Actual Rate = $10 dm^3/min = 0.01 m^3/min = 1.67 \times 10^{-4} m^3/s$

Pressure = 12 bar = 12×10^5 N/m

N = 1500 rev/min

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

Torque = 12.5 N/m

i Volumetric E = $\frac{\text{actual}}{\text{Ideal}} \times 100$

Ideal = speed × nominal display

$= 1500 \times 1 \times 10^{-5} = 0.015 m^3/min$

$\frac{0.01}{0.015} \times 100$

$= 66.67\%$

ii Fluid Power = fluid Rate × P

$= 1.67 \times 10^{-4} \times 12 \times 10^5 = 200.4$ Nm/s

iii Shaft Power = T × ω

$= 12.5 \times 2\pi \, N/60$

$= 12.5 \times 2 \times \pi \times 1500/60$

$= 1963.5$ Nm/s

iv OE = $\frac{\text{fluid Power}}{\text{Shaft Power}} \times 100$

$\frac{\text{Shaft Power}}{1963.5} = \frac{200.4}{1963.5} \times 100$

$= 10.19\%$

(2) Shaft Power = $\frac{100 \times \text{fluid Power}}{OE}$

$= \frac{100 (5.83 \times 10^{-4} \times 100 \times 10^5)}{87} = 6704.98$ Watt

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Mechatronics

18/ENG05/026

3 Actual flow rate = $35 dm^3/min = 0.035 m^3/min$

$N = 850 rev/min$

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

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

$$OE = \frac{\text{fluid power}}{\text{Shaft Power}} = \frac{100 \times 10^5 \times 0.035/60}{15 \times 10^3} = 38.89\%$$

$$VE = \frac{\text{Actual Rate}}{\text{Ideal Rate}} \times 100$$

Ideal = nominal displacement x speed

$= 50 \times 10^{-6} m^3/rev \times 850 rev/min$

$= 0.0425$

$$VE = \frac{0.035}{0.0425} \times 100 = 82.35\%$$

4i. Vol flow rate = 13l/s

$Q = 13/1000 = 13 \times 10^{-3} m^3/s$

$Z = 0 = P$

$$P = \frac{\rho Q \cdot v^2}{2} = \frac{1000 \times 13 \times 10^{-3} \times 66^2}{2} = 28314 Nm/s$$

ii $P = 0, V = 0$

$P = \rho g Q z = 1000 \cdot 9.81 \times 13 \times 10^{-3} \times 240$

$= 30607.2 Nm/s$

iii $\quad Loss = P_{reservoir} - P_{jet}$

$= 30607.2 - 28314$

$= 2293.2 Nm/s$

iv $\quad \eta_{ff} = \frac{P_{jet}}{P_{reservoir}} \times 100$

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

$= 92.5\%$

5: $\quad s.g = 0.89 \quad Q = 220 Lt/sec \quad V_{jet} = 7 m/s \quad z = 30000 cm = 300 m$

