ADENIRAN MUSTAQEEMAT ADEDAMOLA

18/ENG02/007

COMPUTER ENGINEERING

FLUID MECHANICS

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1. Rate of pump delivery = $100 dm^3/min$
Pressure Change = $12 bar = 12 \times 10^5 N/m^2$
Speed of rotation = $1500 rev/min = \frac{1500 rev}{1 min} \times \frac{1 min}{60 sec}$

Nominal displacement = $100 cm^3/rev$
Torque input = $12.5 Nm$

i) Volumetric efficiency = $\frac{\text{actual flowrate}}{\text{ideal flowrate}} \times 100\%$

Actual flowrate = $100 dm^3/min = \frac{100 dm^3}{1 min} \times \frac{1 m^3}{1000 dm^3} \times \frac{1 min}{60 sec}$
$= 1.667 \times 10^{-4} m^3/sec$

Nominal displacement = $\frac{100 cm^3}{1 rev} \times \frac{1 m^3}{10^6 cm^3} = 1 \times 10^{-5} m^3/rev$

Ideal flowrate = nominal displacement × speed
$= 1 \times 10^{-5} \times 25$
$= 2.5 \times 10^{-4} m^3/sec$

Volumetric efficiency = $\frac{1.667 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100 = 66.68\%$

ii) Fluid power = Actual flowrate × Pressure
$= 1.667 \times 10^{-4} \times 12 \times 10^5$
$= 200.04$ watts

iii) Shaft power = Torque input × angular speed
Torque input = $12.5 Nm$
angular speed = $\omega = \frac{2\pi N}{60} = 2 \times \pi \times \frac{1500}{60}$ (rps)

∴ Shaft power = $12.5 \times 2 \times \pi \times 25 = 1963.5$ watts

iv.) Overall efficiency $= \frac{\text{fluid power}}{\text{Shaft power}} \times 100\%$

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

$= 10.21\%$

2.) Rate of delivery $= 35\,dm^3/min = 35/60 = 0.55\,dm^3/s$

Pressure change $= 100\,bar = 100 \times 10^5\,N/m^2$

Overall efficiency $= 87\%$

Shaft power $= ?$

Rate of delivery $= 0.58 \times \frac{1}{1000} = 5.83 \times 10^{-4}\,m^3/sec$

fluid power $=$ actual flowrate $\times$ pressure change

$= 5.83 \times 10^{-4} \times 100 \times 10^5$

$= 5833.33$ watts

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

$87 = \frac{5833.33}{S.P} \times 100$

$\frac{0.87}{5833.33} = \frac{1}{S.P}$

$\therefore$ Shaft power $= 6704.977$ watts

3.) Nominal displacement $= 50\,cm^3/rev = \frac{50\,cm}{rev} \times \frac{1\,m^3}{100^3\,cm}$

$= 5 \times 10^{-4}\,m^3/rev$

Pressure change $= 100\,bar = 100 \times 10^5\,N/m^2$

Shaft Power $= 15\,kW = 15{,}000\,W$

Actual flowrate $= 35\,dm^3/min = \frac{35\,dm^3}{1\,min} \times \frac{1\,min}{60\,sec} \times \frac{1\,m^3}{1000\,dm^3}$

$= 5.833 \times 10^{-4}\,m^3/sec$

Speed of rotation $= 850\,rpm = 14.2\,rps$

Overall Efficiency $= \frac{\text{fluid power}}{\text{Shaft Power}} \times 100$

fluid power = actual flowrate × pressure change

$= 5.833 \times 10^{-4} \times 100 \times 10^{5}$

$= 5833$ watts

Shaft power = Torque input × angular

$= 15\text{kw} = 15000\text{W}$

Overall Efficiency $= \frac{5833}{15000} \times 100$

$= 38.9\%$

Volumetric efficiency $= \frac{\text{actual flowrate}}{\text{Ideal flowrate}} \times 100$

Ideal flow rate = nominal displacement × speed

$= 5 \times 10^{-4} \times 14.2$

$= 7.1 \times 10^{-3}\ m^3/sec$

Volumetric efficiency $= \frac{5.833 \times 10^{-4}}{7.1 \times 10^{-3}} \times 100$

$= 8.22\%$

4) $Z = 24{,}000cm = \frac{24{,}000}{100} = 240m$

flow rate = 13 litres/sec

since 1000 litres = $1m^3$

∴ 13 litres $= \frac{13 \times 1}{1000} = 0.013\ m^3/sec$

Velocity of jet = 6m/sec

Jet issuing from nozzle is at atmospheric pressure at the tailwater level

$P = 0, Z = 0$

Density $= 1000 kg/m^3$

from equation; $P = \left(P + \rho g z + \frac{\rho v^2}{2}\right) Q$

Since $P = 0$; $z = 0$

$P = 0 + \frac{\rho Q v^2}{2} + \rho g \cdot 0$

$P = \frac{\rho Q v^2}{2} = \frac{1000 \times 0.013 \times 66^2}{2}$

$P = 28314 W = 28.314 kW$

ii) At this point ; $P = 0$ while $v = 0$

$P = (\rho Q + \rho Q g z + \frac{\rho Q v^2}{2})$

$P = \rho Q g z = 1000 \times 0.013 \times 9.8 \times 240$

$= 30576 W$

$= 30.576 kW$

iii) Power loss in transmission $= 30.576 - 28.314$

$= 2.262 kW = 2262 W$

Head loss in pipeline ;

