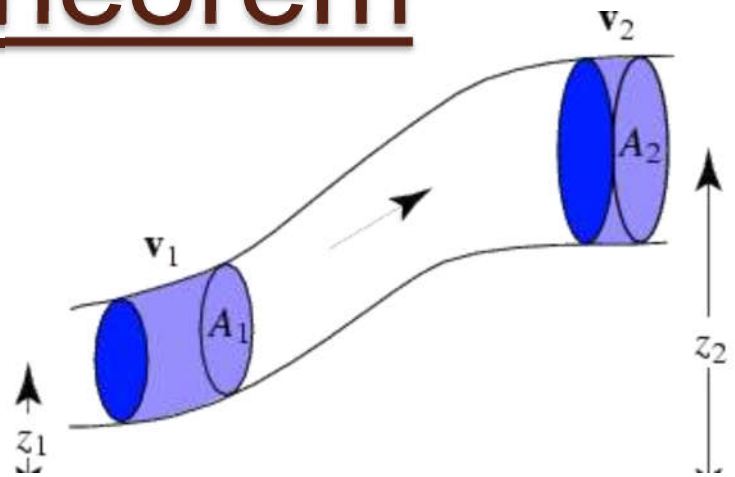
✓Bernoulli's Theorem

Assumptions:

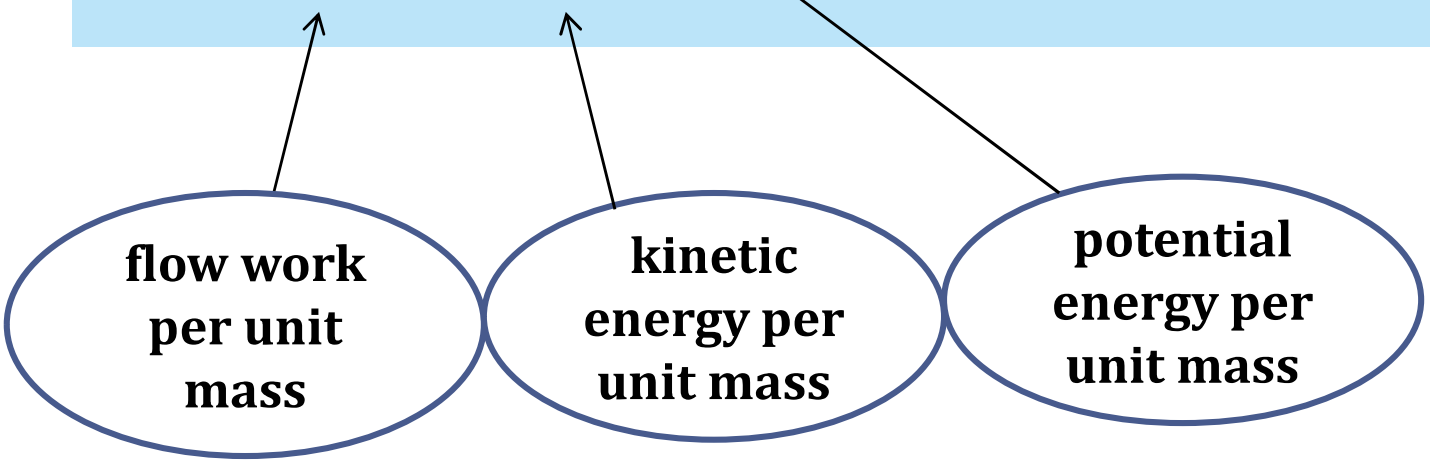


- no work or heat interaction between a fluid element and the surrounding takes place.
- The flow must be incompressible
- Friction by viscous forces has to be negligible.

