ENG 214 ASSIGNMENT
OKPALE AHIOLIAWA GIFT-OHEJI
18/MHS01/272
BIOMEDICAL ENGINEERING

1 Actual Flowrate = 10dm³/min

= 0.01 m³/min = 1.667×10^{-4} m³/sec

Speed = 1500 rev/min

= $\frac{1500}{60}$ = 25 rev/sec = 25 rps

Pressure δp = 12 bar = 12×10^5 N/m²

Nominal displacement = 10 cm³/rev

= 1×10^{-5} m³/rev

torque input = 12.5 Nm

ideal flowrate = norminal displacement x speed

= $25 \times 1 \times 10^{-5}$

= 2.5×10^{-4} m³/sec

i 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%

ii Fluid power $P_f = Q \cdot \delta p$

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

= 200.4 watts

iii Shaft power = $T \cdot \omega$

where ω = angular speed (rad/sec)

T = torque input (Nm) = 12.5 Nm

$\omega = 2\pi N$ for rps

= $\frac{2\pi N}{60}$ for rpm

N = speed

$w = \frac{2 \times 22 \times 25}{7} = 157.08$ rad/sec

Shaft power = 125×157.08

$= 1963.5$ watts

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

$= \frac{2004}{1963.5} \times 100\%$

$= 10.2\%$

2 δp = change in pressure = 100 bar = 100×10^5 N/m²

Actual flowrate Q = 35 dm³/min

$= \frac{35}{1000 \times 60}$

$= 5.83 \times 10^{-4}$ m³/sec

Fluid power $P_f = Q \cdot \delta p$

$= 5.83 \times 10^{-4} \times 100 \times 10^5$

$= 5830$ watts

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

87% $= \frac{5830}{\text{Shaft power}} \times 100$

$\frac{5830 \times 100}{87} = \frac{87 \times \text{Shaft power}}{87}$

Shaft power = 6701.5

$= 6.701 \times 10^3$ watts

3 Normal displacement = 50 cm³/rev

$= 5 \times 10^{-5}$ m³/rev

(3)

Actual flowrate $= 35 dm^3/min$

$= \frac{35}{1000 \times 60}$

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

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

P_F, Fluid power $= Q \cdot \delta p$

$= 5.83 \times 10^{-4} \times 100 \times 10^5$

$= 5830$ Watts

Shaft Power $= 15$ KWatt

$= 15000$ watt

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

$= \frac{5830}{15,000} \times 100$

$= 38.87\%$

Ideal Flowrate = nominal displacement × speed

Speed, $N = 850$ rpm

$= \frac{850}{60}$

$= 14.17$ rps

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

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

Volumetric Efficiency $= \frac{\text{Actual flowrate}}{\text{Ideal Flowrate}} \times 100\%$

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

$= 82.3\%$

4 $z = 2,400$ cm $= 24.0$ m

volumetric flowrate, $Q = 13$ litre/sec

$= 13 \times 10^{-3} m^3/sec$

Velocity of Jet = 66m/sec

The jet issuing from the nozzle will be at atmospheric pressure and at datum level, hence

$P = 0$ and $z = 0$

Density, ρ for water = 1000 kg/m³

$$P = PQ + \frac{\rho QV^2}{2} + \rho g Q z$$

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

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

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

Power of Jet = 28314 watts

= 28.314 kilowatts

ii Power supplied from reservoir

Because the reservoir operates at an atmospheric Pressure, $P = 0$ and $V = 0$

$$P = PQ + \frac{\rho \cdot QV^2}{2} + \rho g Q z$$

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

$$P = \rho g Q z$$

$$= 1000 \times 9.8 \times 13 \times 10^{-3} \times 240$$

= 30607.2 watts

P = 30.6072 Kilowatts

iii Power loss in transmission = Power of Reservoir − Power of Jet

= 30607.2 − 28314

$= 2293.2$ watts

Head loss in pipeline

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

$$= \frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}}$$

$h = 17.98m$

iv Efficiency $= \frac{\text{Power of Jet}}{\text{Power of reservoir}} \times 100\%$

