{4} = \frac{\pi(0.3)^2}{4} = 0.0707m^2$

$y = 50cm\ Hg = 0.5m\ Hg$
$S.g\ oil = 0.9$
$Cd = 0.64$

$$h = y\left[\frac{S.g_{hg}}{S.g_{oil}} - 1\right]$$

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

$$= 0.5[15.1 - 1]$$

$$= 0.5[14.1]$$

$$= 7.056\,m$$

$$Q = \frac{Cd\, A_1 A_0 \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$$

$$= \frac{0.64 \times 0.0707 \times 0.01767 \times \sqrt{2 \times 9.81 \times 7.056}}{\sqrt{(0.0707)^2 - (0.01767)^2}}$$

$$= \frac{7.995 \times 10^{-4} \times \sqrt{138.4}}{\sqrt{(4.99849 \times 10^{-3}) - (3.122 \times 10^{-4})}}$$

$$= \frac{9.4 \times 10^{-3}}{\sqrt{}}$$

$$= \frac{9.4 \times 10^{-3}}{0.068}$$

$$Q = 0.138\, m^3/sec$$

4) $r = 170 mm = 0.17 m$.

$S_m = 13.6$.

$S = 1.026$

$C = 1$

$V = ?$

$$V = C\sqrt{2gr\left(\frac{S_m}{S} - 1\right)}$$

$$V = 1 \times \sqrt{2 \times 9.81 \times 0.17 \times \left(\frac{13.6}{1.026} - 1\right)}$$

$$V = \sqrt{3.3354 \times (13.255 - 1)}$$

~~$V = \sqrt{333}$ 3-~~

$$V = \sqrt{3.3354 \times (12.255)}$$

$$V = \sqrt{40.8765}$$

$$V = 6.39 m/s.$$

5) $Q =$ ~~$0.05m^3/min$~~ $0.05 dm^3/min = 8.335 \times 10^{-7}$

Pressure change $= 15 bar = 15 \times 10^5 N/m^2$.

Speed of rotation $= 1700 rev/min = 28.39 rev/sec$.

Nominal displacement $= 10 cm^3/rev. = 1 \times 10^{-5}$

Torque input $= 15 Nm$.

① ~~Overall~~ Volumetric Efficiency

$$\text{Volumetric efficiency} = \frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times \frac{100}{1}$$

Ideal flowrate = Nominal displacement × speed of rotation

$= 1 \times 10^{-5} \times$ ~~8.335×10^{-7}~~ 28

$= 2.839 \times 10^{-4}\ m^3/s$.

Volumetric ~~Overall~~ efficiency $= \frac{8.33 \times 10^{-5}}{2.39 \times 10^{-4}} \times \frac{100}{1}$

$= 0.294 \times 100$

$= 29.4\%$.

(ii) Fluid power

Fluid power = actual flowrate x change in pressure

$= 8.335 \times 10^{-5} \times 15 \times 10^{5}$

$= 125.025\ W$

$= 0.125\ kW$

(iii) Shaft power

Shaft power = Torque x Angular speed

Angular speed = $2 \times \pi \times$ speed of rotation

Shaft power $= 2 \times \pi \times 28.39$

Shaft power $= 178.38\ W$

$= 0.178\ kW$

(iv) Overall Efficiency

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

$= \frac{125.025}{178.38} \times 100$

$= 0.70089 \times 100$

$= 70.089\%$