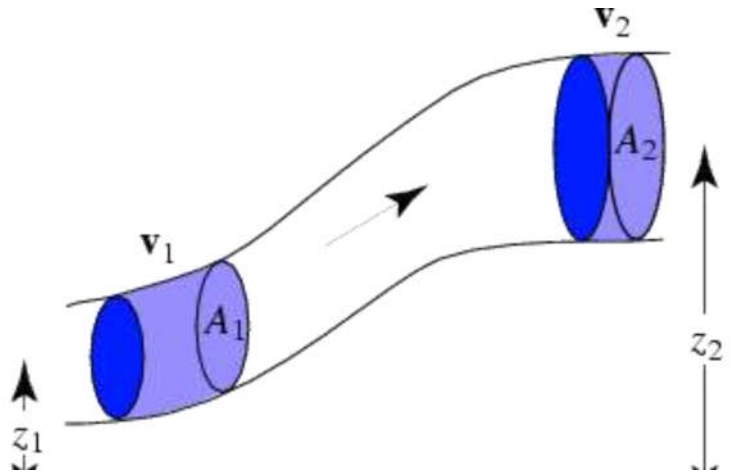
✓Bernoulli's Theorem

- This equation was developed first by Daniel Bernoulli in 1738.

$$\frac{P}{\rho g} + \frac{V^2}{2g} + z = C_1 (\text{constant})$$



✓Bernoulli's Theorem with Head Loss

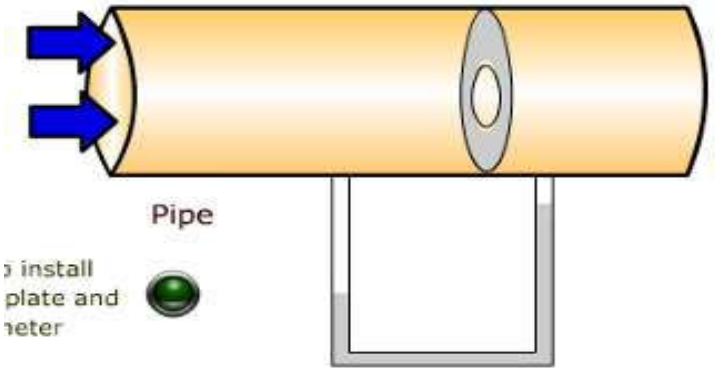


$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+z_2+h_f$$

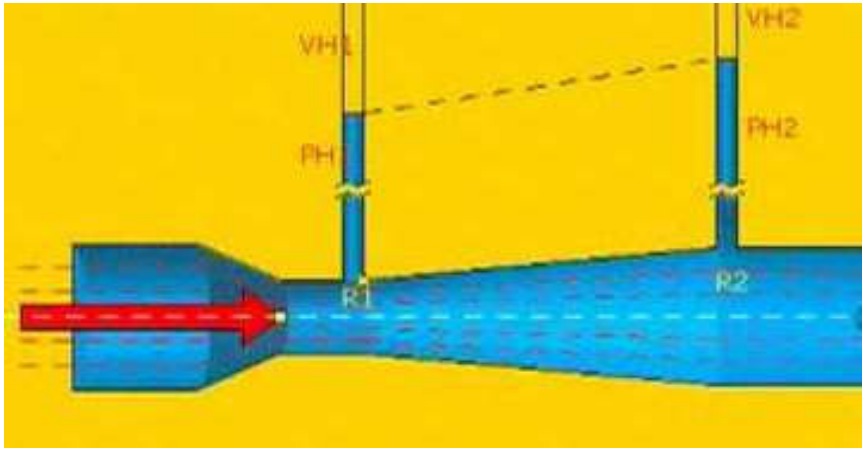
Where, h_f represents the frictional work done (the work done against the fluid friction) per unit weight of a fluid element while moving from a station 1 to 2 along a streamline in the direction of flow.

