ASSIGNMENT 1

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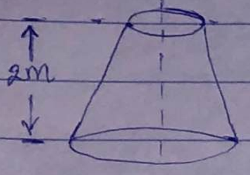
18/ENG03/045

CIVIL ENGINEERING

1)



where $V_1 = 5m/s$

$V_2 = 2m/s$

$PT = \frac{P_1}{w} = 2.5m$

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

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

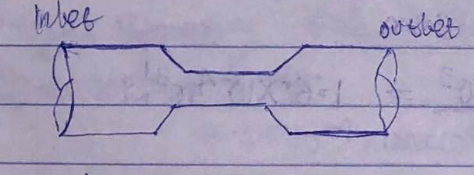
$\frac{P_2}{w} = \frac{P_1}{w} = \frac{V_1^2 - V_2^2}{2g} + (Z_1 - Z_2) - \frac{0.35(V_1-V_2)^2}{2g}$

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

$\frac{P_2}{w} = 2.5 + 1.07 + 2 - 0.161$

$= 5.409m$ of liquid

2)



Inlet, $d_1 = 20cm = 0.2m$

$A = \frac{\pi d^2}{4} = \frac{\pi \times (20 \times 10^{-2})^2}{4} = 0.0314m^2$

throat diameter $d_2 = 10cm = 0.1m$

$A = \frac{\pi d^2}{4} = \frac{\pi (0.2 \times 10)^2}{4} = 7.85 \times 10^{-3}$

$P_1 = 17.668 N/cm^3$, $w = 9.81 \times 10^3$

$C_d = 0.98$

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

however, throat pressure = 30cm of Hg

$= 0.3m Hg$

$= 0.3 \times 13.6 = 4.08$

$\frac{P_2}{w} = -4.08$

$\frac{P_1}{w} = \frac{17.668 \times 10^{14}}{9.81 \times 10^3} = 18$

$\frac{P_1}{w} - \frac{P_2}{w} = 18 - (-4.08)$

$= 22.08$

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

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

$= 2.415 \times 10^{-4}(684.59)$

$= 0.1053$

3) Orifice meter.

Given that $d_o = 15cm = 0.15m$

pipe diameter $D_p = 30cm = 0.3m$

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

$A_p = \frac{\pi d^2}{4} = \frac{\pi (30 \times 10^{-2})^2}{4} = 0.07069$

coefficient of discharge = 0.64

reading of differential = 500mmHg

differential head $h_1 = y\left[\frac{Sh_2}{S_0} - 1\right]$

$Sh_2 = 13.6$

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

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

$= 7.005m$

$Q = \frac{C_d A_o A_p \sqrt{2gh}}{\sqrt{A_p^2 - A_o^2}}$

$= \frac{0.64 \times 0.01767 \times 0.07069 \times \sqrt{2g(7.005)}}{\sqrt{(0.07069)^2 - (0.01767)^2}}$

$= 0.1374 m^3/s$

4) Given that

$y = 170mmHg = 0.17mHg$

$s.g_{Hg} = 13.6$ $s.g_{sw} = 1.026$

$\Delta h = y\left(\frac{s.g_{Hg}}{s.g_{sw}} - 1\right)$

$= 0.17\left(\frac{13.6}{1.026} - 1\right) = 2.08m$

$v = \sqrt{2g\Delta h} = \sqrt{2(9.81)(2.08)}$

$= 6.388m/s$

5) Given that $1000dm^3 = 1m^3$

$Q = 5dm^3$

Volumetric flow rate = $0.005m/min$

actual flow rate = $\frac{0.005}{60} = 8.33\times10^{-5}m^3/sec$

speed rotation = 1700rev/min

$= \frac{1700}{60} = 28.33rev/sec$

$P_p = 15bar = 15\times10^5 N/m^2$

nominal displacement = $10cm^3/rev$

recall that $100^3 cm^3 = 1m^3$

$10cm = ?$

$= \frac{10}{100^3} = 1\times10^{-5}m^3/rev$

Ideal flow rate = nominal displacement (speed rotation)

