18/ENG03/026

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Civil Engineering

Fluid Mechanics Assignment

1) i. Flow rate (Q) = 10dm³/min   Nominal displacement = 10cm³/rev
Pressure change (ΔP) = 12bar   Torque input (T) = 12.5N-m
Speed (N) = 1500rpm

Ideal flow rate = nominal displacement × speed
= 10cm³/rev × 1500rpm
= 15000cm³/min
= 15dm³/min

i. volumetric efficiency = actual flow / ideal flow
= 10/15 = 0.6667 or 66.67%

ii. $Q = \frac{10 \times 10^{-3}}{60}$ m/sec

$= 16.7 \times 10^{-5}$ m³/sec

$\Delta P = 12 \times 10^5 N/m^2$

fluid power = $\Delta P \times Q = 16.7 \times 10^{-0.5}$ m³/sec $\times 12 \times 10^5 N/m^2$ = 200watts

~~shaft~~ fluid power = $\Delta p \times Q$ = 200watts

iii. shaft power = $\frac{2\pi NT}{60} = \frac{2\pi \times 1500 \times 12.5}{60}$

= 1963.5 watts

iv. overall efficiency = F.p/S.p = 200/1963.5
= 10.2% or 0.102

2) flow rate (Q) = 35dm³/min
pressure change (ΔP) = 100bar
overall efficiency = 87%
shaft power = 2πNT/60

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fluid = $\Delta p \times Q$

$Q = \frac{35 \times 10^{-3}}{60} m^3/sec$

$= 58.3 \times 10^{-5} m^3/sec$

$\Delta p = 100 \times 10^5 N/m^2$

fluid power

$= 58.3 \times 10^{-5} \times 100 \times 10^5$

$= 5830$ watts

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

$0.87 = \frac{5830}{\text{shaft power}}$

shaft power = 5830/0.87 = 6701.14 watts

3) Normminal displacement = $50 cm^3/rev$

pressure change (Δp) = 100bar

shaft power = 15 kilowatt = 15000

efficiency = ?

volumetric efficiency = ?

flow rate (Q) = $35 dm^3/min$

speed (N) = 850rpm

ideal flow rate = normminal displacement × speed

$= 50 cm^3/rev \times 850 rpm$

$= 42500 cm^3/min = 42.5 dm^3/min$

volumetric efficiency = actual flow/ideal flow

= 35/42.5 = 0.8235 or 82.35%

$\therefore Q = \frac{35 \times 10^{-3}}{60} m^3/sec = 58.3 \times 10^{-3} m^3/sec$

$\Delta P = 100 \times 10^5 N/m^2$

fluid power = $\Delta P \times Q$ = $58.3 \times 10^{-5} m^3/sec \times 100 \times 10^5$

= 5830 watts

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shaft power = 15000 watts

overall efficiency = $\frac{\text{fluid power}}{\text{shaft power}} = \frac{5830}{15000} = 0.3886$ or 38.86%

4) $H = 240m$ $v = 66m/sec$

$Q = 0.013m^3/s$

i.) power of jet (P_{jet}) $= \frac{1}{2}mv^2_{jet}$

$= \frac{1}{2}\rho Q v^2_{jet}$

$= \frac{1}{2} \times 1000 \times 0.013 \times 66^2$ watt

$= 28314$

$= 28.314$ kilowatts

ii. power from reservoir $= mgh$

$= \rho Q g h$

$= 1000 \times 0.013 \times 9.81 \times 240$ watt

$= 30607.2$

$= 30.6072$ kilowatt

iii. heat used to overcome losses $= H - \frac{v^2_{jet}}{2g}$

$= 240 - \frac{66^2}{2 \times 9.81}$

$= 17.98m$

iv. efficiency of pipeline and nozzle $= \frac{P_{jet}}{P_{res}} \times 100$

$= \frac{28.314}{30.6072} \times 100 = 92.51\%$

5) $Z_1 = 30\ 000cm = 300m$

$Q_1 = 220$ litres/s $= (220 \times 10^{-3})m^3/s$

$V_2 = 7m/s$

Power of jet $= \rho g Q H$

where $\rho = 0.89 \times 1000 = 890kg/m^3$

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$g = 9.81 m/s^2$

$Q = (220 \times 10^{-3}) m^3/s$

$H = Z_2 + \frac{P}{\rho g} + \frac{V^2}{2g}$

$H = 0 + \frac{0}{\rho g} + \frac{(7)^2}{2 \times 9.81}$

$H = 49/19.62 = 2.497 J$

i. Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 2.497$

$= 4797.1$ watts

ii. Power supplied from reservoir

$H = Z_1 + \frac{P}{\rho g} + \frac{V^2}{2g} = 300 + \frac{0}{\rho g} + \frac{0}{2g} = 300 J$

Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 300$

$= 576239.4$ kgm/sec

iii. head used to overcome the loss = power loss / $\rho g Q$

$= (576239.4 - 4797.1) / 1000 \times 9.81 \times 220 \times 10^{-3}$

$= 571442.3 / 2158.2$

$= 264.7772681$

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

$= \frac{4797.1}{576239.4} \times 100$

$= 0.832483$ or 83.2%

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6) Power = workdone/time

workdone = mgh/time

V = velocity of steem

ρ = density of water (1000kg/m³)

$m = \rho \times V$

$V = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 20}$

$= 19.7989 m/s$

$P = \rho \pi r^2 \frac{Vgh}{t}$

$Power = 1000\frac{kg}{m^3} \times \left(\frac{10 \times 10^{-2}}{2}\right) \times 19.7989 m/s \times 9.8 m/s^2 \times 20m$

$= 1000 \times \pi \times 2.5 \times 10^{-3} \times 19.7989 \times 9.8 \times 20$

$= 30478.03w$

Power = 30478.03w

7) diameter $(D_1) = 0.3m$

$A_1 = \pi/4 \times 0.3^2$

$A_1 = 0.070685m^2$

Throat diameter $(D_2) = 0.2m$

$A_2 = \pi/4 \times (0.2)^2$

$= 0.031416m^2$

coefficent of discharge (Cd) = 0.96

specific weight of gas $(\gamma) = 19.62 N/m^3$

$\therefore$ density of gas $(S_g) = \frac{19.62}{9.81}$

$S_g = 2kg/m^3$

head difference $(h) = x - \left(\frac{S_m}{S_g} - 1\right)$

$= 0.06 \times \left(\frac{1000}{2} - 1\right)$

$h = 29.94m$

$\therefore$ Volume flow rate $(Q) = \frac{Cd \cdot A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

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$$= \frac{0.96 \times 0.070685 \times 0.031416 \sqrt{2 \times 9.81 \times 29.94}}{\sqrt{(0.070685)^2 - (0.031416)^2}}$$

$Q = 0.81599 m^3/s$

8) $A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4}(0.152)^2 = 0.018146 m^2$

$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4}(0.076)^2 = 4.5365 \times 10^{-3} m^2$

i. $Q = \frac{c_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$$= \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 0.914}}{\sqrt{(0.018146)^2 - (4.5365 \times 10^{-3})^2}}$$

$Q = 0.01924 m^3/s$

ii. $h = \left(\frac{P_1 - P_2}{\rho g}\right) = \frac{15170}{0.8 \times 10^3 \times 9.81} = 1.933 m$

$$Q = \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.933}}{\sqrt{(0.018146)^2 - (4.5365 \times 10^{-3})^2}}$$

$Q = 0.02798 m^3/s$

9) $d_1 = 300mm = 0.3m$

$A_1 = \pi d^2/4 = \pi(0.3)^2/4 = 0.0707 m^2$

$d^2 = 150mm = 0.15m$

$A_2 = \pi d^2/4 = \pi(0.15)^2/4 = 0.0177 m^2$

$Q = 40 L/s$

$= (40 \times 10^{-3}) m^3/s$

$Z_1 = 10m$, $Z_2 = 6m$, $P_2 = ?$, $P_1 = 400 kN/m^2 = 400{,}000 N/m^2$

$Q = VA$

$V_1 A_1 = Q \therefore (V_1)(0.0707) = (40 \times 10^{-3})$

$V_1 = (40 \times 10^{-3}) / 0.0707$

$V_1 = 0.5658 m/s$

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$Q = V_2 A_2$

$V_2 (0.0177) = 40 \times 10^{-3}$

$V_2 = (40 \times 10^{-3}) / 0.0177$

$V_2 = 2.2599 m/s$

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

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

$$10 + \frac{400000}{9.81 \times 1000} + \frac{(0.5658)^2}{2(9.81)} = 6 + \frac{P_2}{9.81 \times 1000} + \frac{(2.2599)}{2 \times 9.81}$$

$$50.79 = \frac{P_2}{9.81 \times 1000} + 6.260303$$

$$\frac{P_2}{9.81 \times 1000} = 50.79 - 6.28$$

$P_2 = (9.81 \times 1000)(44.53)$

$P_2 = 436836.326 N/m^2$

$P_2 = 436.836 kN/m^2$

10) Calculate the head

ρ_m = density of mercury

ρ_f = density of flowing fluid

y -> manometric reading

$$h = y\left(\frac{\rho_m}{\rho_f} - 1\right)$$

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

$h = 2.0834$

To find velocity of substance

$V = \sqrt{2gh}$

$= \sqrt{2 \times 9.81 \times 2.0834}$

$= 6.393 m/sec$