Sensors & Transducers

FLOW METERS

Riya Jacob K
Dept of BCA
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A flow meter (or flow sensor) is an instrument used to measure flow rate of a liquid or a gas.

Bernoulli's Principle

- Bernoulli's principle states that "as the speed of a moving fluid increases, the pressure within the fluid decreases".
- Bernoulli's principle states that "the total mechanical energy of the moving fluid comprising the gravitational potential energy of elevation, the energy associated with the fluid pressure and the kinetic energy of the fluid motion, remains constant".

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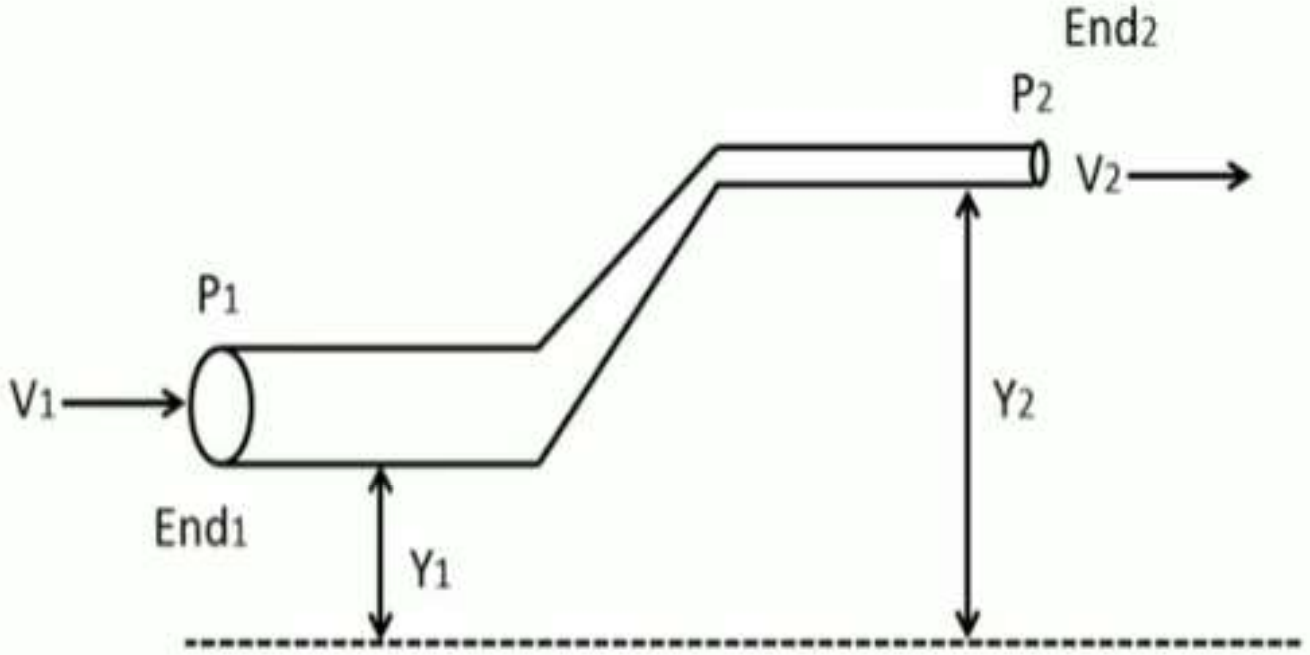
- The pressure exerted by the fluid+ kinetic energy+ the gravitational potential energy of elevation= a constant

- The formula for Bernoulli's principle is given as:

$P + 1/2\ \rho v^2 + \rho gh = \text{constant} \quad \ldots\ldots\ldots (1)$

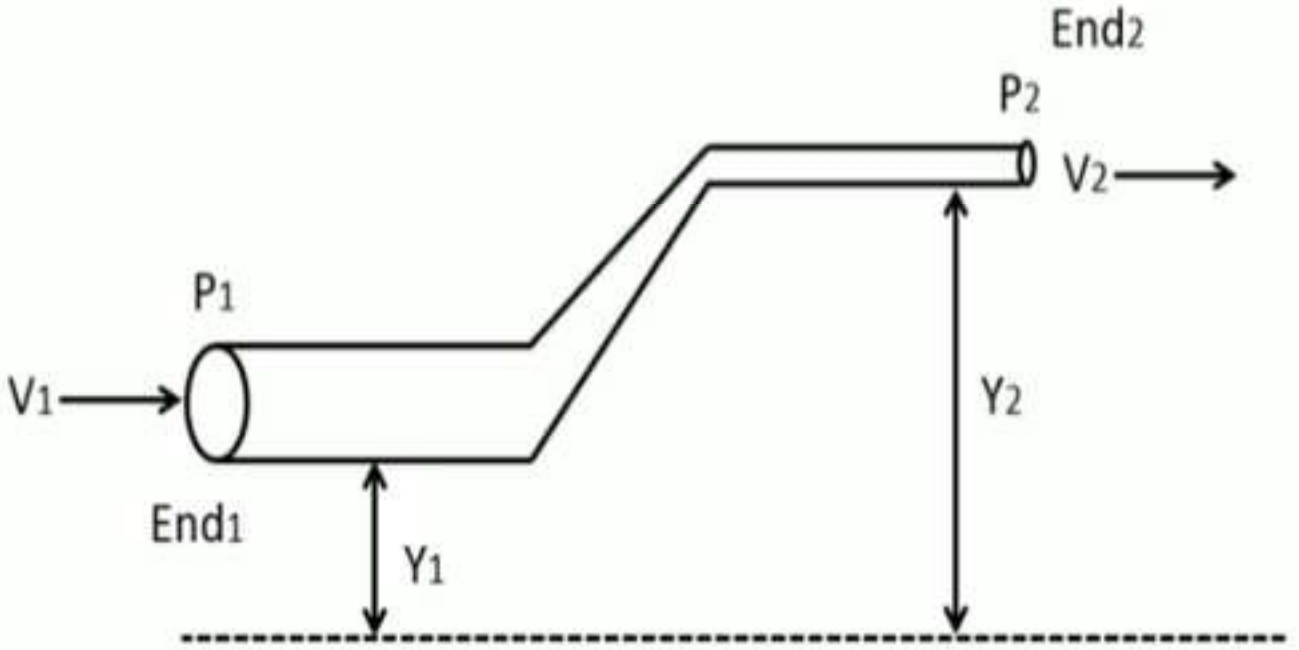
- Where,
  - P is the pressure exerted by the fluid
  - v is the velocity of the fluid
  - ρ is the density of the fluid
  - h is the height of the container
  - g is gravitational constant

- Bernoulli's equation shows the balance between pressure, velocity, and elevation.