Application of Bernoulli's Law

- Orifice meter



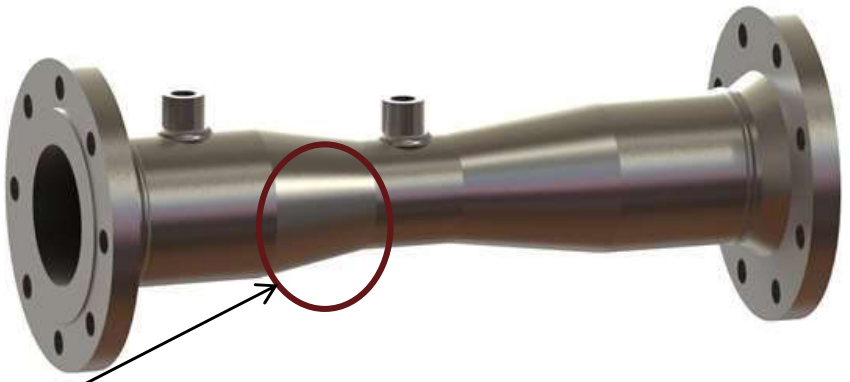
- Venturi meter



✓ Venturimeter

- It is a device used for the measurement of flow in a pipeline.
- Based on Principle of Bernoulli's theorem.
- It consist of 3 parts:
  a) Converging Cone.
  b) Short cylindrical throat.
  c) Diverging cone.

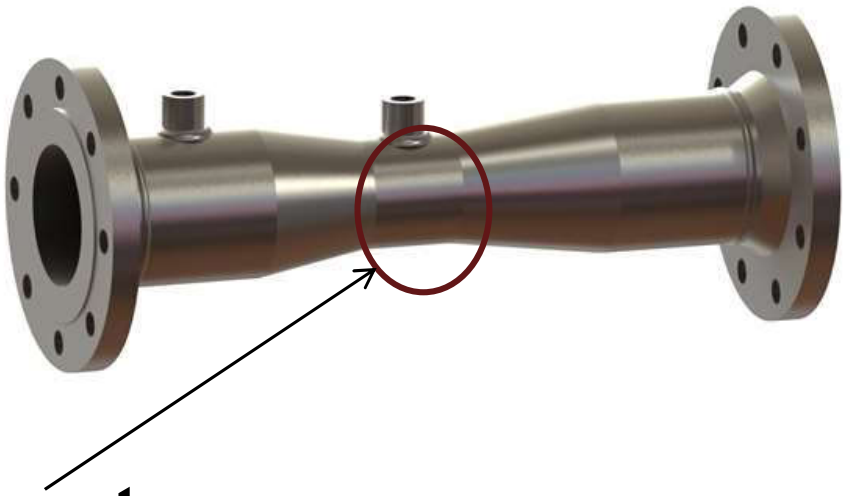
✓ Venturimeter



Converging Cone:

- The function of converging cone is to accelerate the flow and create pressure difference between the inlet to converging cone and the throat.
- Angle of Diverging cone is from 14˚ to 20˚.

✓ Venturimeter



Short Cylindrical throat:

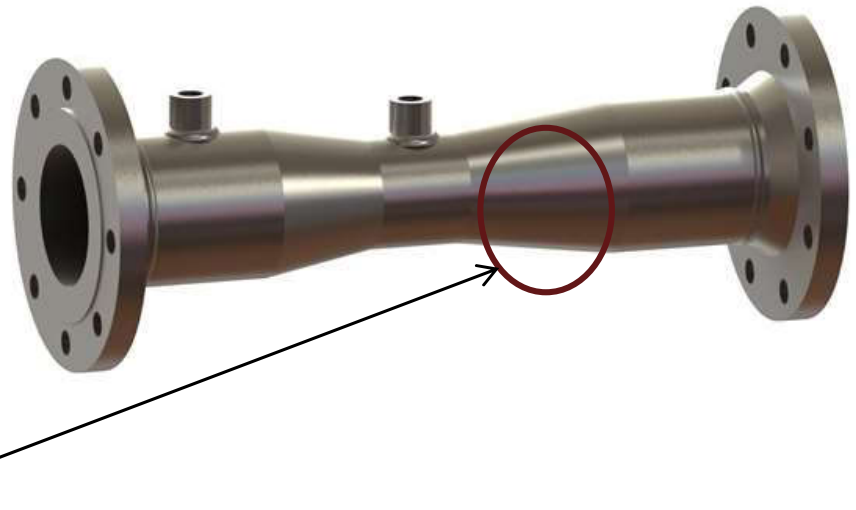
- The function of throat is to stabilize the flow and facilitate the provision of pressure tapping.
- Diameter Ratio:

$$d/D = 0.4 \text{ to } 0.7$$

Where, D= Diameter of Pipeline

d= Diameter of throat

✓ Venturimeter



Diverging cone:

