# UNIT III FLOW THROUGH PIPES

1. List the types of fluid flow.
   - Steady and unsteady flow
   - Uniform and non-uniform flow
   - Laminar and Turbulent flow
   - Compressible and incompressible flow
   - Rotational and ir-rotational flow
   - One, Two and Three dimensional flow

2. Define Steady and Unsteady flow.

**Steady flow**

Fluid flow is said to be steady if at any point in the flowing fluid various characteristics such as velocity, density, pressure, etc do not change with time.

$$\partial V/\partial t = 0 \quad \partial p/\partial t = 0 \quad \partial \rho/\partial t = 0$$

**Unsteady flow**

Fluid flow is said to be unsteady if at any point flowing fluid any one or all characteristics which describe the behaviour of the fluid in motion change with time.

$$\partial V/\partial t \neq 0 \quad \partial p/\partial t \neq 0 \quad \partial \rho/\partial t \neq 0$$

3. Define Uniform and Non-uniform flow.

**Uniform flow**

When the velocity of flow of fluid does not change both in direction and magnitude from point to point in the flowing fluid for any given instant of time, the flow is said to be uniform.

$$\partial V/\partial s = 0 \quad \partial p/\partial s = 0 \quad \partial \rho/\partial s = 0$$

**Non-uniform flow**

If the velocity of flow of fluid changes from point to point in the flowing fluid at any instant, the flow is said to be non-uniform flow.

$$\partial V/\partial s \neq 0 \quad \partial p/\partial s \neq 0 \quad \partial \rho/\partial s \neq 0$$

**4. Compare Laminar & Turbulent Flow**

**Laminar and Turbulent flow**

A flow is said to be laminar if Reynolds number is less than 2000 for pipe flow. Laminar flow is possible only at low velocities and high viscous fluids. In laminar type of flow, fluid particles move in laminas or layers gliding smoothly over the adjacent layer.

**Turbulent flow**

In Turbulent flow, the flow is possible at both velocities and low viscous fluid. The flow is said to be turbulent if Reynolds number is greater than 4000 for pipe flow. In Turbulent type of flow fluid, particles move in a zig – zag manner.

5.Define Compressible and incompressible flow

**Compressible flow**

The compressible flow is that type of flow in which the density of the fluid changes from point to point i.e. the density is not constant for the fluid. It is expressed in kg/sec.

$$\rho \neq \text{constant}$$

**Incompressible flow**

The incompressible flow is that type of flow in which the density is constant for the fluid flow.

Liquids are generally incompressible. It is expressed in $m^3/s$.

$$\rho = \text{constant}$$

6.Define Rotational and Ir-rotational flow.

**Rotational flow**

Rotational flow is that type of flow in which the fluid particles while flowing along stream lines and also rotate about their own axis.

**Ir-rotational flow**

If the fluid particles are flowing along stream lines and do not rotate about their own axis that type of flow is called as ir-rotational flow

7. Define One, Two and Three dimensional flow.

**One dimensional flow**

The flow parameter such as velocity is a function of time and one space co-ordinate only. $\mathbf{u = f(x), v = 0}$ & $w = 0$.

**Two dimensional flow**

The velocity is a function of time and two rectangular Space co-ordinates. $\mathbf{u = f_1(x,y), v = f_2(x,y)}$ **&** $\mathbf{w = 0}$.

**Three dimensional flow**

The velocity is a function of time and three mutually perpendicular directions.

$$\mathbf{u = f_1(x,y,z),\ v = f_2(x,y,z)\ \&\ w = f_3(x,y,z).}$$

8. Write the Bernoulli's equation applied between two sections

$$\mathbf{p_1/\rho g + v^2_1/2g + Z_1 = p_2/\rho g + v^2_2/2g + Z_2}$$

$p/\rho g$ = pressure head

$v^2/2g$ = kinetic head Z = datum head

9. State the assumptions used in deriving Bernoulli's equation

- Flow is steady;
- Flow is laminar;
- Flow is irrotational;
- Flow is incompressible;
- Fluid is ideal.

10.Write the Bernoulli's equation applied between two sections with losses.

$$\mathbf{p_1/\rho g + v^2_1/2g + Z_1 = p_2/\rho g + v^2_2/2g + Z_2 + h_{loss}}$$

11.List the instruments works on the basis of Bernoulli's equation.

- Venturi meter
- Orifice meter
- Pitot tube.

12.Define Impulse Momentum Equation (or) Momentum Equation.

The total force acting on fluid is equal to rate of change of momentum. According to Newton's second law of motion,

$$F = ma$$
$$F\,dt = d(mv)$$

13.Mention the range of Reynold's number for laminar and turbulent flow in a pipe.

If the Reynolds number is less than 2000, the flow is laminar. But if the Reynold's number is greater than 4000, the flow is turbulent flow.

14.What does Haigen-Poiseulle equation refer to?

The equation refers to the value of loss of head in a pipe of length 'L' due to viscosity in a laminar flow.

15.What is Hagen poiseuille's formula?

$$(P_1-P_2) / \rho g = h_f = 32\, \mu \bar{U} L / \rho g D^2$$

The expression is known as Hagen poiseuille formula.

