UNIT 7

HYDRAULICS

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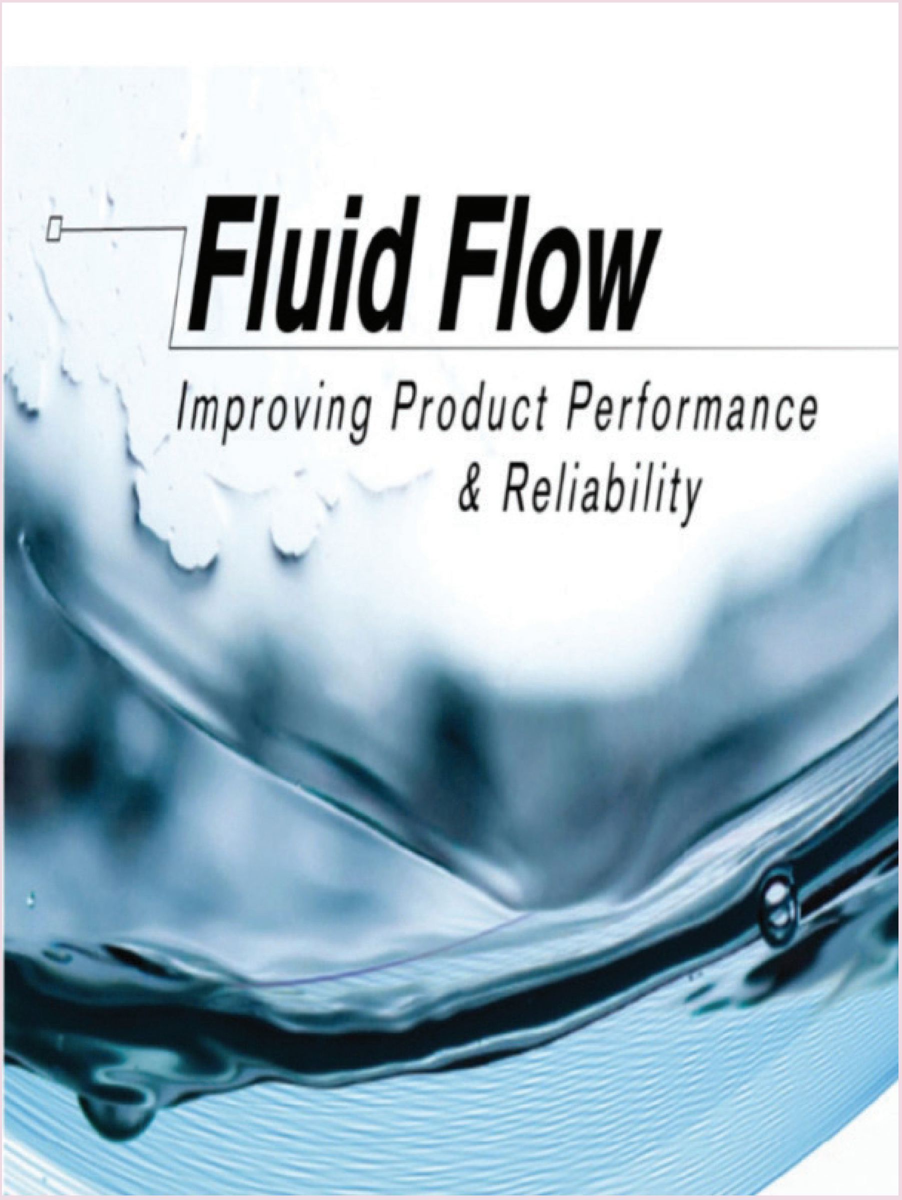

"One small change can have an enormous impact."

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Learning Objectives

At the end of this lesson you shall be able to

- Understand fluids and its properties.
- List the types of pressure.
- Know the pressure measuring devices.
- Explain the different types of pipe flow.
- Understand Orifice, mouthpiece and its types.
- List the Classification of pumps.
- Explain the working of pumps

7.1 Introduction

7.1.1 Hydraulics – Definition

The branch of science, which deals with the properties and behavior of liquids is called 'Hydraulics'. It is otherwise called 'Hydromechanics'.

7.1.2 Fluids

Fluids are substances which are capable of flowing. They confirm to the shape of the container. They change their shape even under the action of very small forces. They have some degree of compressibility and offer little resistance to change of form. They include liquids and gases.

7.1.3 Properties of Fluids

The following are the some of the properties of fluids.

1. Density
2. Specific weight
3. Specific gravity
4. Cohesion
5. Adhesion
6. Surface tension
7. Capillarity
8. Viscosity

1. Density

Density is defined as the mass per unit volume. It is also termed as mass density or specific mass. It is usually denoted by the Greek letter ρ (rho).

$$\text{Density} = \frac{mass}{volume} \quad \text{i.e., } \rho = \frac{m}{v}$$

Unit: kg/m^3

Density of pure water is 1000 kg/m^3.

2. Specific weight

Specific weight is defined as the weight per unit volume. It is otherwise known as weight density. It is denoted by the Greek letter γ (gamma). Specific weight changes from place to place.

$$\text{Specific weight} = \frac{\text{Weight}}{\text{Volume}} \quad \text{i.e., } \gamma = \frac{w}{v}$$

Unit: N/m^3

Specific weight of pure water is 9.81 kN/m^3.

3. Specific Gravity

Specific gravity is defined as the ratio of mass density of liquid to the mass density of pure water at 4^0C. It is also defined as the ratio of specific weight of liquid to the specific weight of pure water at 4^0C. It is usually denoted by the symbol S. It has neither unit nor dimension. It is also called as relative density

Specific gravity/relative density

$$= \frac{mass\,density\,of\,liquid}{mass\,density\,of\,\,pure\,water\,at\,4°C}$$

$$S = \frac{\rho_l}{\rho_w}$$

Specific gravity/relative density

$$= \frac{specific\,weight\,of\,liquid}{specific\,weight\,of\,\,pure\,water\,at\,4°C}$$

$$S = \frac{\gamma_l}{\gamma_w}$$

4. Cohesion

Cohesion is the property of a liquid by which the molecules of the liquid are mutually attracted by each other. This property holds the molecules together.

Example: Mercury globules merge together and do not wet the surface of contact.

