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MATRIC: 18/26GC/004
DEPT: BIOMEDICAL

FLUID MECHANICS

1. Real flowrate = 10 dm^3/min.

$T = 12.5 Nm$

$\therefore = \frac{10 \times 10^{-3}}{60} = 1.67 \times 10^{-4} m^3/s$.

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

speed = 1500 rev/min = $\frac{1500 rev}{60}$ = 25 rev/s

For nominal displacement = $\frac{10 cm^3}{rev} = 1 \times 10^{-5} m^3/rev$

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

i) volumetric efficiency = $\frac{\text{Real flowrate}}{\text{Ideal flowrate}} \times 100\%$

$= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} = 66.8\%$

ii) Fluid power = $Q \cdot dp$

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

$= 200.4$ watts

iii) shaft power = $T \cdot \omega$

$\omega = 2\pi N = 2 \times \pi \times N$

$= 2 \times \pi \times 25$

$= 157.0796$

$\simeq 157.08$

$\therefore$ shaft power = 12.5×157.08

$= 1963.5$ watts

iv) overall efficiency:

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

$\frac{200.4}{1963.5} \times 100\% = 10.206 \simeq 10.21\%$

2.) pump delivery = 35 dm^3/min

$\frac{35 \times 10^{-3}}{60} = 5.833 \times 10^{-4}$

$P = 100bar = 100 \times 10^5 Nm^{-2}$

overall efficiency = 87%

Fluid power = $Q \cdot dp$

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

$= 5830$ watts

Recall,

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

$\therefore$ Shaft power = $\frac{\text{Fluid power} \times 100}{\text{overall efficiency}}$

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

$= 6701.149$ watts

3. Nominal displacement of 50 cm^3/rev

$= 50 \times 10^{-6} m^3/rev$

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

shaft power = 15kw = 15000 watts

Actual flowrate = 35 dm^3/min = $\frac{35 \times 10^{-3} m^3}{60}$

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

speed = 850 rev/min = $\frac{850}{60}$

$= 14.166 \simeq 14.17$ rev/s

Ideal flowrate = Nominal displacement × speed

$= 50 \times 10^{-6} m^3/rev \times 14.17$ rev/s

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

i) volumetric efficiency = $\frac{\text{Real flowrate}}{\text{Ideal flowrate}} \times 100\%$

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

$= 5830$ watts

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

$= 38.867\%$

4) $z = 2400cm = 24m$

volumetric flowrate, Q = 15 litres/sec

$= 0.015 m^3/sec$

Velocity = 66 m/sec

The general formula

$P = \rho g Q \left(\frac{P}{\rho g} + \frac{v^2}{2g} + z\right)$

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

But introducing here (power of jet)

pressure head = 0

$z = 0$

$\therefore P = \rho \frac{Qv^2}{2}$

and, $Q = 0.015$, $\rho = 1000$, $v = 66 m/s$

$P = \frac{1000 \times 0.015 \times (66)^2}{2}$

$P = 28314$ watts = 28.314 kilo watts

ii) power supplied from reservoir

At atmospheric pressure; $P = 0$ and $v = 0$

$\therefore P = \rho g Q z$.

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

$= 30607.2$ watts

$\simeq 30.607$ kilowatts

iii) power loss in transmission,

= power of reservoir − power of jet

$= (30607.2 - 28314)$.

$\simeq 2.2932$ kilowatts

$\simeq 2.2932$ kilowatts

Head loss in pipeline − 2.2932 kwatts

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

$= \frac{2293.2}{1000 \times 9.81 \times 0.013}$

$= \frac{2293.2}{1000 \times 9.81 \times 0.013}$

$= \frac{2293.2}{127.53}$

$h = 17.98m$

Efficiency = $\frac{\text{power of jet}}{\text{power of reservoir}} \times 100\%$

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

$= 92.51\%$

5) Sg of oil = 0.89

$z = 30,000cm = 300m$

Q = 220 l/sec = 0.22 m^3/sec.

v = 7 m/sec.

Introducing $z = 0$, pressure = 0

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

but, $Sg = 0.89$

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

$\therefore x = 890$

$\therefore \rho = x = 890$

$P = \frac{890 \times 0.22 \times (7)^2}{2}$

$P = 4797.1$ watts

ii) power supplied from reservoir

$P = \rho g Q z$

$P = 890 \times 9.81 \times 0.22 \times 300$

$P = 576237.4$ watts

$\simeq 576.2374$ kilowatts

iii) power loss in transmission

= power reservoir − power of jet

$= (576.237.4 - 4.7971)$ kilowatt

$= 571442.3$ watts

$= 571.4423$ kilowatt

Head used to overcome losses

$= \frac{571442.3}{890 \times 9.81 \times 0.22}$

$= 297.51m$

iv) efficiency = $\frac{\text{power of jet}}{\text{power of Reservoir}} \times 100\%$

$= \frac{4797.1 \times 100\%}{571442.3}$

$= 0.83\%$

6) $P = \rho g Q z$

$z = 20m - h$

$\rho = 1000$

$g = 9.81$

$Q = vA$

$d = 10cm = 10 \times 10^{-2} m$

$A = \frac{\pi d^2}{4} = 7.85 \times 10^{-3} m^2$

But we need the velocity at height of initial velocity using one of the equation of motion,

$v = 0$

$v^2 = u^2 - 2gh$

$u = \sqrt{v^2 + 2gh}$

$u = \sqrt{0^2 + 2 \times 9.81 \times 20}$

$u = \sqrt{392.4}$

$u = 19.809 \simeq 19.81 m/s$

The velocity = 19.81

$\therefore Q = vA$

$= 19.81 \times 7.85 \times 10^{-3}$

$= 0.15558 m^3/s$

Then;

$P = \rho g Q z$

$= 1000 \times 9.81 \times 0.156 \times 20$

$P = 30510 = 2077$ watts

$\simeq 30.5$ kilowatts

9) $d_1 = 300mm = 0.3m$

$d_2 = 150mm = 0.15m$

$\therefore A_1 = 0.07069 m^2$

$A_2 = 0.0177 m^2$

Q = 40 lit/sec = 0.04 m^3/sec

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

$P_1 = 400 kN/m^2$, $P_2 = ?$

$\frac{P_1}{\rho g} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{v_2^2}{2g}$

But, $Q = A_1 V_1$

$\therefore V_1 = \frac{Q}{A_1} = \frac{0.04}{0.07059}$

$V_1 = 0.5658 \simeq 0.57 m/s$

then $V_2 = \frac{Q}{A_2} = \frac{0.04}{0.0177}$

$V_2 = 2.2598 \simeq 2.26 m/s$

$\frac{P_1}{\rho g} (z_1 - z_2) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) = \frac{P_2}{\rho g}$

$\frac{400kN}{9.81kN} + (10 - 6) + \left(\frac{0.57^2 - 2.26^2}{2 \times 9.81}\right) = \frac{P_2}{9.81kN}$

$40.77 + 4 + (-0.2438) = \frac{P_2}{9.81kN}$

$44.52 \times 9.81 = P_2$

$P_2 = 436.74 kN$

10. Reading of manometer = 170mm

$= 0.17m$

specific gravity of mercury = 13.6

" " seawater = 1.026

$y = 0.17m$

For $h = y\left(\frac{S_{H}}{S_L} - 1\right)$

$= 0.17\left(\frac{13.6}{1.026} - 1\right)$

$= 0.17 \times 12.255$

$= 2.0834m$

Recall $v = \sqrt{2gh}$

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

$v = \sqrt{40.87}$

$v = 6.393 m/s$