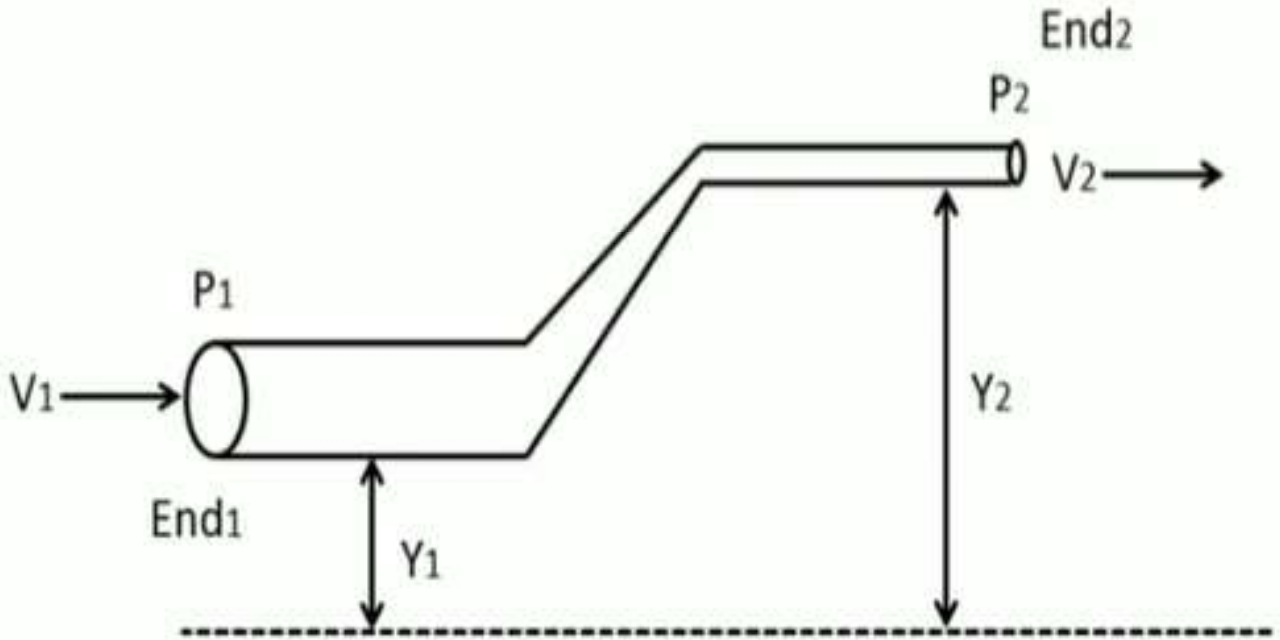


- Consider a pipe as shown in figure. It can be seen that the diameter of the two ends are different. The height from the ground to each end is also different. So, the force of gravity at two ends are different.

- $P + 1/2\ \rho v^2 + \rho gh = \text{constant}$ ..... (1)
- $P_1 + 1/2\ \rho_1 v_1^2 + \rho_1 g Y_1 = P_2 + 1/2\ \rho_2 v_2^2 + \rho_2 g Y_2$ ..... (2)
- Here $\rho_1 = \rho_2 = \rho$ (assume the density of the fluid at both ends of the pipe is same)

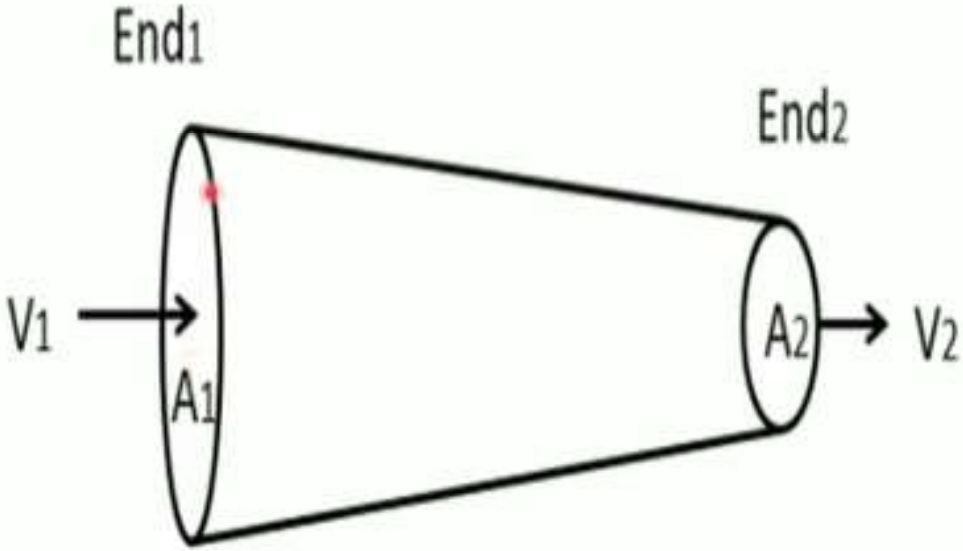


- Hence equation (2) becomes
- $P_1 + 1/2\ \rho\ v_1^2 + \rho g Y_1 = P_2 + 1/2\ \rho\ v_2^2 + \rho g Y_2$ ..... (3)
- This is Bernoulli's equation.

