- In case a non-viscous liquid is moving with streamline flow, the velocity of liquid flow is independent of the nature of liquid.
- In a steady flow through a varying tube, the velocity of flow will increase where the area of cross-section of tube decreases and vice-versa.

ENERGY OF A FLOWING LIQUID

The energy of a flowing liquid at any point is of three types :

- Kinetic energy
- Potential energy
- Pressure energy.

- **Kinetic energy :** It is the energy possessed by a liquid by virtue of its motion.

$$\text{K.E. of the liquid} = \frac{1}{2}mv^2$$

$$\text{K.E. per unit mass of the liquid} = \frac{1}{2}v^2$$

$$\text{K.E. per unit volume of the liquid} = \frac{1}{2}\rho v^2$$

- **Potential energy :** It is the energy possessed by a liquid by virtue of its position.
  P.E. of the liquid $= mgh$
  P.E. per unit mass of the liquid $= gh$
  P.E. per unit volume of the liquid $= \rho gh$.
- **Pressure energy :** It is the energy possessed by a liquid by virtue of its pressure.

$$\text{Pressure energy per unit mass of the liquid} = \frac{P}{\rho}$$

Pressure energy per unit volume of the liquid $= P$

BERNOULLI'S THEOREM

- It states that for the streamline flow of an ideal liquid through a tube, the total energy (the sum of pressure energy, the potential energy and kinetic energy) per unit volume remains constant at every cross-section throughout the tube.

$$P + \rho gh + \frac{1}{2}\rho v^2 = \text{constant}$$

or $\frac{P}{\rho g} + h + \frac{1}{2}\frac{v^2}{g} = \text{another constant}$

Here, $\frac{P}{\rho g}$ = pressure head;

h = potential head and $\frac{1}{2}\frac{v^2}{g}$ = velocity head.

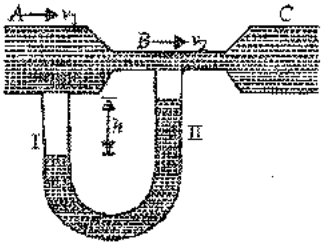
- If the liquid is flowing through a horizontal tube, then h is constant, then according to Bernoulli's theorem,

$$\frac{P}{\rho g} + \frac{1}{2}\frac{v^2}{g} = \text{constant}$$

- Bernoulli's theorem is based on law of conservation of energy.

Applications of Bernoulli's Theorem

- Bunsen's burner
- Atomiser or sprayer
- Lift on an aeroplane wing
- Blowing off the roofs during storm
- **Magnus effect :** When a spinning ball is thrown, it deviates from its usual path in flight. This effect is called magnus effect. This effect also occurs in accordance with Bernoulli's theorem.
- **Venturimeter :** It is a device used to measure the speed of an incompressible liquid and rate of flow of liquid through pipes. Its working principle is based on Bernoulli's theorem.
  Venturimeter is shown in the figure. It is fitted horizontally to the pipe through which the liquid is flowing with steady flow.



- The volume of the liquid flowing per second through the wider tube of area of cross-section A_1 is

$$Q = A_1 v_1 = A_1 A_2 \sqrt{\frac{2\rho_m gh}{\rho(A_1^2 - A_2^2)}}$$

where,
ρ = Density of liquid flowing through the pipe
ρ_m = Density of liquid in U-tube
A_2 = Area of cross-section of smaller tube
h = Difference in the height of the liquid in two arms of U tube

TORRICELLI'S THEOREM

- It states that velocity of efflux *i.e.* the velocity with which the liquid flows out of an orifice (*i.e.* a narrow hole) is equal to that which a freely falling body would acquire in falling through a vertical distance equal to the depth of the orifice below the free surface of the liquid.

  Velocity of efflux, $v = \sqrt{2gh}$.
- The velocity of efflux *i.e.*, velocity of liquid coming out of the orifice is independent of
  - the nature of liquid
  - the quantity of liquid in the vessel
  - the area of the orifice.