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18/ENG02/074

Fluid Mechanics

1.) Actual flow rate = $10dm^3/min$

$\Rightarrow 10dm = 1m$.

$10^3 dm^3 = 1^3 m^3$

$1000dm^3 = 1m^3$ ~~x = ...~~

$10dm^3 \times x$

~~Volumetric flowrate~~ $x = 0.01m^3/min$

Actual flow rate = $\frac{0.01}{60} = 1.67 \times 10^{-4} m^3/s$

Speed = $1500/60 = 25 rev/s$

pressure δp = 12 bar = $12 \times 10^5 N/m^2$

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

Ideal flow rate = $25 \times 1 \times 10^{-5} = 2.5 \times 10^{-4} m^3/s$

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

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

$= 66.8\%$

b.) Fluid power = $1.67 \times 10^{-4} \times 12 \times 10^5$

$= 200.4W$

c) Shaft power = 12.5×157.14
$= 1964.25W$

d) Overall efficiency $= \frac{200.4}{1964.25} \times 100 = 10.2\%$

(2) $\delta p = 100 bar = 100 \times 10^5 N/m^2$
Actual flow rate $= \frac{35}{1000} \times \frac{1}{60} = 5.83 \times 10^{-4} m^3/s$

Fluid power $= 5.83 \times 10^{-4} \times 100 \times 10^5$
$= 5830 W$

Overall efficiency $= \frac{5830}{\text{Shaft power}} \times 100\%$

Shaft power $= \frac{5830}{87} \times \frac{100}{1}$
Shaft power $= 6701.15 W$

(3) Nominal displacement $= 5 \times 10^{-5} m^3/rev$
Actual flowrate $= 5.83 \times 10^{-4} m^3/sec$
$\delta p = 100 bar = 100 \times 10^5 N/m^2$
Fluid Power $= 5830W$

Overall efficiency = $\frac{5830}{15000} \times 100$

$= 38.87\%$

Ideal flowrate = nominal displacement X speed

$= 5 \times 10^{-5} \times (850/60)$

$= 5 \times 10^{-5} \times 14.17$

$= 7.085 \times 10^{-4} m^3/s$

Volumetric efficiency = $\frac{5.83 \times 10^{-4}}{7.085 \times 10^{-4}} \times 100\%$

$= 82.29\%$

(4) $Z =$ ~~24000m = 240~~ 24000cm = 240m

Volumetric flowrate = $13 \times 10^{-3} m^3/s$

Velocity of jet = 66m/s

$P = 0, Z = 0$

~~That~~ density of water = $1000 kg/m^3$

i) introducing $p = 0$ and $Z = 0$ into eqn (4)

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

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

$$= \frac{1000 \times 13 \times 10^{-3} \times 66^2}{2}$$

$$= 28314\,W$$

ii Introducing $p = 0$ & $V = 0$ into eqn (4)

$$P = 0 \cdot Q + \frac{\rho \cdot Q \cdot (0)^2}{2} + \rho g Q Z$$

$$\therefore P = \rho g Q Z$$

$$= 1000 \times 9.81 \times 13 \times 10^{-3} \times 240$$

$$= \sout{6812\,W} = 30607.2\,W$$

iii Power loss in transmission = power of reservoir − power of jet.

$$= 30607.2 - 28314$$

$$= 2293.2\,W$$

$$\therefore h = \frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}} = 17.982\,m$$

iv Efficiency $= \frac{28314}{30607.2} \times 100 = 92.5\%$