EXPERIMENT NUMBER: 3

A) EXPERIMENT NAME: Venturimeter Experiment

B) EXPERIMENTAL SETUP: Venturimeter

Figure 1: Venturimeter

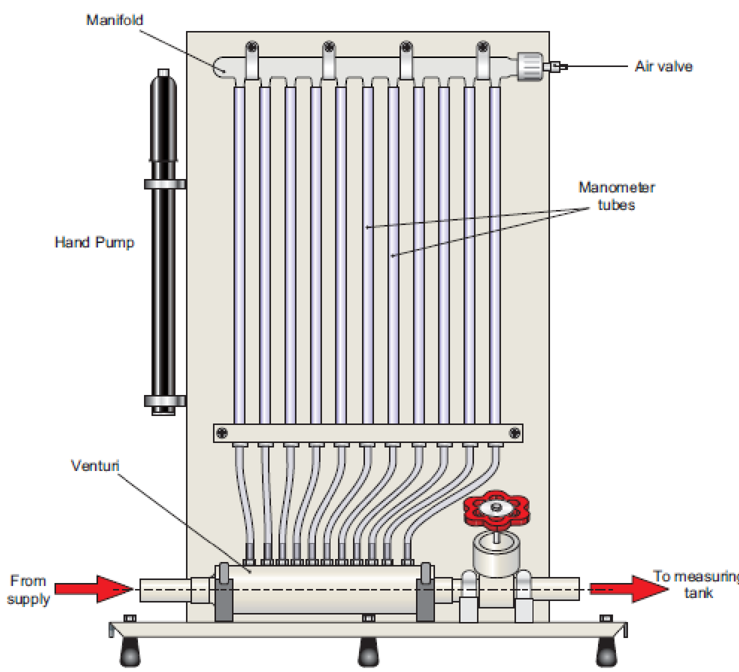

Figure 2: Schematic Diagram of Venturimeter

C) AIM OF THE EXPERIMENT: To measure the discharge (volume flow) along a pipe by using Venturimeter.

D)EXPERIMENTAL PROCEDURE:

1. Put the apparatus on the top of a Hydraulic Bench (supplied separately).

2. Connect the bench supply hose to the upstream (left) side of the Venturi meter.

3. Connect the downstream end of the Venturi Meter to the plastic tube supplied and direct it into the Hydraulic Bench for flow measurement.

4. Set both the apparatus flow control and bench supply valve to approximately one third fully open positions.

5. Check that the air valve on the upper manifold is tightly closed.

6. Switch on the bench supply and allow water to flow. To clear air from the manometer tubes it may help to slightly tilt the apparatus or lightly tap the tubes with your finger.

7. Shut the apparatus flow control valve. Air will now be trapped in the upper parts of the manometer tubing and the manifold.

8. Open the air valve just enough to allow water to rise approximately halfway up the manometer scale.

9. Shut the air valve.

10. Adjust both the bench supply and the apparatus control valves to give full flow.

11. At this condition the maximum pressure difference between the Venturi inlet and throat should be about 240 mm. You may need to connect the pump to the air valve, and add some air to see all levels on the scale.

12. Watch the water levels for a few moments to ensure the air valve is sealing properly.

Sample Calculations

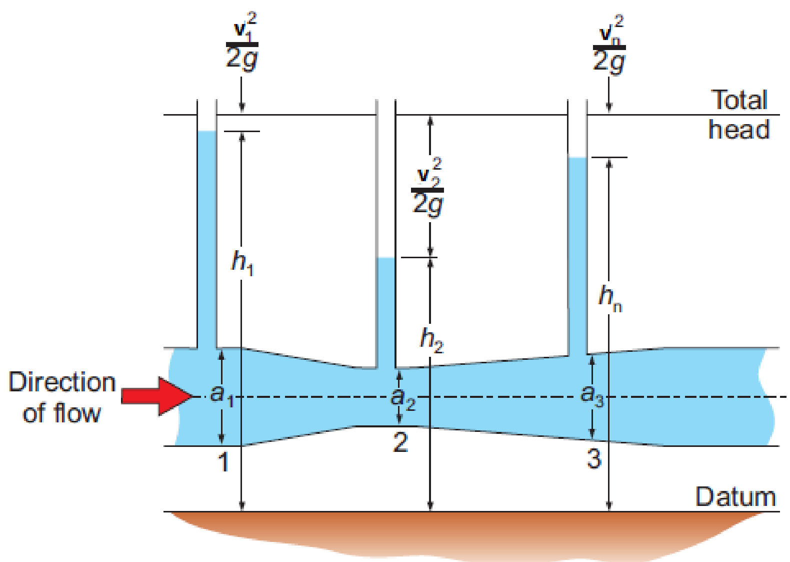

Figure 3: An incompressible fluid flowing along a convergent-divergent pipe with three pressure tappings