5. Adhesion

Adhesion is the property of a liquid by which the molecules of a liquid are attracted by the molecule of another kind of liquid or a solid. This property enables two different liquids adhere to each other or a liquid to adhere to solid body.

Example: Water drops adhere to the surface of contact rather than merging with each other.

6. Surface tension

Surface tension is a phenomenon in which the surface of a liquid, where the liquid is in contact with gas (such as air) acts like a thin elastic sheet. Surface tension is denoted by the Greek letter σ (sigma). It is expressed in Newton per metre i.e., N/m.

Examples:

i. **Floating a needle:** A carefully placed small needle can be made to float on the surface of water even though it is several times denser than water.

ii. **Walking on water:** Small insects such as the water strider can walk on water because their weight is not enough to penetrate the surface.

7. Capillarity

Capillarity is the rise or fall of a liquid in a capillary tube having small cross sectional

DO YOU KNOW?

Father of Hydraulics

Joseph Bramah

Born	13 April 1748 Stainborough, Barnsley, Yorkshire, England
Died	9 December 1814 (aged 66) Pimlico, London, England
Residence	London, England
Known for	Hydraulic press

area like an opening in the porous materials. It occurs due to intermolecular forces between the liquid and surrounding solid surfaces. It is caused by the pressure of cohesion and adhesion, which works against gravity.

8. Viscosity

Viscosity is a physical property of fluids which shows resistance to flow. In a simple example, water has a low viscosity, as it is thin. Syrup and tar, on the other hand, have a high viscosity, as they are thick. It is denoted by the Greek letter μ (mu). It is expressed as Pa.s(Pascal second) i.e., $N.s/m^2$ or kg/ms.

7.2 Measurement of Pressure

7.2.1 Fluid pressure

Pressure is nothing but a force or weight. The fluid pressure at any point in a liquid is due to the weight of liquid standing above that point. Whenever a liquid (such as water, oil, etc) is in a vessel, it exerts force at all points on the side and bottom of the vessel. This fluid pressure is transmitted equally in all directions. It acts normal to the surface of contact.

7.2.2 Pascal's law

Pascal's law states that, "The pressure at any point in a static fluid (fluid at rest) acts equally in all directions".

Pressure at any point in vertical direction is only due to the weight of the liquid above that point. The liquid transmits pressure equally in all directions. Therefore, the pressure in vertical direction causes an equal horizontal pressure on the sides of the vessel.

7.2.3 Intensity of pressure

Intensity of pressure is the fluid thrust (push in a specified direction) per unit area. It is also termed as unit pressure or simply pressure. It is denoted by the letter p. If P is the force acting on an area A. Then,

$$\text{Intensity of pressure, } p = \frac{P}{A}$$

It is expressed in N/m^2or Pascal (Pa), kN/m^2 and N/mm^2

7.2.4 Pressure and Pressure head

Pressure at a point in a liquid is represented by the equation $p = \gamma H$

Where, γ= specific weight

H = pressure head

The vertical height of a liquid producing a particular pressure is known as the pressure head.

7.2.5 Types of pressure

The pressure may be classified as

1. Static pressure
2. Atmospheric pressure
3. Gauge pressure
4. Absolute pressure

1. Static pressure

Static pressure is the pressure that a fluid exerts when it is not moving (at rest).

2. Atmospheric pressure

Atmospheric pressure is defined as the force per unit area exerted against a surface by the weight of the air above that surface.

3. Gauge pressure

Gauge pressure is the pressure relative to atmospheric pressure. Therefore, it is positive for pressures above atmospheric pressure and negative for pressures below it. The negative gauge pressure is also called vacuum pressure.

4. Absolute pressure

Absolute pressure is the pressure measured with absolute zero taken as a reference. Hence, a perfect vacuum called absolute zero is the datum. It is equal to gauge pressure plus atmospheric pressure.

7.2.6 Pressure measuring devices

The atmospheric pressure is measured by using a simple mercury barometer.

The fluid pressure can be measured by using the following devices.

1. Piezometer
2. Manometer
   a. Simple U-tube manometer.
   b. Differential manometer.
   c. Inverted differential manometer.
   d. Sensitive manometer or Micro manometer.
3. Mechanical Pressure Gauges
   a. Bourdon's tube pressure gauge.
   b. Diaphragm pressure gauge.
   c. Dead weight pressure gauge.

Activity 1

Prepare an album of different types of pressure measuring devices.

7.3 Flow of Fluids

7.3.1 Types of flow

When a fluid flows in a pipe line, it meets with resistance at the contact surface. The flow has different patterns of motion. The pattern of flow depends upon the conditions of flow and the surface conditions. The flow may be steady or unsteady, laminar or turbulent and uniform or non-uniform.

1. Steady flow

A steady flow is the one in which the velocity of fluid flowing per second through any section is constant.

2. Unsteady flow

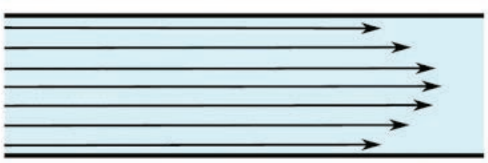
An unsteady flow is the one in which the velocity of fluid flowing per second through any section is not constant.

3. Laminar flow

In this flow, each particle of fluid moves strictly in a straight line as shown in fig. It is also called as steam-line flow. This is possible when,

- The fluid is highly viscous or thick.
- The size of the conduit is small.
- The velocity of fluid is very low.

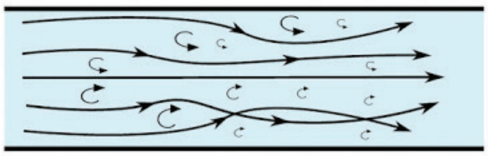
laminar flow



4. Turbulent flow

In this flow, the liquid particles do not have definite paths, but moves in a zig-zag way as shown in fig. Eddies or cross currents are created. Thus, the flow becomes very wavy along its path.

turbulent flow



5. Uniform flow

In this flow, the magnitude and directions of velocities of fluid particles are same at all sections. Example: Constant discharge through a constant diameter pipe.

6. Non Uniform flow

In this flow, the magnitude and directions of velocities of fluid particles are not equal at all sections. Example: Constant discharge through a variable diameter pipe.

