EKOK NZIE OKPOKAM
18/ENG05/045
FLUID MECHANICS

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MECHATRONICS

1.] Speed of rotation = 1500 rev/min
nominal displacement = $10cm^3/rev$
Torque input = 12.5Nm
Pressure change = 12bar
rate = $10 dm^3/min$

Solution

~~Actual flowrate = Nominal displacement x Speed~~

Ideal flowrate = Nominal displacement x speed

$10 \times 1500 = 15000 \ cm^3/min$

$= 15 dm^3/min$

Volumetric efficiency = $\frac{\text{Actual flow}}{\text{Ideal flow}}$

$= \frac{10}{15} = 0.67$ or 67%

$Q = (10 \times 10^{-3})/60 m^3/s = 16.7 \times 10^{-6} m^3/s$

$\Delta p = 12 \times 10^5 N/m^2$

ii] Fluid power = $Q \Delta p$

$16.7 \times 10^{-6} \times 12 \times 10^5 = 20.04$ watts

iii] Shaft power = $2\pi NT/60$

$2\pi \times 1500 \times 12.5/60$

$= 1963.5$ Nm

iv] Overall efficiency = $\frac{F.P}{S.P}$

$= \frac{20.04}{1963.5}$

$= 0.01$

2] delivers $35dm^3/min$
pressure change = 100 bar
efficiency = 87%
Shaft power = $2\pi NT/60$
F.P = $Q \Delta P$

$Q = (35 \times 10^{-3})/60 = 5.8 \times 10^{-4}$

$\Delta P = 100 \times 10^5 N/m^2$

F.P = 5800 watts

Efficiency = $\frac{F.P}{S.P}$

$0.88 = \frac{5800}{S.P}$

$\therefore S.P = \frac{5800}{0.88} = 6590Nm$

3] Nominal displacement = $50cm^3/rev$
pressure = 100 bar
Shaft power = 15 kilowatts
Actual flow rate = $35dm^3/min$
Speed = 850 r.p.m

Solution

Ideal flow rate = $50 \times 850 = 42.5dm^3/min$

Volumetric efficiency = $\frac{35}{42.5} = 0.82$

Fluid power = $((35 \times 10^{-3})/60) \times 100 \times 10^5$

$= 5.8 \times 10^{-10}$

Overall efficiency = $\frac{5.8 \times 10^{-10}}{15 \times 10^{-3}}$

$= 3.9 \times 10^{-8}$

4] Sg =

ρ = 1000 × 1000 = 1000 kg/m³

Z = 240m

Q = 13 litre/sec = 13×10^{-3} m³/sec

Velocity of jet = 0.6 m/s

Since outpnt of pipe is at datum

p = 0   Z = 0

$$P = PQ + \frac{\rho Q v^2}{2} + \rho g Q z$$

$$P = 1000 + 13 \times 10^{-3} \times (66)^2$$

P = 28314 watts

ii) Power supplied through reservoir

Substituting p = 0 and v = 0 in eq ①

P = $\rho g Q Z$ = 1000 × 9.81 × 3×10^{-3} × 240

= 30607.2 watts

iii) Head loss, h = $\frac{\text{Power lost in transmission}}{\rho g Q}$

$$= \frac{(30607.2 - 28314)}{1000 \times 9.87 \times 1.3 \times 10^{-3}}$$

h = 17.982 m

iv) Efficiency = $\frac{\text{Power of jet}}{\text{Power of reservoir}} \times 100$

$$= \frac{28874}{20607.2} \times 100$$

= 92.5%

5] Sg = 0.89

ρ = 890

Z = 300 m

Q = 0.22 m³/sec

Velocity = 7 m/s

$$P = PQ + \frac{\rho Q v^2}{2} + \rho g Q Z$$

(i) power of jet =

$$P = \frac{\rho Q V^2}{2} = \frac{890 \times 0.22 \times (7)^2}{2}$$

= 4797.1 watts

(ii) Power supplied from reservoir

P = $\rho g Q Z$

= 890 × 9.81 × 0.22 × 300

= 576239.4 watts

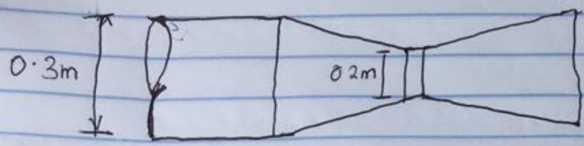
(iii) Head loss, h = $\frac{\text{Power lost in transmission}}{\rho g Q}$