$P_{jet} = \frac{1}{2} \times \rho \times Q \times V^2$

$= \frac{1}{2} \times (0.89 \times 10^3) \times 0.22 \times 7^3$

$P = 4797.1 watt$

ii $\quad P_{resvr} = \rho g Q z$

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

$= 576239.4 kWatt$

iii $\quad$ Power loss $= P_{reservoir} - P_{jet}$

$= 576239.4 - 4797.1$

$= 571442.31 Watt$

iv $\quad \eta_{ff} = \frac{P_{jet}}{P_{reservoir}} \times 100$

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

$= 0.83\%$

6 $h = 20m$ diameter $= 10cm$ $P = ?$ $g = 9.81$

$P = \rho g h$ force x velocity

Velocity $= \sqrt{2gh}$

$= \sqrt{2 \times 9.81 \times 20} =$

$= 19.809$

$A = \frac{\pi d^2}{4} = \frac{\pi 0.1^2}{4} = 7.8539 \times 10^{-3}$

force $= mg = \rho V g = \rho A h g$

$= 1000 \times 7.8539 \times 10^{-3} \times 20 \times 9.81 = 1540.95$

$P = 1540.95 \times 19.809 = 30524.7$ Watt

7 $d_1 = 0.3m$ $d_2 = 0.2$ $Cd = 0.96$ $s.w = 19.62 N/m^3$ $y = 0.06m$

Using bernoulli's theorem

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

$P_1 - P_2 = 19.62(Z_2 - Z_1) + 0.803 u_2^2 \quad - x$

In manometer

$P_1 + \rho g g z = P_2 + \rho g g (z_1 - R) + \rho v g P$

$P_1 - P_2 = 19.62 (z_2 - z_1) + 587.425 \quad - xx$

Comparing x and xx; $0.803 u_2^2 = 587.423$

$\therefore u_2 = 27.05 m/s$

$Q_2 = 27.05 \times 3.14 \times \left(\frac{0.2}{2}\right)^2 = 0.85 m^3/s$

$Q_1 = cd Q_2 = 0.96 \times 0.85 = 0.816 m^3/s$

8 $d_2 = 0.076m$ $d_1 = 0.152m$ $r.d = 0.8$ $(z_1 - z_2) = 0.914m$ $Cd = 0.97$

a) $P_1 = P_2$ $\qquad A = \frac{\pi d^2}{4}$

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

$$h = \left(\frac{P_1}{\omega} - \frac{P_2}{\omega}\right) + (z_1 - z_2)$$

$h = 0.914$

$$Q = 0.97 \times \frac{\left(\frac{\pi \times 0.076^2}{4}\right) \times \left(\frac{\pi \times 0.152^2}{4}\right)}{\sqrt{\left(\frac{\pi 0.152^2}{4}\right)^2 - \left(\frac{\pi 0.076^2}{4}\right)^2}} \times \sqrt{2 \times 9.81 \times 0.914}$$

$$= \frac{0.97 \times (4.54 \times 10^{-3}) \times 0.018}{\sqrt{(0.018)^2 - (4.54 \times 10^{-3})^2}} \times 4.23$$

$$= \cancel{1.105}\ 0.97 \times 4.691 \times 10^{-3} \times 4.23 = \underline{0.019 m^3/s}$$

b) $\frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 15170 N/m^2$

$h = 0.914 + 15170$

$= 15170.914$

$$Q = 0.97 \times \frac{4.54 \times 10^{-3} \times 0.018}{\sqrt{(0.018)^2 - (4.54 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 15170.914}$$

$= 0.97 \times 4.691 \times 10^{-3} \times 545.58 = \underline{2.4823 m^3/s}$

9 $b_1 = 300mm$, $A = \frac{\pi d^2}{4} = 0.0707m^3$ $D_2 = 150mm$ $A = 0.01767m^2$

$P_1 = 400KN/m$ $P_2 = ?$ $z_1 = 10$, $z_2 = 6m$ $Q = 40lt/s = 0.04m^3/sec$

$Q = AV$

from continuity eqn

$A_1V_1 = A_2V_2$

$\therefore V_1 = Q/A_1 = 0.566m/s$ $V_2 = 2.264m/s$

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

$$= \frac{400}{9.81} + \left(\frac{0.566^2}{2\times9.81} - \frac{2.264^2}{2\times9.81}\right) + (10-6)$$

$$\frac{P_2}{\omega} = 44.525m$$

$P_2 = 44.525 \times 9.81$

$= 436.8KN/m^2$

10 Speed/velocity $= \sqrt{2gh}$

$h = y\left(\frac{S_{mec}}{S_g} - 1\right)$

$= 0.17\left(\frac{13.6}{1.026} - 1\right) = 2.0834$

$\therefore V = \sqrt{2\times9.81\times2.0834}$

$= 6.39m/s$