7.3.2 Energy possessed by a fluid body

Energy is the ability to do work. It is available in different forms. The energy possessed by a flowing fluid consists of energies due to position, pressure and velocity. They are classified as,

1. Potential energy or static energy or Datum energy.
2. Pressure energy.
3. Kinetic energy.

1. Potential energy

This is the energy possessed by a mass of fluid by virtue of its position in space.

2. Pressure energy

It is the energy possessed by a fluid particle by virtue of its existing pressure.

3. Kinetic energy

It is the energy possessed by a moving fluid particle by virtue of its motion or velocities.

4. Total energy

The total energy of a particle of a flowing fluid is the sum of its potential energy, pressure energy and kinetic energy.

7.3.3 Bernoulli's Theorem / Energy equation

Bernoulli's theorem states that "for a steadily flowing incompressible fluid, in which there is a continuous connection between all the particles of the fluid, the total energy or total head of each particle is the same, provided there is no loss or gain of energy while the particle moves from one point to another".

Mathematically,

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

Where,

Z = Potential energy or Datum head

$\frac{v^2}{2g}$ = Kinetic energy, (v = velocity of flow, g = acceleration due to gravity)

$\frac{P}{\gamma}$ = Pressure energy, (P = Pressure, γ = unit weight of fluid)

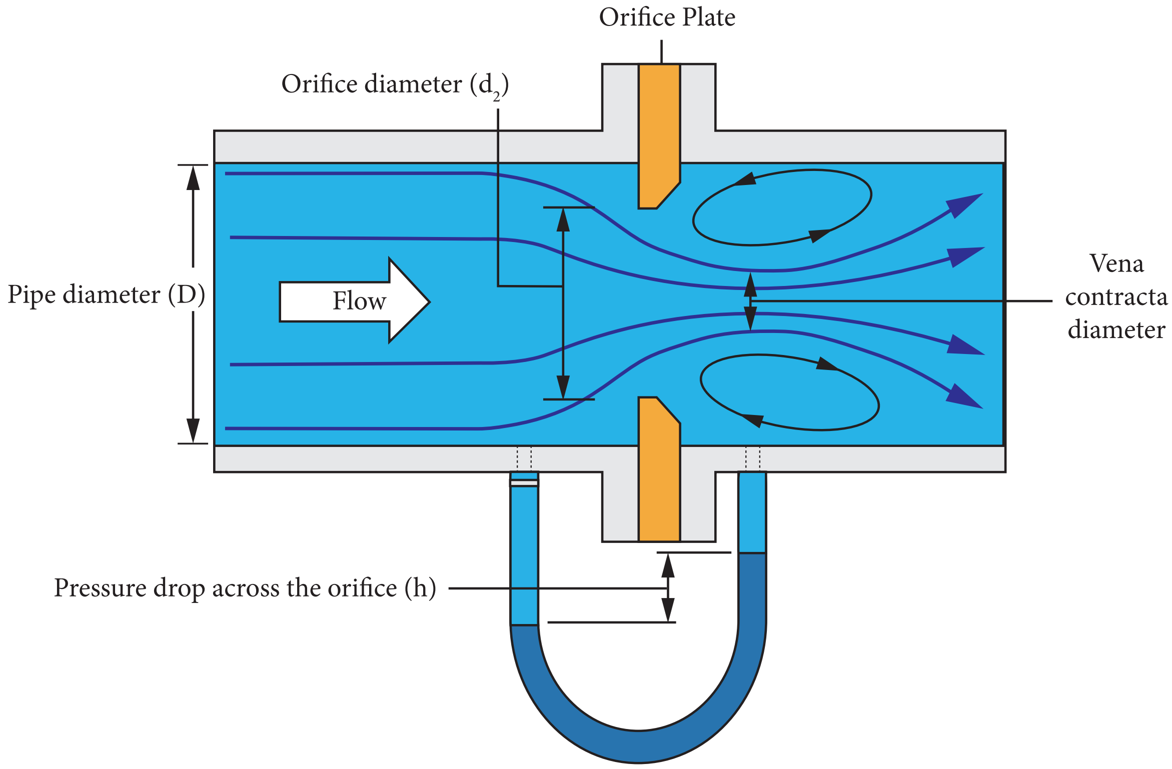
7.4 Flow Through Orifice and Mouthpiece

7.4.1 Orifice – Definition

An opening provided in the side wall or base of a vessel, through which liquid is discharged, is called an Orifice. It is used to measure the discharge.

7.4.2 Types of Orifice

1. According to size
   a. Small Orifice
   b. Large Orifice
2. According to shape
   a. Circular Orifice
   b. Rectangular Orifice
   c. Triangular Orifice



An Orifice plate with venacontracta

3. According to shape of the edge
   a. Sharp-edged Orifice
   b. Bell-Mouthed Orifice
4. According to nature of discharge
   a. Fully submerged Orifice
   b. Partially submerged Orifice

7.4.3 Jet of water

The continuous stream of water that comes out or flows out of an orifice / mouthpiece is known as jet of water.

7.4.4 Venacontracta

When a liquid flows out from a tank under pressure through an Orifice, the diameter of the jet of liquid will be equal to the diameter of the Orifice. But, the diameter of the jet and liquid contracts at a particular place away from the Orifice and then expands again. The point at which the diameter of the jet contracts to the maximum is called 'Venacontracta'.

7.4.5 Hydraulic Coefficients for small Orifice

The following three coefficients are known as hydraulic coefficients or Orifice Coefficients.

1. Coefficient of contraction, C_C
2. Coefficient of velocity, C_V
3. Coefficient of discharge, C_d.

1. Coefficient of contraction

The ratio of the area of jet at vena contracta to the area of the Orifice is known as coefficient of contraction. It is denoted by C_C.

Coefficient of contraction, C_C =

$$\frac{area\ of\ jet\ at\ venacontracta\ (a_c)}{area\ of\ Orifice\ (a)}$$

i.e., $C_C = \frac{a_c}{a}$

2. Coefficient of velocity

The ratio of velocity of jet at vena contracta to the theoretical velocity is termed as coefficient of velocity. It is represented by C_V.