$$= \frac{576239.4 - 4797.1}{0.22 \times 890 \times 9.81}$$

= 29.75m

v) Efficiency = $\frac{\text{Power of jet}}{\text{Power of reservoir}} \times 100$

$$= \frac{4797.1}{576239.4} \times 100 = 0.83.$$



Diameter of inlet = 0·3m

Area of inlet = $\frac{\pi \times 0\cdot3^2}{4} = 0\cdot071\,m^2$

$y = 0\cdot06m$

Diameter of ~~outlet~~ throat = 0·2m

Area of throat = $\frac{\pi \times 0\cdot2^2}{4} = 0\cdot031\,m^2$

~~The differential reading (h) = y~~

Specific weight of gas = $19\cdot62\,N/m^3 = 0\cdot01962\,kN/m^3$

$\therefore$ Specific gravity of gas = $\frac{0\cdot01962}{9\cdot81} = 2\times10^{-3}$.

The differential reading (h) = $y\left[\frac{Sp.W}{Sp.G} - 1\right]$

$= 0\cdot06\left[\frac{1}{2\times10^{-3}} - 1\right]$

$= 29\cdot94$

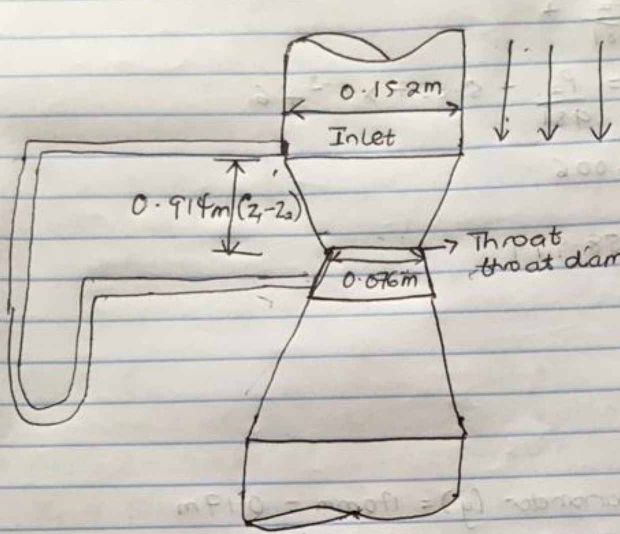
$$Q = Cd \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

$$= 0\cdot96 \times \frac{0\cdot071 \times 0\cdot031}{\sqrt{0\cdot071^2 - 0\cdot031^2}} \times \sqrt{2\times9\cdot81\times29\cdot94}$$

$= 0\cdot96 \times 0\cdot0345 \times 24\cdot24 =$

$= 0\cdot803\,m^3/s$

Number 8



Diameter of inlet = 0.152 m

Area of inlet = $\frac{\pi \times 0.152^2}{4} = 0.018\ m^2$

Diameter of throat = 0.076 m

Area of throat = $\frac{\pi \times 0.076^2}{4}$ = ~~4×5~~ $4.54 \times 10^{-3}\ m^2$

The differential reading (h) = $\left[\frac{P_1}{W} + z_1\right] - \left[\frac{P_2}{W} + z_2\right]$

$$h = \left[\frac{P_1}{W} - \frac{P_2}{W}\right] - \left[z_1 - z_2\right]$$

a) when the pressure gauge reading is the same

i.e $\left[\frac{P_1}{W} - \frac{P_2}{W}\right] = 0$

$\therefore$ ~~$h = 0 - [z_1 - z_2]$~~

~~$= 0 - [0.194]$~~

~~$= -0.194m$~~

$\therefore h = [z_1 - z_2]$

$= 0.194m$

Number 8 Contd.

