CHAPTER – 1

Q. Define specific gravity: (2019)

Ans: Specific gravity of fluid is defined as the density of fluid to density of standard fluid. Specific gravity $= \dfrac{\text{Density fo fluid}}{\text{Density of s tan dard fluid}}$

Q. A volume of 2.5 m^3 of certain fluid weighs 9.81 kN. Determine the specific weight, mass density and specific gravity of liquid.

Ans: Volume of fluid, V =2.5 m^3

Weight of fluid, W = 9.81 kN = 9.81 × 10^3 N

Specific weight (w) $= \dfrac{W}{V} = \dfrac{9.81 \times 10^3}{2.5} = 3924\ \text{N}/\text{m}^3$

Mass density = ?

Mass of fluid, $m = \dfrac{W}{g} = \dfrac{9.81 \times 10^3}{9.81}\text{kg} = 1000\ \text{kg}$

Density of fluid, $(p) = \dfrac{\text{mass of fluid}}{\text{volume of fluid}}$

$$= \frac{1000}{2.5}\text{kg}/\text{m}^3 = 400\ \text{kg}/\text{m}^3$$

$$\text{specific gravity of fluid} = \frac{\text{Density of fluid}}{\text{Density of water}}$$

$$= \frac{400}{1000} 0.4$$

Q. Define specific weight and state its units.

Ans: Specific weight of a fluid is the ratio of weight of fluid to its volume

$$\text{Specific weight(w)} = \frac{\text{Weight of fluid}}{\text{Volume of fluid}}$$

Unit – N/m^3 (S.I.) dyne/cm^3 (C.G.S)

Q.**WHAT IS KINEMATIC VISCOSITY AND ITS UNIT.(2019)**

The **kinematic viscosity** [m^2/s] is the ratio between the dynamic **viscosity** [Pa. s = 1 kg/m·s] and the density of a fluid [kg/m^3]. The SI **unit** of the **kinematic viscosity** is m^2/s. Other units are: 1 St (Stoke) = 1 cm^2/s = 10^{-4} m^2/s.

CHAPTER : 2

Q. Convert intensity of pressure of 20 KPa into equivalent pressure head of oil of specific gravity 0.9

Ans: Intensity of pressure, P = 20 Kpa = 20 × $10^3 N/m^2$

Specific gravity of oil (s) = 0.9

Density of oil, P = 1000 × S = 1000 × 0.9 = 900 kg/m^3

$\rho = \rho gh$

$$\Rightarrow h = \frac{P}{\rho g} = \frac{20 \times 10^3}{900 \times 9.81} mofoil = 2.27 m \text{ of oil}$$

Q. Write different types of fluid pressure measuring instruments. Explain the function of differential manometer with neat sketch.

Ans: Working of various measuring devices for pressure.

The pressure of a fluid may be measured by the following devices.

1. Manometers : Manometers are defined as the devices used for measuring the pressure at a point in a fluid by balancing the column of fluid by the same or another column of liquid/fluid.

Types of Manometer:

Manometer
- Simple Manometer
  - Piezometer
  - U – tube manometer
  - Single column manometer
- Differential manometer

2. Mechanical gauges : These are the devices in which the prewssure is measured by balancing the fluid column by spring (elastic element) or dead weight. These gauges are used for measuring high pressure and where high precision is not required. These are :

i. Bourdon tube pressure gauge

ii. Diaphragm pressure gauge

iii. Bellow pressure gauge

iv. Dead weight pressure gauge.

Simple manometer : A simple manometer is one which consists of a glass tube whose one end is connected to a point where pressure is to be measured and the other end remains open to atmosphere.

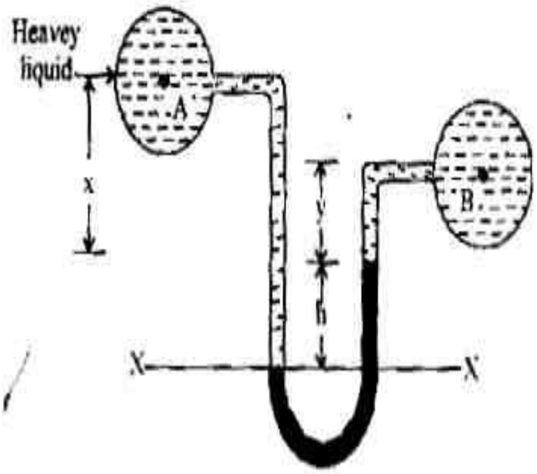
Differential Manometer :

