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(1) $Z_1 = 0$

$Z_2 = 2.0m$

$V_1 = 5m/s$

$V_2 = 2m/s$

The pressure, $h_1 \frac{P_1}{w} = 2.5m$

$\frac{P_2}{w} = ??$

$$hf = 0.35 \frac{(V_1 - V_2)^2}{2g}$$

$$= \frac{0.35(5-2)^2}{2 \times 9.81} = \frac{0.35 \times 9}{2 \times 9.81}$$

$$= 0.1606m.$$

Applying Bernoulli's Equation.

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

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

$$= 2.5 + \frac{5^2}{2 \times 9.81} + 0 - \frac{2^2}{2 \times 9.81} - 2.0 - 0.1606$$

$$= 2.5 + 1.274 - 0.204 - 0.1606 - 2.0$$

$$= 1.4094m$$

$$= 1.41m$$

$\therefore h_2, \frac{P_2}{w} = 1.41m$

(2) $d_1 = \frac{20}{100} = 0.2m$

$d_2 = \frac{10}{100} = 0.1m$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.2)^2}{4}$$

$$= 0.0314m^2$$

Differential head;

$y = 50cm$

$= 0.5m$

$$h = \frac{P}{w} = y\left(\frac{S.G \text{ of mercury}}{S.G \text{ of oil or}} - 1\right)$$

$$= 0.5\left(\frac{13.6}{0.9} - 1\right)$$

$$= 0.5(14.11) = 7.06m$$

$h = 7.06m$

$$Q = \frac{Cd \times A_1 A_0}{\sqrt{A_1^2 - A_0^2}} - \sqrt{2gh}$$

$$= \frac{0.64 \times 0.01767 \times 0.07068 - \sqrt{2 \times 9.81 \times 7.06}}{\sqrt{(0.070686)^2 - (0.01767)^2}}$$

$$= \frac{0.009407}{0.06844}$$

$Q = 0.1374 m^3/s \simeq 0.137 m^3/s$

No 4

Difference of Hg (y)

$$y = 170mm = \frac{170}{1000} = 0.17m$$

SG of mercury = 13.6

S.G of sea water = 1.026

$$\therefore h = y\left(\frac{S.G \text{ of Hg}}{S.G \text{ of sea water}} - 1\right)$$

$$= y\left(\frac{13.6}{1.026} - 1\right)$$

$$= 0.17(12.255)$$

$$= 2.08m$$

Velocity $= \sqrt{2gh}$

$$= \sqrt{2gh}$$

$$= \sqrt{2 \times 9.81 \times 2.08}$$

$V = 6.39 m/s$

$A_2 = \frac{\pi d^2}{d} = \frac{\pi (0.1)^2}{d}$

$= 0.00785 m^2$

$P_1 = 17.658 N/cm^2$

$= 17.658 \times 10^4$

$= 176580 N/m^2$

$P_2 = 30cm$ of mercury

$= 0.3m$ of Hg

$= -0.3m Hg \times 13.6$

$h_2 = -4.08m$

$P_2 \quad h_1 = \frac{P_1}{w} = \frac{126580}{1000 \times 9.81}$

$= 1.8m$

$\therefore h = h_1 - h_2$

$h = 18 - (-4.08)$

$= 18 + 4.08$

$= 22.08$

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

$$= \frac{0.98 \times 0.0314 \times 0.00785 \times \sqrt{2 \times 9.81 \times 18}}{\sqrt{(0.0514)^2 - (0.00736)^2}}$$

$$Q = \frac{0.00503}{0.0304}$$

$Q = 0.1653 m^3/s$

$Q = 0.1653 m^3/s$

No 3

Orifice diameter, $d_0 = 15cm = 0.15m$

Pipe diameter, $d_1 = 30cm = 0.3m \quad \therefore Cd = 0.6$

$A_0 = \frac{\pi d_0^2}{4} = \frac{\pi (0.15)^2}{4} = 0.01767 m^2$

$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.30)^2}{4} = 0.070686 m^2$

Actual flow rate $= 5 dm^3/min$

$= \frac{5 \times 10^3}{6} m^3/sec$

$= 5.33 \times 10^{-5} m^3/s$

Change in pressure $\delta p = 1.5$ bar

$= 1.5 \times 10^5 N/m^2$

Speed of rotation, $N = 1700$ rev/min

$= \frac{1700}{50} = 28.33$ rev/secs

Nomal displacement $= 10 cm^3/rev = \frac{10}{10^6} m^3/rev$

$= 1.5 \times 10^{-5} m^3/rev$

Torque Input, $T = 15 Nm$

(i) Volumetric Efficiency

$= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100\%$

Actual flow rate $= 8.33 \times 10^{-5} m^3/sec$

Ideal flow rate = Speed of rotation x nominal

$= 28.33 \times 1 \times 10^{-5}$

$= 2.833 \times 10^{-4}$

$\therefore$ Volumetric efficiency $= \frac{8.33 \times 10^{-5}}{2.833 \times 10^{-4}} \times 100\%$

$= 29.40\%$

(ii) Fluid Power, $P_f = Q \times \delta p = 8.33 \times 10^{-5} \times 15 \times 10^5$

$= 124.95$ Watts

Shaft power $= T \cdot \omega$

$T = 15 Nm$

$\omega = 2\pi N$ rad/s

$= 2 \times \frac{22}{7} \times 28.33 = 178.07$ rad/s $=$ ~~26.71~~ 2671.11 watts

$\therefore$ Overall efficiency = $\dfrac{\text{Fluid Power}}{\text{Shaft Power}} \times 100\%$

$= \dfrac{124.95}{2671.11} \times 100$

$= 4.678\%$

$\therefore$ The overall efficiency is 4.68%