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18/SCI14/025
CIVIL ENGINEERING

1. $Q = 10 dm^3/min$

$= \frac{10 \times 10^{-3}}{60} \frac{m^3}{s}$

$= 1.67 \times 10^{-4} m^3/s$

$\delta p = 12 bar = 12 \times 10^5 N/m^2$

Speed of rotation $= 1500 rev/min$

$\therefore \frac{1500}{60} \frac{rev}{sec}$

$= 25 rev/s$

Nominal displacement $= 10 cm^3/rev$

$= (10 \times 10^{-6}) m^3/rev$

$= 1 \times 10^{-5} m^3/rev$

Torque input $= 12.5 Nm$

I) Volumetric Efficiency $= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100\%$

Ideal flow rate = speed of rotation x nominal displacement

$= rev/s \times m^3/rev$

$= m^3/s$

$\therefore$ Ideal flow rate $= 25 \times 10^{-5} m^3/sec$

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

Volumetric Efficiency $= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100\%$

$= 66.8\%$

II Fluid power $= Q \times \delta P$

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

$= 200.4$ Watts

III Shaft power = Torque input x angular speed

Angular speed = rad/sec

$\Rightarrow \frac{25 rev}{1 sec} = \frac{25 \times 2\pi}{1 sec} = 50\pi rad/sec$

$= 157.08 rad/sec$

$\therefore$ Shaft power $= 12.5 Nm \times 157.08 rad/s$

$= 1963.495$ Watts

IV) Overall Efficiency $= \frac{\text{Fluid power}}{\text{Shaft power}} \times 100\%$

$= \frac{200.4}{1963.495} \times 100\%$

$= 10.206\%$

$\approx 10\%$

2) $Q = 35 dm^3/min$

$= \frac{35 \times 10^{-3}}{60} \frac{m^3}{s}$

$= 5.83 \times 10^{-4} m^3/s$

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

Overall Efficiency $= 87\%$

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

Fluid Power = $Q \times \delta P$ = $(5.83 \times 10^{-4}) \times (100 \times 10^5)$

$\Rightarrow$ 5830 watts

$\Rightarrow \frac{5830}{x} \times 100 = 87$

$\Rightarrow \frac{5830 \times 100}{87} = x$

$\Rightarrow x = 6701.149425$

$\therefore$ Shaft Power = 6701.1 Watts.

3) Nominal Displacement $50 cm^3/rev$

Pressure charge = 100 bar

Shaft Power = 15 kilowatts = 15000

Flowrate (Q) = $35 dm^3/min$

Speed (N) = 850 rpm

Overall efficiency = ?

Volumetric efficiency = ?

Ideal flow rate = Nominal Displacement x speed

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

= $42.5 dm^3/min$

Volumetric efficiency = Actual flow/ideal flow

= 35/42.5 = 82.35%

ii) $Q = \frac{35 \times 10^{-3}}{60} \frac{m^3}{s} = 58.3 \times 10^{-5} m^3/s$

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

Fluid power = ~~Fluid power~~ $Q \times \delta P$

$= 58.3 \times 10^{-5} m^3/sec \times 100 \times 10^5$

= 5830 watts.

Shaft power = 15000 watts

Overall Efficiency = $\frac{\text{Fluid power}}{\text{shaft power}}$

$= \frac{5830}{15000} = 0.3886$

or

38.86%

4. $H = 240m$

$Q = 0.013 m^3/s$

$V = 66 m/sec$

a) power of jet = $\frac{1}{2} m v^2_{jet}$

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

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

= 28314

= 28.314 kilo watts

b.) Power supplied by reservoir = mgh

$= \rho Q g h$

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

= 30607.2

= 30.6072 Kilowatt

c) Head used to overcome losses (H_f)

$= H - \frac{v^2_{jet}}{2g}$

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

= 17.98 m

d) Efficiency of pipeline & nozzle = $\frac{P_{jet}}{P_{res}} \times 100$

$= \frac{28.314}{~~2830~~ 30.6072} \times 100$

= 92.51%

5. $Z_1 = 30{,}000cm = 300m$

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

$v_2 = 7m/s$

Power of jet $= \rho g Q H$

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

$g = 9.81 \, m/s^2$

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

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

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

$$H = 49/19.62 = 2.497J$$

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

$= 4797.1$ Watts

II Power supplied from the reservoir

$$H = Z_1 + \frac{P}{\rho g} + \frac{v^2}{2g}$$

$$\Rightarrow 300 + \frac{0}{\rho g} + \frac{0}{2g}$$

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

$= 576239.4$

III Heat 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 $= \dfrac{\text{Power of jet}}{\text{power of reservoir}} \times 100$

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

$\Rightarrow$ ~~0.832~~ $0.8324834 86\%$

6) Power $= \dfrac{\text{Workdone}}{\text{time}}$

workdone $= \dfrac{mgh}{\text{time}}$

v = velocity of steam

ρ = density of water ($1000 \, kg/m^3$)

$\dot{m} = \rho Q V$

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

$= 19.7989 m/s$

$=$

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

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

$= 30478.03W$

7. Diameter $(D_1) = 0.3m$

$A_1 = \pi/4 \times 0.3^2 = 0.070685 m^2$

Throat diameter $(D_2) = 0.2$

$A_2 = \pi/4 \times (0.2)^2 = 0.0314 16 m^2$

Coefficient of Discharge $(C_d) = 0.96$

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

$\therefore$ Density of gas $(\rho_g) = \dfrac{19.62}{9.81}$

$\rho_g = 2kg/m^3$

Piezometric head difference $(h) = 0.06 \times \left(\frac{S_m}{S_g} - 1\right)$

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

$h = 29.94m$

∴ volume flow rate $(\dot{Q}) = \frac{C_d \times A_1 . A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$= \cancel{0.96 \times 0.070685 \times 0.031416 \sqrt{2g}}$

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

$Q = 0.81599 m^3/s$

8) $A_1 = \pi/4 \times D_1^2 = \pi/4 (0.152)^2 = 0.018146 m^2$

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

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

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

$Q = 0.01924 m^3/s$

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

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

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

$Q = 0.02798 m^3/s$

9) $d_1 = 300mm = 0.3m$

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

$d_2 = 150mm = 0.15m$

$A_2 = \pi/4 \times d^2 = \pi/4 \times 0.15^2 = 0.0177 m^2$.

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

$Z_1 = 10m$, $Z_2 = 6m$, $P_1 = ?$

$P_2 = 400 kN/m^2 = 400{,}000 N/m^2$

$Q = VA$

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

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

$V_1 = 0.5658 m/s$

$Q = V_2 A_2$

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

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

$V = 2.2599 m/s$

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

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

$\Rightarrow 10 + \frac{400000}{9.81 \times 1000} + \frac{(0.5658)}{(2 \times 9.81)} = 6 + \frac{P_2}{(9.81 \times 1000)} + \frac{(2.26)}{2 \times 9.81}$

$\Rightarrow 50.79 = \frac{P_2}{9.81 \times 1000} + (6.260308)$

$\frac{P_2}{9.81 \times 1000} = 50.79 - 6.26$

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

$P_2 = 436836.326 N/m^2$

$P_2 = 436.836 kN/m^2$

10.) $h = y\left(\frac{S_m}{S_f} - 1\right)$

where S_m = density of mercury
S_f = density of flowing fluid
y = manometric reading

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

$h = 2.0834$

Calculate the velocity of submarine

$v = \sqrt{2gh}$

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

$v = 6.39 m/s$