Bernoulli's principle stated that a change in fluid velocity is directly linked to a change in its pressure (or potential energy). To obey the laws of fluid dynamics for an incompressible fluid, its velocity increases as it passes through a constriction, thereby conserving mass. If the flow remains constant, its pressure must decrease, thereby conserving energy. Figure 11 shows an incompressible fluid flowing along a convergent-divergent pipe with three pressure tappings. One tapping measures upstream pressure at section 1, the second measures pressure at the throat (section 2) and the third measures pressure downstream (section 3). The cross-sectional area at the upstream section 1 is a_1 and at throat section 2 is a_2. Any other arbitrary section n is a_n. Piezometer tubes at these sections register h_1, h_2 and h_n as shown.

Symbol	Meaning	Units
V	Velocity of flow	m/s
D	Diameter of the pipe	m
h	Head of water	m
Δh	Head differential of water	m
Q	Flow rate	m^3/s
a	Cross-sectional areas	m^2
Cd	Discharge coefficient	-

Finding the Coefficient of Discharge (Cd)

The Bernoulli equation is a relation between pressure, velocity, and elevation in steady, incompressible flow, and is expressed along a streamline and in regions where net viscous forces are negligible as

$$\frac{p_1}{\rho} + \frac{V^2}{2} + gz = constant \qquad (1)$$

It can also be expressed between any two points on a streamline as

$$\frac{p_1}{\rho} + \frac{V_1^2}{2} + gz_1 = \frac{p_2}{\rho} + \frac{V_2^2}{2} + gz_2 \qquad (2)$$

The Bernoulli equation is an expression of mechanical energy balance and can be stated as: The sum of the kinetic, potential, and flow energies of a fluid particle is constant along a streamline during steady flow when the compressibility and frictional effects are negligible.

After these definitions, to explain the relationship between pressure, velocity and flow rate, the mass balance and the Bernoulli equations between a location before the constriction (point 1) and the location where constriction occurs (point 2) can be written as

$Q_1=Q_2 \longrightarrow V_1.a_1= V_2.a_2 \longrightarrow V_1=\frac{a_2}{a_1}V_2$ (Mass Balance) (3)

$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} = \frac{p_2}{\gamma} + \frac{V_2^2}{2g}$ Bernoulli Equation where ($z_1=z_2$) (4)

Combining eqs. (3) and (4) and solving for velocity V_2 gives

$$V_2 = \sqrt{\frac{2g(p_1-p_2)}{\gamma\left[1-\left(\frac{a_2}{a_1}\right)^2\right]}} \qquad (5)$$

Eq. (5) can be written as

$$V_2 = \sqrt{\frac{2g(h_1-h_2)}{\left[1-\left(\frac{a_2}{a_1}\right)^2\right]}} \qquad (6)$$

Theoretical Flow rate is

$$Q_{teo} = a_2\sqrt{\frac{2g(h_1-h_2)}{\left[1-\left(\frac{a_2}{a_1}\right)^2\right]}} \qquad (7)$$

The flow actually losses some energy between section 1 and 2, and the velocity is not absolutely constant across either of these sections. As a result, the measured value of Q is always slightly less than value calculated from theory (Eq. 7). To allow for this, the equation becomes

$$Q_{exp} = Cd.a_2 \sqrt{\frac{2g(h_1-h_2)}{\left[1-\left(\frac{a_2}{a_1}\right)^2\right]}} \quad (8)$$

Where Cd is an adjustment factor called the discharge coefficient, which you can find by experiment. It is usually between 0.92 to 0.99.

V(lt)	**t (s)**	**Q_{exp} (lt/s)**	**Q_{exp} (m^3/s)**	**h_1(m)**	**h_2(m)**	**$\Delta h=(h_1-h_2)$m**	**Cd**	**D(m)**	**V(m/s)**	**Re**

E) REQUIREMENTS IN REPORT: Experiment number, name and aim of the experiment. The table values, calculations and explanations. Plot a graph of Δh vs experimental flow rate (Q_{exp}) m^3/s and find f (Δh) equation in terms of experimental flow rate Q_{exp}.Find Cd. Plot a graph of Reynolds number (Re) vs Cd and find Cd equation in terms of Reynolds number (Re).