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18/ENG05/007 -- Mechatronics Engineering

1) Flow rate = 10 dm³/min
Pressure = 12 bar
Nominal displacement = 10 cm³/
Speed = 1500 rev/min
Torque input = 12.5 N/m
Ideal flowrate = Nominal displacement × Speed
= 10 × 1500 cm³/min
= 15 dm³/min

(i) Volumetric Efficiency

$= \frac{\text{Actual Flow}}{\text{Ideal Flow}} = \frac{10}{15} = 0.667 = 66.7\%$

(ii) Fluid Power = $\Delta T \times Q$

where $Q = \frac{10 \times 10^{-3}}{60}$ m³/sec

$= 1.67 \times 10^{-2}$ m³/sec

and $\Delta T = 12.5 \times 10^{3}$ N/m²

Fluid Power $= (1.67 \times 10^{-2})(12.5 \times 10^{3})$

$= 200.4$ W

Shaft Power $= 2\pi NT/60 = \frac{2 \times \pi \times 1500 \times 12.5}{60} = 1963.5$ W

Overall Efficiency $= \frac{Fp}{Sp} = \frac{200.4}{1963.5} = 0.102 = 10.2\%$

2) Overall Efficiency = 87% — where $Q = \frac{35 \times 10^{-3}}{60} = 5.83 \times 1$

where $0.E = \frac{Fp}{Sp}$; $0.87 = \frac{\Delta P \times Q}{Sp}$; $Sp = \frac{100 \times 10^{-5}(5.83 \times}{0.87}$

$Sp = 6.7$ W

N.D = 50 cm³/rev = 50×10^{-5} m³/rev

P = 100 bar = 100×10^{5} N/m² ; Speed = 850 rev/min = $\frac{850}{60}$

S.P = 15 KW = 15000 W

Flowrate = 35 dm³/min $= \frac{35 \times 10^{-3}}{60} = 5.83 \times 10^{-4} \frac{m^3}{s}$

Using $Q = \frac{C_d\sqrt{2gh} \cdot A_1 A_2}{\sqrt{A_1^2 - A_2^2}} = \frac{0.95 \times \sqrt{2 \times 9.81 \times 2208} \times (3.142 \times 0.785)}{\sqrt{(3.142)^2 - (0.785)^2}}$

$Q = \frac{503.096}{1000} cm^2/s = 0.503096$ Lit/sec //

(3) $d_1 = 30cm$, $A_1 = \pi d_1^2/4 = \frac{\pi(30^2)}{4} = 706.95 cm^2$

$d_2 = 15cm$, $A_2 = \pi d_2^2/4 = \pi(15^2)/4 = 176.73 cm^2$

s.g oil = 0.9 ; s.g Hg = 13.6 ; $C_d = 0.64$, Differential manometer reading, x = 50cm of reading

Differencial head, $h = x\left(\frac{S.g_{Hg}}{S.g_{oil}} - 1\right)$

$h = 50\left(\frac{13.6}{0.9} - 1\right) = 705.56cm$

9.87216
0.61675
9.255935

$Q = \frac{C_d\sqrt{2gh}\, A_1 \times A_2}{\sqrt{A_1^2 - A_2^2}} = \frac{0.64 \times \sqrt{2 \times 9.81 \times 705.56} \times 706.95 \times 176.73}{\sqrt{706.95^2 - 176.73^2}}$

$= \frac{13744.21}{1000} cm^3/s = 13.744$ Lit/sec //

(4) Difference of mercury, $x = 170mm = 170 \times 10^{-3} = 0.17m$

s.g mecury = 13.6 ; s.g Seawater = 1.026

speed, $v = \sqrt{2gh}$ where $h = x\left(\frac{S.g_{Hg}}{S.g_{sea\ water}} - 1\right)$

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

Recall $v = \sqrt{2gh}$

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

From m/s to km/min $= \frac{6.393 \times 1000}{60} = 106.55$ km/min //

(3) $Q = 0.05\,m^3/min = 50\,dm^3/min$

$P_s = 15\,bar = 15 \times 10^5\,Nm^{-2}$

Speed $= 1700\,rev/min$

$N \cdot D = 10\,cm^3/rev$

$T = 15\,Nm$

(i) $V \cdot E = \dfrac{\text{Actual Flow rate}}{\text{Ideal Flow rate}} = \dfrac{0.05}{\quad}$

where Ideal Flow rate $= N \cdot D \times$ Speed

$= 10\,cm^3/rev\,(1700\,rev/min)$

$= 17000\,cm^3/min = 0.17\,m^3/min$

$V \cdot E = \dfrac{0.05}{0.17} = 2.94\%$

(ii) $F \cdot P = P \times Q = (15 \times 10^5)(0.05\,m^3/min)$

$Q = 0.05\,m^3/min = \dfrac{0.05}{60} = 8.33 \times 10^{-4}\,m^3/s$

$\therefore F \cdot P = (15 \times 10^5)(8.33 \times 10^{-4}) = 1249.5W$

(iii) $S \cdot P = \dfrac{2 \pi N T}{60} = \dfrac{2 \times \pi \times 1700 \times 15}{60} = 2670.35W$

(iv) $O \cdot E = \dfrac{F \cdot P}{S \cdot P} = \dfrac{1249.5}{2670.35} = 0.468$

$= 46.8\%$