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ASSIGNMENT III

1\. Actual Flow rate = $10\, dm^3/min$

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

$1000\, dm^3 = 1 m^3$

$10\, dm^3 = x$

$1000 = 10$

$x = 0.01\, m^3/min$

Convert from m^3/min to m^3/sec

$60 sec = 1 min$

$x = 0.01$

$x = \frac{0.01}{60}$

$Q = 1.67 \times 10^{-4}\, m^3/sec$

Speed, N = 1500 rev/min

$= \frac{\cancel{1500}^{5}}{\cancel{60}_{3}}$

$= 25\, rev/Sec$

$= 25\, rps,$

Pressure, dp = 12bar

$1 bar = 1 \times 10^5\, N/m^2$

$12 bar = x$

$x = 12 \times 10^5\, N/m^2$

$dp = 12 \times 10^5\, N/m^2$

Nominal displacement = $10 cm^3/rev$

$100^3 cm^3 = 1 m^3$

$10 cm^3 = x$

$x = \frac{10}{1{,}000{,}000}$

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

Ideal Flowrate = nominal displacement x Speed

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

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

i) Volumetric Efficiency: $\frac{\text{Actual Flowrate}}{\text{Ideal Flow rate}} \times 100\%$

$\frac{\cancel{0.01}}{\cancel{2.5 \times 10^{-4}}} \cancel{\times 100}$ $\frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100$

$= 66.8\%$

ii) $P_F = Q \times dp$

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

$= 200.4$ Watts

iii) Shat Power: $T \times w$

where T = 12.5 N/m (Torque input)

$W = \frac{\cancel{2\pi N}}{\cancel{60}}$ (Angular Speed) = $2\pi N$

$W = 2 \times \frac{22}{7} \times 25 = 157.14\, rps.$

Shaft Power = 12.5×157.14

$= 1964.25$ Watts

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

$= \frac{200.4}{1964.25} \times 100\%$

$= 10.2\%$

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Solution

$\partial P = 100$ bar

$1\text{bar} = 1 \times 10^5 \, N/m^2$

~~δp~~ ~~1b~~ $100 = x$

$\partial p = 100 \times 1 \times 10^5 \, N/m^2$

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

Actual Flow rate, $Q = 35 dm^3/min$

$1000 dm^3 = 1 m^3$

$35 dm^3 \overset{\times}{=} x$

$x = \frac{35}{1000}$

$x = 0.035 \, m^3/min$

Convert m^3/min to m^3/sec

$60 secs = 1 min$

$0035 \overset{\times}{=} x$

$\frac{0.035}{60}$

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

$P_F = Q \cdot \partial P$

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

= ~~5/8~~ 5830 Watts

Shaft Power!

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

~~Shaft Power = Overall Efficiency / Fluid Power~~

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

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

$= 6701.15$ Watts or $\simeq 6.701 \times 10^3$ Watts

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3. Actual Flowrate = $35 dm^3/min$

$1000 dm^3 = 1m$

$35 dm^3 = x$

$$x = \frac{35}{1000} = 0.035 m^3/min$$

Convert from m^3/min to m^3/sec

60sec = 1min

$$x = \frac{0.035}{60}$$

$x = 5.83 \times 10^{-4}$

$Q = 5.83 \times 10^{-4}$

Speed = 850rpm

60sec - 1min

$$\frac{850}{60}$$

= 14.17rps

Pressure = 100bar

$1 bar = 1 \times 10^5 N/m^2$

100 bar = x

$x = 100 \times 10^5 Nm^2$

$\delta p = 100 \times 10^5 Nm^2$

Nominal Displacement = $50 cm^3/rev$

$$x = \frac{50}{1000000}$$

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

Ideal flow rate = nominal displacement × Speed

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

$= 7.085 \times 10^{-4}$

P_F = 5830 Watts

Shaft Power = 15 Kilowatts

1 Kilowatts = 1000watts

15 Kilowatts = x

$x = 15 \times 1000$

x = 15000 Watts

i) Overall Efficiency =

$$\frac{\text{Fluid Power}}{\text{Shat Power}} \times 100\%$$

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

= 38.87%

ii) Volumetric Efficiency =

$$\frac{\text{Actual Flowrate}}{\text{Ideal Flow rate}} \times 100\%$$

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

= 82.3%

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$z = 24000$

$100\text{cm} = 1\text{m}$

$24000 = x$

$24000 = 100x$

$$x = \frac{24000}{100}$$

$x = 240\text{m}$

Volumetric Flowrate = 13 Litres/sec

1 Litres : 1000m

13 Litres = x

$$x = \frac{13}{1000}$$

$= 0.013\text{m/s}$

Velocity of Jet = 66m/s , Density of Water = 1000Kg/m³

The jet issuing from the nozzle will be at atmospheric Pressure at datum level $P = 0, Z = 0$

i) Introducing $P = 0$ & $Z = 0$ into the equation

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

$$\cancel{P} = \cancel{0 \times Q + \frac{\rho Q V^2}{2}} + \cancel{\rho}$$

$$P = 0 \times 0.013 + \frac{1000 \times 0.013 \times (66)^2}{2} + 1000 \times 9.81 \times 0.013 \times 0$$

$$P = \frac{1000 \times 0.013 \times (66)^2}{2} = 28314 \text{ Watts}$$

$\simeq 28.314$ KiloWatts

ii) Power Supplied from reservior

Because the reservior operates at an atmospheric pressure, $P = 0$ & $V = 0$. ∴ Introduce $P = 0$ & $V = 0$ to the equation

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

$$P = 0 \times 0.013 + \frac{1000 \times 0.013 \times (0)^2}{2} + 1000 \times 9.81 \times 0.013 \times 240$$