$= 1\times10^{-5}\times28.33$

$= 2.83\times10^{-4}m^3/sec$

Volumetric efficiency = $\frac{\text{actual flowrate}}{\text{Ideal flowrate}}$

$\frac{8.33\times10^{-5}\times100}{2.83\times10^{-4}}$

$= 29.46\%$

fluid power = $Q(\Delta p)$

$= 8.33\times10^{-5}\times15\times10^{5}$

$= 124.95watts$

shaft power, $T\times\omega$

$\omega = 2\pi$(speed rotation)

$= 177.81$

Shaft power = $15(177.81)$

$= 2667.2watts$

Overall efficiency = $\frac{\text{fluid power}}{\text{shaft power}}$

$= \frac{124.95\times100}{2667.2}$

$= 4.68\%$

ASSIGNMENT 2

1) real flowrate = $10dm^3/min$

$T = 12.8Nm$

$= \frac{10\times10^{-3}}{60} = 1.67\times10^{-4}m^3/s$

pressure = 12bar = $12\times10^5 N/m$

speed = 1500rev/min = $\frac{1500rev}{60} = 25rev/sec$

Nominal displacement = $\frac{10cm^3}{rev} = 1\times10^{-5}m^3/rev$

Ideal flowrate = Nominal displacement (speed)

$= 1\times10^{-5}\frac{m^3}{rev}\times25\frac{rev}{sec}$

$= 2.5\times10^{-4}m^3/sec$

volumetric efficiency = $\frac{\text{real flowrate}}{\text{Ideal flowrate}}\times100$

$= \frac{1.67\times10^{-4}}{2.5\times10^{-4}}\times100$

$= 66.8\%$

ii fluid power = Q.dp

$= 1.67\times10^{-4}\times12\times10^{5}$

= 200.4 watts

iii Shaft power = T.w

$w = 2\pi N = 2\pi\,25$

= 157.0796

shaft power = 12.8 × 157.08

= 1963.5 watts

Overall efficiency = $\frac{\text{fluid power}}{\text{shaft power}} \times 100$

$\frac{200.4 \times 100}{1963.5} = 10.21\%$

2) Pump delivery = 35 dm³/min

$\frac{35\times10^{-3}}{60} = 5.83\times10^{-4}$

$P = 100\text{bar} = 10\times10^{6}\,Nm^{-2}$

Overall efficiency = 87%

fluid power = Q.dp

$5.83\times10^{-4}\times100\times10^{5}$

= 5830 watts

Overall E = $\frac{\text{fluid power}}{\text{shaft power}} \times 100$

∴ shaft power = $\frac{\text{fluid power}}{\text{overall E}} \times 100$

$= \frac{5830 \times 100}{87} = 6701.149$ watts

3) Nom

Nominal displacement of 50cm³/rev

$= 50\times10^{-6}\,m^3/rev$

pressure = 100 bar = $100\times10^{5}\,N/m^2$

shaft power = 15 kw = 15000 watts

Actual flow rate = 35dm³/min = $\frac{35\times10^{-3}\,m^3}{60}$

$= 5.83\times10^{-4}\,m^3/s$

speed = 850 rev/min = $\frac{850}{60}$ = 14.17 rev/s

Ideal flowrate = Nominal displacement (speed)

$= 50\times10^{-6}\,\frac{m^3}{rev}\times 14.17\,\frac{rev}{sec}$

$= 7.085\times10^{-4}\,m^3/s$

i volumetric efficiency = $\frac{\text{real flowrate}}{\text{ideal flowrate}} \times 100\%$

$\frac{5.83\times10^{-4}\times100\%}{7.085\times10^{-4}} = 82.29\%$

ii fluid power = Q.dp

$5.83\times10^{-4}\times100\times10^{5}$

= 5830 watts

Overall efficiency = $\frac{5830 \times 100}{15000} = 38.867\%$

4) Z = 2400cm = 24m

volumetric flowrate, Q = 13 litres/sec

= 0.013m³/sec

Velocity = 66m/sec

General formula $\left[P = \rho g Q\left(\frac{P}{\rho g}+\frac{V^2}{2g}+Z\right)\right.$

