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18/ENG04/055.
ELECTRICAL/ELECTRONICS ENGINEERING

1) Actual flowrate = $10dm^3/min = \frac{10}{1000 \times 60} = 1.67 \times 10^{-4} m^3/s$

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

Speed = 1500rev/min = 25rev/s

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

Torque input = 12.5Nm

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

Ideal flowrate = Speed x Displacement = 25×10^{-5}

$= 2.5 \times 10^{-4} m^3/s$

∴ Volumetric efficiency = $\frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100$

= 66.8%

b) Fluid Power = $Q\Delta P$

$= (1.67 \times 10^{-4}) \times (12 \times 10^5)$

= 200.4 Nm/s

c) Shaft power = Torque x angular speed

Angular speed (ω) = $2\pi N$

$= 2 \times \frac{22}{7} \times 25$

= 157.07 rad/sec

∴ Shaft Power = 12.5 x 157.07

= 1963.375W

= 1.963 KW

d) Overall efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100$

$= \frac{200.4}{1963.375} \times 100 = 10.21\%$

2) Actual flowrate = $35dm^3/min = 5.83 \times 10^{-4} m^3/s$

$\Delta P = 100bar = 10^7 N/m^2$

Overall efficiency = 87%

Shaft Power = ?

Overall efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100$

Fluid Power = $Q\Delta P$

$= (5.83 \times 10^{-4}) \times 10^7$

= 5830 Nm/s

Shaft Power = $\frac{5830 \times 100}{87}$

= 6701.15W

= 6.701 KW

3 Displacement = $50cm^3/rev$ = $5\times10^{-5} m^3/rev$
$\Delta P = 100bar = 10^7 N/m^2$

Shaft Power = $15KW = 15\times10^3 W$
Actual flowrate = $35dm^3/min = 5.83\times10^{-4} m^3/s$
Speed of rotation = 850 rev/min = 14.17 rev/s

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

$= \frac{(5.83\times10^{-4}) \times 10^7 \times 100}{15\times10^3}$

$= 38.87\%$

Volumetric efficiency = $\frac{\text{Actual Flow}}{\text{Ideal Flow}} \times 100$

$= \frac{5.83\times10^{-4}}{(5\times10^{-5})\times14.17} \times 100$

$= 82.29\%$

4 $Q = 13L/s = 0.013m^3/s$
Velocity of jet = 66m/s
$Z = 24000cm = 240m$

Volumetric flow rate $Q = 13L/s = 0.013 m^3/s$
Since jet issues from a nozzle at datum level,
Hence
$P = 0, Z = 0$
ρ for water = $1000kg/m^2$

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

$= \frac{1000\times0.013\times66^2}{2} = 28314W$

$= 28.3KN$

ii Power supplied at reservoir
$P = 0, V = 0$
$P = \rho g \cdot Qz = 1000\times9.81\times0.013\times290$
$P = 30607.2W$
$P = 30.6KW$

iii Power lost in transmission = Power in reservoir − Power of jet

$30.607 - 28.314 = 2.293KW$

Head loss in pipeline

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

$h = \frac{2293}{1000 \times 9.81 \times 0.013} = 17.98m$

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

$= \frac{28814}{30607} \times 100 = 92.50\%$

5 S.g of oil = 0.89

$Z = 30{,}000cm = 300m$

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

Velocity = 7m/s

Density of oil = $0.89 \times 1000 = 890 kg/m^3$

At datum

Power of jet $= \frac{\rho Q v^2}{2} = \frac{890 \times 0.22 \times 7^2}{2} = 4797.1W$

$= 4.797kW$

ii Power supplied from reservoir

$= \rho g Q Z$

$= 890 \times 9.81 \times 0.22 \times 300 = 576239.4$

$= 576.24 kW$

iii Head used to overcome losses

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

Power lost in transmission $= 576.24 - 4.797$

$= 571.44kW$

$h = \frac{571443}{1000 \times 9.81 \times 0.22} = 264.78m$

IV Efficiency $= \frac{\text{Power of jet}}{\text{Power of resistor}} \times 100$