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

$= 30607.2$ Watts

$\simeq 30.6072$ KiloWatts

ii) Head used to overcome losses

$$H = \frac{\text{Power loss in Transmission}}{\rho g Q}$$

Power loss in Transmission = Power from reservior − Power of Jet

$30.6072 - 28.314$

$= 2.293$ Watts

$$∴ H = \frac{2.293}{1000 \times 9.81 \times 0.013}$$

$$= \frac{2.293}{127.53} = 0.0179\text{m}$$

iv) Transmission Efficiency

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

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

$= 92.5\%$

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5. $z = 30000cm$

$100cm = 1m$

$30000 = x$

$30000 = 100x$

$$x = \frac{3000\cancel{0}}{10\cancel{0}}$$

$x = 300m$

Volumetric Flowrate = 220litres/sec

$1 \text{ litres} = 1000m$

$220 \text{ litres} = x$

$$x = \frac{22\cancel{0}}{100\cancel{0}}$$

$Q = 0.22m/s$

Velocity of jet = 7m/sec

Specific gravity of oil = 0.89

i. Power of Jet

The jet issuing from the nozzle will be at atmospheric Pressure at datum level $P=0, Z=0$

Introducing $P=0$ & $Z=0$ into the equation

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

$$P = 0 \times 0.22 + \frac{0.89 \times 0.22 \times (7)^2}{2} + 0.89 \times 9.81 \times 0.22 \times 0$$

$$P = \frac{0.89 \times 0.22 \times 49}{2}$$

$P = 4.7971$ Watts

$P = 4.7971 \times 10^{-3}$ KiloWatts

ii) Power Supplied from reservior

Because the reservior operates at an atmospheric pressure, $P=0$ & $V=0$.

$\therefore$ Introduce $P=0$ & $V=0$ to the equation.

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

$$P = 0 \times 0.22 + \frac{0.89 \times 0.22 \times (0)^2}{2} + 0.89 \times 9.81 \times 0.22 \times 300$$

$P = 0.89 \times 9.81 \times 0.22 \times 300$

$P = 576.2$ Watts

$P = 576.2 \times 10^{-3}$ Kilowatts

iii) Head loss in reservior

$$H = \frac{\text{Power loss in Transmission}}{\rho g Q}$$

Power loss in Transmission = Power from reservior − Power of Jet

$576.2 \times 10^{-3} - 4.7971 \times 10^{-3}$

$= 0.571$ Watts

$$H = \frac{0.571}{0.89 \times 9.81 \times 0.22}$$

$H = 0.297m$

iv Transmission Efficiency

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

$$\frac{4.7971 \times 10^{-3}}{576.2 \times 10^{-3}} \times 100\%$$

$= 82.7\%$

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6 $\mathcal{E} = mgh$

$t = \sqrt{\frac{20 \times 2}{g} \times 4.07s}$

$$P = \frac{\pi \times 0.05^2 \times 20 \times 1000 \times 9.81 \times 20}{4.07} = 7558.4W$$

7 $P_g = 19.62N/m^2$

$c_d = 0.96$

$\delta_1 = 0.3m \quad \delta_2 = 0.2m$

$V_1 = Q_1 = 0.0707 \quad V_2 = Q_2 = 0.0314$

$P_1 + P_g Qz = P_2 + P_g g(z_2 - z_1) + P_w g R_1$

$P_1 - P_2 = 19.62(z_2 - z_1) + 587.423 \cdots Q_1$

For the Ventirimeter

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

$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803 V_2^2 \cdots Q_2$

Combine Q & Q_2

$0.803 V_2^2 = 587.423$

V^2 ideal = 27.47m/s

Q ideal $= 27.047 \times \pi \left(\frac{0.2}{2}\right)^2$

$= 0.85 m^3/s$

$Q = c_d \, Q_{ideal} = 0.96 \times 0.85 = 0.816 m^3/s$

8. $\delta_1 = 0.152m \qquad A_1 = 0.01814m$

$\delta_2 = 0.076m \qquad A_2 = 0.00454m$

$P = 300Kg/m^3$

$c_d = 0.97$

Apply Bernoullis Method

$$\frac{P_1}{P_g} + \frac{V^2}{2g} + z_1 = \frac{P_2}{P_g} + \frac{V_2^2}{2g} + z_2$$

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

$Q = V_1 A_1 = V_2 A_2$

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$V_2 = \frac{V_1A_1}{A_2} = V_1A$

$V = \frac{\sqrt{0.914\times2\times9.81}}{15}$

$= 1.0934 m/s$

$Q = CdA_1V_1$

$Q = 0.96\times0.01814\times1.0984$

$= 0.019 m^3/s$

$A_1V_1 = A_2V_2 =$ 40 Litres/sec $= 40\times10^{-3}$ m/sec

$V_1 = \frac{40\times10^{-3}}{0.707}$

$= 0.566 m/s$

$V_2 = \frac{40\times10^{-3}}{0.01767}$

$= 2.264 m/s$

$$\frac{400\times10^3}{9800} + \frac{(0.566)^2}{2\times9.8} + 10 = \frac{P_2}{w} + \frac{(1.274)^2}{2\times9.8} + 6$$

$P_2 = 436.8 KN/m^2$

10. Reading of the Manometer = 170mm

Specific gravity of Mecury = 13.6

Specific gravity of Water = 1.026

$h = y\left(\frac{S.g \text{ of Mercury}}{S.g \text{ of Water}} - 1\right)$

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

$h = 2.083$

Velocity of Submarine

$V = \sqrt{2gh}$

$\sqrt{2\times9.81\times2.083}$

$= 6.39 m/s$

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