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

$= 92.5\%$

5 Specific gravity $= 0.89$

$z = 30,000cm = 3000m$

Volumetric flowrate, $Q = 220$ litre/sec

$= 220 \times 10^{-3} m^3/sec$

Velocity of Jet $= 7m/sec$

The jet issuing from the nozzle will be at atmosphere pressure and at datum level, hence

$P = 0$ and $z = 0$

Density, ρ of oil $= 0.89 \times 1000 = 890$

$$P = PQ + \rho \frac{Qv^2}{2} + \rho g Q^2$$

$$= 0 \cdot Q + \frac{\rho Q v^2}{2} + \rho g \cdot Q \cdot 0$$

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

$$= \frac{890 \times 220 \times 10^{-3} \times 7^2}{2}$$

Power of Jet $= 4,797.1$ watts

$= 4.797$ Kilowatts

ii Power supplied from reservoir

Because the reservoir operates at an atmospheric pressure, $P = 0$ and $V = 0$

$$P = PQ + \rho \cdot \frac{Qv^2}{2} + \rho g Q z$$

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

$$P = \rho g Q z$$

$$= 890 \times 9.81 \times 220 \times 10^{-3} \times 3000$$

$= 5762394$ watts

$= 5762.394$ KW

iii Power loss in transmission = Power of Reservoir − Power of Jet

$= 5762.394 - 4797.1$

$= 5757596.9$ Watts

Head loss in pipeline

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

$$= \frac{5757596.9}{890 \times 9.81 \times 220 \times 10^{-3}}$$

$h = 2997.5$ m

iv Efficiency $= \frac{\text{Power of Jet}}{\text{Power of reservoir}} \times 100\%$

$$= \frac{4797.1}{5757396.9} \times 100\%$$

$= 0.083\%$

8. $d_1 = 300mm = 0.3m$ $P_2 = ?$

$d_2 = 150mm = 0.15m$ $P_1 = 400 kN/m^2 = 400 \times 10^3 N/m^2$

$Q = 40 lit/sec = \frac{40}{1000} = 0.04 m^3/sec$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.07069m$

$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.01767m$

$Q = A_1 V_1 = A_2 V_2$ $z_1 = 10m$

$V_1 = \frac{Q}{A_1} = \frac{0.04}{0.07069}$ $z_2 = 6m$

$= 0.566 m/s$

$V_2 = \frac{Q}{A_2} = \frac{0.04}{0.01767} = 0.2264 m/sec$

Applying Bernaulli's equation at section (1) and (2), we get

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$\frac{400 \times 10^3}{1000 \times 9.81} + \frac{(0.566)^2}{2 \times 9.81} + 10 = \frac{P_2}{1000 \times 9.81} + \frac{(0.2264)^2}{2 \times 9.81} + 6$$

$$40.775 + 0.0163 + 10 = \frac{P_2}{9810} + 2.55 \times 10^{-3} + 6$$

$$50.79 = \frac{P_2}{9810} + 6.0026$$

$$50.79 \times 9810 = P_2 + 6.0026$$

$$498249.9 = P_2 + 6.0026$$

$$498249.9 - 6.0026 = P_2$$

$$P_2 = 498243.90$$

$$= 498.24390 kN/m^2$$

10 Diff of mercury level, $x = 170mm = 0.17m$

Sp. gr. of mercury, $S_g = 13.6$

Sp. gr of Sea-water, $S_o = 1.026$

$$\therefore h = x\left[\frac{S_g}{S_o} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right]$$

$$= 2.0834m$$

$$V = \sqrt{2gh} = \sqrt{2\times 9.81\times 2.0834} = 6.393 m/s$$

$$= \frac{6.393\times 60\times 60}{1000} km/hr = 23.01 km/hr$$