Differential manometers are the devices which are used for measuring the difference of pressures between two points in a pipe or in two different pipes. Most common types of differential manometers are

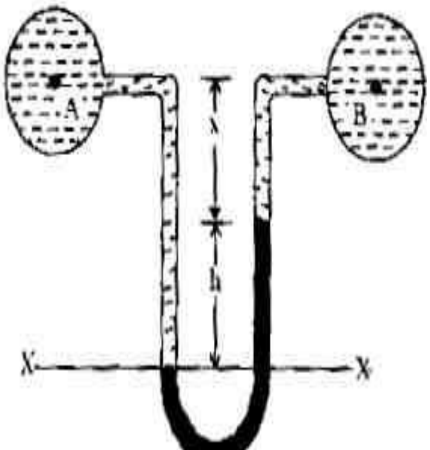
1. U-tube differential manometer and
2. Inverted U-tube differential manometer

U-tube Differential Manometer.

The following fig. shows the differential manometers of U-tube type.



(a) Two pipes at different levels



(b) Two pipes at the same level

In fig. (a) let the two points A and B are at different level and also contains liquids of different specific gravity. These points are connected to the U-tube differential manometer. Let the pressure at A and B are P_A and P_B

Let h = Difference of mercury level in the U – tube

Y = Distance of the centre of B, from the mercury level in the right limb.

X = distance of the centre of A, from the mercury level in the right limb.

ρ_1 = Density of liquid at A

ρ_2 = Density of liquid at B.

P_A = Pressure at A

P_B = Pressure at B

ρ_2 = Density of heavy liquid or mercury

Taking datum line at X – X

Pressure above X-X in the left limb = $\rho_1 g(h+x)+P_A$

Pressure above X-X in the right limb

$$= \rho_g \times g \times h + \rho_2 \times g \times y + P_B$$

Equating the two pressure, we have

$\rho_1 g(h+x) + P_A = \rho_g \times g \times h + \rho_2 gy + P_B$

Or $P_A - P_B = \rho_g \times g \times h + \rho_2 gy - \rho_1 g(h + x)$

$\therefore\ P_A - P_B = \rho_g \times g \times h + \rho_2 gy - \rho_1 gh - \rho_1 gx$

$= h \times g\ (\ \rho_g - \rho_1) + \rho_2 gy - \rho_1 gx$

$\therefore$ Difference of pressure at A and B

$P_A - P_B = (\rho_g - \rho_1)\ gh + \rho_2 gy - \rho_1 gx$

In fig. (b) pipes A and B are at the same level and contains the same liquid of density ρ_1. Then

Pressure above x-X in right limb = $\rho_g \times g \times h + \rho_1 \times g \times x + P_b$

Pressure above X-X in the left limb = $\rho_1 g(h + x) + P_a$

Equating the two pressure $\rho_g \times g \times h + \rho_1 gx + P_B = P_1 \times g \times (h + x) + P_a$

$\therefore\ P_A - P_B = \rho_g \times g \times h + \rho_1 gx - \rho_1 g(h+x)$

$= \rho_g gh + \rho_1 gx - \rho_1 gh - \rho_1 gx$

$= \rho_g gh + \rho_1 gx - \rho_1 gh - \rho_1 gx.$

$\therefore\ P_A - P_B = \rho_g gh - \rho_1 gh =)\rho_g - \rho_1)gh$

Q. Problem At a point A in a fluid flow system the pressure reading was observed to be $-25 kN/m^2$. Exprss this pressure in meters of water, meters of oil (0.8), meters of CCl_4 (sp.gr -1.6) and absolute pressure if mercury barometer records 740 mm.

Ans: Given

Intensity of pressure, $P = -215\ kN/m^2 = -25 \times 10^3\ N/m^2$

For water, density $(\rho) = 1000\ kg/m^3$

$$p = \rho gh \Rightarrow h = \frac{p}{\rho g} = \frac{-25 \times 10^3}{1000 \times 9.81} = -2.55 \text{ m of water}$$

For Oil

Sp. Gr = 0.8, Density $(\rho) = 1000 \times 0.8 = 800\ kg/m^3$

$$h = \frac{p}{\rho g} = \frac{-25 \times 10^3}{800 \times 9.81} = -3.19 \text{ m of oil}$$

For CCl_4

Sp. Gr = 1.6

Density $(\rho) = 1000 \times 1.6 = 1600\ kg/m^3$

$$h = \frac{p}{\rho g} = \frac{-25 \times 10^3}{1600 \times 9.81} = -1.6 \text{ m of } CCl_4$$

