(1)

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18/ENG03/020
Civil Engineering

Flow rate (Q) = 10 dm^3/min
Pressure change (ΔP) = 12 bar
Speed (N) = 1500 rpm
Norminal displacement = 10 cm^3/rev
Torque input (T) = 12.5 N-m

i) Ideal flow rate = normal Displacement × Speed
= 10 cm^3/rev × 1500 rpm
= 15000 cm^3/min = 15 dm^3/min

Volumetric efficiency = Actual flow / ideal flow
= 10/15 = 0.6667 or 66.67%

ii) $Q = \frac{10 \times 10^{-3}}{60} m^3/sec = 16.7 \times 10^{-5} m^3/sec$

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

Fluid power = $\Delta P \times Q = 16.7 \times 10^{-0.5} m^3/sec \times 12 \times 10^5 N/m^2$ = 200 watts

Shaft power = $\frac{2\pi NT}{60} = \frac{2\pi \times 1500 \times 12.5}{60}$
= 1963.5 watts

Overall Efficiency = F.P/S.P = 200/1963.5
= 0.102 or 10.2%

Summary: there we can see that shaft power almost 10 times of fluid power can be either increase by the change in pressure or discharge

(3)

Norminal displacement = 50 cm^3/rev
Pressure change (ΔP) = 100 bar
Shaft Power = 15 kilo watts = 15000
Overall Efficiency = ??
Volumetric Efficiency = ??
Flow rate (Q) = 35 dm^3/min
Speed (N) = 850 rpm

ideal flow rate = Norminal displacement × speed
= 50 cm^3/rev × 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%

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

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

Fluid power = $\Delta P \times Q$ =
= $58.3 \times 10^{-5} m^3/sec \times 100 \times 10^5$
= 5830 watts

Shaft power = 15000 watts

Overall Efficiency = $\frac{\text{Fluid power}}{\text{Shaft Power}} = \frac{5830}{15000}$ = 0.3886 or 38.86%
38.86%

(4)

$H = 240m$
$Q = 0.013 m^3/s$
$V = 66 m/sec$

a) Power of Jet (P_{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 (P_{res}) $= mgh$

$= \rho Q g h$

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

$= 30607.2$

$= 30.6072$ Kilowatt

c) Head used to overcome losses

$(H_f) = H - \frac{V^2_{jet}}{2g}$

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

$= 17.98m$

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

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

(5)

$Z_1 = 30000cm = 300m$
$Q_1 = 220$ litres/s $= (220 \times 10^{-3}) m^3/s$
$V_2 = 7 m/s$

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

Power supplied from reservoir

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

$= 300J$

Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 300$
$= 576239.4$ kg m/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 $= \frac{\text{Power of Jet}}{\text{Power of reservoir}} \times 100$

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

$= 0.83248386\%$

(6)

Power $= \frac{\text{workdone}}{\text{time}}$

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

V = velocity of steam
ρ = density of water ($1000 kg/m^3$)

$m = \rho \times V$
$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 20}$
$= 19.7989 m/s$

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

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 $(D_1) = 0.3m$

$A_1 = \frac{\pi}{4} + 0.3^2$

$A_1 = 0.070685 m^2$

Throat diameter $(D_2) = 0.2m$

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

$A_2 = 0.031416 m^2$, Coefficient of discharge $(C_d) = 0.96$

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

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

$S_g = 2 kg/m^3$

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

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

$Q = 0.81599 m^3/s$

(8)

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

$A_2 = \frac{\pi}{9} D_2^2 = \frac{\pi}{4}(0.076)^2 = 4.5365 \times 10^{-3} m^2$

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

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

$Q = 0.01924 m^3/s$

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

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

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

$Q = 0.02795 m^3/s$

(9)

$d_1 = 300mm$

$= 0.3m$

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

$= 0.0707 m^2$

$d_2 = 150mm = 0.15m$

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

$Q = 40 l/s$

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

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

$Q = VA$

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

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

$V_1 = 0.5658 m/s$

$Q = V_2 A_2$

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

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

$V_2 = 2.2599 m/s$

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

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

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

$P_2 = 436830.326 N/m^2$

$P_2 = 436.8364 N/m^2$

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

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

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

(10)

Calculate the head

$h = y\left[\frac{\rho_m}{\rho_f} - 1\right]$

ρ_m = density of mercury

ρ_f = density of flowing field

$y \rightarrow$ manometric reading

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

$h = 2.0834$

Calculate the velocity of the submarine

$V = \sqrt{2gh}$

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

$= 6.393\,m/sec$

(2)

Flow rate (Q) = 35 dm^3/min

Pressure change (ΔP) = 100 bar

Overall Efficiency = 87%

Shaft power $= \frac{2\pi NT}{60}$

Fluid = $\Delta p \times Q$

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

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

Fluid power

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

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

$= 5830$ watts

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

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

Shaft power $= \frac{5830}{0.87} = 6701.14$ watts

Balogun's fluid assignment