Coefficient of velocity, C_V =

$$\frac{actual\ velocity\ of\ jet\ at\ venacontracta\ (V_a)}{theoretical\ velocity\ (V_t)}$$

i.e., $C_V = \frac{V_a}{V_t}$

3. Coefficient of discharge

The ratio of actual discharge through the Orifice to the theoretical discharge is termed as coefficient of discharge. It is denoted by C_d.

Coefficient of discharge, C_d =

$$\frac{actual\ discharge\ (Q_a)}{theoritical\ discharge\ (Q_t)}$$

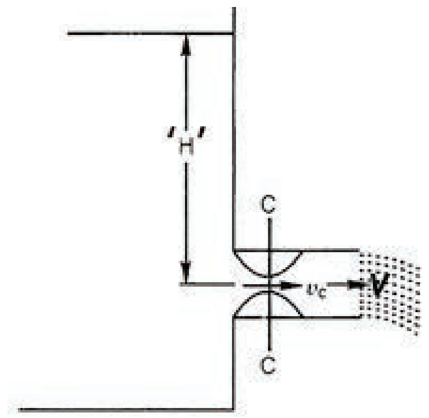
i.e., $Cd = \frac{Q_a}{Q_t}$

7.4.6 Practical applications of Orifice

1. Circular, square and rectangular sluices provided in irrigation tanks.
2. Vent ways of culverts.
3. The openings provided in swimming pools.
4. The openings of canal lock gates to fill up and empty.
5. The openings of balancing reservoirs and surge tanks.

7.4.7 Mouthpiece – Definition

A mouthpiece is a short length of pipe fitted to an Orifice either inwardly or outwardly. Generally, the length of the pipe varies from twice to thrice the diameter of Orifice. It is fitted to increase the discharge of the Orifice.



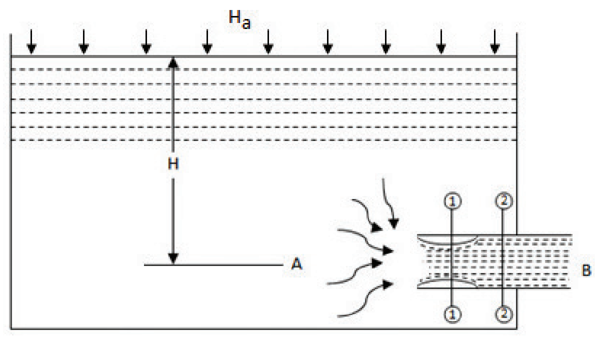
V_C = Velocity at Venacontracta

V = Velocity at Mouth piece

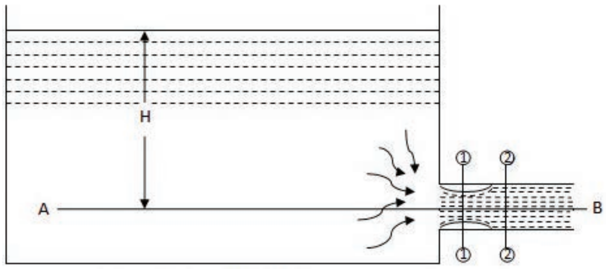
7.4.8 Types of mouthpieces

Mouthpieces are classified as below

1. According to location
   a. Internal mouthpiece



   b. External mouthpiece



2. According to shape
   a. Cylindrical mouthpiece
   b. Convergent mouthpiece
   c. Divergent mouthpiece
   d. Convergent - divergent mouthpiece
3. According to nature of discharge
   a. Running full
   b. Running free

7.5 Flow Through Pipes

7.5.1 Definition

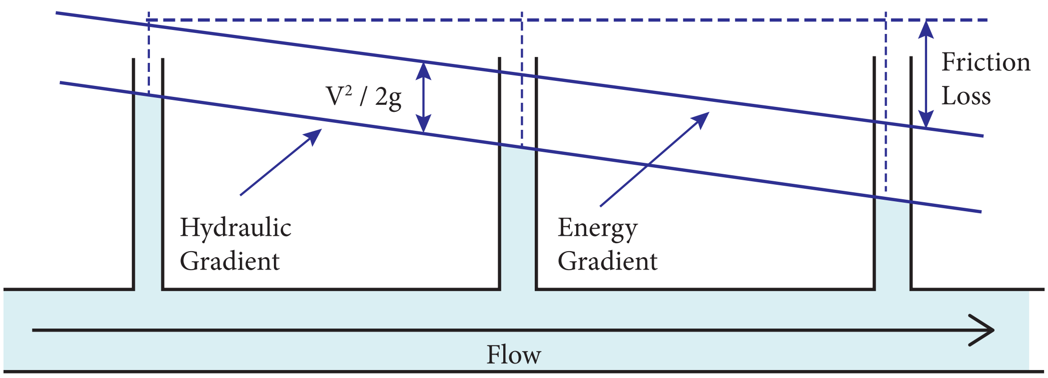
A pipe is a conduit, generally of circular cross section, used to carry liquid under pressure. When the pipe is running full, the flow is under pressure. This kind of flow is known as pipe flow. But, if the pipe is not running full, the flow is not under pressure. In such a case, the atmospheric pressure exist inside the pipe. This kind of flow is termed as channel flow.

7.5.2 Hydraulic gradient line

If pressure heads $\frac{P}{\gamma}$ of a flowing liquid in a pipe be plotted as vertical ordinates on the centerline of the pipe, then the line joining the tops of such ordinates is knows as hydraulic gradient line (H.G.L).

7.5.3 Total energy line

If the sum of pressure heads and velocity heads $\left(\frac{P}{\gamma}+\frac{v^2}{2g}\right)$ of a liquid flowing in a pipe be plotted as vertical ordinates on the center line of the pipe, then the line



joining the tops of such ordinates is known as total energy line (T.E.L).

7.5.4 Loss of head in pipes

When a liquid flows under pressure in a pipe, there will be some losses. These losses are classified as below

1. Major or primary loss (frictional loss)
2. Minor or secondary loss (other losses)

   Major loss is mainly due to viscosity, turbulence and roughness of pipe. This loss is called loss due to friction and is denoted by h_f. The losses due to other causes are called minor losses.

