DEPARTMENT OF ENVIRONMENTAL, WATER RESOURCES, AND COASTAL ENGINEERING

MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY

FLUID MECHANICS SESSIONAL

EWCE 262

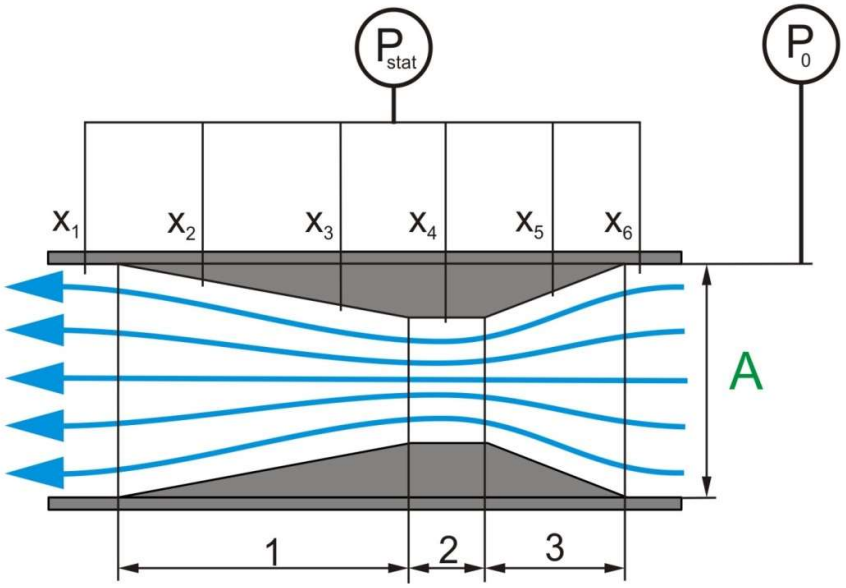
Experiment No. 4

FLOW THROUGH A VENTURI METER

4.1General

The converging tube is an efficient device for converting pressure head to velocity head, while the diverging tube converts velocity head to pressure head. The two may be combined to form venturi tube. As there is a definite relation between the pressure differential and the rate of flow, the tube may be made to serve as metering device.

Venturi meter consists of a tube with a constricted throat that produces an increased velocity accompanied by a reduction in pressure followed by a gradual diverging portion in which velocity is transformed back into pressure with slight friction loss.



Measuring principle of the Venturi tube: 1 divergent part, 2 narrowest cross-section, 3 convergent part; A cross-sectional area, P_{stat} static pressure, P_0 total pressure, $x_1 ... x_6$ pressure measuring points

4.2 Applications

The venturimeter is used for measuring the rate of flow of both compressible and incompressible fluids.

The venturimeter provides an accurate means for measuring flow in pipelines. Aside from the installation cost, the only disadvantage of the venturi meter is that it introduces a permanent frictional resistance in the pipelines.



4.3 Theory

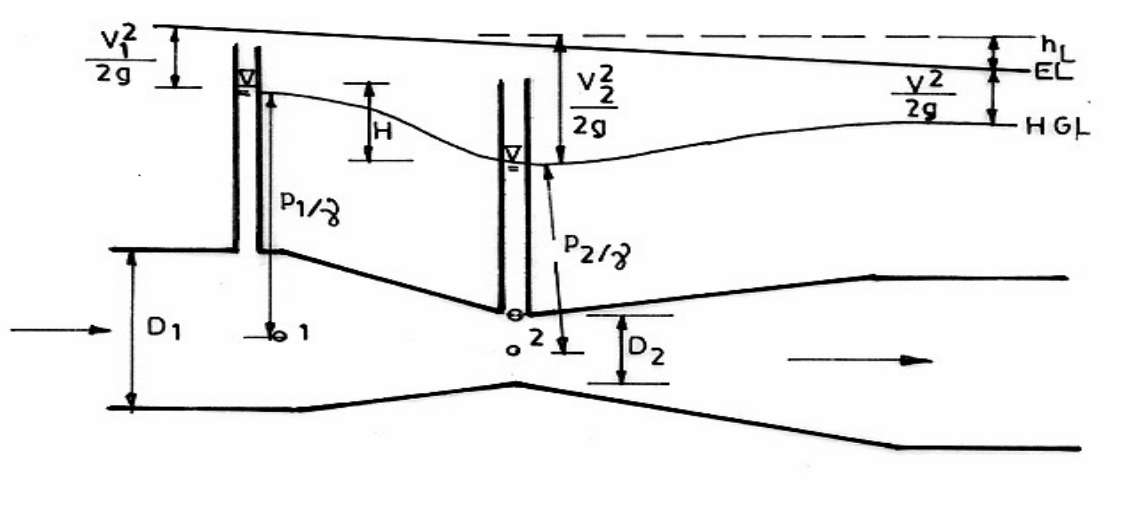


Fig. 1 Flow through a Venturimeter

Consider the Venturimeter shown in the above figure. Applying the Bernoulli's equation between Point 1 at the inlet and Point 2 at the throat, we obtain

