ENG 214 ASSIGNMENT

MECHATRONICS

18/ENG05/015

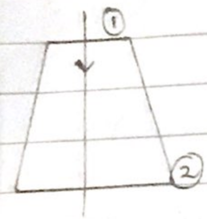
EJIM CHISOM PRECIOUS

(1)

Length of tube = 2.0m = L

$V_1 = 5\,m/s$

$P_1/\rho g = 2.5m$ of the liquid



$V_2 = 2\,m/s$

Loss of head $= h_L = \dfrac{0.35(V_1-V_2)^2}{2g}$

$h_L = \dfrac{0.35(5-2)^2}{2\times 9.81} = 0.16m$

Pressure head, $P_2/\rho g = ?$

Applying bernoulli's equation,

$P_1/\rho g + V_1^2/2g + z_1 = P_2/\rho g + V_2^2/2g + z_2$

As the datum line passes through section 2, $z_2 = 0$, $z_1 = 2m$

Substituting,

$2.5 + \dfrac{5^2}{2\times 9.81} + 2 = \dfrac{P_2}{\rho g} + \dfrac{2^2}{2\times 9.81} + 0 + 0.16$

$2.5 + 1.27 + 2 = P_2/\rho g + 0.203 + 0.16$

$P_2/\rho g = (2.5+1.27+2) - (0.203+0.16)$

$P_2/\rho g = \underline{5.407m \text{ of fluid}}$

(2)

AT INLET, $d_1 = 20cm = 0.2m$

$a_1 = \frac{\pi}{4} d_1^2 = \frac{22}{7}\times\frac{0.2^2}{4} = 0.0314\,m^2$

AT THROAT, $d_2 = 10cm = 0.1m$

$a_2 = \frac{\pi}{4} d_2^2 = \frac{22}{7}\times\frac{0.1^2}{4} = 7.857\times 10^{-3}\,m^2$

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

$\rho_w = 1000\,kg/m^3$, $\dfrac{P_1}{\rho g} = \dfrac{176580}{9.81\times 1000} = 18m$ of water

$\dfrac{P_2}{\rho g} = -30$ cm of mercury $= -0.3m$ of mercury $= -0.3\times 13.6 = -4.08m$ of water

Differential head, $h = \dfrac{P_1}{\rho g} - \dfrac{P_2}{\rho g} = 18 - (-4.08)$

$h = 22.08m$ of water

Discharge, $Q = C_d \dfrac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$

~~Q = 0.98 × 314.16 × 78.54 × √2×9.81×~~

$Q = \dfrac{0.98\times 0.0314\times 7.857\times 10^{-3}\times\sqrt{2\times 9.81\times 22.08}}{\sqrt{0.0314^2 - (7.857\times 10^{-3})^2}}$

$Q = \dfrac{5.032242\times 10^{-3}}{0.03040111102} = \underline{0.1655\,m^3/s}$

$Q = 0.1655\times 1000 = \underline{165.5\,l/s}$

(3)

Orifice diameter, $d_0 = 15cm = 0.15m$

$a_0 = \frac{\pi}{4}\times d_0^2 = \frac{22}{7}\times\frac{0.15^2}{4} = 0.01768\,m^2$

Pipe diameter, $d_1 = 30cm = 0.3m$

$a_1 = \frac{\pi}{4}\times d_1^2 = \frac{22}{7}\times\frac{0.3^2}{4} = 0.070714\,m^2$

Specific gravity of oil, $S_o = 0.9$

Reading of differential manometer, $x = 50cm$ of mercury $= 0.5m$ of mercury

Differential head = h

$h = x\left(\dfrac{S_g}{S_o} - 1\right)$

Specific gravity of mercury, $S_g = 13.6$

$h = 0.50\left(\dfrac{13.6}{0.9} - 1\right) = 0.5\times 14.11$

$h = 7.055m$ of oil

$C_d = 0.64$

Rate of flow, $Q = \dfrac{C_d\times a_0\times a_1\times\sqrt{2gh}}{\sqrt{a_1^2 - a_0^2}}$

$Q = \dfrac{0.64\times 0.01768\times 0.070714\times\sqrt{2\times 9.81\times 7.055}}{\sqrt{0.070714^2 - 0.01768^2}}$

$Q = \dfrac{9.413815\times 10^{-3}}{0.06846814877}$ = ~~0.1375~~ m³/s

$Q = 0.137492\,m^3/s$

$Q = 0.137492\times 1000 = \underline{137.492\,l/s}$

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(4)

Difference of mercury level, $x = 170mm$
$= 0.17m$

specific gravity of mercury, $S_g = 13.6$
specific gravity of sea water, $S_o = 1.026$

$h = x\left(\frac{S_g}{S_o} - 1\right) = 0.17\left(\frac{13.6}{1.026} - 1\right)$

$h = 2.0834m$

$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0834} = 6.393 m/s$

OR $\frac{6.393 \times 3600}{1000} = 23.01 km/hr = V$

(5)

Actual flow rate $= 0.05 m^3/min$

$Q = \frac{0.05}{60} = 8.33 \times 10^{-4} m^3/s$

Speed, $N = 1700 rev/min = \frac{1700}{60}$
$= 28.33 rev/sec$

Pressure change, $\delta P = 15 bar =$
$\delta P : 15 \times 10^5 N/m^2$

Norminal displacement $= 10 cm^3/rev$
$= \frac{10}{100^3} = 1 \times 10^{-5} m^3/rev$

Ideal flow rate = Nominal displacement × speed

$= 1 \times 10^{-5} \times 28.33 = 2.833 \times 10^{-4} m^3/s$

Torque input = 15Nm

(i) Volumetric efficiency

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

$= \frac{8.33 \times 10^{-4}}{2.833 \times 10^{-4}} \times 100\% = 294.03\%$

II. FLUID POWER

fluid power $P_F = Q \times \delta P$
$= 8.33 \times 10^{-4} \times 15 \times 10^5$

fluid power = 1249.5 Watts

III Shaft Power

Shaft power = $T \times w$

w = angular speed

T = ~~12.5 Nm~~ 15Nm

$w = 2\pi N$ (for rps)

$= 2 \times \frac{22}{7} \times 28.33 = 178.07 rad/s$

Shaft power = 15 × 178.07
= 2671.05 Watts

IV Overall Efficiency

overall efficiency $= \frac{\text{Fluid Power}}{\text{Shaft power}} \times 100\%$

$= \frac{1249.5}{2671.05} \times 100$
$= 46.779\%$

overall efficiency ≃ 46.78%