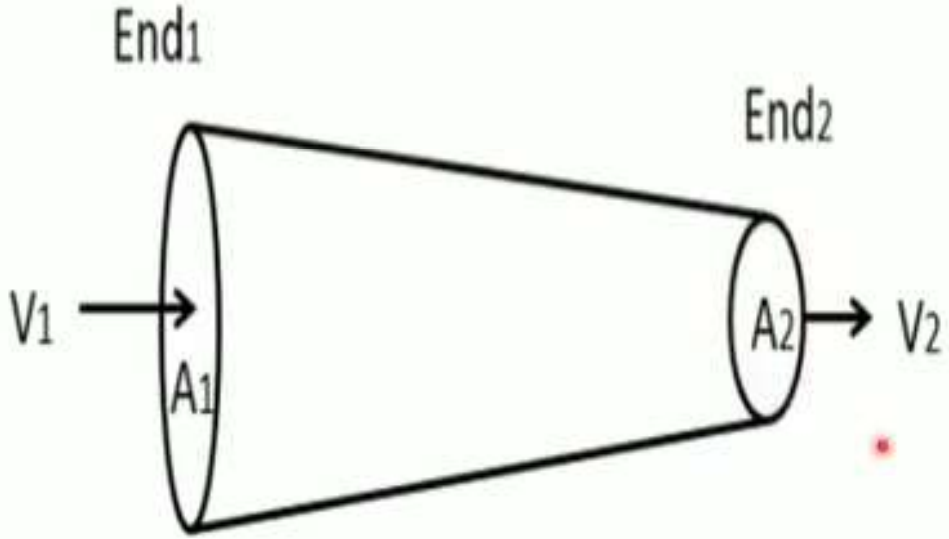


Bernoulli's Principle of Continuity

- According to the principle of continuity "If the fluid is in streamline flow then the mass of fluid passing through different cross sections are equal".



- According to Bernoulli's principle of continuity,
- The rate of mass entering = Rate of mass leaving
- The rate of mass entering = $\rho A_1 V_1 \Delta t$ ..... (4)
- The rate of mass leaving = $\rho A_2 V_2 \Delta t$ ..... (5)
- Where Δt is the duration of fluid flow



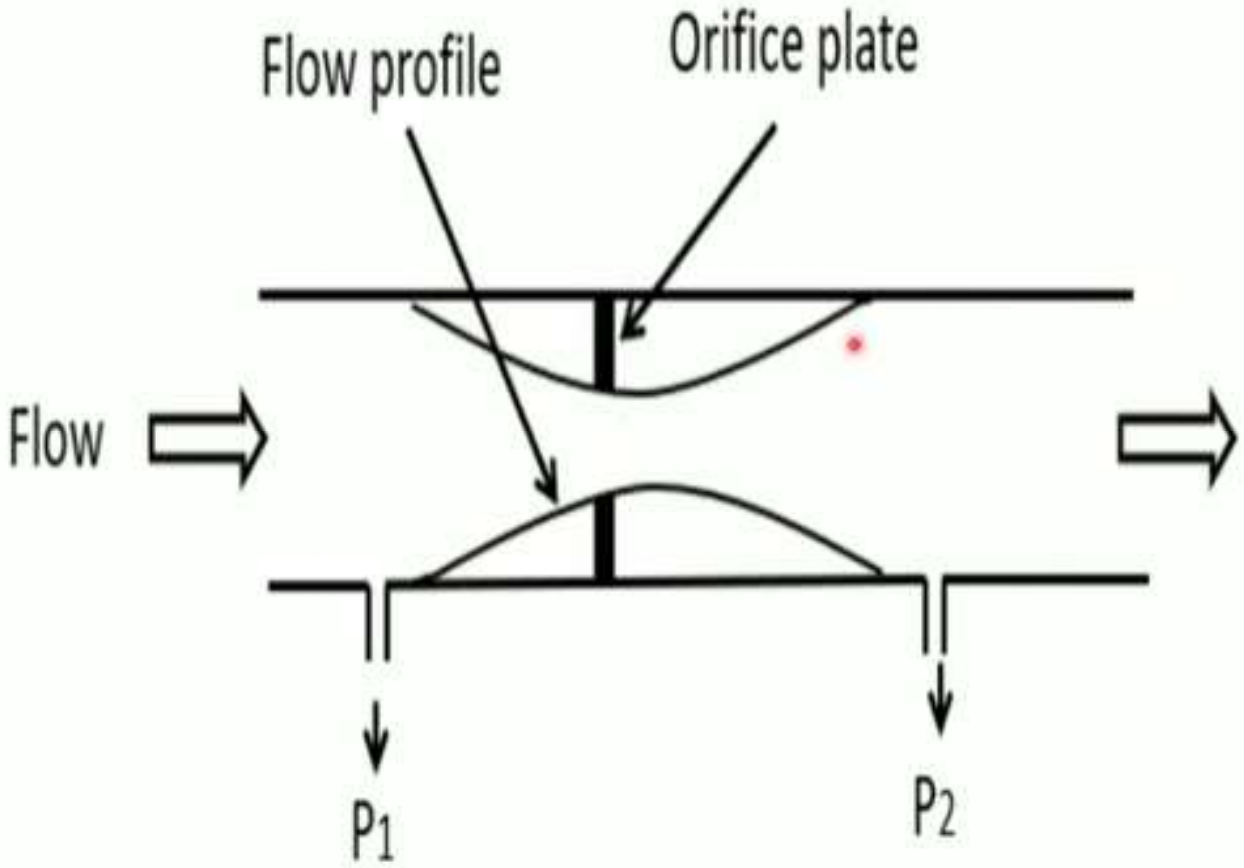
- The rate of mass entering = $\rho A_1 V_1 \Delta t$ ..... (4)
- The rate of mass leaving = $\rho A_2 V_2 \Delta t$ ..... (5)
- Using the equations (4) and (5) we can write
- $\rho A_1 V_1 \Delta t = \rho A_2 V_2 \Delta t$
- $A_1 V_1 = A_2 V_2$
- This equation is known as the Principle of continuity.