$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}=\frac{P_2}{\gamma}+\frac{V_2^2}{2g} \tag{1}$$

Where P_1 and V_1 are the pressure and velocity at Point 1, P_2 and V_2 are the corresponding quantities at Point 2, γ is the specific weight of the fluid and g is the acceleration due to gravity. From continuity equation, we have

$$A_1V_1 = A_2V_2 \tag{2}$$

Where, A_1 and A_2 are the cross-sectional areas of the inlet and throat, respectively. Since

$$A_1=\frac{\pi}{4}D_1^2, A_2=\frac{\pi}{4}D_2^2$$

From Equations (1) and (2), we have

$$V_1 = \sqrt{\frac{2g}{\left(\frac{D_1}{D_2}\right)^4 - 1}\frac{(P_1 - P_2)}{\gamma}}$$

$= K_1 H^{1/2}$ (3)

Where,

$$K_1 = \sqrt{\frac{2g}{\left(\frac{D_1}{D_2}\right)^4 - 1}} \qquad \text{and,} \quad H = \frac{(P_1 - P_2)}{\gamma}$$

The head H is indicated by the piezometer tubes connected to the inlet and throat.

The theoretical discharge, Q_t, is given by

$Q_t = A_1 V_1$

$= KH^{1/2}$ (4)

Where,

$K = K_1 A_1$ (5)

Coefficient of discharge

Theoretical discharge is calculated from theoretical formula neglecting friction losses. For this reason we introduce a coefficient named coefficient of discharge which is the ratio of actual discharge to theoretical discharge.

Now, if C_d is the coefficient of discharge (also known as the meter coefficient) and Q_a is the actual discharge, then

$$C_d = \frac{Q_a}{Q_t}$$

$Q_a = C_d Q_t$

$= C_d K H^{1/2}$

$= CH^n$ (6)

The value of Cd may be assumed to be about 0.99 for large meter and about 0.97 or 0.98 for small ones provided the flow is such as to give reasonably high Reynolds number.

Calibration

One of the objectives of the experiment is to find the values of C and n for a particular meter so that in future we can measure actual discharge only by measuring H. Here C and n are called calibration parameters.

For five sets of actual discharge and H data we plot Q_a vs. H in log-log paper and draw a best-fit straight line.

The equation of line

$$\log Q_a = \log C H^n$$

$$\Rightarrow \log Q_a = \log C + n \log H$$

Now from the plotting we take two points on the straight line say (H_1, Q_{a1}) and (H_2, Q_{a2})