Where $P_1-P_2 / \rho g$ = Loss of pressure head, $\bar{U}$= Average velocity, $\mu$ = Coefficient of viscosity, D = Diameter of pipe, L = Length of pipe

16. Write the expression for shear stress?

$$\text{Shear stress } \zeta = -(\partial p/\partial x)\ (r/2)$$
$$\zeta_{max} = -(\partial p/\partial x)\ (R/2)$$

17. Give the formula for velocity distribution: -

The formula for velocity distribution is given as

$$u = -(1/4\mu)\ (\partial p/\partial x)\ (R^2-r^2)$$

Where R = Radius of the pipe,

r = Radius of the fluid element

18. Give the equation for average velocity: -

The equation for average velocity is given as

$$\bar{U} = -(1/8\mu)\ (\partial p/\partial x)\ R^2$$

Where R = Radius of the pipe

19. Write the relation between Umax and Ū?

$$\mathbf{Umax / \bar{U} = \{ - (\tfrac{1}{4} \mu) (\partial p/\partial x) R^2 \} / \{ - \tfrac{1}{8}\mu (\partial p/\partial x) R^2 \}}$$

$$\mathbf{Umax / \bar{U} = 2}$$

20. Give the expression for the coefficient of friction in viscous flow?

Coefficient of friction between pipe and fluid in viscous flow

**f =16/ Re**

Where, f = Re = Reynolds number

21. What are the factors to be determined when viscous fluid flows through the circular pipe?

The factors to be determined are:

a. Velocity distribution across the section.

b. Ratio of maximum velocity to the average velocity.

c. Shear stress distribution.

d. Drop of pressure for a given length

22. State Darcy-Weisbach equation **OR** What is the expression for head loss due to friction?

$$\mathbf{h_f = 4flv^2 / 2gd}$$

where, $h_f$ = Head loss due to friction (m),

L = Length of the pipe (m),

d = Diameter of the pipe (m),

V = Velocity of flow (m/sec)

f = Coefficient of friction

23. What are the factors influencing the frictional loss in pipe flow?

Frictional resistance for the turbulent flow is,

i. Proportional to $v^n$ where v varies from 1.5 to 2.0.

ii. Proportional to the density of fluid.

iii. Proportional to the area of surface in contact.

iv. Independent of pressure.

v. Depend on the nature of the surface in contact.

## PART - B

1. Find the head lost due to friction in a pipe of diameter 300 mm and length 50 m, through which water is flowing at a velocity of 3 m/s using (i) Darcy formula, (ii) Chezy's formula for which C = 60.
2. An oil of sp.Gr 0.9 and viscosity 0.06 poise is flowing through a pipe of diameter 200 mm at the rate of 60 litres/sec./ find the head lost due to friction for a 500 m length of pipe. Find the power required to maintain this flow.
3. The rate of flow of water through a horizontal pipe is 0.25 $m^3$/s. The diameter of the pipe which is 200 mm is suddenly enlarged to 400 mm. The pressure intensity in the smaller is 11.772 N/$cm^2$. Determine: (i) loss of head due to sudden enlargement, (ii) pressure intensity in the large pipe, (iii) power lost due to enlargement.
4. A horizontal pipe line 40 m long is connected to a water tank at one end discharges freely into the atmosphere at the other end. For the first 25 m of its length from the tank, the pipe is 150 mm diameter and its diameter is suddenly enlarged to 300 mm. The height of water level in the tank is 8 m above the centre of the pipe. Considering all losses of head which occur, determine the rate of flow. Take f = 0.01 for both sections of the pipe.
5. A pipe line, 300 mm in diameter and 3200 m long is used to pump up 50 kg per second of oil whose density is 950 kg/$m^3$ and whose kinematic viscosity is 2.1 stokes. The centre of the pipe line at the upper end is 40 m above than that at the lower end. The discharge at the upper end is atmospheric. Find the pressure at the lower end and draw the hydraulic gradient and the total energy line.
6. A siphon of diameter 200 mm connects two reservoirs having a difference in elevation of 15 m. The total length of the siphon is 600 mm and the summit is 4 m above the water level in the upper reservoir. If the separation takes place at 2.8 m of water absolute, find the maximum length of siphon from upper reservoir to the summit. Take f = 0.004 and atmospheric pressure = 10.3 m of water.
7. The difference in water surface levels in two tanks, which are connected by three pipes in series of lengths 300 m, 170 m and 210 m and of diameters 300 mm, 200 mm and 400 mm respectively, is 12m. Determine the rate of flow of water if co – efficient of friction are 0.005, 0.0052 and 0.0048 respectively, considering: (i) minor losses also (ii) neglecting minor losses.
8. A main pipe is divided into two parallel pipes which again forms one pipe. The length and diameter for the first parallel pipe are 2000 m and 1.0 m respectively, while the length and diameter of $2^{nd}$ parallel pipe are 2000 m and 0.8 m. Find the rate of flow in each parallel pipe, if total flow in the main is 3 $m^3$/s. The co efficient of friction for each parallel pipe is same and equal to 0.005.

9. A pipe of diameter 20 cm and length 2000 m is connects two reservoirs, having difference of water levels as 20 m. determine the discharge through the pipe.

   If an additional pipe of diameter 20 cm and length 1200 m is attached to the last 1200 m length of the existing pipe, find the increase in the discharge. Take f = 0.015 and neglect minor losses.

10. A pipe line 60 cm diameter bifurcates at a Y- junction into two branches 40 cm and 30 cm in diameter. If the rate of flow in the main pipe is 1.5 $m^3$/s and mean velocity of flow in 30 cm diameter pipe is 7.5 m/s, determine the rate of flow in the 40 cm diameter pipe.
11. A pipe line of length 2000 m is used for power transmission. If 110.3625 kW power is to be transmitted through the pipe in which water having a pressure of 490.5 N/$cm^2$ at inlet is flowing. Find the diameter of the pipe and efficiency of transmission if the pressure drop over the length of pipe is 98.1 N/ $cm^2$. Take f = 0.0065.
12. Find the maximum power transmitted by a jet of water discharging freely out of nozzle fitted to a pie = 300 m long and 100 mm diameter with co efficient of friction as 0.01. the available head at the nozzle is 90 m.