1. Major loss

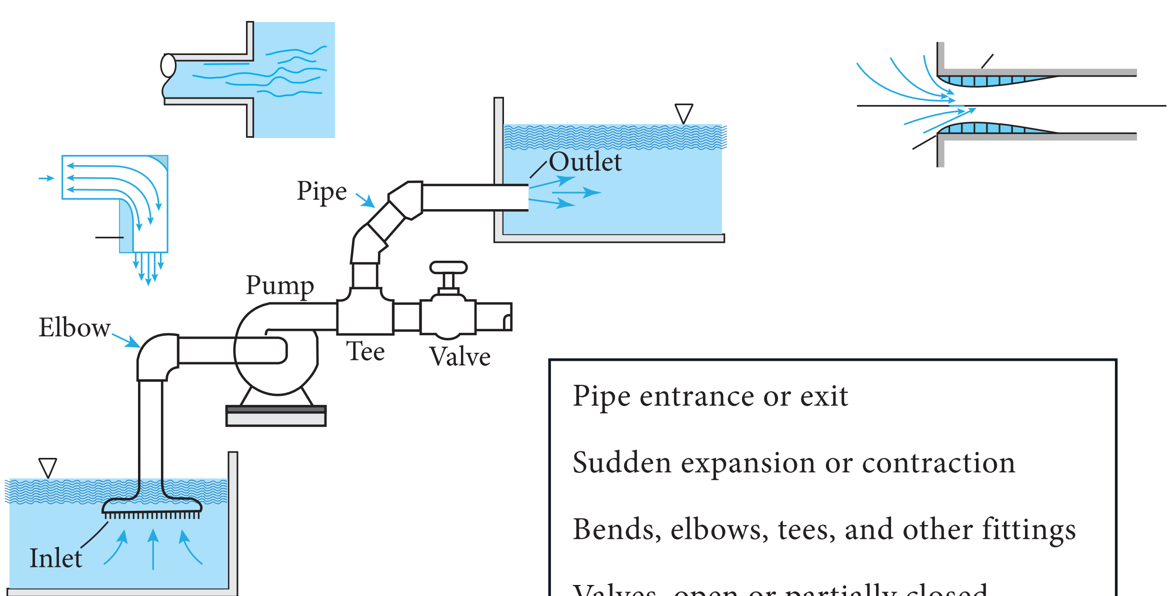
When liquid is flowing in a pipe, it experiences some resistance to its motion due to friction offered by the inner surface of the pipe. This effect is to reduce the velocity and ultimately the head of water. It has been experimentally found that more the roughness of the inside surface of the pipe, greater will be the resistance.

2. Minor losses

The following are the minor losses which occur in a pipe.

a. Loss of head at inlet or entry of a pipe line.
b. Loss of head due to pipe fittings.
c. Loss of head due to change in direction.
d. Loss of head due to sudden enlargement.
e. Loss of head due to sudden contraction.
f. Loss of head due to obstruction.
g. Loss of head at exit of a pipe.

Minor Losses



Pipe entrance or exit

Sudden expansion or contraction

Bends, elbows, tees, and other fittings

Valves, open or partially closed

Gradual expansions or contractions

7.5.5 Darcy's formula for loss of head in pipes in terms of velocity

$$\text{Head loss due to friction (hf)} = \frac{flv^2}{2gd}$$

Where,

f = coefficient of friction

l = length of pipe

v = velocity of water in the pipe

g = acceleration due to gravity ($9.81\ m/s^2$)

d = diameter of the pipe

7.5.6 Darcy's formula for loss of head in terms of discharge

$$\text{Head loss due to friction (hf)} = \frac{flQ^2}{12d^5}$$

Where,

f = coefficient of friction

l = length of pipe

Q = discharge of water from the pipe

d = diameter of the pipe

7.5.7 Problems

Example – 1

Water flows through a pipe of 100 mm diameter and 120 m long with a velocity of 3 m/sec. Find the loss of head due to friction by using Darcy's formula. Take the friction factor as 0.002.

Given data:

Diameter of pipe (d) = 100 mm = 0.10 m

Length of pipe (l) = 120 m

Velocity of flow (v) = 3 m/sec

Friction factor (f) = 0.002

To find out:

Loss of head due to friction (h_f)

Solution:

Loss of head due to friction

$$(h_f) = \frac{flv^2}{2gd}$$

$$= \frac{0.002 \times 120 \times 3^2}{2 \times 9.81 \times 0.10} = 1.10\,m$$

Result:

Loss of head, h_f = 1.10 m

Example – 2

A pipe line, 300 mm diameter and 400 m long connects two reservoirs. The discharge through the pipe is 191 lps. Taking the friction factor as 0.002, determine the loss of head due to friction.

Given data:

Diameter of the pipe (d) = 300 mm

= 0.30 m

Length of the pipe (l) = 400 m

Discharge of water (Q) = 191 lps

= $0.191\ m^3/sec$

Friction factor (f) = 0.002

To determine:

Loss of head due to friction, h_f.

Solution:

Loss of head due to friction

$$(h_f) = \frac{flQ^2}{12d^5}$$

$$= \frac{0.002 \times 400 \times 0.191^2}{12 \times 0.30^5}$$

= 1.00 m

Result:

Loss of head, hf = 1.00 m.

Example – 3

The difference in head between two ends of a pipeline, 400 m long and 200 mm diameter is 2 m. Find out the discharge through the pipe by taking friction factor as 0.003. Neglect minor losses.

