

1) Question 1  
 Parameters  
 $Z_1 = 0, Z_2 = 2m, V_1 = 5m/s$   
 $V_2 = 2m/s, \frac{P_1}{w} = 2.5m$   
 $\frac{P_2}{w} = ?$

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

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

$$h_L = \frac{3.15}{19.62} = 0.16$$

Using

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

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

$$\frac{P_2}{w} = 0.5 + \frac{5^2}{19.62} - \frac{2^2}{2 \times 9.81} - 0.16$$

$$\frac{P_2}{w} = 0.34 + \frac{25-9}{19.62}$$

$$\frac{P_2}{w} = 0.34 + 0.82$$

$$\frac{P_2}{w} = 1.16m$$

2) Question 2  
 Parameter  
 $d_1 = 20cm, d_2 = 10cm$   
 $P_1 = 17.658 N/cm^2$   
 $C_d = 0.98$   
 $Q_{actual} = \frac{C_d \cdot A_1 \cdot A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$$d_1 = 20 = 0.2m$$

$$A_1 = \frac{3.142 \times (0.2)^2}{4} = 0.031m^2$$

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

$$A_2 = \frac{3.142 \times (0.1)^2}{4} = 0.008m^2$$

$$P_1 = 17.658 N/cm^2 = \frac{17.658}{10^{-4}} = 17.658 \times 10^4 N/m^2$$

$$P_2 = 30cm = 0.3m$$

$$\frac{P_1}{w} = \frac{17.658 \times 10^4}{1000 \times 9.81}$$

$$= 1.8 \times 10^1$$

$$P_1 = 18m$$

$$h = \frac{P_1 - P_2}{w} = 18 - 0.3$$

$$= 17.7$$

$$Q_{actual} =$$

$$0.98 \cdot 0.031 \cdot 0.008 \sqrt{2 \times 9.81 \times 17.7}$$

$$\sqrt{(0.031)^2 - (0.008)^2}$$

$$= \frac{0.00024204 \times \sqrt{347.274}}{\sqrt{9.81 \times 10^{-9} - 6.44 \times 10^{-5}}}$$

$$= 0.15$$

Question 3

$$d_0 = 15 \text{ cm} = 0.15 \text{ m}$$

$$d_1 = 30 \text{ cm} = 0.3 \text{ m}$$

$$A_0 = \frac{\pi d_0^2}{4} = \frac{3.142 \times 0.15^2}{4}$$

$$= 0.018 \text{ m}^2$$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{3.142 \times 0.3^2}{4}$$

$$= 0.0707 \text{ m}^2$$

$$y = 50 \text{ cm of Hg}$$

$$y = 0.5 \text{ m of Hg}$$

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

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

$$h = 2.06$$

$$Q = \frac{C_d \cdot A_0 \cdot A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$$

$$Q = \frac{0.64 \times 0.018 \times 0.07 \sqrt{2 \times 9.81 \times 2.06}}{\sqrt{(0.07)^2 - (0.018)^2}}$$

$$Q = 0.14$$

Question 4

SP.gr of mercury = 13.6  
 SP.gr of sea water = 1.026  
 $y = 170 \text{ mm} = 0.17 \text{ m}$

$$h = \left( \frac{\text{SP.gr of mercury} - 1}{\text{SP.gr of sea water}} \right) \times y$$

$$h = \left( \frac{13.6}{1.026} - 1 \right) \times 0.17$$

$$h = 2.08$$

$$V = \sqrt{2gh}$$

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

$$V = 6.388 \text{ m/s}$$

Question 5

i) Volumetric efficiency 100%  
 $= \frac{\text{Actual flow rate}}{\text{Ideal flow rate}}$

$$= \frac{\text{Actual flow rate}}{60} = 0.05 \text{ m}^3/\text{min}$$

$$= \frac{0.05}{60} = 8.33 \times 10^{-4}$$

Ideal flow rate = nominal x speed displacement

$$= 1 \times 10^{-5} \text{ m}^3/\text{rev}$$

$$\text{Speed} = 1700 \text{ rev/min}$$

$$= \frac{1700}{60} = 28.33$$

$$\text{Ideal flow rate} = 28.33 \times 1 \times 10^{-5}$$



Actual System  
 SP.gr of sea water  
 SP.gr of mercury

$$= \frac{0.004 \times \sqrt{347.274}}{\sqrt{9.81 \times 10^{-9} - 6.44 \times 10^{-5}}}$$

$$= 0.15$$

$$\text{Ideal flow rate} = 2.833 \times 10^{-4}$$

$$\begin{aligned} V \cdot E &= \frac{8.33 \times 10^{-4}}{2.833 \times 10^{-4}} \times 100 \\ &= 2.940 \times 100 \\ &= 294\% \end{aligned}$$

ii) Fluid power

$$P_f = Q \cdot \Delta P$$

$$= \frac{8.33 \times 10^{-4}}{2.833 \times 10^{-4}}$$

$$\Delta P = 1.5 \text{ bar}$$

$$\Delta P = 1.5 \times 10^5 \text{ N/m}^2$$

$$P_f = 8.33 \times 10^{-4} \times 1.5 \times 10^5$$

$$P_f = 1249.5 \text{ watts}$$

iii)

$$\text{Shaft power} = T \cdot \omega$$

where

$T$  = Torque ~~input~~ (Nm)

$\omega$  = angular speed (rad/sec)

$$T = 15 \text{ Nm}$$

$$\omega = 2\pi N$$

$N$  = Speed rotation

$$= 1760 \text{ rev/min}$$

$$= \frac{1760}{60} = 28.33$$

60

$$\omega = 2 \times \frac{2\pi}{7} \times 28.33$$

$$\omega = 178.07$$

$$S_p = 1.5 \times 178.07$$

$$= 2671.05$$

iv) Overall efficiency

$$= \frac{\text{Fluid power}}{\text{Shaft power}} \times 100\%$$

$$= \frac{1249.5}{2671.05} \times 100\%$$

$$= 46.779\%$$

20
40
60
80
100
120
140
160
180
200
220
240

NE

N NIGERIA

Actual Sys  
S, mic  
P, mic  
PCE

204x

40x10<sup>-4</sup>

0.007  
0.007