Barometer reading = 740 mm of Hg

$= 740 \times 13.6$ mm of water $= \frac{740 \times 13.6}{1000}$ m of water

= 10.06 m of water

Absolute pressure = Atmospheric pressure + gauge pressure

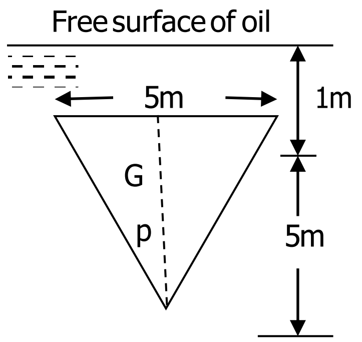
= (10.06 – 2.55) m of water

$= 7.51$ m of water $= \frac{7.51}{13.6}$ m of mercury

= 0.55 m of mercury

CHAPTER:3

Q. Determine the total pressure and centre of pressure on an Isosceles triangular plate of base 5m and altitude 5m when the plate is immersed vertically in an oil of specific gravity 0.8. the base of plate is 1m below the free surface of water



Ans: Base of plate, b = 5 m

Altitude, h = 5 m

Area of plate, A = ½ × b × h = ½ × 5 × 5 = 12.5 m^2

Specific gravity of oil, S = 0.8

Density of oil , P = 0.8 × 1000 = 800 kg/m^3

Distance of C.G. from free surface of oil

H = 1 + h/3 = 1 + 5/3 = 2.67 m

Total pressure, f = ρg A h = 800 × 9.81 × 12.5 × 2.67 = 261927 N

Moment of inertia of triangular section

About its C.G $= \frac{bh^3}{36} = \frac{5 \times 5^3}{36} = 17.36\ m^4$

Centre of pressure from free surface of oil

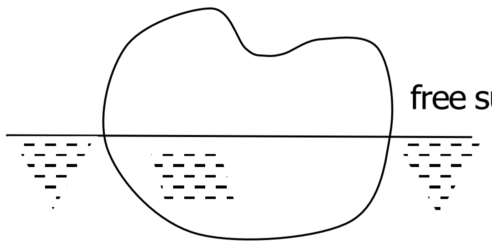
$$h^* = \frac{IG}{Ah} + h = \frac{17.36}{12.5 \times 2.67} + 2.67 = 3.19\ m$$

Q. Explain concept of buoyancy and floatation.

Ans: FLOATATION AND BUOUANCY

FLOATATION:

When a body floats at the free surface of a liquid it remains partially submerged in liquid as shown in fig. Some of the portion of the body remains in contact with air and rest portion being submerged in liquid. In this case since the specific weight of air is negligible as compared with the specific weight of liquid, the weight of the air displaced by the top portion of the body may be neglected. The weight of the body W acts downward always. According to principle of floatation the weight of a body floating in a liquid is equal to the buoyant force F_B which is equal to weight of the liquid displaced by the body. If the buoyant force exceeds the weight of the body the body will rise up util its weight equals the buoyant force. On the other hand if the weight exceeds the buoyant force the body will tend to move downward and it may finally sink.



BUOYANCY

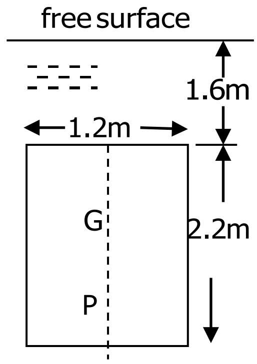
When a body is immersed in a fluid, an upward force id exerted by the fluid on the body. This upward force is equal to the weight of the fluid displaced by the body and is called the force of buoyancy or simply Buoyancy.

Q. A rectangular lamina is 1.2 m wide and 2.2 m deep is held vertically immersed in water so that its upper edge is horizontal and 1.6 m below the free water surface . Determine total pressure on the lamina and depth of centre of pressure .

Ans: Width of plate, b = 1.2 m

Depth of plate, d = 2.2 m

Area of plate, a = b × d



= 1.2 × 2.2 = 2.64 m^2

Distance of C.G. from free surface

H = 1.6 + 1.1 = 2.7 m

Moment of inertia of rectangular plate about its C.G.,

$$IG = \frac{bd^3}{12} = \frac{1.2 \times (2.2)^3}{12} = 1.065\ m^4$$

Total pressure , F = ρgA h = 1000 × 9.81 × 2.64 × 2.7 = 69925.68 N

Position of centre of pressure, h* = $\frac{Ig}{Ah} + h = \frac{1.065}{2.64 \times 2.7} + 2.7 = 2.85\ m$

Q. State Archimedes Principles(2019)

Ans: ARHIMEDES PRINCIPLE

It states the "when a body is immersed in a fluid either whooly or partially it is buoyed or lifted up by a force, which is equal to the weight of fluid displaced by the body."

