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Assignment

i) Ideal flow rate = Nominal displacement x speed
$= 10cm^3/rev \times 1500rpm$
$= 15000cm^3/min = 15dm^3/min$

Volumetric efficiency = Actual flow/ideal flow
$= \frac{10}{15} = 0.667 = 66.7\%$

ii) $Q = \frac{10 \times 10^{-3}}{60} = 16.7 \times 10^{-5} m^3/s$

$\Delta P = 12 \times 10^5 N/m^2$

iii) Fluid power $= \Delta P \times Q = 16.7 \times 10^{-5} m^3/s \times 12 \times 10^5 N/m^2$
$= 200$ watts

iv) Shaft power $= \frac{2\pi NT}{60} = \frac{2\pi \times 1500 \times 12.5}{60}$
$= 1963.5$ watts

v) Overall efficiency $= \frac{F.P}{S.P} = \frac{200}{1963.5}$
$= 0.102 = 10.2\%$

2) ~~Shaft power = $\frac{2\pi NT}{60}$~~ Fluid power $= \Delta p \times Q$

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

$= 58.3 \times 10^{-5} m^3/sec$

Fluid power $= 58.3 \times 10^{-5} \times 100 \times 10^5$
$= 5830$ watts

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

$0.87 = \frac{5830}{\text{Shaft power}}$

Shaft power = $\frac{5830}{0.87}$ = 6701.14 watts

3) Ideal flow rate = Nominal displacement × speed

= $50 cm^3$ (rev × 850 rpm)

= $42500 cm^3/min$ = $42.5 dm^3/min$

Volumetric efficiency = $\frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{35}{42.5}$

= 0.8235 = 82.35%

ii) $Q = \frac{35 \times 10^{-3}}{60} = 58.3 \times 10^{-5} m^3/s$

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

fluid power = $\Delta p \times Q$ = $58.3 \times 10^{-5} \times 100 \times 10^5$

= 5830 watts

Shaft power = 15000 watts

Overall efficiency = $\frac{\text{fluid power}}{\text{shaft power}} = \frac{5830}{15000}$

= 0.3886 = 38.86%

4) Power of jet = $\frac{1}{2} m v_{jet}^2$

= $\frac{1}{2} \rho Q v_{jet}^2$

= $\frac{1}{2} \times 1000 \times 0.013 \times 66^2$

= 28314 watts

= 28.314 kilowatts

b) Power supplied by reservoir = mgh

= $\rho Q g h$

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

= 30607.2 watts

= 30.6072 kilowatts

c) Heat used to overcome losses = $H - \frac{v_{jet}^2}{2g}$

= $240 - \frac{66^2}{2 \times 9.81}$

= 17.98m

d) Efficiency of pipeline and nozzle = $\frac{\text{fluid}}{\text{Power supplied by reservoir}} \times 100$

$= \frac{23.314}{80.6092} \times 100$

$= 92.51\%$

e) Power of jet = $\rho g Q H$

and $\rho = 0.89 \times 1000 \ kg/m^3$

$g = 9.81 \ m/s^2$

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

$H = Z_2 + \frac{P}{\rho g} + \frac{V^2}{2g}$

$H = 0 + \frac{0}{\rho g} + \frac{(7^2)}{2 \times 9.81}$

$H = \frac{49}{19.62} = 2.497 J$

Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 2.497$

$= 4797.1$ watts

Power supplied from reservoir

$H = Z_1 + \frac{P}{\rho g} + \frac{V^2}{2g}$

$= 300 + \frac{0}{\rho g} + \frac{0}{2g}$

$= 300 J$

Power $= 890 \times 9.81 \times 220 \times 10^{-3} \times 300$

$= 576239.4 \ kgm/s$

Head used to overcome the loss = $\frac{\text{Power loss}}{\rho g Q}$

$= \frac{576239.4 - 4797.1}{1000 \times 9.81 \times 220 \times 10^{-3}}$

$= \frac{571442.3}{2158.2}$

$= 264.78$

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

$= \frac{4797.1}{576239.4} \times 100$

$= 0.832\%$

6) Power = $\frac{\text{Work done}}{\text{time}}$

Work = $\frac{mgh}{\text{time}}$

$\dot{m} = \rho \times v$

$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 20}$

$= 19.7989 m/s$

$P = \rho \pi w^2 \frac{vgh}{t}$

$= 1000 \times \left(\frac{10 \times 10^{-2}}{2}\right) \times 19.7989 \times 9.8 \times 20$