Given data:

Length of pipe (l) = 400 m

Diameter of pipe (d) = 200 mm

= 0.20 m

Difference in head (hf) = 2 m

Friction factor (f) = 0.003

To find out:

Discharge through the pipe, Q

Solution:

Loss of head due to friction,

$$h_f = \frac{flQ^2}{12d^5}$$

$$\text{i.e., } 2 = \frac{0.003 \times 400 \times Q^2}{12 \times (0.20)^5}$$

$$2 \times 12 \times (0.20)^5 = 0.003 \times 400 \times Q^2$$

$$\therefore Q^2 = \frac{2 \times 12 \times (0.20)^5}{0.003 \times 400} = 0.0064$$

$$Q = \sqrt{0.0064} = 0.08 \ m^3/\text{sec}$$

Result:

Discharge through the pipe

$$(Q) = 0.08 \ m^3/\text{sec}$$

7.5.8 Chezy's formula for velocity of flow in pipes

Velocity, $v = c\sqrt{mi}$

Where,

v = velocity of flow

c = chezy's constant

m = Hydraulic mean depth

i = Hydraulic gradient

Hydraulic mean depth

$$(m) = \frac{Area\ of\ pipe(A)}{wetted\ perimeter(p)}$$

Wetted perimeter of pipe (p) = πd

$$\text{Area of pipe (A)} = \frac{\pi d^2}{4}$$

$$\therefore m = \frac{A}{p} = \frac{\left(\frac{\pi d^2}{4}\right)}{\pi d} = \frac{d}{4}$$

Hydraulic mean depth, $m = \frac{d}{4}$

Hydraulic gradient, $i = \frac{h_f}{l}$

7.5.9 Chery's formula for loss of head in terms of velocity

We know, Velocity, 'v' = $c\sqrt{mi}$

$$v = c\sqrt{m \times \frac{h_f}{1}} \qquad (i = \frac{h_f}{1})$$

Squaring on both sides,

$$v^2 = c^2 \times m \times \frac{h_f}{l}$$

$$v^2 \times l = c^2 \times m \times h_f$$

$$\therefore h_f = \frac{v^2 l}{c^2 m}$$

Loss of head due to friction, $h_f = \frac{v^2 l}{c^2 m}$

Example – 4

A 300 mm diameter and 600 m long pipe connects two reservoirs. The difference in water levels between the reservoirs is 3 m. Determine the velocity of flow in the pipe. Take Chezy's constant as 60.

Given data:

Diameter of pipe (d) = 300 mm

= 0.30 m

Length of pipe (l) = 600 m

Difference in water level (h_f) = 3 m

Chezy's constant (c) = 60

To determine:

Velocity of flow in the pipe (v)

Solution:

Velocity of flow, v = $c\sqrt{mi}$

Hydraulic mean depth,

$$m = \frac{d}{4} = \frac{0.30}{4} = 0.075m$$

Hydraulic gradient,

$$i = \frac{h_f}{l} = \frac{3}{600} = 0.005$$

$$\therefore Velocity, v = c\sqrt{mi}$$

$$= 60 \times \sqrt{0.075 \times 0.005} = 1.162 \, m/s$$

Result:

Velocity of flow, v = 1.162 m/s.

Example – 5

Water flows through a pipe, 50 mm diameter and 20 m long with a velocity of 3 m/sec. Find out the loss of head due to friction. Take Chezy's constant as 60.

Given data:

Diameter of pipe (d) = 50 mm = 0.05 m

Length of pipe (l) = 20 m

Velocity of flow (v) = 3 m/s

Chezy's constant (c) = 60

To find out:

Loss of head due to friction, h_f

Solution:

We know, Chezy's formula for loss of head in terms of velocity $h_f = \frac{v^2 l}{c^2 m}$

Hydraulic mean depth, m = $\frac{d}{4} = \frac{0.05}{4}$

= 0.0125 m

Head loss due to friction,

$$h_f = \frac{v^2 l}{c^2 m}$$

$$= \frac{3^2 \times 20}{60^2 \times 0.0125} = 4 \text{ m}$$

Result:

Loss of head due to friction, h_f = 4 m.

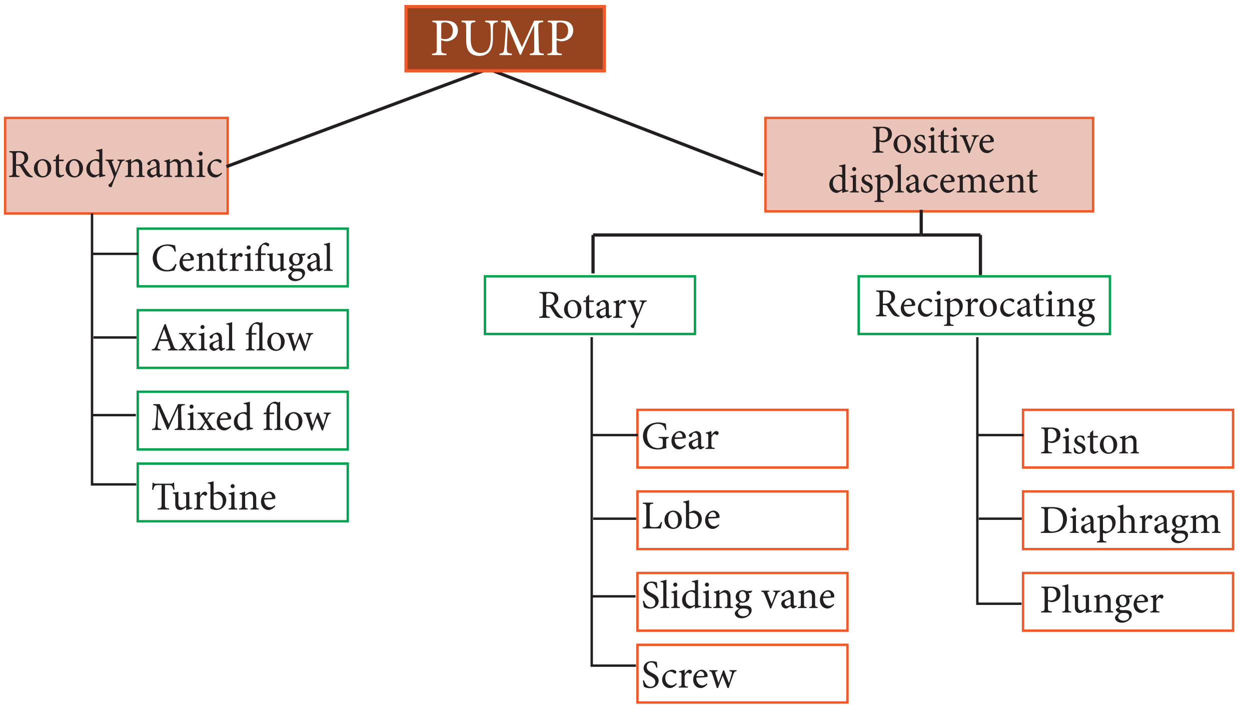
7.6 Pumps

7.6.1 Definition

A pump is a device that moves fluids (liquids or gases) or sometimes slurries by mechanical action. There are two basic classification of pumps. They are,