Q. Explain working of Bourden tube pressure gauge.

Ans: Pressure Gauge

A pressure gauge is used to measure the pressure of the steam inside the steam boiler. It is fixed in front of the steam, boiler. The pressure gauges generally used are of Bourden type.

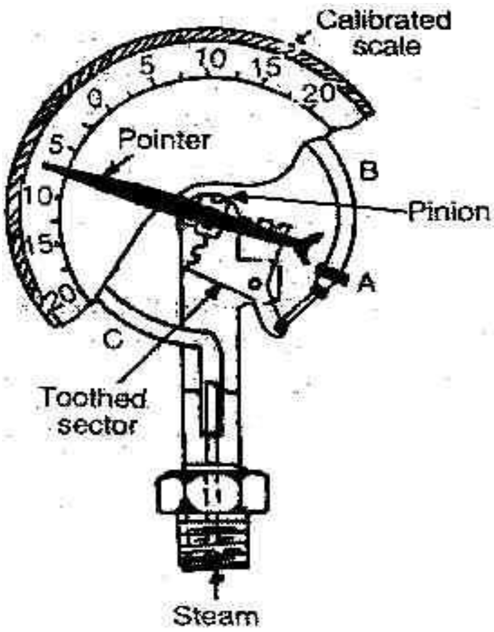


Fig. 14.2. Bourden type pressure

A Bourden pressure gauge, in its simplest form consists of an elliptical elastic tube ABC bent into an arc of a circle, as shown in fig. This bent up tube is called Bourden's tube.

One end of the tube gauge is fixed and connected to the steam space in the boiler. The other end is connected to a sector through a link. The steam, under pressure, flows into the tube. As a result of this increased pressure, the Bourden's tube tends to straighten itself. Since the tube is encased in a circular curve, therefore it tends to become circular instead of straight. With the help of a simple pinion and sector arrangement, the elastic deformation of the Bourden's tube rotates the pointer. This pointer moves over a calibrated scale, which directly gives the gauge pressure.

CHAPTER : 4

Q. Continuity equation ;-(2019)

→ continuity equation is based upon the conservation of mass.

→ It states that for a fluid flowing through the pipe, mass of fluid passing across different cross section will constant.

Q. WHAT IS THE FUNCTION OF VENTURIMETER? (2019)

Venturi meters are flow measurement instruments which use a converging section of pipe to give an increase in the flow velocity and a corresponding pressure drop from which the flowrate can be deduced.

Q. A venture meter having diameter of 100 mm at the throat and 175 mm at the enlarged end is installed in a horizontal pipeline of 175 mm in diameter carrying an oil of specific gravity 0.95. The difference of pressure head is 180 mm of Hg. Determine the discharge through the pipe

Ans: Diameter at inlet, d_1 = 175 mm = 0.175 m

Diameter at throat , d_2 = 100 mm = 0.1 m

Area at inlet, $a_1 = \pi/4 \times d_1^2 = \pi/4 \times (0.175)^2 = 0.024\ m^2$

Area at throat, $a_2 = \pi/;4 \times d_2^2 = \times (0.1)^2 = 0.008\ m^2$

Specific gravity (s) = 0.95

Co-efficient of discharge, C_d = 0.97

Reading of differential manometer x = 740 mm of Hg = 0.74 m of Hg

Difference of pressure head

$$h = x\left[\frac{S_h}{S_0} - 1\right] = 0.74\left[\frac{13.6}{0.95} - 1\right] \text{m of oil} = 9.86 \text{ mof oil}$$

$$\text{Discharge, } Q = C_d \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

$$= 0.97 \times \frac{0.024 \times 0.008}{\sqrt{(0.024)^2 - (0.008)^2}} \times \sqrt{2 \times 9.81 \times 9.86}$$

$$= 0.07\ m^3 / s = 70 \text{ litrs / sec}$$

Q. **Difference Between Laminar and Turbulent Flow.**(2019)

It is a fluid **flow** in which the fluid layers move parallel to each other and do not cross each other. ... The **laminar flow** generally occurs **in the** fluid **flowing** with low velocity. The **turbulent flow** occurs when the fluid **flows** with high velocity.