$P = Qp + \frac{\rho Q V^2}{2} + \rho g Q z$

But introducing here (power of jet)

pressure head = 0

Z = 0

$\therefore P = \frac{\rho Q V^2}{2}$ where Q = 0.013

ρ = 1000

v = 66m/s

$P = \frac{1000\times0.013\times66^2}{2}$

= 28.314 kilowatts

ii Power supplied from reservoir

at atm pressure $p=0$ and $v=0$

$P = \rho g Q Z$

$= 1000 \times 9.81 \times 0.013 (240)$

$= 30607.2$ watts

$= 30.607$ Kwatts

iii Power loss in transmission

= Power of reservoir − power of jet

$= (30607.2 - 28314)$

$= 2293.2$ watts

$= 2.2932$ kilo watts

Head loss on pipeline $= 2.2932$ kwatts

$h = \frac{\text{Power lost in transmission}}{\rho g Q}$

$= \frac{2293.2}{1000 \times 9.81 \times 0.013}$

$= \frac{2293.2}{127.53} = 17.98m$

Efficiency $= \frac{\text{Power of jet}}{\text{power of reservoir}} \times 100$

$= \frac{28314}{30607.2} \times 100 = 92.51\%$

5) Sg of oil $= 0.89$

$Z = 30,000m - 300m$

$Q = 220 L/sec = 0.22 m^3/sec$

$V = 7 m/sec$

Introducing, $z=0$ pressure $=0$

i $P = \frac{\rho Q V^2}{2}$ but $sg = 0.89$

$sg = \frac{x}{1000}$

$x = 1000 (0.89)$

$= 890$

$\rho = x = 890$

$P = \frac{890 \times 0.22 \times (7)^2}{2}$

$P = 4797.1$ watts

ii power supplied from reservoir

$P = \rho g Q Z$

$= 890 \times 9.81 \times 0.22 \times 300$

$= 576239.4$ watts

$= 576.2394$ Kwatts

iii Power loss in transmission

= Power reservoir − Power of jet

$= (576239.4 - 4797.1)$ kilowatt

$= 571442.3$ watts

$= 571.4423$ kilowatt

head used to overcome losses

$= \frac{571442.3}{890 \times 9.81 \times 0.22} = 297.51m$

iv efficiency $= \frac{\text{power of jet}}{\text{power of reservoir}} \times 100$

$= \frac{4797.1 \times 100}{571442.3} = 0.83\%$

6) $P = \rho g Q Z$ where $z = 20m = h$

$\rho = 100$, $g = 9.81$

$Q = VA$

$d = 10cm = 0.1m$

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

Using equation of velocity

$V = 0$

$V^2 = u^2 - 2gh$

$u = \sqrt{v^2 + 2gh}$

$u = \sqrt{0^2 + 2(9.81) \times 20}$

$= \sqrt{392.4}$

$u = 19.809 \simeq 19.81 m/s$

The velocity = 19.81

$Q = VA$

$= 19.81 \times 7.89 \times 10^{-3}$

$= 0.15988 m^3/s$

$= 0.156 m^3/s$

Then, $P = \rho g Q z$

$= 1000 \times 9.81 \times 0.156 \times 20$

$= 30510.787$ watts

$= 30.5$ Kwatts

7) $d_1 = 0.3$,

$A_1 = \frac{\pi (0.3)^2}{4} = 0.07068 m^2 = 0.707 m^2$

$d_2 = 0.2m$

$A_2 = \frac{\pi (0.2)^2}{4} = 0.0314 m^2$

$C_d = 0.96$

specific weight of gas = $19.62 N/m^2$

$\gamma = \frac{mg}{V} = \rho g$

$= \frac{19.62}{9.81} = \frac{\rho \times 9.81}{9.81}$

$\therefore \rho = 2 kg/m^2$

calculating $Q = A_1 V_1$

$V_1 = \frac{Q_1}{A_1}$ $Q_2 = A_2 V_2$

$V_2 = \frac{Q_2}{A_2}$

$V_1 = \frac{Q}{0.707}$ $V_2 = \frac{Q}{0.034}$

for manometer

$P_1 + \rho g g z_1 = P_2 + \rho g g (z_2 - R_p) + \rho_w g R_p$

$P_1 - P_2 = \rho g g(z_2 - R_p) + \rho_w g R_p - \rho g g z$

$P_1 - P_2 = 19.62(z_2 - z_1) + 587.423$ ... i

for the venturometer

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

$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803 V_2^2$ ... ii

$z_2 - z_1 = 0.06m$

equating eq (i and ii)

