



### Venturi Meter

**OBJECTIVE:**

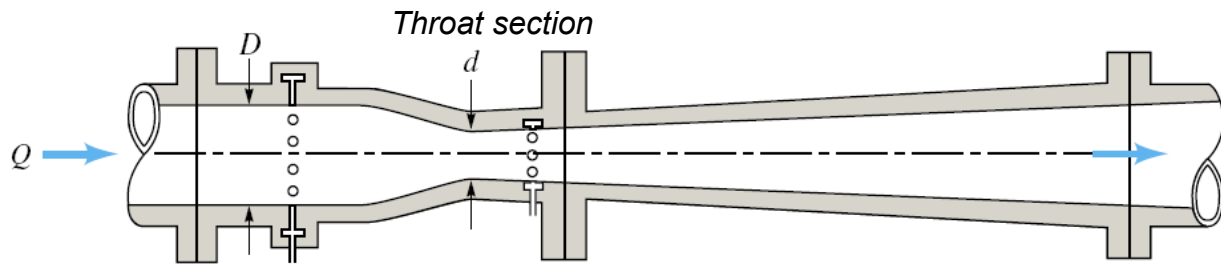
To find the water flow rate using the Venturi meter and the pressure distribution along the meter.

**APPARATUS:**

Venturi meter, hydraulics bench, stop watch.

**THEORY:**

The Venturi flow meter consists of a streamlined contraction and a streamline expansion as shown the diagram.



*Typical Venturi meter construction*

Writing Bernoulli's equation between section 1 and 2 we have:

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

Where:

1

$V$  : velocity (m/s)

$p$  : pressure (Pa)

$z$  : elevation (m)

If the meter is horizontal  $z_1$  and  $z_2$  cancel each other.

Also from continuity

$$V_1 A_1 = V_2 A_2$$

Where  $A$  is the area. Solving for  $V_2$  we have:

$$V_2 = \sqrt{\frac{2(p_1 - p_2)/\rho}{1 - \left(\frac{A_2}{A_1}\right)^2}}$$

The pressure  $p$  equals  $p = \rho gh$

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

The volumetric flow rate is then given by:

$$Q = V_2 A_2$$

i.e.

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

This equation is valid for incompressible and inviscid fluids so it can be used only at high Reynolds numbers. At low Reynolds numbers the coefficient of velocity  $C_v$  must be applied:

$$Q = C_v Q_{ideal} = \frac{C_v A_2}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}} \sqrt{2g(h_1 - h_2)}$$

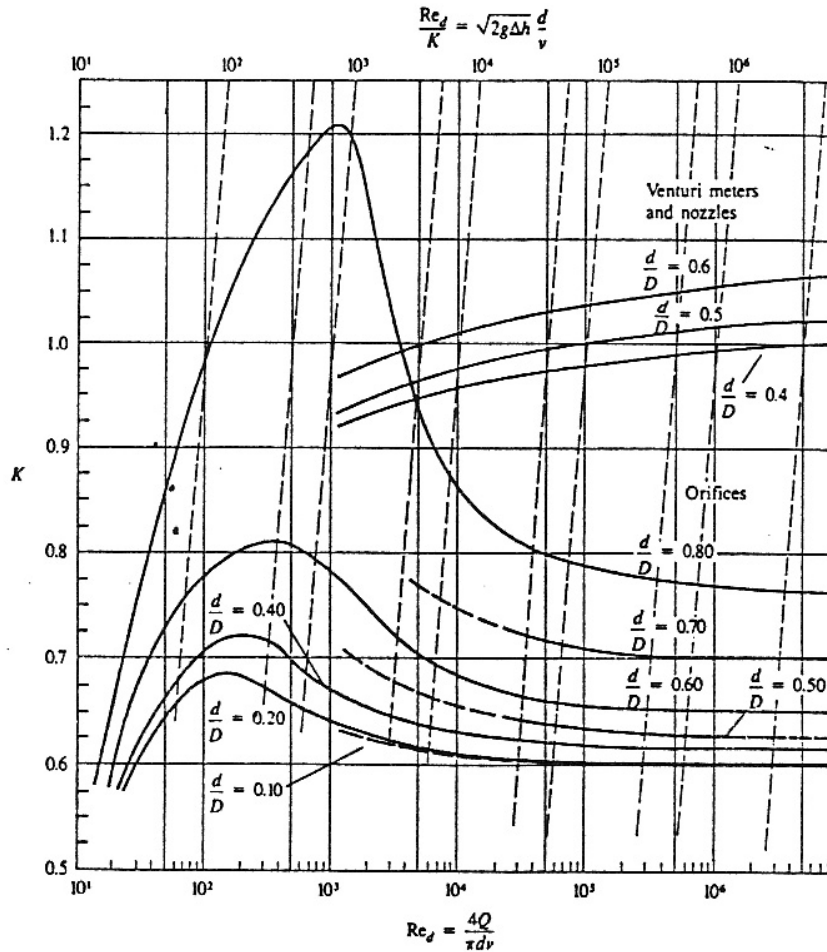
The flow coefficient  $K$  is then defined as:

