OBSTRUCTION FLOW METER : VENTURIMETER

Aim: Find the coefficient of discharge for different rates of flow and plot it. Get idea of how these meters work and theory behind apparatus.

APPARATUS

1) Venturimeter set-up
2) Water supply
3) Manometer
4) Stopwatch
5) Setup for measuring the actual flow rate.

THEORY

This obstruction flow meter is used to measure internal flow. It is calculated by measuring the drop in pressure with inclusion of the obstruction. There are basically 3 type, i.e. Orifice meter, Venturimeter, Pitot tube. Rotatometer is of 2nd category.

Venturimeter is based on the principle of Bernoulli's equation. There the pressure is created by reducing the cross-sectional area of the flow. Therefore, a U-tube is used to measure that. This pressure difference helps in determination rate of flow or discharge and velocity is increased.

Venturimeters are generally made from castings machine to close tolerance to duplicate the performance of standard design, so they are heavy, bulky & expensive. Inside venturimeter, the fluid is accelerated through the converging cone of 15 to 20°. The pressure difference by using differential manometer. The conical downstream gives excellent pressure recovery and overall head loss is low. They are self-cleaning due to smooth internal shape.

The expression for discharge through OFM can be theoretically using continuity & Bernoulli's equations.

$$Q_{th} = \underbrace{A}_{\text{flow area}} \times \underbrace{V}_{\text{flow velocity}}$$

$d_1 = 0.0224$ m
$d_2 = 0.0112$ m

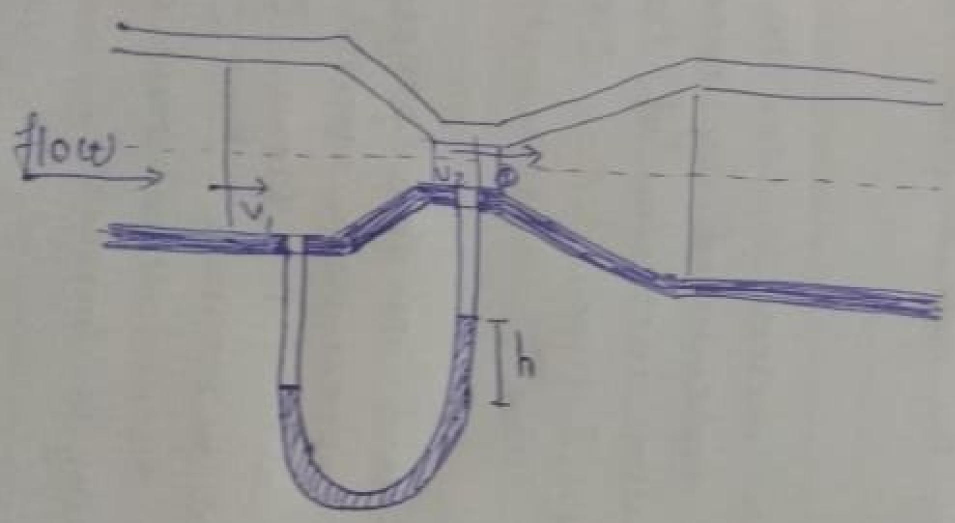
$\beta = d_2/d_1 = 0.5$

Bernoulli's eqn

$$\frac{P_1}{\rho_w g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho_w g} + \frac{V_2^2}{2g} + Z_2$$

$$V_2 = \sqrt{\frac{2\Delta P}{\rho_w \{1 - (\frac{A_2}{A_1})^2\}}} \qquad \Delta P = P_1 - P_2$$

Teacher's Signature



Venturimeter

Mercury differential manometer to measure ΔP

$$\Delta P = (\rho_{Hg} - \rho_w)$$

ρ_{Hg} = density of manometer fluid. (kg/m³)

ρ_w = density of flowing fluid. (kg/m³)

$$Q_1 = A_1 A_2 \sqrt{\frac{2(\rho_{Hg}/\rho_w - 1) g h}{(A_1^2 - A_2^2)}}$$

Actual discharge $Q_{AC} = \frac{a \times H}{t}$ (m³/s)

a = area of collecting tank (m²)
H = height difference (m)
t = time taken.

$$C_D = \frac{Q_{ac}}{Q_{th}} \quad \text{(or)} \quad C_D = \frac{Q_{as}}{S_2} \sqrt{1-\beta^4} \Big/ \sqrt{2gh}$$

S_2 = area of throat
$\beta = D_1/D_2$

PROCEDURE

1) Check the experimental setup for leaks. Measure the dimension of collection tank. Note the flow meter specifications.
2) Open the inlet valve fully and allow the water fully.
3) Make sure the height of mercury colomn in both limbs if there is no discharge.
4) Slightly open the outlet valve of the flow meter and observe the manometer limb.
5) Adjust it to get a steady pressure difference between the limbs of the manometer.
6) Measure the time t to collect H height of water in the collecting tank.
7) Repeat the above procedure for different flow rates by changing the outlet valve opening.
8) Close the inlet to the apparatus after taking the necessary readings.
9) Complete the tabulation and find the average value of C_D.

RESULT & INFERENCE

The average coefficient of discharge of the given obstruction meters are venturimeter C_D =

Flow	Manometer Reading			Actual discharge	Time for H cm rise in collection tank	Initial water level	Final water level	Theoretical discharge Q_{th}	Coefficient discharge C_D
—	h_1	h_2	net h (cm)	m^3/s	sec	cm	cm	m^3/s	$\frac{Q_{ac}}{s_2}\sqrt{\frac{1-\beta^2}{2gh}}$
HIGH	7.5	15	0.42	0.61×10^{-3}	20	4.7	14.7	13.4×10^{-4}	1.398
MEDIUM	7.8	12.5	0.592	0.34×10^{-3}	20	5.3	10.9	13.4×10^{-4}	0.983
LOW	5.9	11.9	0.315	0.2×10^{-3}	20	4.8	8.1	13.4×10^{-4}	0.791