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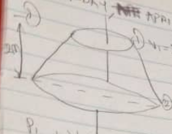
MECHATRONICS
THURSDAY, APRIL 16TH

FLUID MECHANICS

(1)



$V_1 = 5m/s$ $P_T = \frac{P_1}{W} = 2.5m$

$V_2 = 2m/s$ $H_L = \frac{0.35(V_1 - V_2)}{2g}$

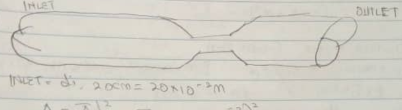
$\frac{P_1}{W} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{W} + \frac{V_2^2}{2g} + Z_2 + H_L$

$\frac{P_2}{W} = \frac{P_1}{W} = \frac{V_1^2 - V_2^2}{2g} + 2 - \frac{0.35(5-2)^2}{2(9.81)}$

$\frac{P_2}{W} = 2.6 + 1.07 + 2.0161$

$\frac{P_2}{W} = 5.439m$ of liquid.

(2)



INLET = d_1, 20cm = $20 \times 10^{-2}m$

$A = \frac{\pi d^2}{4} = \frac{\pi \times (20 \times 10^{-2})^2}{4}$

$A_1 = 0.0314m^2$

THROAT DIAMETER $= 10 \times 10^{-2}$

$\pi 4^2 = \frac{\pi \times (10 \times 10^{-2})^2}{4}$

$A_2 = 7.85 \times 10^{-3} m^2$

$P_1 = 17.668N/cm^2$
$= 17.668 \times 10^4 N/m^2$

$Cd = 0.98$

to get h,

$\frac{P_1}{W} - \frac{P_2}{W} = h$

$P_1 = 17.668 \times 10^4 N/m^2$

$W = 9.81 \times 10^3 N/m^3$

But we have that throat vacuum pressure

$= 30cm$ of Hg
$= 0.3m$ Hg
$= 0.3 \times 13.6 = 4.08$

$\frac{P_2}{W} = -4.08$ (since vacuum pressure)

then $\frac{P_1}{W} = \frac{17.658 \times 10^4}{9.81 \times 10^3} = 18.$

$\therefore \frac{P_1}{W} - \frac{P_2}{W} = 18 - -4.08 = 22.08$

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

$= 0.98 \times 0.0314 \times 7.85 \times 10^{-3} \times \sqrt{\frac{2 \times 9.81 \times 22.08}{(0.0314^2) - (7.85 \times 10^{-3})^2)}}$

$= 2.4156 \times 10^{-4} \times 684.39$
$= 0.1653$

Q actual $= 0.1653 m^3/s$

(3) Orifice meter; Given that

$d_0 = 15cm = 15 \times 10^{-2}m$ Pipe diameter, $dp = 30cm = 30 \times 10^{-2}m$

$A_0 = \frac{\pi \times (15 \times 10^{-2})^2}{4}$

$A_P = \frac{\pi \times (30 \times 10^{-2})^2}{4}$

$= 0.01767m^2$

SPG of oil $= 0.9$ ... $= 0.07069m^2$

Coefficient of discharge $= 0.64$

Reading of differential $= 50mHg$

Differential head $h_1 = y\left(\frac{Sh_1}{S_0} - 1\right)$

$Sh_1 = 13.6$

$y = 50 \times 10^{-2}$

$h = 50 \times 10^{-2}\left[\frac{13.6}{0.9} - 1\right]$

h =

Q =

= 0.

=

(4) y

(5)

$h = 60 \times 10^{-2} \times 14.1$

$= 7.032m$

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

$= \frac{0.84 \times 0.01767 \times 0.07069 \times \sqrt{2 \times 9.81 \times 7.053}}{\sqrt{(0.07069^2) - (0.01767^2)}}$

$= \frac{7.794 \times 10^{-4} \times 11.763}{\sqrt{4.68 \times 10^{-3}}}$

$= 0.1314 m^3/s$

(4) $y = 170mm\,Hg = 0.17m\,Hg$, $S_{sH_2O} = 1.026$

$\Delta H = y\left(\frac{S.g + Hg}{S.g.\,Sw} - 1\right)$

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

$\Delta h = 2.08m$

$v = \sqrt{2g\Delta h}$

$v = \sqrt{2 \times 9.81 \times 2.08}$

$v = 6.388 m/s$

(5) $Q = 0.05 dm^3/min = 833 \times 10^{-6} m^3/sec$

Speed of Rotation $= 1700 rev/min = 28.3 rev/s$

Nominal Displacement $= 10 cm^3/rev = 10^{-5} m^3$

Torque Input $= 15Nm$

Pressure Change $= 15 bar$ or $15 \times 10^5 N/m^2$

Ideal flow rate = Nominal displacement × speed Rotation

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

$= 2.83 \times 10^{-4} m^3$

(A) Volumetric efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$

$= \frac{833 \times 10^{-3}}{2.83 \times 10^{-4}} \times 100$

$= 29.45\%$

(B) Fluid Power, $FP = Q \times \Delta P$

$= 8.33 \times 10^{-3} \times 15 \times 10^{3}$

$= 124.95$ watts

(C) Shaft power $= T \times \omega$

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

$\omega = 2 \times \pi \times 28.3$

$\omega = 177.81 rad/sec$

$\therefore$ Shaft power $= 15 \times 177.81$

$= 2667.2$ watts

(D) Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft power}} \times 100$

$= \frac{124.95}{2667.2} \times 100$

$= 4.68\%$