Q. Define uniform flow and laminar flow

Ans: UNIFORM FLOW

Fluid flow is said to be uniform in which the flow parameters like velocity pressure, temperature and density etc and any given time does not change with respect to space (i.e. length of direction of fluid flow)

Mathematically,

$$\left(\frac{\partial v}{\partial s}\right)_{t=\text{constant}} = 0 \qquad \left(\frac{\partial T}{\partial s}\right)_{t=\text{constant}} = 0$$

$$\left(\frac{\partial p}{\partial s}\right)_{t=\text{constant}} = 0 \qquad \left(\frac{\partial \rho}{\partial s}\right)_{t=\text{constant}} = 0$$

Example :

1. Flow of liquid under pressure through long pipe lines of constant diameter.
2. Flow through a straight prismatic conduit (i.e. flow through a straight pipe of constant diameter)

LAMINAR FLOW

A laminar flow is that type of flow in which one lamina or layer of fluid glide smoothly over another adjacent layer. The fluid particles move along well-defined paths or stream line and all the stream lines are straight and parallel. The fluid particles retain the same relative position at successive cross-section of the flow passage. Flow.

Example:

1. Flow through a capillary tube
2. Flow of blood in veins and arteries

Q. Establish relation between C_d, C_c and C_v

(i) Co-efficient of velocity (C_v)- it is ratio of the actual velocity of jet at vena contract to the theoretical velocity

$$\text{Co}-\text{efficient of velocity } (C_v) = \frac{\text{Actual velocity of jet}}{\text{Theoretial velocity of jet}}$$

(ii) Co-efficient of contraction (C_c) – It is the ratio of actual area of jet at Vena contract to the area of orifice

$$\text{Co}-\text{efficient of contraction } (C_c) = \frac{\text{Area of jet at vena contrat}}{\text{Area of orifice}}$$

Co-efficient of discharge – It is the ratio of actual discharge from an orifice to the theoretical discharge from orifice.

(iii)

$$\text{Co}-\text{efficient of discharge} = \frac{\text{Atual discharge from on orifice}}{\text{Theoretial discharge from orifice}}$$

$$= \frac{\text{Actual velocity} \times \text{Atual arera}}{\text{Theoretical velocity} \times \text{Theoretical area}}$$

$$\Rightarrow \quad C_d = C_c \times C_v$$

Q. A horizontal venturimeter of size 0.65 m × 0.35 m is used to measure the flow of oil of specific gravity 0.85. the discharge of oil through venturimeter is 100 litres/s. Find the reading of oil mercury differential manometer. Take C_d = 0.98.

Ans:

$$\text{Diameter at inlet } d_1 = 0.65 \text{ m}$$

$$\text{Area at inlet, } a_1 = \frac{\pi}{4} \times d_1^2 = \frac{\pi}{4} \times (0.65)^2 = 0.33 \text{ m}^2$$

$$\text{Diameter sat throat, } d_2 = 0.35 \text{ m}$$

$$\text{Area at throat, } a_2 = \frac{\pi}{4} \times d_2^2 = \frac{\pi}{4} \times (0.35)^2 = 0.95 \text{ m}^2$$

$$\text{Discharge, } Q = 100 \text{ loitres / s} = \frac{100}{1000} \text{m}^3 \text{ / s}$$

$$\text{Co}-\text{efficient of discharge, } C_d = 0.98$$

$$\text{Discharge, } Q = C_d \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

$$\Rightarrow 0.1 = 0.98 \times \frac{0.33 \times 0.095}{\sqrt{(0.33)^2 - (0.095)^2}} \times \sqrt{2 \times 9.81 \times h}$$