~~$19.62(z_2 - z_1)$~~ $+ 587.423 =$ ~~$19.62(z_2 - z_1)$~~ $+ 0.803 V_2^2$

$\therefore 0.803 V_2^2 = 587.423$

$V_2 = \frac{587.423}{0.803}$

$V_2^2 = 731.583$

$V_2 = \sqrt{731.535}$

$V_2 = 27.0469$

$= 27.047 m/s$

$Q_{ideal} = A_2 V_2$

$= 27.047 \times 0.034$

$= 0.8492$

$= 0.85 m^3/s$

$Q_{real} = C_d \times Q_{ideal}$

$= 0.96 \times 0.85$

$= 0.816 m^3/s$

8) Throat diameter = 0.076m (d_2)

Vertical diameter = 0.152m (d_1)

relative density = 0.8

Throat being = 0.94m

$C_d = 0.91$

Bernoulli's equ

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

recall that

$Q = V_1 A_1 \quad Q = V_2 A_2$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.076^2}{4}$

$= 4.64 \times 10^{-3} m^2$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi 0.0152^2}{4} = 0.0181 m^2$

ii then $P_1 - P_2 = 18170$

$\left(\frac{P_1}{\rho g} + Z_1\right) - \left(\frac{P_2}{\rho g} + Z_2\right) = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$

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

recall, $Z_1 - Z_2 = 0.914$

$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g} - 0.914$

recall, $Q = VA, \; V = \frac{Q}{A}$

$\rho = 800, \; g = 9.81$

$\frac{18170}{800 \times 9.81} = \left(\left(\frac{Q}{A_2}\right)^2 - \left(\frac{Q}{A_1}\right)^2\right) - 0.914$

$\frac{18170}{7848} = Q^2\left(\left(\frac{1}{A_2}\right)^2 - \left(\frac{1}{A_1}\right)^2\right) - 0.914$

$1.932 = \frac{Q^2(48816.36 - 3052.41)}{2g} - 0.914$

$(1.932 + 0.914)2g = Q^2(48816.36 - 3052.41)$

$\frac{56.3578}{45463.95} = Q^2 \frac{45463.95}{45463.95}$

$Q^2 = 1.24 \times 10^{-3}$

$= \sqrt{1.24 \times 10^{-3}}$

$= 0.0352 m^3/s$

9 $d_1 = 300mm = 0.3m$

$d_2 = 150mm = 0.15m$

$A_1 = 0.07069 m^2$

$A_2 = 0.0177 m^2$

$Q = 40 lit/sec = 0.04 m^3/sec$

$Z_1 = 10m, \; Z_2 = 6m$

$P_1 = 400 kN/m^2$

$P_2 = ?$

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

But, $Q = A_1 V_1$

$\therefore V_1 = \frac{Q}{A_1} = \frac{0.04}{0.07069}$

$V_1 = 0.5658 = 0.57 m/s$

then $V_2 = \frac{Q}{A_2} = \frac{0.04}{0.0177}$

$V_2 = 2.26 m/s$

$\frac{P_1}{\rho g}(Z_1 - Z_2) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) \frac{P_2}{\rho g}$

$\frac{400}{9.81} + (10-6) + \left(\frac{0.57^2 - 2.26^2}{2(9.81)}\right) = \frac{P_2}{9.81 kN}$

$40.77 + 4 + (-0.2438) = \frac{P_2}{9.81 kN}$

$44.32 \times 9.81 = P_2$

$P_2 = 43.74 kN$

10) Reading of manometer = 170mm

$= 0.17m$

specific gravity of mercury = 13.6

seawater = 1.026

$y = 0.17m$

for $h = y\left(\frac{S_{hl}}{S_l} - 1\right)$

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

$= 0.17 \times 12.25 = 2.0884$

Recall $V = \sqrt{2gh}$

$= \sqrt{2(9.81)2.0834}$

$= \sqrt{40.81}$

$= 6.398 m/s$