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18/ENG 05/ 024
MECHATRONICS

QUESTION 1

$Q = 10dm^3/min = \frac{10}{1000 \times 60}$ = ~~0.16m~~

$= 1.667 \times 10^{-4}\ m^3/s$

$\Delta P = 12\,bar = 12 \times 10^{+5}\ N/m^2$

Speed of Rotation = $1500\ rev/min = 1500/60$

$= 25\ rev/s$

Norminal Displacement = $10cm^3/rev = 10/1000000$

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

Torqe Input = 12.5Nm

I) Volumetric Efficiency = $\frac{Q}{\text{Ideal Flow Rate}}$

Ideal Flow Rate = Norminal displacement x speed
$= (1 \times 10^{-5}) \times 25$
$= 2.5 \times 10^{-4}$

∴ Volumetric Efficiency = $\frac{1.667 \times 10^{-4}}{2.5 \times 10^{-4}}$

$= 0.6668 \times 100\%$
$= 66.68\%$

II) Fluid Power = $Q \times \Delta P$

$= (1.667 \times 10^{-4}) \times (12 \times 10^{+5})$

$= 200.04\ W$

III) Shaft Power = $2\pi T \times$ Speed

$= 2 \times 3.14 \times 12.5 \times 25$

$= 2 \times \pi \times 12.5 \times 25$

$= 1963.50\ W$

IV) Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}}$

$= \frac{200.04}{1963.50}$

$= 0.102 \times 100\%$

$= 10.2\%$

QUESTION 2

$Q = 35\ dm^3/min = \frac{35 \times 0.001}{60}$

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

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

Overall Efficiency = 87%

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

$= \frac{Q \times \Delta P}{87 \div 100}$

$= \frac{(5.83 \times 10^{-4}) \times (100 \times 10^5)}{0.87} = \frac{5830}{0.87}$

$= 6701.15\ W$

QUESTION 3

$$Q = 35 dm^3/min = \frac{35 \times 0.001}{60}$$
$$= 5.83 \times 10^{-4} m^3/s$$

$$\Delta P = 100 bar = 100 \times 10^5 N/m^2$$
P_{shaft} = Shaft Power = 15 kW
Speed of rotation = 850 rev/min $= \frac{850}{60}$
$= 14.167$ rev/s

I) Volumetric Efficiency = $\frac{\text{Actual Flow Rate, Q}}{\text{Ideal Flow Rate}}$

Ideal Flow Rate = Norminal displacement x speed
$= (50 cm^3/rev) \times 14.167$
$= (5 \times 10^{-5}) \times 14.167$
$= 7.0835 \times 10^{-4} m^3/s$

∴ Volometric Efficiency $= \frac{5.83 \times 10^{-4}}{7.0835 \times 10^{-4}}$
$= 0.823 \times 100\%$
$= 82.3\%$

II) Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}}$
$= \frac{Q \times \Delta P}{\text{Shaft Power}}$
$= \frac{(5.83 \times 10^{-4}) \times (100 \times 10^5)}{(15 \times 10^3)} = \frac{5830}{15000}$
$= 0.3887 \times 100\%$
$= 38.87\%$

QUESTION 4

$Z = 24000cm = 240m$

Volumetric Flow Rate = 13 litre/s = $13 \times 0.001\ m^3/sec$
$= 0.013\ m^3/s$

Jet Velocity = 66 m/s

I) Jet Power = ~~$\frac{\rho Q V^2}{2}$~~ $\rho \times \frac{Q}{2} \times V^2$

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

$= 28314\ W$

$= 28.3\ kW$

II) Power Supplied from reservoir

$= \rho g Q z$

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

$= 30\,607.2\ W$

$= 30.6\ kW$

III) Head losed to over-come loss $= \frac{\text{Power lost in transmission}}{\rho g Q}$

Power lost = Reservoir Power − Jet Power

$= (30.6 - 28.3)\ kW$

$= (30\,607.2 - 28314)\ W$

$= 2293.2\ W$

∴ Head losed $= \frac{2293.2}{1000 \times 9.81 \times 0.013}$

$= 17.982\ m$

iv) Efficiency of pipeline and nozzle

$= \frac{\text{Jet Power}}{\text{Reservoir Power}} \times 100\%$

$= \frac{28314}{30607.2} \times 100\%$

$\simeq 92.5\%$

QUESTION 5

Specific gravity of oil = 0.89

z = 30000 cm = 300m

Volumetric flow Rate = 220 l/s = 220 × 0.001

= 0.22 m³/s

Velocity = 7m/s

1) Power of Jet $= \frac{\rho Q}{2} \times V^2$

S.g of oil = 0.89

$Sg = \frac{x}{1000} \Rightarrow 0.89 = \frac{x}{1000}$

x = 1000 × 0.89

= 890

∴ Power of Jet $= 890 \times \frac{0.22}{2} \times 7^2$

= 4797.1 W

= 4.7971 kW

II) Power supplied from reservoir

$$= \rho g Q z$$
$$= 890 \times 9.81 \times 0.22 \times 300$$
$$= 576239.4 \text{ W}$$
$$= 576.2394 \text{ kW}$$

III) Head used to over-come loss $= \dfrac{\text{Power lost in transmission}}{\rho g Q}$

Power lost $= 576239.4 - 4797.1$
$= 571442.3 \text{ W}$

$\therefore$ Head used $= \dfrac{571442.3}{890 \times 9.81 \times 0.22}$
$= 297.5 \text{ m}$

IV) Efficiency $= \dfrac{\text{Jet Power}}{\text{Reserve Power}}$

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

QUESTION 6

h = 20m = ~~0.2m~~

d = 10cm = 0.1m

$$A = \frac{\pi d^2}{4} = \frac{\pi(0.1)^2}{4}$$

$$= 7.854 \times 10^{-3}\ m^2$$

$V_{initial} = ?$

$V_{final} = 0$ - when it gets to the top

$$V_{final}^2 = V_{initial}^2 - 2gh$$

$$V_{final}^2 = 0$$

$$0 = V_{initial}^2 - (2 \times 9.8 \times 20)$$

$$0 = V_{initial}^2 - 392$$

$$V_{initial}^2 = 392$$

$$V_{initial} = \sqrt{392}$$

$$= 19.79\ m/s$$

Power required to send the water

$$= \rho g Q h$$

where $Q = A \times V$

$$= (1000 \times 9.81 \times (7.854 \times 10^{-3}) \times 19.79 \times 20)$$

$$= 30495.5\ W$$