So from the equation (3) we get

$$\log Q_{a1} = \log C + n \log H_1$$

$$\log Q_{a2} = \log C + n \log H_2$$

Solving, $$n = \frac{\log \frac{Q_{a1}}{Q_{a2}}}{\log \frac{H_1}{H_2}}$$

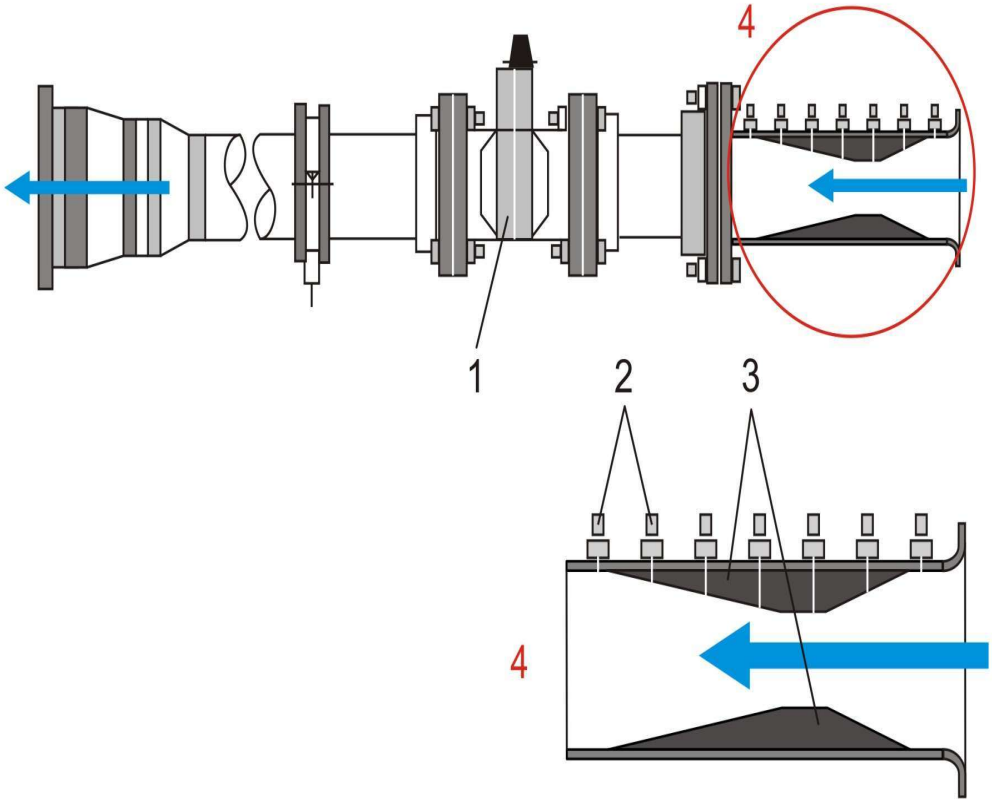
$$C = \text{antilog}\,[\log Q_{a1} - n \log H_1]$$

So the calibration equation is $Q_a = CH^n$

Now $C = C_d K$

$\Rightarrow C_d = C/K$

Now from the calibration equation we can calculate actual discharge for a different H and plot on a plain graph paper. In practice we can use the plot to find actual discharge for any H. Thus the venturi meter is calibrated.



1 iris diaphragm, 2 pressure measuring point, 3 Venturi-shaped contour; 4 Venturi tube

4.4Objectives

1. To find C_d for the Venturimeter
2. To plot Q_a against H in log-log paper and to find (a) the exponent of H, and (b) C_d.
3. To calibrate the Venturimeter

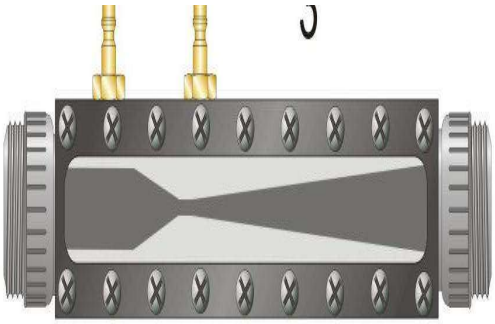
4.5 Procedure

1. Measure the diameter of the Venturi tube.
2. Measure the piezometer reading of fluid friction apparatus.
3. After measure the piezometer reading collect required time to store 10 liter water in hydraulic bench.

4. Repeat the procedure for different combinations of discharge.

4.6. Apparatus

Venturi meter, Fluid friction apparatus, hydraulic bench and stop watch etc.



Venturi meter



Stop Watch



Fluid friction apparatus

4.7

FLOW THROUGH A VENTURIMETER

Experimental Data Sheet

Experiment No. 4

Collection time = _____

Volume of water = _____

Discharge Q = _____

D_1 =

D_2 =

Group No	Manometer reading h_1	Manometer reading h_2	H = $h_1 - h_2$	K_1	Volume of water	Time	Q_a	Q_t	C_d
1									
2									
3									
4									
5									
6									

Level / Term : **Dept. :**

Reg No. : **Section:**

Group No. : **Date :**

_____

Signature of the Teacher

4.8 Calculation from graph

4.9 Discussion

What are the probable errors in performing the test?

Was there formation of cavitations in this experiment? Why?

What are the practical values of the calibration parameters? Compare with your experimental results.

Give the reasons if there are considerable differences.

4.10 Practice Questions

1. Why is the diverging angle smaller than the converging angle for a venturimeter?

2. How can the accuracy of venturimeter be increased in use?

3. On what factors does the meter co-efficient depend?

4. What is cavitation? Discuss its effect on flow through a venturimeter. How can you avoid cavitation in a venturimeter?

5. A venturi meter having a throat 3 in. in diameter is installed in a horizontal 10 in. pipe line carrying a liquid that has a sp gr of 0.80. A mercury U tube shows a difference in height of mercury columns of 7 in., the remainder of the tube being filled with the liquid. Find the value of C_d. Here the actual discharge is 1x10^-3 cubic meter per second.