$= 1000 \times \pi \times 2.5 \times 10^{-3} \times 19.7989 \times 9.8 \times 20$

$= 30478.03 w$

7) ~~[illegible]~~ $A_2 = \frac{\pi}{4} \times 0.2^2$

$= 0.031416 m^2$

density of gas $= \frac{19.62}{9.81} = 2 kg/m^3$

Pizzometric head difference $= x\left(\frac{S_m}{S_g} - 1\right)$

$= 0.06 \times \left(\frac{1000}{2} - 1\right)$

$h = 29.94$

Volumetric flow rate $= C_d \cdot \frac{A_1 \cdot A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$= \frac{0.96 \times 0.070685 \times 0.031416 \times \sqrt{2 \times 9.81 \times 29.94}}{\sqrt{0.070685^2 - 0.031416^2}}$

$= 0.81599 m^3/s$

8) $A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} \times 0.152^2$

$= 0.018146 m^2$

$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4} \times 0.076^2$

$= 4.5365 \times 10^{-3} m^2$

i) $Q = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$= \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 0.914}}{\sqrt{0.018146^2 - (4.5365 \times 10^{-3})^2}}$

$Q = 0.01924 m^3/s$

ii) $h = \frac{P_1 - P_2}{\rho g} = \frac{15170}{0.8 \times 10^3 \times 9.81}$

$= 1.933 m$

$Q = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$Q = \frac{0.97 \times 0.018146 \times 4.5365 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 1.933}}{\sqrt{0.018146^2 - (4.5365 \times 10^{-3})^2}}$

$Q = 0.02798 m^3/s$

9) $A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} \times 0.3^2$

$= 0.0707 m^2$

$A_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4} \times 0.15^2$

$= 0.0177 m^2$

$Q = \frac{40l}{5}$

$= 40 \times 10^{-3} m^3/s$

$Q = VA$

$V_1 A_1 = Q_1$

$\therefore 40 \times 10^{-3} = V_1 \times 0.0707$

$\frac{40 \times 10^{-3}}{0.0707} = V_1$

$V_1 = 0.5658 m/s$

$Q = V_2 A_2$

$40 \times 10^{-3} = V_2 \times 0.0177$

$\frac{40 \times 10^{-3}}{0.0177} = V_2$

$V_2 = 2.2599 \, m/s$

$$Z_1 + \frac{P_1}{w} + \frac{V_1^2}{2g} = Z_2 + \frac{P_2}{w} + \frac{V_2^2}{2g}$$

$$Z_1 + \frac{P_1}{\rho g} + \frac{V_1^2}{2g} = Z_2 + \frac{P_2}{\rho g} + \frac{V_2^2}{2g}$$

$$10 + \frac{400000}{9.81 \times 1000} + \frac{(0.5658)^2}{2 \times 9.81} = 6 + \frac{P_2}{9.81 \times 1000} + \frac{2.2599}{2 \times 9.81}$$

$$50.79 = \frac{P_2}{9.81 \times 1000} + 6.260303$$

$$\frac{P_2}{9.81 \times 1000} = 50.79 - 6.260303$$

$P_2 = 9.81 \times 1000 \times 44.53$

$P_2 = 436836.326 \, N/m^2$

(c) $h = y\left(\frac{S_m}{S_f} - 1\right)$

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

$h = 2.0834$

$V = \sqrt{2gh}$

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

$= 6.393 \, m/s$