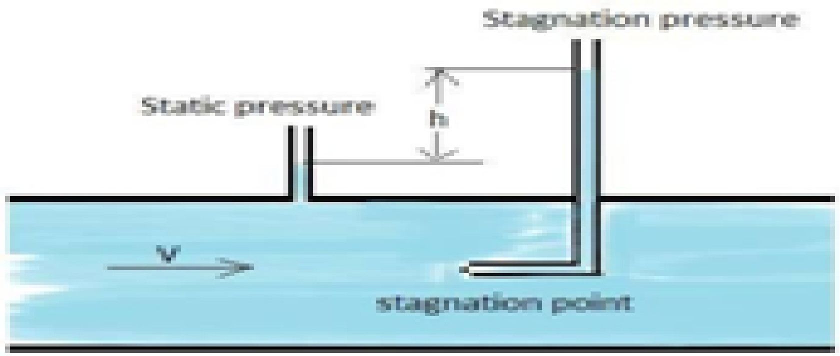
# FLUID MECHANICS
# (BTME 301-18)

# Unit 7: Pressure and Flow Measurement

# PITOT TUBE

- A Pitot tube is a simple device used for measuring the velocity of flow.
- The basic principle used in this is that if the velocity of flow at a particular point is reduced to zero, which is known as stagnation point, the pressure there is increased due to conversion of the kinetic energy in to pressure energy and by measuring the increase in pressure energy at this point,the velocity of flow may be determined.



- Simplest form of a pitot tube consists of a glass tube, large enough for capillary effects to be negligible and bent at right angles.
- A single tube of this type is used for measuring the velocity of flow in an open channel.
- The tube is dipped vertically in the flowing stream of fluid with its open end A directed to face the flow and other open end projecting above the fluid surface in the stream.
- The fluid enters the tube and the level of the fluid in the tube exceeds that of the fluid surface in the surrounding stream. This is so because the end A of the tube is a stagnation point, where the fluid is at rest, and the fluid approaching end A divides at this point and passes around tube.

- Since at stagnation point the kinetic energy is converted in to pressure energy, the fluid in the tube rises above the surrounding fluid surface by a height, which corresponds to the velocity of flow of fluid approaching end A of the tube.
- The pressure at the stagnation point is known as stagnation pressure.
- Consider a point 1 slightly upstream of end A and lying along the same horizontal plane in the flowing stream of velocity V.
- Now if the point 1 and A are at a vertical depth of $h_o$ from the free surface of fluid and h is the height of the fluid raised in the pitot tube above the free surface of the liquid.

- Then by applying Bernoulli's equation between the point 1 and A, neglecting loss of energy,

$$\text{we get} \qquad h \;=\; V^2 \;=\; h \;+\; h$$

- ($h_o$ + h) is the stagnation pressure head at a point A, which consists of static pressure head $h_o$ and dynamic pressure head h.
- Simplifying the expression,

$$\frac{V^2}{2g} = h \quad \text{Or} \quad v = \quad 2gh \qquad\qquad (1)$$

- This equation indicates that the dynamic pressure head h is proportional to the square of the velocity of flow close to end A.
- Thus the velocity of flow at any point in the flowing stream may be determined by dipping the Pitot tube to the required point and measuring the height 'h' of the fluid raised in the tube above the free surface.