$h = \frac{\text{power transmission loss}}{\rho g Q}$

$= \frac{2262}{1000 \times 9.81 \times 0.013} = 17.73 m$

iv) Efficiency of the pipeline and nozzle ;

$\frac{\text{power of jet}}{\text{power of reservoir}} \times 100 = \frac{28314}{30576} \times 100$

$= 92.6\%$

5) Specific gravity of oil $= 0.89$

$z = 30000 cm = 300 m$

$Q = 220$ litres/sec

~~Since~~ Since 1000 litres $= 1 m^3$

220 litres $= \frac{220}{1000} \times 1 = 0.220 m^3/sec$

Velocity of Jet $= 7 m/sec$.

i) Specific gravity = $\frac{\text{Specific weight of liquid}}{\text{Specific weight of water}}$

0.89×9.81 = Specific weight of liquid

$8.730\,kN/m^3 = 8730\,N/m^3$

$\therefore$ density $(\rho) = \frac{8730.9}{9.81} = 890\,kg/m^3$

Recall:

At the point of jet issuing from nozzle; $P = 0$, $z = 0$

from equation; $\left(PQ + \rho g z Q + \frac{\rho v^2 (Q)}{2}\right)$ = Power

$$P = \frac{\rho v^2}{2} Q = \frac{890 \times 7^2}{2} \times 0.22$$

$= 4797.1\,W = 4.7971\,kW$

ii) Power supplied from reservoir; $P = 0$; $V = 0$

$$\text{Power} = \left(PQ + \rho z g Q + \frac{\rho v^2 Q}{2}\right)$$

$$\text{Power} = \rho z g Q = 890 \times 300 \times 9.81 \times 0.22$$

$= 576239.4\,W = 576.2394\,kW$

iii) Power loss in transmission $= 576239.4 - 4797.1$

$= 571442.3\,W$

Head used $= \frac{\text{Power loss in transmission}}{\rho g Q}$

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

$= 297.5\,m$

iv) Efficiency $= \frac{\text{Power of Jet}}{\text{Power of reservoir}} \times 100$

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

$= 0.83\%$

4

Area $= \pi \times (0.05)^2 = 7.854 \times 10^{-3} m^2$

Volume $= 7.854 \times 10^{-3} \times 20 = 0.1571 m^3$

Q = flow rate $= \frac{0.1571}{60} = 2.62 m^3/s$

Power $= 196200 \times 2.62$

$= 514044 W = 514.044 kW$

7) Inlet diameter $= 0.3m = \frac{\pi \times 0.3^2}{4} = 0.071 m^2 =$ Inlet area (A_1)

Throat diameter $(D_2) = 0.2m = \frac{\pi \times 0.2^2}{4} = 0.031 m^2 =$ Throat area (A_2)

$C_d = 0.96$; $h = 0.06m$; Sp. gravity of water $= 1$

Specific weight of gas $= 19.62 N/m^3$

Specific gravity of gas $= \frac{19.62 \times 1000}{9.81} = 0.002$

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

$Q = \frac{0.96 \times 0.071 \times 0.031}{\sqrt{(0.071)^2 - (0.031)^2}} \times \sqrt{2 \times 9.81 \times 0.06}$

$Q = 0.0359 m^3/s$

Volume flowing $= 0.0359 m^3$

8) Throat diameter $(D_2) = 0.076m$

Throat area $(A_2) = \frac{\pi \times (0.076)^2}{4} = 4.54 \times 10^{-3} m^2$

Relative density $= 0.8$

Pipe diameter $= 0.152m = D_2$

Pipe area $(A_1) = 0.018 m^2$

Difference between inlet and throat $= 0.9140$

$C_d = 0.97$

Since $h = \left(\frac{P_1}{w} - \frac{P_2}{w}\right) + (Z_1 - Z_2)$

a) When $P_1 = P_2$

$\therefore h = 0$

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

Since $h = 0$

$\therefore Q = 0$

b) When $P_1 - P_2 = 15170$; $0.8 \times 1000 = 800 kg/m^3$

$h = \frac{15170}{7848}$ $\quad w = \rho g$

$w = 800 \times 9.81 = 7848 N/m^3$

$h = 1.933m + 0.914m$

~~$\therefore h = 2.28$~~ $\therefore h = 2.847 m$

$\therefore$ Discharge $(Q) = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$Q = 0.97 \times \frac{0.0181 \times 4.54 \times 10^{-3}}{\sqrt{(0.0181)^2 - (4.54 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 2.847}$

$Q = 0.034 m^3/seconds$

9) Section 1 diameter $= 300mm = 0.3m$ (D_1)

Section 1 Area $= \frac{\pi \times 0.3^2}{4} = 0.071 m^2$ (A_1)

Section 2 diameter $= 150mm = 0.15m$ (D_2)

Section 2 Area $= \frac{\pi \times 0.15^2}{4} = 0.018 m^2$ (A_2)

$Q = 40$ litres/sec $= 0.04 m^3/sec$.

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

$P_1 = 400 kN/m^2$ $P_2 = ?$

$= 400 kPa$

$V_1 = \frac{Q}{A_1} = \frac{0.04}{0.071} = 0.563 m/s$

$V_2 = \frac{Q}{A_2} = \frac{0.04}{0.018} = 2.27 m/s$