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18/ENG01/013
MECHANICAL

(1) $P_1 = 2m$ V_1 Inlet $= 5ms^{-1}$
V_2 Outlet $= 2ms^{-1}$
$P_2 = x$
Given:
$P_1 = 2m$ $V_1 = 5ms^{-1}$
$P_2 = x$ $V_2 = 2ms^{-1}$
$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h$
$h = \frac{P_1 - P_2}{\rho g} + \frac{V_1^2 - V_2^2}{2g}$
But $h = \frac{f L}{2gD}(V_1 - V_2)^2 = \frac{0.35(5-2)^2}{2 \times 9.81}$
$= 0.161m$
$0.161 = \frac{2-x}{1000 \times 9.81} + \frac{5^2 - 2^2}{2 \times 9.81}$
$0.161 = \frac{250}{327} + \frac{21 - x}{9810}$
$21 - x = 9810 \times (-0.9093)$
$21 - x = -8920.59$
$x = 21 + 8920.59$
$x = 8941.59m$

(2) Given: $D_1 = 20cm = 20 \times 10^{-2}m$
$D_2 = 10cm = 10 \times 10^{-2}m$
$P_1 = 17.658 N/mm^2 = 17.658 \times 10^6 Nm^{-2}$
Vacuum Pressure $= \frac{-P}{W} = \frac{20 \times 10^{-2}}{1000 \times 9.81}$
$= 3.058 \times 10^{-5}$
$Cd = 0.98$
$A_1 = \frac{\pi d^2}{4} = \frac{\pi (20 \times 10^{-2})^2}{4} = 0.0314m^2$
$P_1 = 1.7658 \times 10^{-2} N/m^2$
$A_2 = \frac{\pi (10 \times 10^{-2})^2}{4} = 7.851 \times 10^{-3} m^2$
$P_2 = -3.058 \times 10^{-2} N/m^2$
$L = \frac{P_1 - P_2}{W} = \frac{1.7658 \times 10^2 - 3.058 \times 10^{-5}}{1000 \times 9.81}$
$= 1.83 \times 10^{-2}m$
$Q = \frac{Cd \cdot A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$
$\sqrt{2gh} = \sqrt{2 \times 9.81 \times 1.83 \times 10^{-2}}$
$= \sqrt{35.90466 \times 10^{-2}}$
$= 1.81 \times 10^{-1}$

$\sqrt{A_1^2 A_2^2} = \sqrt{0.0314^2 \cdot 0.0314 \times 10^{-2}}$
$= \sqrt{9.858 \times 10^{-4}} = 0.0314$
$Q = \frac{0.98 \times 0.0314 \times 7834 \times 10^{-2} \times 1.81 \times 10^{-1}}{0.0314}$
$Q = 1.4547 \times 10^{-1} = 1.45 \times 10^{-1}$

(3) $d_1 = 15cm = 15 \times 10^{-2}m = 0.15m$
$d_2 = 30cm = 30 \times 10^{-2}m = 0.3m$
$g = 50cm\,Hg = 50 \times 10^{-2}mHg$
$Cd = 0.64$
Specific gravity $= 0.9$
$h = y\left[\frac{\rho_{Hg}}{\rho_f} - 1\right]$
$h = 50 \times 10^{-2}\left[\frac{13.6}{0.9} - 1\right]$
$\therefore h = 50 \times 10^{-2}(26.2) = 13.1$
$\therefore h = 13.1$
$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.0177m^2$
$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.0707m^2$
$Q_{actual} = \frac{Cd \cdot A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$
$Q = \frac{0.64 \times 0.0177 \times 0.0707 \sqrt{2 \times 9.81 \times 13.1}}{\sqrt{(0.0177)^2 - (0.0707)^2}}$
$Q = \frac{0.08009 \times 16.03191}{0.0288 \times 5} = 18.76m^3$
ans $= 15m$

(4) Given: $y = 170mm$ of mercury $= 0.17m$
$S.G$ of mercury $= 13.6$
$S.G$ of sea water $= 1.026$
$h = y\left[\frac{S.G \text{ of mercury}}{S.G \text{ of fluid}} - 1\right]$
$h = 0.17\left[\frac{13.6}{1.026} - 1\right]$
$h = 2.085m$
$V = \sqrt{2gh}$
$V = \sqrt{2 \times 9.81 \times 2.085}$
$V = 6.39m/s$

(5) Actual flowrate $Q = 0.05m^3/min$
$\frac{0.05}{60} = 8.33 \times 10^{-4}m^3/sec$
Speed $= 1700 rev/min \rightarrow rev/sec \div 60$
$= \frac{1700}{60} = 28.33 rev/s$
Pressure $(ep) = 15 bar$
$= 15 \times 10^5 N/m^{-2}$
Norminal displacement $= 10cm^3/rev$
$= 10 \times 10^{-6} m^3/rev$
(6) Volumetric Efficiency $= \frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\%$
But Ideal flowrate $=$ no. of displacement $\times$ speed
$= 1 \times 10^{-5} \times 28.33 = 2.833 \times 10^{-4} m^3/s$
$\therefore$ Volumetric efficiency $= \frac{8.33 \times 10^{-4}}{2.833 \times 10^{-4}} \times 100\% = 294.03$
(7) Fluid Power $= \Delta p = 8.33 \times 10^{-4} \times 15 \times 10^5 = 1249.5 Nm/s$
(8) Shaft Power $= T\omega = T \times (2\pi \times \text{speed}) = \text{angular speed}$
$\omega = 2 \times \pi \times 28.33 = 178$
$\therefore$ Shaft Power $= 15 \times 178 = 2670 Nm/s$
(d) Overall Efficiency $= \frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100$
$= \frac{1249.5}{2670} \times 100 = 46.798\%$
$= 46.8\%$