$= \frac{4.797}{576.24} \times 100 = 0.83\%$

6 $Z = 20m$ $d = 10cm = 0.1m$

$A = \frac{\pi \times 0.1^2}{4} = 0.00786 m^2$

$\rho = 1000 kg/m^3$, $g = 9.81 m/s^2$

At the highest point, final velocity, $v = 0$

To obtain velocity at height, Z

$v^2 = u^2 - 2gh$

$0 = u^2 - 2 \times 9.81 \times 20$

$0 = u^2 - 392.4$

$u^2 = 392.4$

$u = 19.81 m/s$

$\therefore Q = Av$

$= 0.00786 \times 19.81 = 0.156 m^3/s$

Power $= \rho g Q Z$

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

$= 30607 W$

$= 30.607 KW$

7 $d_1 = 0.3m$ $C_d = 0.96$

$d_2 = 0.2m$ S.w of gas $= 19.62 N/m^3$

manometer differential reading $(x) = 0.06m$ of water

$A_1 = \frac{\pi \times 0.3^2}{4} = 0.0707 m^2$

$A_2 = \frac{\pi \times 0.2^3}{4} = 0.0314 m^2$

$h = x\left[\frac{S.g\ water}{S.g\ gas} - 1\right]$

$S.g\ gas = \frac{W_{gas}}{W_{water}} = \frac{19.62}{9.807 \times 10^3} = 0.002$

$h = 0.06\left[\frac{1}{0.002} - 1\right]$

$h = 29.94m$

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

$= 0.96 \times 0.0314 \times 0.0707 \times \sqrt{\frac{2 \times 9.81 \times 29.94}{0.0707^2 - 0.0314^2}}$

$= 2.13 \times 10^{-3} \times 382.62 = 0.815 m^3/s$

8 $d_1 = 0.152 m$, $d_2 = 0.076m$

$S.g = 0.8$, $\rho = 0.8 \times 1000 = 800 kg/m^3$

$C_d = 0.97$, $Z_1 = 0.914$, $Z_2 = 0$

$A_1 = \frac{\pi \times 0.152^2}{4} = 0.01814 m^2$

$A_2 = \frac{\pi \times 0.076}{4} = 0.00454 m^2$

a) when $P_1 = P_2$

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

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

By continuity

$$Q = A_1V_1 = A_2V_2$$

$$V_2 = \frac{A_1V_1}{A_2}$$

Substituting this, we have;

$$\frac{V_1^2}{2g} + Z_1 = \frac{A_1^2V_1^2}{A_2^2 \times 2g} + Z_2$$

$$\frac{V_1^2}{19.6} + 0.914 = \frac{15.96V_1^2}{19.6}$$

$$V_1^2 - \frac{15.96V_1^2}{19.6} = -0.914$$

$$-14.96V_1^2 = -17.9144$$

$$V_1^2 = 1.197$$

$$V_1 = 1.09 m/s$$

$$\therefore Q = A_1V_1 = 0.01814 \times 1.09 = 0.0019 m^3/s$$

b) $P_1 = P_2 + 15170$

$$P_1 - P_2 = 15170$$

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

$$\frac{15170}{1000 \times 9.81} = \frac{\frac{Q^2}{A_2^2} - \frac{Q^2}{A_1^2}}{2g} - 0.914$$

$$\frac{15170}{9810} = \frac{Q^2(220^2 - 55.13^2)}{2g} - 0.914$$

$$2.847 = Q^2(2320.28)$$

$$Q^2 = 0.00123$$

$$Q = 0.035 m^3/s$$

9) $d_1 = 300mm = 0.3m$, $Z_1 = 10m$

$d_2 = 150mm = 0.15m$, $Z_2 = 6m$

$Q = 40 l/s = 0.04 m^3/s$

$P_1 = 400 \times 10^3 N/m$

$P_2 = ?$

$$A_1 = \frac{\pi \times 0.3^2}{4} = 0.0707 m^2$$

$$A_2 = \frac{\pi \times 0.15^2}{4} = 0.0177 m^2$$

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

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

$$V_1 = \frac{Q}{A_1} = \frac{0.04}{0.0707} = 0.566 \text{ m/s}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.04}{0.0177} = 2.26 \text{ m/s}$$

$$\frac{(400 \times 10^3) - P_2}{1000 \times 9.81} = \frac{2.26^2 - 0.566^2}{2 \times 9.81} + (6 - 10)$$

$$\frac{(400 \times 10^3) - P_2}{9810} = 0.244 - 4$$

$$(400 \times 10^{-3}) - P_2 = -36846.378$$

$$P_2 = 400000 + 36846.378$$

$$P_2 = 436846.378 \text{ N/m}^2$$

$$P_2 = 436.8 \text{ kN/m}^2$$

10 $V = \sqrt{2gh}$

Difference of mercury level (x) = 170 mm Hg = 0.17 m Hg

s.g of mercury = 13.6

s.g of sea water = 1.026

$$h = x\left[\frac{\text{s.g mercury}}{\text{s.g sea water}} - 1\right]$$

$$= 0.17\left[\frac{13.6}{1.026} - 1\right]$$

$h = 2.08$ m of sea water

$$\therefore V = \sqrt{2 \times 9.81 \times 2.08} = \sqrt{40.8096}$$

$$\therefore V = 6.39 \text{ m/s}$$