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18/ENG06/043

Mechanical Engineering

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1) $l = 2m$

Velocity flow rate at smaller end, $V_1 = 5m/s$

" " " " larger ", $V_2 = 2m/s$

Pressure head at small end, $P_s = 2.5m$

Loss of head, $H_L = \frac{0.35(V_1 - V_2)^2}{2g}$

$= \frac{0.35 \times 9}{2 \times 9.81} = 0.161m$

Applying Bernoulli's eqn.

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

$Z_1 = 2$ and $Z_2 = 0$

$$2.5 + \frac{5^2}{2 \times 9.81} + 2 = P_2 + \frac{2^2}{2 \times 9.81} + 0.161$$

$$4.5 + \frac{25}{19.62} = P_2 + \frac{4}{19.62} + 0.161$$

$$P_2 = \left(4.5 + \frac{25}{19.62}\right) - \left(\frac{4}{19.62} + 0.161\right)$$

$$P_2 = 5.774 - 0.365$$

$$= 5.409m \text{ of fluid}$$

2) $D_1 = 20cm$

$D_2 = 10cm$

$A_1 = \frac{\pi \times 20^2}{4} = 314.16cm^2$

$A_2 = \frac{\pi \times 10^2}{4} = 78.54cm^2$

Inlet pressure $= 17.658\ N/cm^2 = 17.658 \times 10^4\ N/m^2$

Density of water $= 1000\ kg/m^3$

$\frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18m$

$\frac{P_2}{\rho g} = -30cm$ of mercury, $s.g_{Hg} = 13.6$

$\frac{P_2}{\rho g} = -30 \times 10^{-2} m \times 13.6 = -4.08m$

$h = \frac{P_1}{\rho g} - \frac{P_2}{\rho g}$

$= 18 - (-4.08)$

$= 22.08m = 2208cm$

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

$= \frac{0.98 \times \sqrt{2 \times 9.81 \times 2208} \times 314.16 \times 78.54}{\sqrt{314.16^2 - 78.54^2}}$

$= \frac{0.98 \times 208.137 \times 314.16 \times 78.54}{304.184}$

$= 16,545.534$

$Q = \frac{16545.534}{1000} = 16.546$ litr/sec

8) $d_1 = 30cm$

$A_1 = \frac{\pi \times 30^2}{4} = 706.86cm^2$

$d_2 = 15cm$

$A_2 = \frac{\pi \times 15^2}{4} = 176.72cm^2$

S.g of oil = 0.9

S.g of mercury = 13.6

Differential manometer reading, X = 50cm of mercury

$C_d = 0.64$

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

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

$h = 705.56cm$ of oil

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

$= \frac{0.64 \times \sqrt{2 \times 9.81 \times 705.56} \times 708.86 \times 176.72}{\sqrt{708.86^2 - 176.72^2}}$

$Q = \frac{13740.926}{1000} = 13.740926$ litt/sec

4) Difference of mercury head, x = 170mm = 0.17m

s.g of mercury = 13.6

s.g of sea water = 1.026

$V = ?$

$V = \sqrt{2gh}$, $h = ?$

$$h = x\left[\frac{\text{s.g of mercury}}{\text{s.g of sea water}} - 1\right] = 0.17\left(\frac{13.6}{1.026} - 1\right)$$

$h = 2.0834m$

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

$V = 6.393 m/s = 23.01 km/hr$

5) $Q = 0.05 m^3/min = 50 dm^3/min$

$P_o = 15 \text{ bar} = 15 \times 10^5 N/m^2$

speed = 1700 rev/min

$T = 15 Nm$, $ND = 10 cm^3/rev$

(I) Volumetric eff. = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

Ideal flow rate = Nominal flow rate x speed

$= 10 cm^3/rev \times 1700 rev/min$

$= 17000 cm^3/min = 0.017 m^3/min$

Actual flow rate = $0.05 m^3/min$

∴ Volumetric eff. = $\frac{0.05}{0.017}$ = 2.94% = 294%

II) Fluid power = $P \times Q$

$P = 15 \times 10^5 N/m^2$

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

Fluid power = $15 \times 10^5 \times 8.33 \times 10^{-4}$

= 1249.5 watts

III) Shaft power = $\frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60}$

= 2670.33 watts

(IV) Overall efficiency = $\frac{\text{Fluid power}}{\text{Shaft power}} \times 100 = \frac{1249.5}{2670.35} \times 100 = 46.8\%$