NAME: SUNDAY WINNER CHIGOZIRIM
DEPT: MECHATRONICS ENGINEERING
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SOLUTION:

(1) let, L = 2.0m

$V_1 = 5m/s$

$V_2 = 2m/s$

Pressure head = 2.5m

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

$h_L = \frac{0.35(5-2)^2}{2 \times 9.81} = 0.161m$

Bernoulli's equation for real fluids

$\frac{P_1}{w} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{w} + z_2 + \frac{V_2^2}{2g} + h_L$

$2.5 + 2 + \frac{5^2}{2 \times 9.81} = \frac{P^2}{w} + 0 + \frac{2^2}{2 \times 9.81} + 0.161$

$\frac{P_2}{w} = 5.41$

(2) Inlet diameter = 20cm = 0.2m

$A_1 = \frac{\pi}{4} \times 0.2^2 = 0.0314\ m^2$

throat diameter = 10cm = 0.1m

A_2 = Area of throat = $\frac{\pi}{4} \times 0.1^2 = 0.007785\ m^2$

P_1 = pressure at inlet = $17.658\ N/cm^2$
$= 176.58\ KN/m^2$

$\frac{P_1}{w} = \frac{176.58}{9.81} = 18m$

$\frac{P_2}{w}$ = −30cm of mercury = −0.3m of mercury
$= -0.3 \times 13.6 = -4.08m$ of water.

Discharge of water, Q

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

$Q = \frac{0.98 \times 0.0314 \times 0.00785 \times \sqrt{2 \times 9.81 \times 22.08}}{\sqrt{(0.0314)^2 - (0.00785)^2}}$

$Q = 0.1654 m^3/s$

(3) Orifice diameter = 15cm = 0.15m

Ao = Orifice area = $0.0176m^2$

Pipe diameter = 30cm = 0.3m

A_1 = Pipe area = $0.071m^2$

Cd = 0.64

Sp.g = 0.9 (oil)

Reading of differential manometer = 50cm of mercury
= 0.5m of mercury

$h = y\left(\frac{S_{hL}}{S_P} - 1\right)$

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

$h = 7.06$

Discharge, $Q = \frac{Cd \times Ao \cdot A_1 \sqrt{2gh}}{\sqrt{A_1^2 - Ao^2}}$

$= \frac{0.64 \times 0.0176 \times 0.071 \times \sqrt{2 \times 9.81 \times 7.06}}{\sqrt{(0.071)^2 - (0.0176)^2}}$

$= 0.1368 m^3/s$

(4) $V = \sqrt{2g\Delta h}$

Manometer reading = 170mm = 0.17m of mercury

Sp. gravity of mercury = 13.6

Sp. gravity of sea water = 1.026

$\Delta h = y\left(\frac{Sm}{S} - 1\right)$

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

$\Delta h = 2.0834$

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

$V = 6.39 m/s$

$V = 23.004\ Km/hr$

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(3) Rate of pump delivery = $5dm^3/min$
Pressure change = 15 bar = $15 \times 10^5 N/m^2$
Speed of rotation = 1700 rev/min = 28.33 rev/sec
normal displacement = $10cm^3/rev$
Torque input = 15Nm

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

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

$$\frac{5dm^3}{1min} \times \frac{1m^3}{1000dm^3} \times \frac{1min}{60sec}$$

$5dm^3/min = 8.33 \times 10^{-5} m^3/sec$

nominal displacement = $\frac{10cm^3}{rev} \times \frac{1m^3}{100^3cm^3}$

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

Ideal flow rate = normal displacement × ~~pressure~~ speed

$= 1 \times 10^{-5} \times$ ~~15×10^5~~ 28.33

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

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

$= 29.4\%$

(ii) Fluid power = Actual flow rate × pressure

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

$= 124.95$ watts or Nm/sec

(iii) Shaft power = Torque input × angular speed

Torque input = 15Nm

Angular speed = $2\pi N = w$ (rps)

$w = \frac{2\pi N}{60}$ (rpm)

$w = 2 \times \frac{22}{7} \times \frac{1700}{60} = 178.09$ rad/sec

Shaft power = 15×178.09

$= 2671.35$ watts

(iv)

Overall efficiency:

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

~~$= \frac{124.95}{178.09} \times 100$~~

~~$= 70\%$~~

$= \frac{124.95}{2671.35} \times 100$

$= 4.67\%$