- The function of diverging cone is to reduce the velocity and increase the pressure to its original value to the extent it is possible practically.
- Angle of Diverging cone is from 5˚ to 7˚

✓ Venturimeter

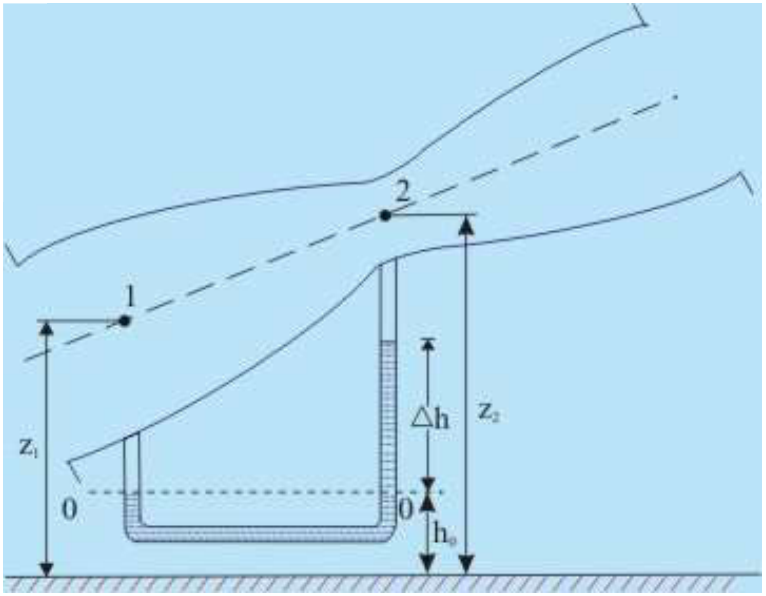
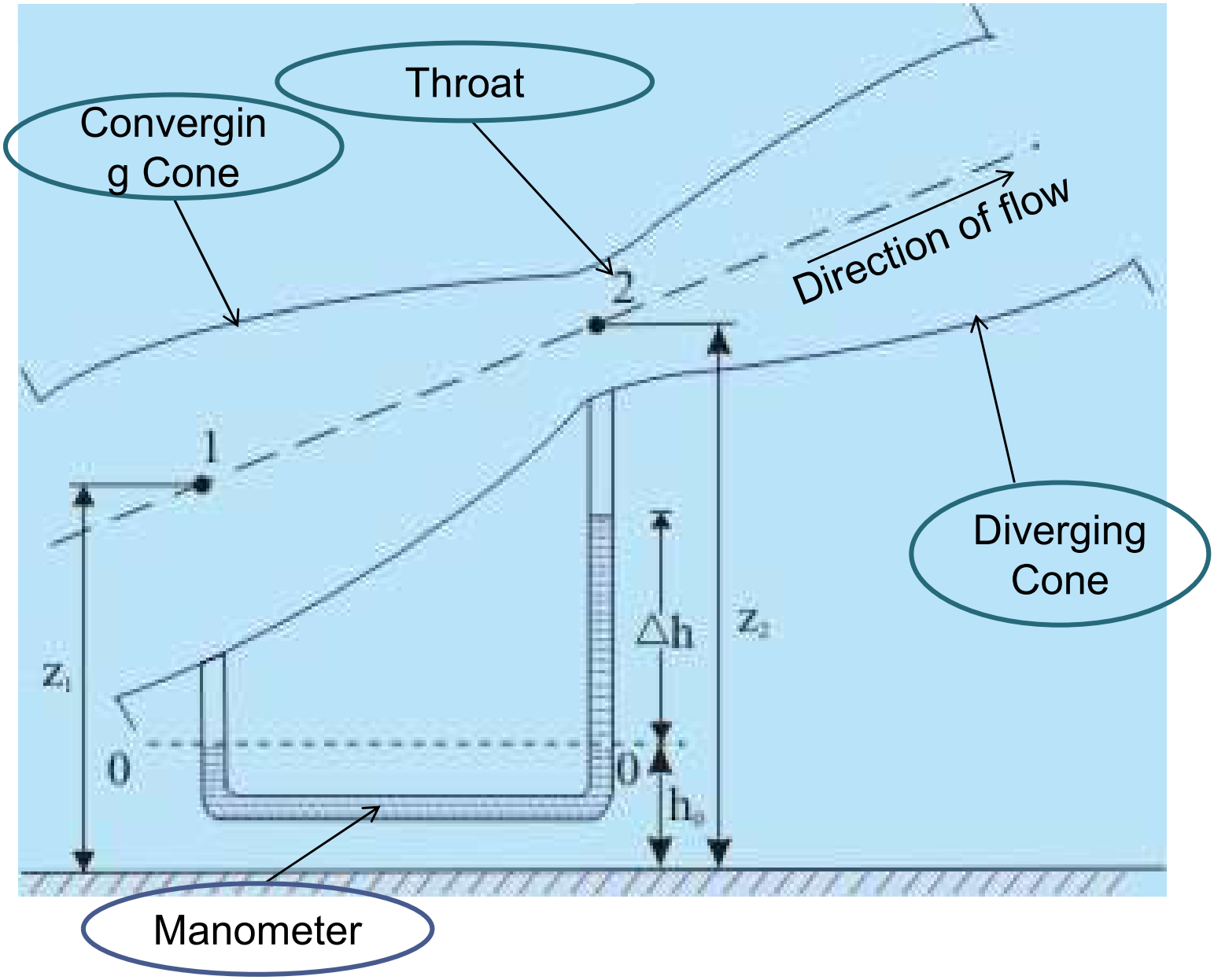