$$K = \frac{C_v}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}}$$

So that

$$Q = K A_2 \sqrt{2g(h_1 - h_2)}$$

The flow coefficient can be obtained from the following figure. In this figure  $d$  is the diameter of the throat section and  $D$  the diameter of the inlet (section 1).  $\nu = \frac{\mu}{\rho}$  is the kinematic viscosity of water.



**PROCEDURE:**

A schematic of the Venturi meter is shown on the diagram at the end of the procedure. The inlet diameter equals  $d = 26$  mm and the throat diameter  $d = 16$  mm. The pressure along the meter is obtained using the 11 pressure taps at the locations shown on the diagram. The water flow rate can be adjusted using the valves on the hydraulics bench. For the flow rate examined make sure that the pressure level in the manometer tubes is within the range of their scales. If not, add air pressure in the common manifold using the air pump provided until the manometer levels are within the required range. The mass flow rate can be measured using the hydraulics.

**METHOD:**

For two different water flow rates do the following:

- (1) Obtain the pressure distribution along the Venturi meter.

- (2) Using the inlet pressure (tap No.1) and the throat pressure (tap No.4) calculate volumetric water flow rate using the formula derived in theory.
- (3) Compare the volumetric flow rate to the actual flow rate as obtained using the hydraulics bench measuring tank.
- (4) Plot the non-dimensional pressure distribution along the length of the Venturi meter against the distance from the inlet cross section. Plot results from both flow rates on the same graph. The non-dimensional pressure is defined as:

$$\frac{h_n - h_t}{\frac{U_t^2}{2g}}$$

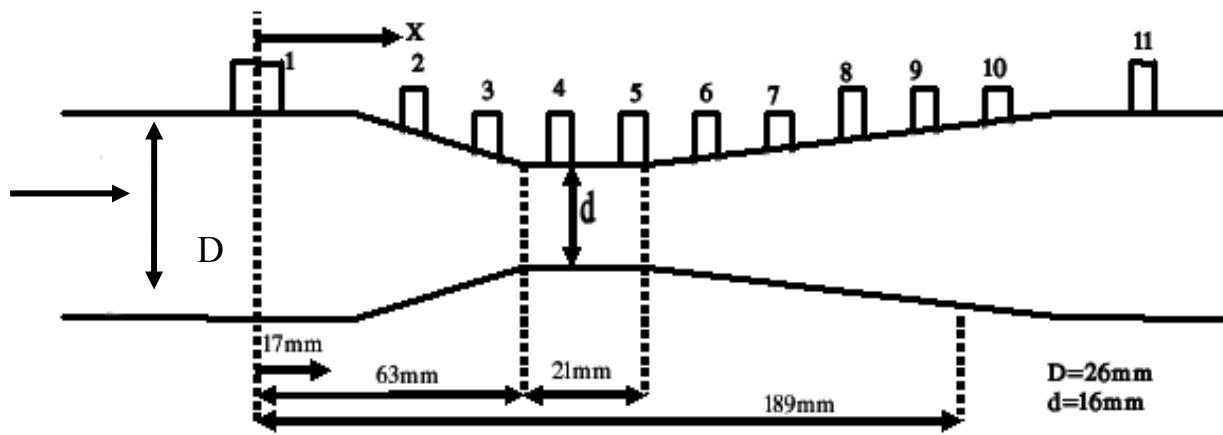
Where  $U_t$  is the velocity at the throat of the Venturi meter as obtained from the actual flow rate of the water.

- (5) Plot on the figure of step No.(4) the ideal pressure distribution which is found by considering Bernoulli's equations as:

$$\frac{h_n - h_t}{\frac{U_t^2}{2g}} = \left(\frac{A_t}{A_1}\right)^2 - \left(\frac{A_t}{A_n}\right)^2$$

Where  $A$  is the cross-sectional area.

Comment on your results. Is the actual pressure distribution different than the ideal one? Explain why. Is the exit pressure equal to the inlet one? If not, explain.



Tap No.	Distance of Tap from tap No.1 (mm)
1	0
2	44
3	56
4	70
5	84
6	97
7	111
8	128
9	143
10	158
11	203