Hydraulics / Mechanical Engineering

(1)

$z_1 = 2m$, $\frac{P_1}{\rho g} = 2.5m$, $v_1 = 5m/s$, $v_2 = 2m/s$

h_L = loss of head (Energy lost)

$= \frac{0.35 (v_1 - v_2)^2}{2g}$

$= \frac{0.35 (5-2)^2 m^2/s^2}{2 \times 9.81 m/s^2} = 0.1606m$

According to conservation of energy

$T_1 = T_2$ = Total head

$\frac{P_1}{\rho g} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{v_2^2}{2g} + h_L$

$2.5m + 2m + \frac{25}{(2 \times 9.81)} m = \frac{P_2}{\rho g} + 0m + \frac{4}{(2 \times 9.81)} + 0.1606m$

$= 5.774m - 0.1606m - 0.2039m$

$\frac{P_2}{\rho g} = 5.4095 m$

Pressure head at base $= 5.4095m$

$d_1 = 20cm$, throat diameter $= 10cm$

$7.658 N/cm^2$, Pressure at throat $= 30cm$ of Hg

Find Q. $C_d = 0.98$

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

$A_1 = \pi d_1^2 = \frac{\pi}{4} \times \frac{(20)^2}{4} = 0.0314 m^2$

$A_2 = \pi \frac{d_2^2}{4} = \frac{\pi}{4} \times (10)^2 = 7.857 m^2$

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

$P_2 = \frac{30}{100} m \times 13600 \times 9.81$

$P_2 = 40024.8 N/m^2$

$\frac{P_1}{\rho g} = \frac{17.658}{(100)^2 \times 1000 \times 9.81} m$

$= 1.8 \times 10^{-7} m$

$h = (1.80 \times 10^{-7} - 0.3) m$

$h = -0.30m$

$Q = \frac{0.98 \times 0.0314 \times 7.857 \times 10^{-3} \sqrt{2 \times 9.81 \times 0.3}}{\sqrt{0.0314^2 - (7.857 \times 10^{-3})^2}}$

$Q = 0.0193 m^3/s$

(3) $d_0 = 15cm = 0.15m$

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

$A_2 = \pi d_2^2 = \frac{22}{7} \times \frac{(0.15)^2}{4} = 0.0177 m^2$

$A_1 = \frac{\pi d_1^2}{4} = \frac{22}{7} \times \frac{(0.3)^2}{4} = 0.0707 m^2$

$h = y\left(\frac{S_{hg}}{S_L} - 1\right)$

$h = \frac{50}{100}\left(\frac{13.6}{0.9} - 1\right)$

$h = 7.056 m$

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

$Q = 0.1377 m^3/s$

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

$\Delta h = y\left(\frac{S_{hg}}{S_L} - 1\right)$

$\rho_{hg} = 13600 \therefore S_{hg} = 13.6$

$\rho_L = 1000 \therefore S_L = 1$

$\Delta h = \frac{170}{1000}\left(\frac{13.6}{1} - 1\right)$

$\Delta h = 2.142 m$

$V = \sqrt{2 \times 9.81 \times 2.142}$

$V = 6.483 m/s$

$Q = 0.05 m^3/min$ $P = 15 bar$

$N = 1700 rev/min = 28.3 rev/sec$

...al displacement $= 10 cm^3/rev$

$T = 15 Nm$

(i) Fluid Power

Power = Force x Speed

Force is exerted on the fluid

~~F = x x ω~~

Pressure x Area x Speed

Pressure x Discharge

$= 15 \times 10^5 \times \frac{0.05 m^3/s}{60}$

$= 1250 W$

(ii) Shaft power

Force x speed

The shaft rotates

$\Rightarrow$ Force x r x ω

$\Rightarrow$ Torque x ω

Shaft power

$= 15 Nm \times 28.3 rev/s$

$= 424.5 W$

(iii) Volumetric efficiency

$\eta_v = \frac{Q}{Q + q} = \frac{0.05}{(0.05 + (28.3 \times 10^{-5}))}$

$\eta_v = 0.994$

$q = \omega \times$ displacement

$q = 28.3 \times 10^{-5} m^3/s$

(iv) Overall efficiency

$\eta_o = \frac{\text{Shaft power}}{\text{Fluid power}} \times 100\%$

$= \frac{424.5}{1250} \times 100$

$= 33.96\%$