$$\Rightarrow 0.1 = 0.98 \times \frac{0.03}{0.32} \times \sqrt{19.62 \times h}$$

$$\Rightarrow 0.1 = 0.09 \times \sqrt{19.62 \times h}$$

$$\Rightarrow \frac{0.01}{0.09} = \sqrt{19.62 \times h}$$

$$\Rightarrow 1.1 = \sqrt{19.62 \times h}$$

Squaring both sides we get

$(1.1)^2 = 19.62 \times h$

$\Rightarrow 1.21 = 19.62 \times h$

$\Rightarrow h = 1.21/19.62 = 0.06$ m

Let x = reading of differential manometer

Difference of pressure head

$$h = x\left[\frac{S_h}{S_0} - 1\right]$$

$$\Rightarrow 0.06 = x\left[\frac{13.6}{0.85} - 1\right]$$

$$\Rightarrow 0.06 = x\left[16 - 1\right] \Rightarrow 15x = 0.06$$

$$\Rightarrow x = \frac{0.06}{15} = 0.004 \text{ m of Hg}$$

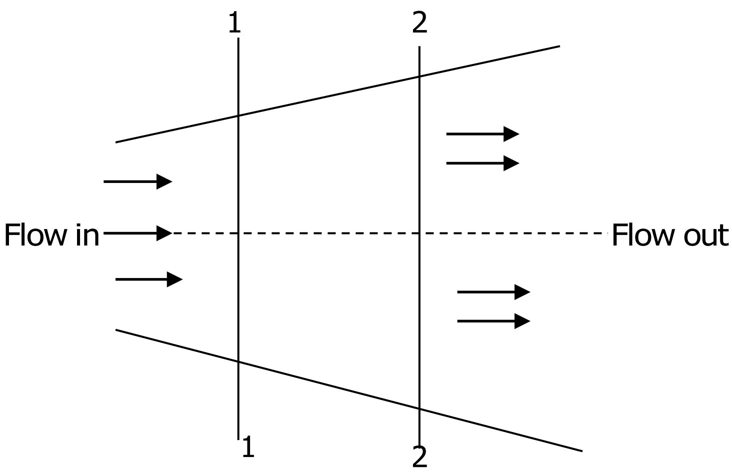
$$= 4\text{mm of Hg}$$

Q. State & Explain continuity Equation

Ans: Continuity equation ;-

→ continuity equation is based upon the conservation of mass.

→ It states that for a fluid flowing through the pipe, mass of fluid passing across different cross section will constant.



Consider two cross section of a pipe as shown in figure.

Let, A_1 = Area of cross section of section 1 – 1

V_1 = Average velocity of fluid of section 1- 1

S_1 = Density of fluid of section 1 – 1

Similarly,

A_2 = Area of cross section of section 2 – 2

V_2 = Average velocity of fluid of section 2 – 2

S_2 = Density of fluid of section 2 – 2

From the law of conservation of mass of continuity equation.

Mass at section 1 – 1 = mass at section 2 – 2

$S_1A_1V_1 = S_2 V_2 A_2$

This equation is applicable to the compressible as well as incompressible fluid and is called continuity equation.

In case of compressible fluid $s_1 = s_2$ the equation reduces to $A_1 V_1=A_2V_2$

CHAPTER : 5

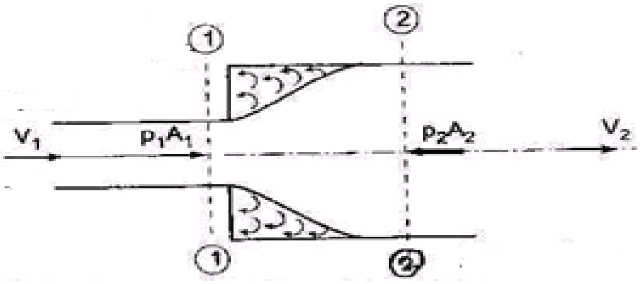
Q. Mention different head losses in flow through pipe.

Ans: 1. Loss of head due to sudden enlargement

2. Loss of head due to sudden contraction
3. Loss of head at entrance of pipe
4. Loss of head at exit of pipe
5. Loss of head due to obstruction in a pipe
6. Loss of head due to bend in pipe
7. Loss of head due to various pipe fittings.

Q. Show that the loss of head due to sudden expansion in a pipe line is a function of velocity head.

Ans: Loss of head due to sudden enlargement. Consider a liquid a flowing a pipe which has sudden enlargement as shown in fig. consider two section (1)-(1) and (2)-(2) before and after the enlargement.



Let p = pressure intensity as section 1-1

V_1 = velocity of flow of section 1-1

A_1 = area of pipe at section 1-1

P_2, V_2 and A_2 = corresponding values at section 2-2

Due to sudden change of diameter of the pipe from D_1 to D_2, the liquid flowing from the smaller pipe is not able to follow the abrupt change of the boundary. Thus the flow separates from the boundary and turbulent eddies are formed as shown n fig. the loss of head (or energy) takes place due to the formation of these eddies.