Obstruction type flowmeter

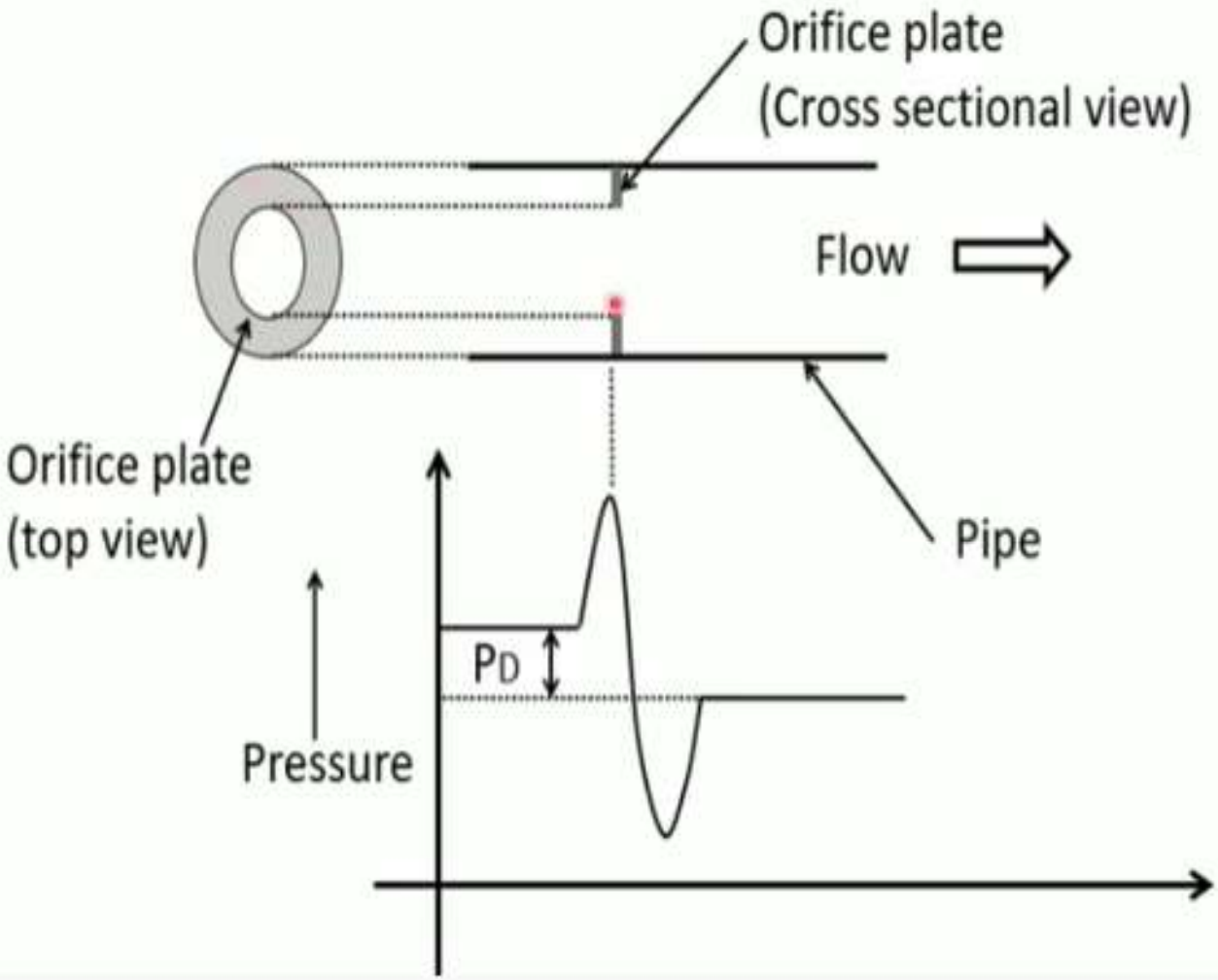
- In this type an obstruction is created in the flow passage. So, a pressure drops across the obstruction. The pressure drop across the obstruction is a function of the flow rate.
- Orifice meter
- Venturi meter
- flow nozzles