- Positive displacement pumps
- Rotodynamic pumps

7.6.2 Classification of Pumps



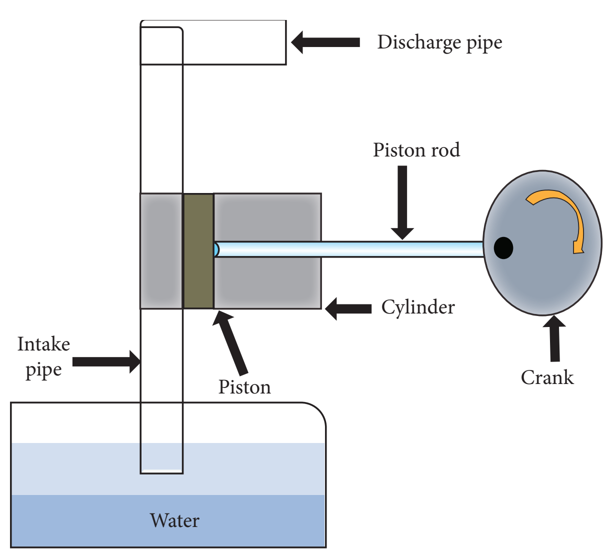
7.6.3 Types of Reciprocating pumps

The following are commonly known types of reciprocating pumps.

- **Single acting reciprocating pump:** This has one suction valve and one delivery valve.
- **Double acting reciprocating pump:** Unlike single acting pump, here there are two suction and delivery valves.

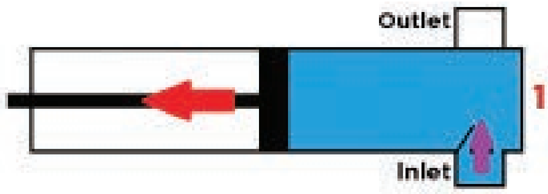
7.6.4 Single acting Reciprocating pump

Structure: A piston or a plunger moves to and fro in a stationary cylinder, alternatively drawing in and pushing out liquid through valves. The suction and delivery pipes are connected to cylinder where suction valve and delivery valve are connected respectively. Piston rod and connecting rod are connected to crank. This revolving crank moves the piston forward and backward in the cylinder. The length of travel of the piston is known as the stroke, which should be equal to the diameter of the crank wheel.



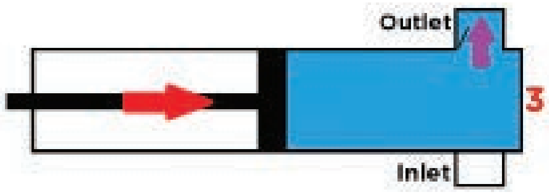
Working

Action1: The piston is pulled back. This action increases the volume of the cavity (cylinder). As the cavity volume expands, fluid is drawn in through the inlet to fill the expanded cavity (Suction stroke).



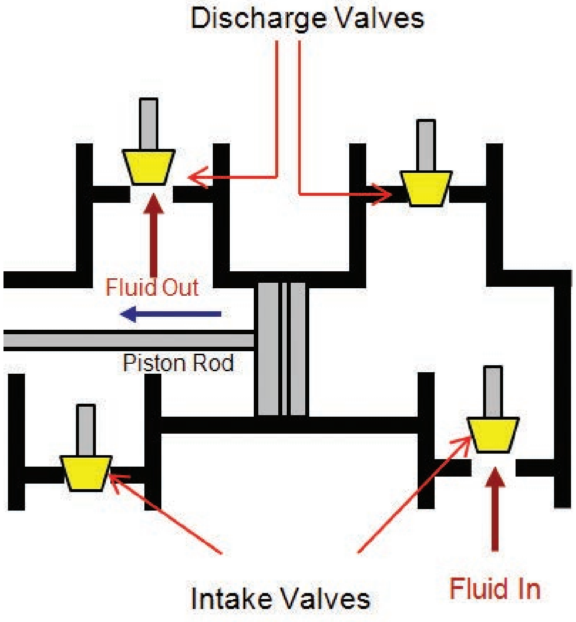
Action 2: The piston has reached its maximum displacement. Since it is not moving into or out of the cavity, fluid is not following through the inlet or the outlet.

Action 3: The piston is then pushed back into the cavity. During this process, the piston applies enough pressure in the outlet of the pump. This pressure pushes the fluid from inside the cavity through outlet of the pump. (Delivery stroke)



Action 4: The piston reaches its maximum extension into the cavity. Here the volume of the cavity at a minimum and fluid is not flowing through the inlet or the outlet. The next action repeats the process starting again with action1.

7.6.5 Double acting reciprocating pump



Working

It is similar to single acting reciprocating pump. It has two suction and two delivery pipes and valves on either side of the piston connected to the cylinder

When piston moves, water is collected on one side and discharged on other side, so the water is discharged continuously.

There are two suction strokes and delivery strokes during each revolution of the crank. Thus, water is supplied uniformly in the delivery pipe and the quantity of discharge is double that of single acting reciprocating pump.

7.6.6 Centrifugal Pump

A hydraulic machine which converts the mechanical energy into the pressure energy by means of centrifugal force, used to pump a fluid is called centrifugal pump.

The following are the main parts of centrifugal pump.

- Impeller
- Casing
- Suction pipe with foot valve
- Strainer
- Delivery pipe
- Prime mover

Impeller

It is the rotating part of the pump. The impeller is mounted on a shaft and is connected with an electric motor. It is rotated by the motor and consists of series of backward curved blades.

Casing

It is an air tight passage which surrounds the impeller. The design of the casing is done in such a way that it is capable of converting the kinetic energy of the water discharging from the outlet of the impeller into pressure energy before it leaves the casing and enters into the delivery pipe.

DO YOU KNOW?

History of Centrifugal pumps

- The inventor not be named with assurance.
- In the 17th century, Jordan an Italian had made some drawing of a centrifugal pump.
- In the early 18 century, French physicist Papin built a centrifugal pump of primitive design.
- In 1732 Demouir pumps was put on service in France.
- In 1818 Andrews (USA) built a single stage centrifugal pump.
- Then many developments came in the industry.

