VENTRIMETER

Venturi meters are instruments for **fluid flow measurement**. It has a converging section that gives an increase in the flow velocity with a corresponding drop in pressure from which the flow rate can be calculated. The reduction in the fluid pressure that occurs when a fluid moves through a constricted passage is known as the Ventri effect. Ventruri meters are widely used wherever there is a need for fluid flow measurement, specifically in water, chemical and oil industries.

Venturimeter is a type of flowmeter that works on the principle of Bernoulli's Equation. This device is widely used in the water, chemical, pharmaceutical, and oil and gas industries to measure the flow rates of fluids inside a pipe. The pipe cross-sectional area is reduced to create a pressure difference which is measured with a manometer to determine the rate of fluid flow. SO, the venture meter is a **differential head type flowmeter** that convertes pressure energy into kinetic energy.

The principle of the Venturimeter was demonstrated by Giovanni Bastista Venturi, But it was first in pratical metering applications by Clemens Herchel.

Venturimeter Diagram and Parts

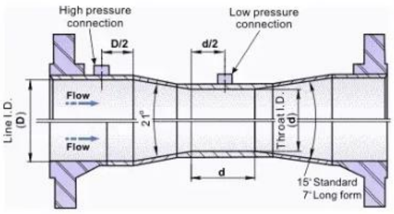
A venturimeter consists of four parts:

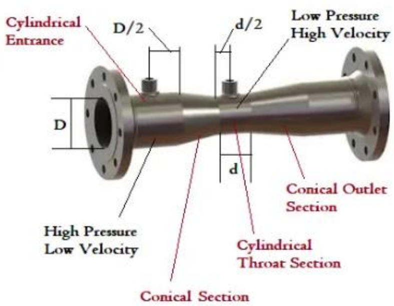
1. Cylindrical Inlet Section

2. Conical convergent Section

3. Cylindrical throat

4. Conical divergent outlet





Cut-View of a Venturimeter

Typical Flanged Venturimeter

There are two tappings on the venture meter for pressure measurement; the upstream pressure tapping is located at a distance of one-half of pipe diameter (D/2) upstream of the convergent entry, while the down stream pressure tapping is located in the throat (d/2)

- **Cylindrical Entrance Section**: Ventrurimeter entrance is a straight cylindrical section with a length equal to 5 to 5 times the pipe diameter.

- **Convergence Conical Section**: In this section, the ventruimeter tube diameter gradually decreases. The concial angle is normally $21^0 \pm 2^0$. While the liquid flows inside the venturimeter, the velocity of fluid increases at the expense of a decrease in pressure.
- **Cylindrical Throat:** Throat consists of the minimum ventrrimeter diameter. In the throat section, the velocity is maximum and pressure is minimum . Normally, throat diameter = 13 to 1/4th of inlet pipe diameter.
- **Diverging Conical section**: At this section **of ventuirmeter, the tube diameter gradually increases. So, the pressure is built again to the original** inlet pressure. The cone angle is 5 – 70. British Standard BS-1042 specifies two conical angles, 5–7^0 and 14–15^0 for the outlet cone.

Working Principle of a Venturimeter

When a fluid flows through a venturimeter, it accelerates in the convergent section and then decelerates in the convergent section and then decelerates in the divergent section. The pressure difference between an upstream section and the thrat is measured by a manometer. Using that differential pressure, applying Bernoulli's Equation and Continuity Equation the volumetric flow rate can be estimated.

Venturimeter Equations

Bernoulli's principle states the relation between pressure (P) , kinetic energy, and gravitational potential energy of a fluid inside a pipe. The mathematical formula of Bernoulli's equation is given as:

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

Where,

- P = pressure inside the pipe
- ρ = density of the fluid
- g = acceleration due to gravity
- v =velocity
- z=elevation or head
- a =cross-sectional area of the pipe
- d = diameter of the pipe

  Suffixes 1 and 2 are used to denote two different areas; 1 denotes the cylindrical inlet section and 2 denotes the throat section.

Now as the pipe is horizontal; there is no difference in the elvation of the pipe centreline; So, $z_1 = z_2$. Re-arrahnging the above equation we get the following:

$$\frac{P_1 - P_2}{\rho g} = \frac{v_2^2 - v_1^2}{2g}$$

$\frac{P_1 - P_2}{\rho g}$ is the difference of pressure heads in sections 1 and 2 which is equal to h that can be measured in the differential manometer. So, the above equation becomes

$$h = \frac{v_2^2 - v_1^2}{2g}$$

Now applying countinuity equations between the same sections 1 and 2, we get

$$a_1 v_1 = a_2 v_2$$

Putting this value of v_1 and solving we get,

$$v_2 = \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

So, the rate of flow through the throat (Q) can be calculated as Q $= a_2 v_2$; Substituting tha above the value of v_2 we get,

$$Q = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

This Q represents **the theoretical discharge** of Venturimeter in ideal conditions. But in actual practice, there will always be some frictional loss. Hence, the actual discharge will always be less than theoretical discharge. So, to calculate the actual discharge, the above Q value is multiplied by C_d called **the Coefficient of discharge of venturimeter**. So the actual flow rate through the throat of the venturimeter will be given by the following equation.

$$Q_{actual} = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

Coefficient of Discharge of Venturimeter (C_d)

The coefficient of discharge for Ventrimeter, C_d is defined as the ratio of the actual flow rate through the ventruri meter discharge coefficient is given by

$$C_d = \frac{Q_{actual}}{Q_{theoretical}}$$

The typical range of the discharge coefficient of a Venturimeter is 0.95 – 0.99. but this can be increased by proper machining of the convergent section. The value of venturimere discharge coefficient differs from on eflowmeter to the other depending on the ventrimetere geometry and the Reynolds number.