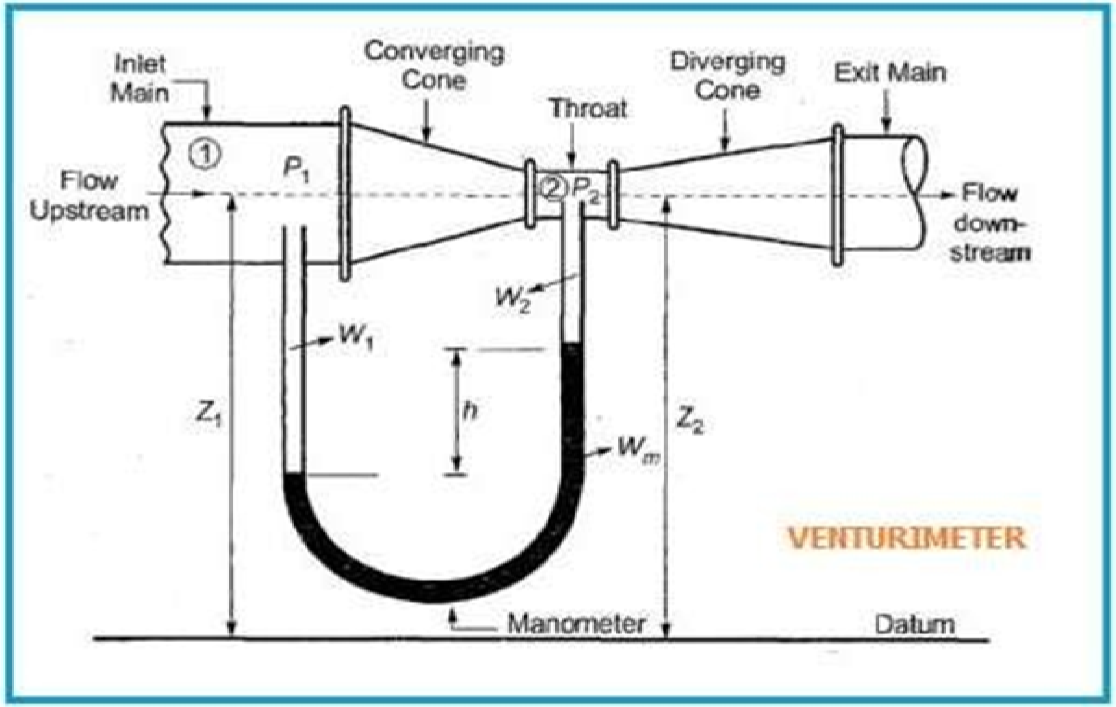
- The velocity of flow given by the above equation (1) is more than actual velocity of flow as no loss of energy is considered in deriving the above equation.
- When the flow is highly turbulent the Pitot tube records a higher value of h, which is higher than the mean velocity of flow.
- In order to take in to account the errors due to the above factors, the actual velocity of flow may be obtained by introducing a co-efficient C or $C_V$ called Pitot tube co-efficient.
- So the actual velocity is given by

$$v = C \quad 2gh$$

(Probable value of C is 0.98)

# VENTURIMETER

- A venturimeter is a device used for measuring the rate of flow of fluid through a pipe.
- The basic principle on which venturimeter works is that by reducing the cross-sectional area of the flow passage, a pressure difference is created and the measurement of the pressure difference enables the determination of the discharge through the pipe.



- A venture meter consists of (1) an inlet section, followed by a converging cone (2) a cylindrical throat and (3) a gradually divergent cone.
- The inlet section of venture meter is the same diameter as that of the pipe which is followed by a convergent cone.
- The convergent cone is a short pipe, which tapers from the original size of the pipe to that of the throat of the venture meter.
- The throat of the venture meter is a short parallel – sided tube having its cross-sectional area smaller than that of the pipe.
- The divergent cone of the venture meter is a gradually diverging pipe with its cross-sectional area increasing from that of the throat to the original size of the pipe.
- At the inlet section and the throat i.e sections 1 and 2 of the venture meter pressure gauges are provided.

$$Q = C_d Q_{th} = \frac{C_d a_1 a_2 \sqrt{2gh}}{\sqrt{a_1{}^2 - a_2{}^2}}$$

$$= C_d C \sqrt{h} \quad \left(\because C = \frac{a_1 a_2 \sqrt{2g}}{\sqrt{a_1{}^2 - a_2{}^2}}\right)$$

