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1 Smaller section (V_1) = 5m/s
Larger section (V_2) = 2m/s
Height (h) = 2m

Pressure head at smaller section ($\frac{P_1}{w}$) = 2.5m
Head loss (h_L) = $\frac{0.35(V_1 - V_2)^2}{2g}$

Using Bernoulli's equation

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

$$2.5 + \frac{5^2}{2 \times 9.81} + 2 = \frac{P_2}{w} + \frac{2^2}{2 \times 9.81} + 0 + \frac{0.35(5-2)^2}{2g}$$

$$2.5 + 1.274 + 2 = \frac{P_2}{w} + 0.2039 + 0.1606$$

$$5.774 = \frac{P_2}{w} + 0.3645$$

$$\frac{P_2}{w} = 5.774 - 0.3645 = 5.4095 \simeq 5.41$$

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

The pressure head at second section is 5.41m

1. Inlet diameter (d_1) = 20cm = 0.2m ∴ (A_1) = $\frac{\pi}{4} \times 0.2^2$ = 0.03142 m^2
Throat diameter (d_2) = 10cm = 0.1m ∴ (A_2) = $\frac{\pi}{4} \times (0.1)^2$ = 7.854 $\times 10^{-3}$ m
Inlet pressure (P_1) = 17.658 N/cm² = 176580 N/m²
Vacuum pressure at the throat = 30cm of mercury = 0.3m of mercury
Cd = 0.98

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

But $\frac{P_1}{\rho g} = \frac{176580}{9810}$ = 18m

Vacuum pressure at throat ($\frac{P_2}{\rho g}$) = -0.3m of mercury
= -0.3 × 13.6 = -4.08m of water

Differential head = 18 - (-4.08)
= 22.08

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

= $\frac{0.98 \times 0.03142 \times 7.854 \times 10^{-3}}{\sqrt{(0.03142)^2 - (7.854 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 22.08}$

= $0.98 \times \frac{2.468 \times 10^{-4}}{0.0304} \times 20.81$

= 0.165 m³/s

2) Diameter of orifice = 15cm = 0.15m ∴ Area (orifice) = $\frac{\pi}{4} \times (0.15)^2$ = 0.01767 m²
Pipe Diameter = 30cm = 0.3m ∴ Pipe Area = $\frac{\pi}{4} \times (0.3)^2$ = 0.0707 m²
Specific gravity of oil = 0.9
Coefficient of discharge = 0.64
Reading of the manometer (x) = 50cm of mercury = 0.5m of mercury

Differential head = $g\left[\frac{S_g \text{ of } Hg}{S_g \text{ of oil}} - 1\right] = 0.3\left[\frac{13.6}{0.9} - 1\right] =$ [illegible]

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

$= 0.69 \times \frac{0.0137 \times 0.0 \ldots}{\sqrt{(0.0137)^2 - (0.0 \ldots)^2}} \times \sqrt{2 \times 9.81 \times \ldots}$

$= 0.69 \times 0.0 \ldots \times 11.47 = 0.\ldots \, m^3/s$

4. Reading of the differential manometer $(x) = \ldots mm = 0.\ldots m$
Specific gravity of mercury $(S_g\ Hg) = 13.6$
Specific gravity of sea water $(S_g\ sw) = 1.025$

Head $(h) = x\left[\frac{S_g\ Hg}{S_g\ sw} - 1\right]$

$= 0.\ldots\left[\frac{13.6}{1.025} - 1\right] = 2.09$

Velocity of submarine $= \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.09} = 6.403\, m/s$

5) Actual flowrate $(Q_a) = 5\, dm^3/min$
$= 0.005\, m^3/min$
Pressure change $(P) = 15\, bar = 15 \times 10^5\, N/m^2$
Speed $= 1750\, rev/min$
Torque $= 13\, Nm$
Nominal displacement $= \ldots cm^3/rev$
Ideal flowrate $(Q_i) =$ Nominal displacement $\times$ Speed
$= \ldots \times 1750 = 17\ldots cm^3/min$
$Q_i = \frac{17\ldots cm^3}{1\, min} = \frac{17\ldots \times 10^{-6}\, m^3}{1\, min} = 0.0\ldots m^3/min$

(i) Volumetric Efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100\% = \frac{0.005}{0.017} \times 100\%$

$= 29.41\%$

ii) Fluid power = Vol. flowrate x pressure

Fluid power = $Q \times P$

$Q = 0.005\ m^3/min = \frac{0.005\ m^3}{60\ s} = 8.33 \times 10^{-5}\ m^3/s$

2. Fluid power = $8.33 \times 10^{-5}\ m^3/s \times 15 \times 10^5\ Nm^{-2} = 125W$

iii) Shaft power = Torque x Angular Velocity (ω)

Speed = 1700 rev/min

1 rev - 360° - 2π radians

1 min = 60 secs

angular velocity = $\frac{1700 \times 2\pi\ rad}{1 \times 60\ secs}$

angular Velocity (ω) = 178.024 rad/s