Mechatronics Engineering

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(1) $l = 2m$; $v_1 = 5m/s$, $v_2 = 2m/s$

Pressure head at the smaller end

$P_s = 2.5m$ of liquid

Loss of head, $Z_2 = \frac{0.35(V_1 - V_2)^2}{2g} = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.151m$

Pressure head at the lower end, $P_2 = ?$

Applying Bernoulli's equation,

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

where $P_s = \frac{P_1}{\rho g}$; $P_L = \frac{P_2}{\rho g}$ and $Z_1 = 2$ and $Z_2 = 0$

$$2.5 + \frac{5^2}{2 \times 9.81} + 2 = P_L + \frac{2^2}{2 \times 9.81} + 0 + 0.151$$

$\therefore P_L = 5.774 - 0.365 = 5.409m$

(2) $d_1 = 20cm = 0.02m$; $A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times (0.02)^2}{4} = 0.000314\,m^2$

$d_2 = 10cm = 0.01m$; $A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times (0.01)^2}{4} = 0.0785 \times 10^{-3}\,m^2$

$\rho = 1000kg/m^3$; Pressure at Inlet, $P_1 = 17.658N/cm^2 = 17.658 \times 10^4 N/m^2$

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

$\frac{P_2}{\rho g} = -30m$ of mercury ; $S.g\,Hg = 13.6$; $\frac{P_2}{\rho g} = -30 \times 10^{-2}m \times 13.6 = -4.08m$

Differential head, $H_d = \frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 18 - (-4.08) = 22.08m$

$= 22.08 \times 100 = 2208cm$

Ideal Flow rate = N.D × Speed

$= (5\times10^{-5})(14.7) = 7.085\times10^{-4}\ m^3/sec$

(i) $V.E = \frac{A.\ Flowrate}{Ideal\ Flow\ rate}\times100 = \frac{5.83\times10^{-4}}{7.085\times10^{-4}}\times100$

$= 82.29\%$

(ii) $F.P = Q\times\Delta p = (5\times10^{-4})(100\times10^{5}) = 5830W$

(iii) $O.E = \frac{F.P}{S.P}\times100 = \frac{5830}{15000}\times100 = 38.9\%$

(4) $z = 2400cm = 24m$

Volumetric Flowrate, $Q = 13\ lit/sec = 0.013 m^3/sec$

Velocity = 66m/s ;

$$P = \rho g Q\left(\frac{P}{\rho g}+\frac{v^2}{2g}+z\right) = PQ + \frac{\rho Q v^2}{2} + \rho g Q z$$

(i) Introducing Power of Jet, Pressure head = 0

$z = 0,\ P = \frac{\rho Q v^2}{2} = \frac{1000\times0.013\times66^2}{2} = 28314W$

(ii) Power Supplied from reservoir at P = 0, V = 0

$\therefore P = \rho g Q Z = 1000\times9.81\times0.013\times240$

$= 30607.2W$

(iii) Power loss in transmission = Power of reservoir − Power in Jet

$= 30607.2 - 28314$

$= 2293.2W$

Head loss in Pipe line = 2293.2W

(ii) h = Power loss in Transmission $= \frac{2293.2}{1000 \times 9.81 \times 0.013}$
$\rho g Q$

$h = 17.98\,m$

(iii) Efficiency $= \frac{P \cdot \text{Jet}}{P \cdot \text{Total}} \times 100 = \frac{28714}{30\,(17.2)} \times 100 = 92.51\%$

(10) Reading of manometer $= 170mm = 0.17\,m$
s.g of mercury $= 13.6$
s.g of sea water $= 1.026$
$y = 0.17$

$$h = y\left(\frac{s.g_{mercury}}{s.g_{water}} - 1\right) = 0.17\left(\frac{13.6}{1.026} - 1\right)$$

$= 2.0834m$

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

(5) s.g oil $= 0.89$
$z = 30\,000cm = 300m$
$q = 220\,L/s = 0.22m^3/sec$
$v = 7m/s$

Introducing $z = 0,\ P = 0$

(i) $P = \frac{\rho q v^2}{2}$, $s.g = 0.89$; $0.89 = \frac{x}{1000}$; $x = 890$

$= \frac{890 \times 0.22 \times 7^2}{2} = 4797.1W$

(ii) Power reservoir

$P = \rho g Q z = 890 \times 9.81 \times 0.32 \times 300 = 576239$

(iii) Power loss in transmission

$= 576239.4 - 4797.1$

$= 571442.3 W$

Head used to overcome loss $= \frac{\text{Power loss in transm}}{\rho g Q}$

$= \frac{571442.3}{890 \times 9.81 \times 0.32}$

$= 297.51 m$

(v) Efficiency

$= \frac{P.\ Jet}{P.\ Reser} \times 100$

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

(6) $P = \rho g Q z$ where $z = 20m = h$, $Q = ...$, $d = 10cm = ...$

$\rho = 1000$, $g = 9.8$

$A = \frac{\pi d^2}{4} = \frac{\pi \times (10 \times 10^{-2})^2}{4} = 7.85 \times 10^{-3} m^2$

Using equation of motion, velocity of ...

$v = 0$

$v^2 = u^2 - 2gh \therefore u = \sqrt{v^2 - 2gh} = \sqrt{0^2 + (2 \times 9.81 \times ...)}$

$u = 19.81 m/s$

$Q = VA$
$= 19.81 \times (7.85 \times 10^{-3})$
$= 0.15558 \, m^3/sec = 0.156 \, m^3/s$

$P = \rho g Q z = 1000 \times 9.81 \times 0.156 \times 20$
$= 30510.767 \, W$

$Q_{ideal} = A_2 V_2$
$= 27.047 (0.0314)$
$= 0.8492 \, m^3/s$

$Q_{actual} = C_d \times Q_{ideal}$
$= 0.96 \times 0.85 = 0.816 \, m^3/s$