Suction Pipe with Foot Valve

A pipe whose one end is connected with the inlet of the pump and the other end is dipped into the sump of water is called suction pipe.

The suction pipe consists of a foot valve and strainer at its lower end. The foot valve is a one way valve (Non-return valve / NRV) that opens only in the upward direction.

Strainer

The strainer is used to filter the unwanted particle present in the water to prevent the centrifugal pump from blockage.

Delivery Pipe

It is a pipe whose one end is connected to the outlet of the pump and other end goes up to the required height where water is to be delivered.

Prime mover

It is an electric motor or oil engine to drive the pump.

Working

As the electric motor starts rotating, it also rotates the impeller. The rotation of the impeller creates suction at the suction pipe. Due to suction created, the water from the sump starts coming to the casing through the eye of the impeller.

From the eye of the impeller, due to the centrifugal force acting on the water, the water starts moving towards the outer of casing.

Because of the impeller rotating at high velocity, it also rotates the water around it in the casing. As the area of the casing increases gradually in the direction of rotation, the velocity of the water decreases and the pressure increases at the outlet of the pump. Here the pressure is maximum.

Now from the outlet of the pump, the water goes to its desired location through the delivery pipe.

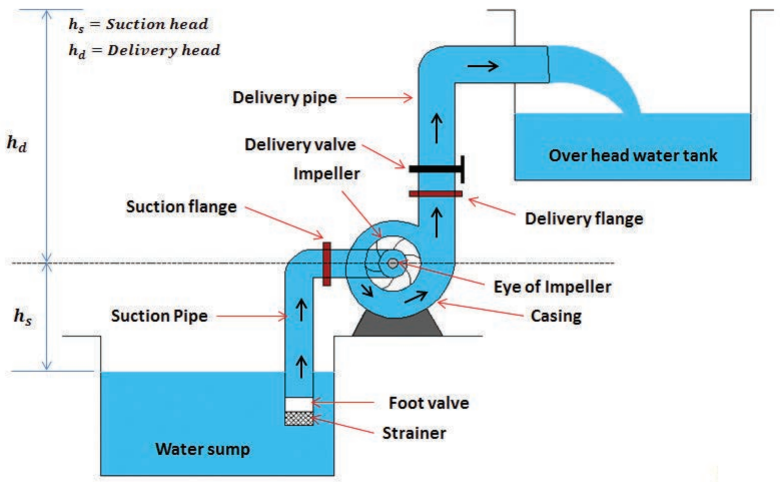
Uses

The centrifugal pump is used to raise the liquid from lower level to higher level. They are mostly used at home for filling overhead water tanks, in industries, for irrigation, etc.

7.6.7 Priming of pump

It is the process in which the suction pipe, casing and delivery pipe upto the delivery valve is filled completely with liquid to be raised from outside source before starting the motor. Priming is done to remove the air from the pump.

If air is not removed from the pump a small negative pressure created at the suction pipe doesnot allow to suck the water. So it is advised to fill the pump with water before starting it.



Centrifugal Pump

Activity 2

Collect the pictures of different types of pumps and prepare an album.

7.6.8 Comparison between Centrifugal Pump and Reciprocating Pump

Centrifugal pumps	Reciprocating Pumps
1. The discharge is continuous and smooth	1. The discharge is fluctuating and pulsating
2. It can handle large quantity of liquid	2. Handles small quantity of liquid
3. It is used for large discharge through small heads	3. It is meant for small discharge at high heads
4. Cost of centrifugal pump is less as compared to reciprocating pump	4. Cost of reciprocating pump is approximately four times the centrifugal pump.
5. Runs at high speed	5. Runs at low speed
6. Efficiency is high	6. Efficiency is low
7. Needs smaller area and cost of installation is less	7. Needs large area and installation cost is high
8. Low maintenance cost	8. High maintenance cost
9. It can also be used for lifting highly viscous liquids	9. Used only for lifting pure water or less viscous liquids

EL QUESTIONS

LQQNPG

Part – I

Choose the Correct answer (1 Mark)

1. Density of pure water is __________ .
   a. 2000 kg/m^3 b. 1000 kg/m^3
   c. 1500 kg/m^3 d. 2500 kg/m^3
2. The unit for surface tension is __________.
   a. N/mm b. N/mm^2
   c. N/m d. N/cm
3. The pressure happens when a fluid is at rest is __________.
   a. Static Pressure
   b. Gauge Pressure
   c. Absolute Pressure
   d. Vacuum Pressure
4. In steady flow, the quantity of flowing liquid is __________.
   a. Non Constant b. unsteady
   c. constant d. varying
5. An Orifice is used to measure the __________ of liquid.
   a. Velocity b. Head loss
   c. Pressure d. Discharge
6. Head loss due to friction in a pipe is denoted by __________.
   a. h_f b. f_h
   c. Q d. v

Part – II

Answer in one or two sentences (3 Marks)

7. List any four properties of fluids.
8. Write short note on Density.
9. Define Pascal's Law?
10. List the types of Pressure.
11. List out the types of liquid flow.
12. Define – Orifice.
13. Write the types of mouthpieces according to its shape.
14. Write the Darcy's formula to find out loss of head.
15. What do you mean by pump?

Part – III

Answer in brief (5 Marks)

16. Write briefly about
    (a) Fluid pressure.
    (b) Intensity of pressure.
17. State the Bernoulli's Theorem or Energy equation.
18. Write briefly about Vena contracts with simple sketch.
19. Write briefly about Hydraulic gradient line with sketch.

Part – IV

Answer in detail (10 Marks)

20. Water flows through a pipe of 250 mm diameter and 200 m long with a velocity of flow 2.75 m/s. Find the loss of head due to friction. Take friction factor (f) as 0.003
21. Determine the loss of head in a pipe line 200 mm diameter and 450 m long. The discharge of water through the pipe is 0.255 m^3/s. Take the value of friction factor as 0.002.
22. Water flows through a pipe line 150 mm diameter and 400 m long. The velocity of flow of water in the pipe is 2.5 m/s. Find out the loss of head in the pipe by taking Chezy's constant as 40.

Answers

1. (b) 2. (c) 3. (a) 4. (c) 5. (d) 6. (a)