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

$= 0.97 \times \frac{0.018 \times 4.54 \times 10^{-3}}{\sqrt{0.018^2 - (4.54 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 0.194}$

$= 0.97 \times 4.692 \times 10^{-3} \times 1.951$

$= 8.88 \times 10^{-3}\ m^3/s$

b) when the inlet gauge reads 15170 N/m^2 higher than the throat gauge

i.e

$\cancel{\left[\frac{P_1}{W} - \frac{P_2}{W}\right] = 15170 N/m^2}$ $\therefore P_1 - P_2 = 15170\ N/m^2$

$\Rightarrow \frac{P_1 - P_2}{W} = \frac{15170}{W} = \frac{15170}{9.81} =$

$\Rightarrow \frac{P_1 - P_2}{W} = 1546.38m$

$\therefore h = \frac{P_1 - P_2}{W} - [Z_1 - Z_2]$

$\therefore h = 1546.38 - 0.194$

$= 1546.2m$

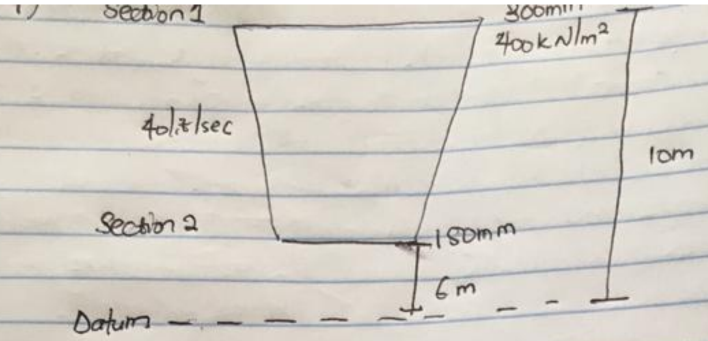
$\therefore Q = Cd \times \frac{A_1 \times A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$

$Q = 0.97 \times \frac{0.018 \times 4.54 \times 10^{-3}}{\sqrt{0.018^2 - (4.54 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 1546.2}$

$= 0.793 m^3/s$

m

$(\cancel{P_1 - P_2}) \times N = \frac{P_1 - P_2}{W}$



Section 1

(d_1) Diameter = 300mm

(P_1) Pressure = 400 kN/m²

$Z_1 = 10m$

Section 2

(d_2) Diameter = 150 mm

(P_2) Pressure = ?

$Z_2 = 6m$

Volumetric rate(Q) = 40lit/sec = 0.04m³/s

$Q = 0.04 m^3/s$

Recall $Q = A_1V_1 = A_2V_2$

But $A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times 0.3}{4} = 0.236 m^2$

$\therefore 0.04 = 0.236 \times V_1$

$V_1 = 0.169 m/s$

But $A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times 0.15}{4} = 0.118 m/s$

$V_2 = \frac{0.04}{0.118} = 0.339 m/s$

From Bernoulli's equation

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

$$\frac{400}{9.81} + \frac{0.169^2}{2 \times 9.81} + 10 = \frac{P_2}{9.81} + \frac{0.339^2}{2 \times 9.81} + 6$$

~~$40.77 + 1.456 + 10 = \frac{P_2}{9.81} +$~~

$$40.77 + 1.456 \times 10^{-3} + 10 = \frac{P_2}{9.81} + 5.857 \times 10^{-3} + 6$$

$$50.771 = \frac{P_2}{9.81} + 6.006$$

$$498.064 = P_2 + 58.919$$

$$439.145 = P_2$$

$$P_2 = 439.145 \ kN/m^2$$

10) Reading of differential manometer (y) = 170mm = 0.17m
~~Reading~~ Specific gravity of mercury = 13.6
Specific gravity of sea ~~water~~ = 1.025

to Find head $(h) = 0.17\left[\frac{13.6}{1.025} - 1\right] = 2.09$

~~$= 0.17[$~~ 2.0

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