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① $l = 2m$

$V_1 = 5ms^{-1}$

$V_2 = 2ms^{-1}$

$P = 2.5m$

$h_L = 0.35(V_1 - V_2^2)/2g = \frac{0.35(5-2)^2}{2 \times 9.8} = 0.16m$

$2.5 + \frac{5^2}{2 \times 9.8} + 2 = x + \frac{2^2}{2 \times 9.8} + 0.16$

$2.5 + 1.27 + 2 = x + 0.203 + 0.16$

$x = 5.77 - 0.363 = 5.077m$

② $d_1 = 20cm$; $a_1 = \pi d^2/4 = \frac{\pi \times 0.2^2}{4} = 0.0314m^2$

$d_2 = 10cm$; a_2 $\pi d^2/4 = \frac{\pi \times 0.4^2}{4} = 0.00785m^2$

$P_1 = 17.658 Ncm^{-2} \approx 17.658 \times 10^4 Nm^{-2}$

$\rho_w = 1000 Kgm^{-3}$ $\rho_m = 13.6 Kgm^{-3}$

Pressure head (inlet) $= \frac{P_1}{\rho g} = \frac{17.658 \times 10^4}{1000 \times 9.81} = 18m$

Pressure head (throat) = 30cm of mercury $= 0.3 \times 13.6 = 4.08m$

$h = 18 - (-4.08) = 22.08m$ of water

$Q = Cd \left(\frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} * \sqrt{2gh} \right)$ $Cd = 0.98$

$= 0.98 \left(\frac{0.0314 \cdot 0.00785}{\sqrt{0.0314^2 - 0.00785^2}} * \sqrt{2 \times 9.81 \times 22.08} \right)$

$= 0.98 \left(\frac{0.000235}{0.0304} \times 20.81 \right) = 0.98 \times 0.00775 \times 20.81$

$= 0.158 m^3/s \approx 158 ls^{-1}$

③ $d_{orifice} = 15cm$ $a_{orifice} = \frac{\pi d^2}{4} = \frac{\pi \times 0.15^2}{4} = 0.0176m^2$

$d_{pipe} = 30cm$ $a_{pipe} = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.0706m^2$

$S_{oil} = 0.9$

reading of mano ~~Pressure head~~ = 30cm of mercury

$Cd = 0.64$

$h = 0.5\left(\frac{13.6}{0.9}-1\right) = 0.5 \times 14.11 = 7.055m$ of oil

$Q = Cd \left(\frac{a_0 a_1}{\sqrt{a_1^2 - a_0^2}} \right) \times \sqrt{2gh}$

$= 0.64 \times \left(\frac{0.0706 \times 0.0176}{\sqrt{0.0706^2 - 0.0176^2}} \right) \times \sqrt{2 \times 9.81 \times 7.055}$

$= 0.64 \times \left(\frac{0.00124}{0.06837} \right) \times 11.65 = 0.64 \times 0.018 \times 11.65$

$= 0.134 m^3 s^{-1} \approx 134 ls^{-1}$

④ difference = 170mm = 0.17m

S.g of hg = 13.6 ; Sg of sea water in pipe = 1.026

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

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

$= 6.39 ms^{-1}$.

⑤ $Q = 0.05 m^3/min$

$P_2 - P_1 = 15bar$

Vrotation = 1700 rev/min

$S = 10cm^3/rev$

torque = 15Nm

Volumetric Efficiency = $\frac{\text{theoretical flow } (= \text{pump's displacement} \times \text{speed})}{\text{actual flow}}$

$\therefore Ft = 1700 \times 10 = 17000 cm^3 min^{-1} \approx 0.017 m^3 min^{-1}$

$\therefore V.E = \frac{0.017}{0.05} \times 100 = 34\%$

Fluid Power = $\frac{\text{Pressure (Psi)} \times \text{flow}}{1714}$ (15bar = 217.557 Psi)

$= \frac{217.557 \times 0.05}{1714} = 0.0063hp$ (1hp = 746W)

$\therefore$ Fluid Power $= 0.0063 \times 746 = 4.73W$

Shaft Power = $\frac{\text{hydraulic Power } \left(= \frac{Q\Delta P}{60{,}000}\right)}{\text{Efficiency}}$

hydraulic Power $= \frac{50 \times 1500}{60{,}000} = 1.25KW$

$\therefore P_s = \frac{1.25}{0.34 \times 1} = 3.69KW$

Overall efficiency = volumetric eff × mech eff $\left(= \frac{\text{displ} \times P}{2\pi}\right)$

mech eff $= \frac{\text{displacement} \times \text{Pressure}}{2\pi} = \frac{0.00001 \times 15 \times 10^5}{2\pi} = 23.56 \approx 24\%$

$\therefore$ overall efficiency $= \frac{34 \times 24}{100} = 8.16\%$