Let p′ = pressure intensity of the liquid eddies on the area $(A_2 - A_1)$

H_e = loss of head due to sudden enlargement

Applying Bernoulli's equation at sections 101 and 2-2

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + \text{loss of head due to sudde enlargement}$$

But $z_1 = z_2$ as pipe is horizontal

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + h_e$$

$$h_e = \left(\frac{p_1}{\rho g} - \frac{p_2}{\rho g}\right) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) ---------- (i)$$

Consider the control volume of liquid between section 1-1 and 2-2. Then the force acting on the liquid in the control volume in the direction of flow is given by

$F_x = p_1A_1 + p'(A_2 - A_1) - p_2A_2$

But experimentally it is found that $p' = p_1$

$F_x = p_1A_1 + p_1(a_2 - a_1) - p_2A_2 = p_1A_2 - p_2A_2$

$= (p_1 - p_2)\, A_2$ ....(ii)

Momentum of liquid/se at section 1-1 = mass × velocity

$\rho_1 A_1 \; V_1 \times V_1 = \rho A_1 V_1^2$

Momentum of liquid/sec at section 2-2 = $\rho a_2 V_2 \times V_2 = \rho A_2 V_2^2$

$\therefore$ Change of momentum/sec = $\rho A_2 V_2^2 - \rho A_1 V_1^2$

But from continuity equation, we have

$$A_1V_1 = A_2V_2 \text{ or } A_1 = \frac{A_2V_2}{V_1}$$

$\therefore$ change of momentum/sec $\rho A_2 V_2^2 - \rho \times \frac{A_2V_2}{V_1} \times V_1^2 = \rho A_2 V_2^2 - \rho A_2 V_1 V_2$

$= \rho A_2 [V_2^2 - V_1V_2]$ ....(iii)

Now net force ating on the control volume in the direction of flow must be equal to the rate of change of momentum or change of momentum per second. Hence equating (ii) and (iii)

$$(p_1 - p_2)A_2 = \rho A_2 [V_2^2 - V_1V_2]$$

$$\frac{p_1 - p_2}{\rho} = V_2^2 - V_1V_2$$

Dividing by g on both sides,we have

$$\frac{p_1 - p_2}{\rho} = \frac{V_2^2 - V_1V_2}{g} \text{ or } \frac{p_1}{\rho g} - \frac{p_2}{\rho g} = \frac{V_2^2 - V_1V_2}{g}$$

Q. State Darcy's formula for loss of head in a pipe.

The loss of head in pipes due to friction s given by $h_f = \frac{4fLV^2}{2g \times d}$

Where h_f = loss of head due to friction

f = co-efficient of friction which is a function of Reynolds number

L = length of pipe, V = mean velocity of flow, d = diameter of pipe.

Explain hydraulic gradient line and total gradient line.

Hydraulic gradient line, It can be defined as a line which gives the sum of pressure head (p/w) and datum head or potential head (z) of a flowing fluid in a pipe with respect to some reference line. The sum of pressure head and potential head $\left(\frac{p}{\rho g} + z\right)$ at any point is called piezometric head. If a line is drawn which joins piezometric head at various points the line obtained is known as "hydraulic gradient line"

Total energy line : It can be defined as the line which gives the total head is sum of pressure head, velocity head and kinetic head $\left(\frac{p}{\rho g} + \frac{V^2}{2g} + z\right)$ of a flowing fluid in a pipe with respect to some reference line.

When the fluid flows through the pipe there is always some loss of energy (head and the total energy decreases in the direction of flow.

If the total energy at various points along the axis of pipe is plotted and joined by a line the line so obtained is called total energy line.

Q. Water flows through an old pipe 3.30 m in diameter and 500 m long at the rate of 0.2 cumecs. Find the head lost in friction by using.

(i) Chezy's formula

(ii) Darcy's formula

Ans: Diameter of pipe, d = 3.3 m

Length of pipe, L = 500 m

Discharge, Q = 0.2 m^3/s

Assume kinematic viscosity

V = 0.01 stoke = 0.01×10^{-4} m^2/s

And Chezy's constant , C = 60

Velocity of flow, $V = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4} \times d^2} = \frac{0.2}{\frac{\pi}{4} \times (3.3)^2} = 0.02\ m/s$

$$\text{Re ynoldnum, ber, Re} = \frac{Vd}{\upsilon} = \frac{0.2 \times 3.3}{0.01 \times 10^{-4}} = 66000$$

$$\text{Co} - \text{efficient of friction } f = \frac{0.079}{Re^{1/4}}$$

$$= \frac{0.079}{(66000)^{1/4}} = 0.005$$

Los of head due to friction

$$hf = \frac{4fLV^2}{2gd} = \frac{4 \times 0.005 \times 500 \times 0.02}{2 \times 9.81 \times 3.3} = 0.00006\ m$$

Chezy's formula

Assume , c = 60

V = C√mi

Hydraulic mean depth m = d/4 = 3.3/4 = 0.825 m

Using Chezy's equation

$$V = C\sqrt{mi}$$

$$\Rightarrow 0.02 = 60\sqrt{0.825 \times i}$$

Squaring both sides

$$(0.02)^2 = 3600 \times 0.825 \times i \Rightarrow i = \frac{(0.02)^2}{3600 \times 0.825}$$

$$i = \frac{hf}{L} \Rightarrow hf = i \times L = 0.0000003 \times 500 = 0.0000003 = 0.00015\ m$$