Figure shows that a venturimeter is inserted in an inclined pipe line in a vertical plane to measure the flow rate through the pipe.

Let us consider a steady, ideal and one dimensional (along the axis of the venturi meter) flow of fluid. Under this situation, the velocity and pressure at any section will be uniform.

Let the velocity and pressure at the inlet (Sec. 1) are V_1 and p_1 respectively, while those at the throat (Sec. 2) are V_2 and p_2.

✓ Venturimeter



✓ Venturimeter

- Now, applying Bernoulli's equation between Section 1 and 2, we get

$$\frac{p_1}{\rho\, g} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\rho\, g} + \frac{V_2^2}{2g} + z_2$$

$$\frac{V_2^2 - V_1^2}{2g} = \frac{p_1 - p_2}{\rho\, g} + z_1 - z_2$$

where ρ is the density of fluid flowing through the venturimeter.
From continuity,

$$V_2 A_2 = V_1 A_1$$

where A_1 and A_2 are the cross-sectional areas of the venturi meter at its throat and inlet respectively. With the help of Eq. 1, Eq. 2 can be written as

$$\frac{V_2^2}{2g}\left(1 - \frac{A_2^2}{A_1^2}\right) = \left(\frac{p_1}{\rho\, g} + z_1\right) - \left(\frac{p_2}{\rho\, g} + z_2\right)$$

$$V_2 = \frac{1}{\sqrt{1 - \frac{A_2^2}{A_1^2}}}\sqrt{2g(h_1^* - h_2^*)}$$

piezometric pressure heads respectively at point 1 & 2 respectively.

✓ Venturimeter

$$h_1^* = \frac{p_1}{\rho\, g} + z_1$$

$$h_2^* = \frac{p_2}{\rho\, g} + z_2$$

Hence, the volume flow rate through the pipe is given by

$$Q = A_2 V_2 = \frac{A_2}{\sqrt{1 - \frac{A_2^2}{A_1^2}}} \sqrt{2g(h_1^* - h_2^*)}$$

This is the Equation of Discharge of flow through venturimeter.

• Actual Discharge can be calculated by Multiplying the Theoretical Discharge with Coefficient of Discharge.

• The value of coefficient of discharge is ranging from 0.91 to 0.99, depends upon the condition of flow and losses.

✓ Merit & Demerits

Merits:

- Recovery of Pressure is near original value
- Loss of energy is minimum.

Demerits:

- Its cost is High.
- Occupies more space than orifice meter.

✓ Uses & Applications

- Calculating flow rate of fluid in a tube.
- Setting the flow of gasoline in the ignition system of a motor vehicle.
- In the field of medicine, has also designed venturi meter is used to measure the rate of blood flow in the arteries.

Any
Questions
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