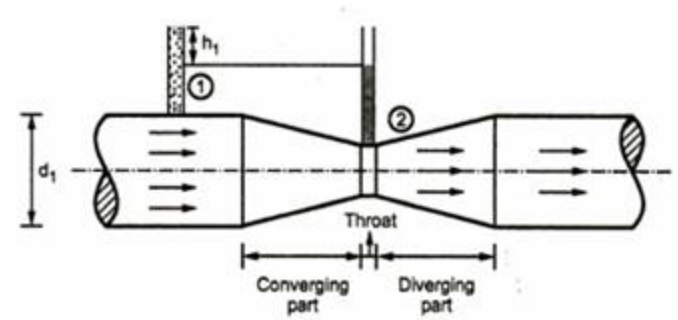
Venturimeter

Aim:- To determine the coefficient of discharge of given venturimeter.

Apparatus Required:- Venturi meter, differential manometer, collecting tank, piezometer, stopwatch, measuring scale .

Theory

Venturi meter is a flow measurement device, which is based on the principle of Bernoulli's equation. Inside the pipe pressure difference is created by reducing the cross-sectional area of the flow passage. This difference in pressure is measured with the help of manometer and helps in determining rate of fluid flow or other discharge from the pipe line. Venturi meter has a cylindrical entrance section, converging conical inlet, a cylindrical throat and a diverging recovery cone. The major disadvantages of this type of flow detection are the high initial costs for installation and difficulty in installation and inspection. The Venturi effect is the reduction in fluid pressure that results when a fluid flows through a constricted section of pipe. The fluid velocity must increase through the constriction to satisfy the equation of continuity, while its pressure must decrease due to conservation of energy: the gain in kinetic energy is balanced by a drop in pressure or a pressure gradient force. An equation for the drop in pressure due to venturi effect may be derived from a combination of Bernoulli's principle and the equation of continuity.



Let, d1 = Diameter at inlet or at section 1

V1 = velocity of fluid at section 1

$$a_1 = \text{Area at inlet} = \frac{\pi d_1^2}{4}$$

P1 = Pressure at section 1

and d2, V2, a2 and P2 are the corresponding values at section 2.

Applying Bernoulli's equations at section 1 and section 2, we get,

$$\frac{P_1}{\rho g}+\frac{v_1^2}{2g}+z_1=\frac{P_2}{\rho g}+\frac{v_2^2}{2g}+z_2 \text{ ---------- } (1.1)$$

Since the pipe is horizontal, so z1 = z2

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

$$\frac{P_1-P_2}{\rho g}=\frac{v_2^2-v_1^2}{2g} \text{ ---------- } (1.2)$$

But $\frac{P_1-P_2}{\rho g}$ difference of pressure head at section 1 and 2 = h --------(1.3)

substituting this value of $\frac{P_1-P_2}{\rho g}$ = h in equation (1.2)

$$h=\frac{v_2^2-v_1^2}{2g} \text{ ---------- } (1.4)$$

Now applying continuity equation at section 1 and 2

$a_1v_1=a_2v_2$ or $v_1=\frac{a_2v_2}{a_1}$

Substituting value of v1 in equation (1.4) we

$$h=\frac{v_2^2}{2g}-\frac{(\frac{a_2v_2}{a_1})^2}{2g}$$

$$=\frac{v_2^2}{2g}-\frac{(a_2^2v_2^2)}{a_1^2 2g}$$

$$=\frac{v_2^2}{2g}\left(1-\frac{a_2^2}{a_1^2}\right)$$

$$v_2^2=2gh\left(\frac{a_1^2}{a_1^2-a_2^2}\right)$$

$$v_2=\sqrt{2gh\left(\frac{a_1^2}{a_1^2-a_2^2}\right)}$$

$$v_2=2gh\left(\frac{a_1^2}{a_1^2-a_2^2}\right)$$

$$v_2=\frac{a_1}{\sqrt{a_1^2-a_2^2}}\sqrt{2gh} \qquad \left(h=x\left(1-\frac{\rho_L}{\rho}\right)\right)$$

Where x = difference between the liquid column in U tube, ρL = density of lighter liquid, ρ = density of liquid flowing through pipe.

But, discharge through venturimeter,

$Q=a_2v_2$

$$v_2 = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh} \text{ ------(1.5)}$$

$Q = C\sqrt{h}$, where C= constant of venturi meter.

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

Equation (1.5) gives the discharge under ideal conditions and is called as theoretical discharge. Actual discharge is given by,
Actual discharge = Coefficient of venturimeter x Theoretical discharge

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

Procedure:-

1. A pipe is selected of required diameter.
2. The main inlet is opened to allow water t flow through the selected diameter pipe.
3. Open the pipe valve, and change the knot of manometer from isolate position to air- vent position to remove the air inside the pipe.
4. The knot is then kept in the read position and note down the manometer reading.
5. Water is allowed to flow through the selected venturimeter and this flow is made constant. At this flow rate the difference in pressure between inlet and throat is measured.
6. The exit valve of the collecting tank is closed and time taken for the tank water to be noted.

Observation

d_1 =
d_2=
Area A_1 =
Area A_2 =
Area of collecting tank (A)
Head loss (H) =
Acceleration due to gravity (g)

Calculations

Q_{act} =

Q_{th} =

C_d =

Results :- Coefficient of discharge of venturimetre is =