CHAPTER:6

Q **Definition of *hydraulic gradient(2019)***

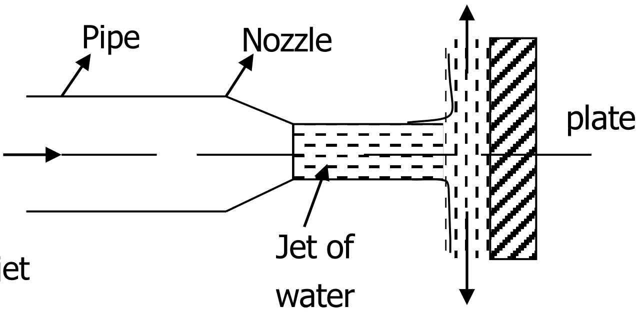
: a line joining the points of highest elevation of water in a series of vertical open pipes rising from a pipeline in which water flows under pressure

Q. Define the term impact of jet

Ans: When a fluid jet strikes an obstruction placed in its path, it will exert a force on the obstruction. This force is known as impact of jet.

Q. Derive an expression for the force of a jet on a fixed plate.

Ans: Consider a jet of water coming out from the nozzle strikes a flat vertical plate



Let V = velocity of jet

D = diameter of jet

A = cross sectional area of jet = $\pi/4 \times d^2$

The jet after striking the plate will move along the plate

Force exerted by jet on the plate in the direction of jet = Rate of change of momentum in the direction of force

$$= \frac{\text{Initial momentum} - \text{Final momentum}}{\text{Time}}$$

$$= \frac{\text{Mass} \times \text{initial veloity} - \text{mass} \times \text{final velocity}}{\text{Time}}$$

$$= \frac{\text{mass}}{\text{time}} \times (\text{Initial velocity} - \text{final velocity})$$

$$= \text{mass/ sec} \times \left[\text{Velocity of jet before striking} - \text{velocity of jet after striking}\right]$$

$$= \rho aV\left[V - 0\right] = \rho aV^2 \left[\text{mass / sec} = \rho \times aV\right]$$

Q. A jet of water of diameter 50 mm strikes a fixed plate in such a way that the angle between plate and jet is 30°. the force exerted in the direction of jet is 1471.5 n. Determine the rate of flow of water.

Ans: Diameter of jet, d= 50 mm = 0.05 m

Area of jet, a = $\pi/4 \times d^2 = \pi/4 \times (0.05)^2 = 0.0019\ m^2$

Angle, $\theta = 30^o$

Force in the direction of jet , $F_x = 1471.5$ N

Force in the direction of jet $F_x = paV^2 \sin\theta$

$\Rightarrow \quad 1471.5 = 1000 \times 0.0019 \times V^2 \times \sin 30^o$

$\Rightarrow \quad 1471.5 = 1000 \times 0.0019 \times v^2 \times 0.5$

$$\Rightarrow \quad v^2 = \frac{1471.5}{1000 \times 0.0019 \times 0.5} = 1548.95$$

$$\Rightarrow \quad V = \sqrt{1548.95} = 39.36\ m/s$$

Discharge, θ = area × velocity = 0.0019 × 39.36 = 0.075 m^3/s

Q. A jet of water 40 mm diameter moving with a velocity of 120 m/s impinging on a series of venes moving with a velocity of 5 m/s. Find the force exerted, work done and efficiency.

Ans: Diameter of jet, d = 40 mm = 0.04 m

Area of jet, a = $\pi/4 \times d^2 = \pi/4 \times (0.04)^2\ m^2 = 0.00125\ m^2$

Velocity of vane, U = 5 m/s

Velocity of jet V = 120 m/s

Force exerted by jet, $f = \rho a\,(V - U)^2$

$= 1000 \times 0.00125 \times (120 - 5)^2 = 16531.25$ N = 16.53 kN

Workdone = force × distance

16.53 × 5 = 82.65 kJ

$$\text{Efficiency of jet, } \eta = \frac{2(V-U)\times 4}{V^2}$$

$$= \frac{2 \times (120-5) \times 5}{(120)^2} = 0.08 \text{ or } 80\ \%$$

Q. What is reaction turbine

Ans: If at the inlet of turbine the water possess kinetic energy as well as pressure energy then it is known as reaction turbine.