OKANG EFFIONG BASSEY

18/ENG08/013

BIOMEDICAL ENGINEERING

1) Smaller end ①

Larger end — ②

Given paramaters

$L = 2.0m$

$V_1 = 5m/s$

$P_1/\rho g \times 2.5m$ of liquid

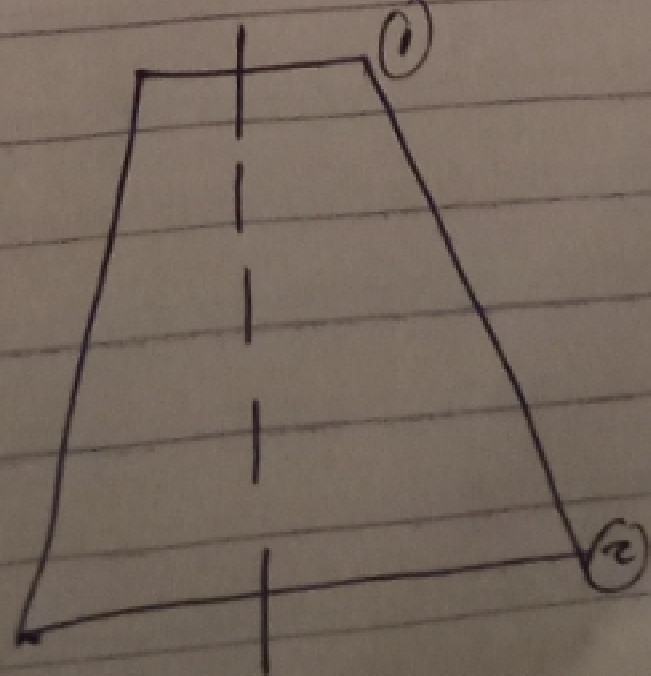
$V_2 = 2m/s$

loss of head $(h_L) = \frac{0.35(V_1 - V_2)^2}{2g}$

$= \frac{0.35(5-2)^2}{2 \times 9.81} = 0.16m$

bernoulli's equation

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



$\therefore Z_1 = 2.0 \quad Z_2 = 0$

$2.5 + \frac{5^2}{2 \times 9.81} + 2.0 = \frac{P_2}{\rho g} + \frac{2^2}{2 \times 9.81} + 0 + 0.16$

$2.5 + 1.27 + 2.0 = \frac{P_2}{\rho g} + 0.204 + h_L$

$5.77 = \frac{P_2}{\rho g} + 0.364$

$\therefore \frac{P_2}{\rho g} = 5.77 - 0.364 =$ 5.406m of liquid

a) Volume Efficiency = $\frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100\%$

$= \frac{8.33\times10^{-5}}{2.833\times10^{-4}} \times 100$

$= 29.4\%$

b) fluid Power = $Q.\partial p$

$= 8.33\times10^{-5} \times 15 \times 10^{5}$

$= 124.95$ Nm/sec

c) Shaft power = $T.W$

$T = 15$ Nm

$W = 2\times\frac{22}{7} \times 28.33 = 178.07$ rad/sec

$S.P = 15 \times 178.07 = 2671.05$ watts

d) Overall Efficiency = $\frac{\text{fluid power}}{\text{shaft power}} \times 100\%$

$= \frac{12495}{2671.05} \times 100 = 4.67\%$

2) $d_{Inlet} = \frac{20cm}{100} = 0.2m$

$a_{Inlet} = \frac{\pi}{4} \times (0.2)^2 = 0.0314m^2$

$d_{throat} = \frac{10cm}{100} = 0.1m$

$a_{throat} = \frac{\pi}{4} \times (0.1)^2 = 7.85 \times 10^{-3} m^2$

ρ for water $= 1000 kg m^{-3}$

$P_1 = 17.658 N/cm^2 = 17.658 \times 10^4 N/m^2$

$\frac{P_2}{\rho g} = -30cm$ of mercury

$-0.3 \times 13.6 = -4.08m$ of H_2O

$\therefore$ Differential head $(h) = \frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 18 + 4.08$

$= 22.08m$ of water

Using discharge equation

$$= \frac{0.98 \times 0.0314 \times 7.85 \times 10^{-3}}{\sqrt{0.0314^2 - (7.85 \times 10^{-3})^2}}$$

$= 0.98 \times 8.107 \times 10^{-3} \times 20.81$

$= 0.165 m^3/s = 165.3 lit/s$

3) Volumetric flow rate

$10dm = 1m$

$\therefore 10^3 dm^3 = 1m^3$

$1000 dm^3 = 1m^3$

$5 dm^3 = ?$

$? = \frac{5}{1000} = 0.005$

Volumetric flow rate $= 0.005 m^3/min$

Actual flow rate $= \frac{0.005}{60} = 8.33\times10^{-5} m^3/sec$

Speed $= 1700$ r.p.m

Changing to rps

$\frac{1700}{60} = 28.33$ rev/sec

$\partial p = 15 bar = 15\times10^5 N/m^2$

Nominal displacement $= 10cm^3/rev$

Note that $100^3 cm^3 = 1m^3$

$10 cm^3 = x$

$x = \frac{10}{100^3} = 1\times10^{-5} m^3/rev$

Ideal flow rate = Nominal displacement $\times$ speed

$28.33 \times 1\times10^{-5}$

$= 2.833\times10^{-4}$

3) $A_{orifice} = \frac{\pi}{4} \times (15)^2 = 176.714 cm^2$ (A area of orifice)

$A_{pipe} = \frac{\pi}{4} \times (30)^2 = 706.858 cm^2$ (Ap area of pipe)

differential head $(h) = \left[\frac{13.6}{0.9} - 1\right] \times 50 cm$ of oil

$= 705.556 cm$ of oil

$$Q = \frac{C_d \times A_o A_p}{\sqrt{A_p^2 - A_o^2}} \times \sqrt{2gh}$$

$$= \frac{0.64 \times 176.714 \times 706.858}{\sqrt{706.858^2 - 176.714^2}} \times \sqrt{2 \times 9.81 \times 705.556}$$

$= 0.64 \times 182.5094 \times 117.656$

$= 13742.96 cm^3/sec$

$= 13.74296$ Lits/sec

4) Difference of mmHg level $x = 170 mm = 0.17 m$

Sp.gr of Sea water $S_{sw} = 1.026$

Sp.gr of Mercury $S_g = 13.6$

$\therefore h = x \left[\frac{S_g}{S_{sw}} - 1\right] = 0.17 \left[\frac{13.6}{1.026} - 1\right] = 2.0834 m$

Using $V = \sqrt{2gh}$

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

Converting to km/hr

$\frac{6.393 \times 60 \times 60}{1000} \doteq 23 km/hr$