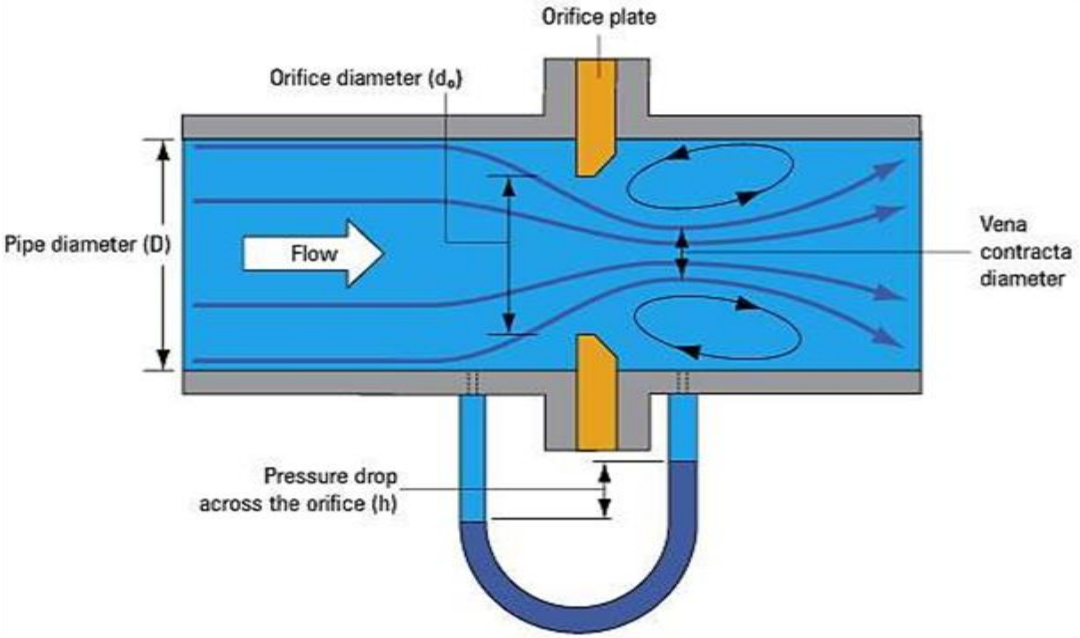
$$\boldsymbol{Q_{actual} = C_d C \sqrt{h}}$$

$C_d$ = Co-efficient of discharge $< 1$

- The Venturimeter which has long been used in hydraulics is here applied to the measurement of volume flow of blood through vessels.
- In fluid flow, **friction loss** (or skin friction) is the loss of pressure or “head” that occurs in pipe or duct flow due to the effect of the fluid's viscosity near the surface of the pipe or duct.
- In mechanical systems such as internal combustion engines, the term refers to the power lost in overcoming the friction between two moving surfaces, a different phenomenon.
- Rigorous calculation of the pressure loss for flowing gases, based on as properties, flow, and piping configuration (pipe length, fittings, and valves). Results can be printed out or "cut and paste" into other applications.

# ORIFICEMETER

- An orifice meter is a simple device for measuring the discharge through pipes.
- Orifice meter also works on the same principle as that of venture meter i.e by reducing cross-sectional area of the flow passage, a pressure difference between the two sections is developed and the measurement of the pressure difference enables the determination of the discharge through the pipe.



- Orifice meter is a cheaper arrangement and requires smaller length and can be used where space is limited.

$$Q = C a_0 a_1 \frac{\sqrt{2gh}}{\sqrt{{a_1}^2 - {a_0}^2}}$$

- This gives the discharge through an orifice meter and is similar to the discharge through venture meter.
- The co-efficient C may be considered as the co-efficient of discharge of an orifice meter.
- The co-efficient of discharge for an orifice meter is smaller than that for a venture meter.
- This is because there are no gradual converging and diverging flow passages as in the case of venture meter, which results in a greater loss of energy and consequent reduction of the co-efficient of discharge for an orifice meter.