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Subject- Fluid Mechanics I

To:

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Q 1– Part-A:

Energy Head:

It is the sum of all energy head at a point in a fluid.

Forms of Energy Heads

There are various forms of energy head which are as follow;

1) Kinetic head.
2) Potential head.
3) Pressure head.

1) Kinetic Head:

It is the kinetic energy per unit weight of the fluid.

Mathematical form:

$$\frac{K.E}{W} = \frac{\frac{1}{2} m v^2}{mg}$$

$$\frac{K.E}{W} = \frac{1}{2}\frac{v^2}{g}$$

This is also known as velocity Head.

Unit:

Its unit is meter (m).

2) Potential Head:

It is the unit potential energy per unit weight of the fluid.

Mathematical form:

$$\frac{P.E}{W} = \frac{mgh}{mg} = h$$

3) Pressure Head:

The vertical height of the

free surface above any point in a liquid at rest is pressure head.

OR

Level of fluid due to pressure exerted by fluid.

<u>Mathematical form:</u>

$$\text{Pressure Head} = \frac{P_v E}{\text{Weight}} = \frac{P}{\gamma}$$

OR

$$= \frac{F \cdot ds}{W}$$

$$= \frac{P.A.ds}{W}$$

$$= \frac{P.V}{W} \cdot \frac{P}{\gamma}$$ is pressure.

Q1-Part-B:

Hydraulic Grade Line (HGL):

The surface or profile of water flowing in an open channel or a pipe flowing partially full. If a pipe is under pressure, the hydraulic grade line is that level water would rise to in a small, vertical tube connected to the pipe. also see energy grade line.

Hydraulic Radius:

The ratio of cross-sectional area of a channel or pipe in which a fluid is flowing to the wetted perimeter of the conduit.

Energy Grade line (EGL):

A line that represents the elevation of energy head (in feet or meters) of water flowing in a pipe, conduit or channel. The line is drawn above the hydralic grade line (gradient) a distance equal to the velocity head ($v^2/2g$) of the water flowing at each section or point along the pipe or channel.

Q 2-(Part-A):

Given data:

Velocity = $V = 2\, m/s$.

Pressure = $P = 300$ Kpa.

datum = $Z = 5\, m$

Solution:

H = Pressure head + K.E + P.E

$$H = \frac{P}{\gamma} + \frac{v^2}{2g} + Z$$

$$H = \frac{300 \times 10^3}{9810} + \frac{2^2}{2 \times 981} + 5$$

$$\boxed{H = 35.784\, m}$$

Q2-(Part-B)

Given:

Diameter = d_1 = 300mm

Diameter = d_2 = 200mm

Pressure = P_1 = 300 Kpa = 300×10^3 N/m²

P_2 = 120 Kpa = 120×10^3 N/m²

Datum = Z = ?

$$Q = \frac{40}{1000} \text{ m}^2\text{/sec}$$

d_1 = 300mm = 0.3m

d_2 = 200mm = 0.2m

Required:

Z_2 = ?

Solution:

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

$$A_1 = \frac{3.14 \times (0.3)^2}{4}$$

$$\boxed{A_1 = 0.0706}\ m^2$$

$$A_2 = \frac{\pi d_2^2}{4}$$

$$A_2 = \frac{3.14 \times (0.2)^2}{4}$$

$$\boxed{A_2 = 0.0314}\ m^2$$

We know that

$$Q_1 = V_1 A_1$$

$$V_1 = \frac{Q_1}{A_1}$$

$$V_1 = \frac{0.04}{0.0706}$$

$$\boxed{Q = \frac{40}{1000} \Rightarrow 0.04}$$

$$\boxed{V_1 = 0.566}$$

$$V_2 = \frac{Q}{A_2}$$

$$V_2 = \frac{0.04}{0.0314}$$

$$\boxed{V_2 = 1.27}$$

Now,

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

$$Z_1 = 0$$

$$\gamma = 9810$$

$$\frac{300 \times 10^3}{9810} + \frac{0.566^2}{2(9.91)} + 0 = \frac{120 \times 10^3}{9810} + \frac{1.27^2}{2(9.8)} + Z_2$$

$$30.59 = 12.314 + Z_2$$

$$\boxed{Z_2 = 18.276}$$

Q No-03

Given:

Length of pipe = l = 500 m

dia = d = 0.2 m

Specific gravity of oil = 0.9

flow rate = Q = 0.06 m^3/s

Viscosity = μ = 6×10^{-5} $N.S/m^2$

Required:

Pressure loss = ΔP = ?

Solution:

As we know that

$$f = \left(0.0032 + \left(\frac{0.221}{R^{0.2}}\right)\right)$$

Where, R = Reynolds No and is given as

$$R = \frac{V.d}{\nu} \quad \text{—} (1)$$

and, $\nu = \frac{\mu}{\rho} = \frac{6\times10^{-5}}{900}$

$\nu = 6.67\times10^{-8}\ m^2/s$

and,

$V = \frac{Q}{A}$ $\therefore$ for circular pipe

$A = \frac{\pi}{4} d^2$

$V = \frac{0.06}{0.031}$

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

$A = 0.031\ m^2$

$V = 1.95\ m/s$

Now eq (1) =)

$$R = \frac{1.95\times0.2}{6.67\times10^{-5}} = 5.73\times10^{6}$$

$$f = 0.0032 + \frac{0.221}{(5.73\times10^{6})^{0.237}}$$

$$f = 8.79\times10^{-3}$$

or $f = 0.00879$

Now from Bernoulli's eq:

$$\text{Head loss} = h_L = \frac{f L v^2}{2gD} \quad \text{—(ii)}$$

Putting values in eq (ii)

$$h_2 = \frac{(0.00879)(500)(1.95)^2}{2(9.81)(0.2)}$$

$$h_2 = 4.259 \, m$$

Now to find pressure loss due to friction;

As pressure head formula

$$h_2 = \frac{DP}{\delta g}$$

$$DP = h_2 \times \delta g$$

Putting values

$$DP = 4.259 \times 900 \times 9.81$$

$$DP = 37602.7 \text{ pa.}$$

$$DP = 37.602 \text{ Kpa.}$$