Orifice meter

- In orifice meter flow transducer, an orifice plate is placed in the passage, as shown in figure.



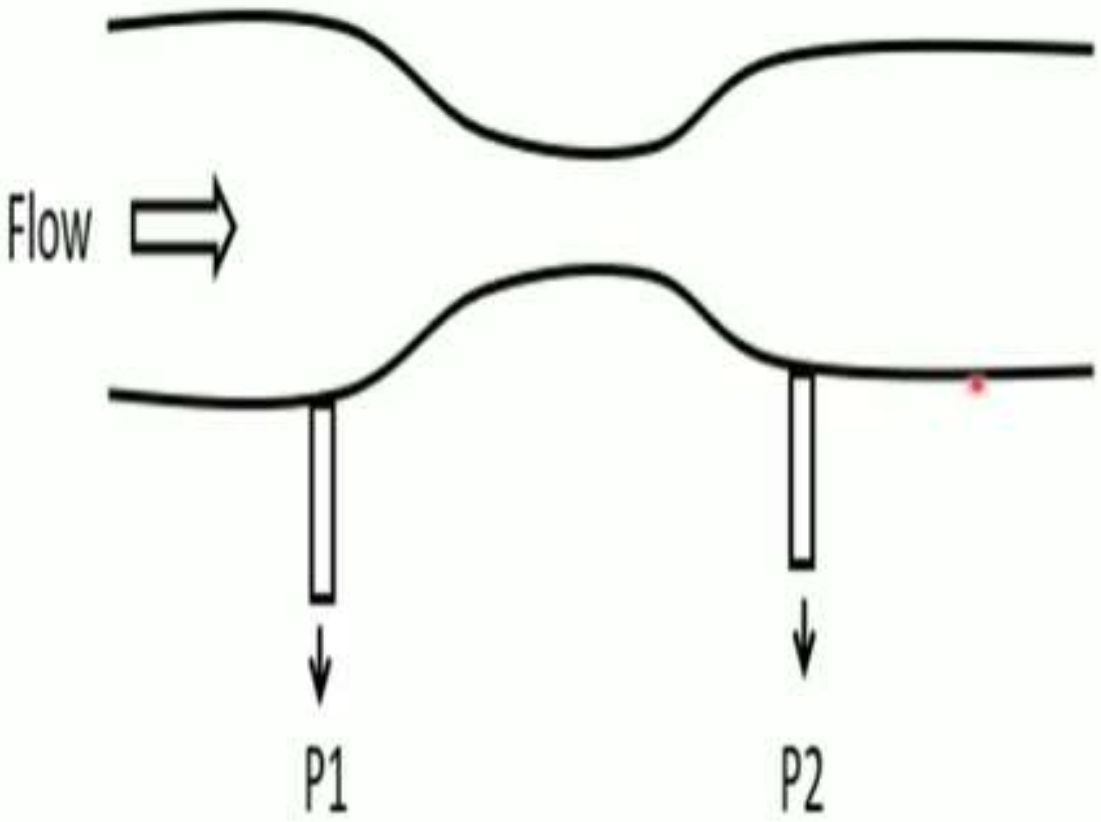
- From the figure it can be seen that there exists a permanent pressure difference (P_D) in between the two sides of the orifice plate. This is the major disadvantage of using orifice plate. So, it requires more pressure to pump the liquid.



- Otherwise we can say that the flow rate is reduced with the presence of orifice plate.
- This problem can be reduced by improving the design of the obstacle.
- Venturi meters and flow nozzles are modified orifice plate meter.

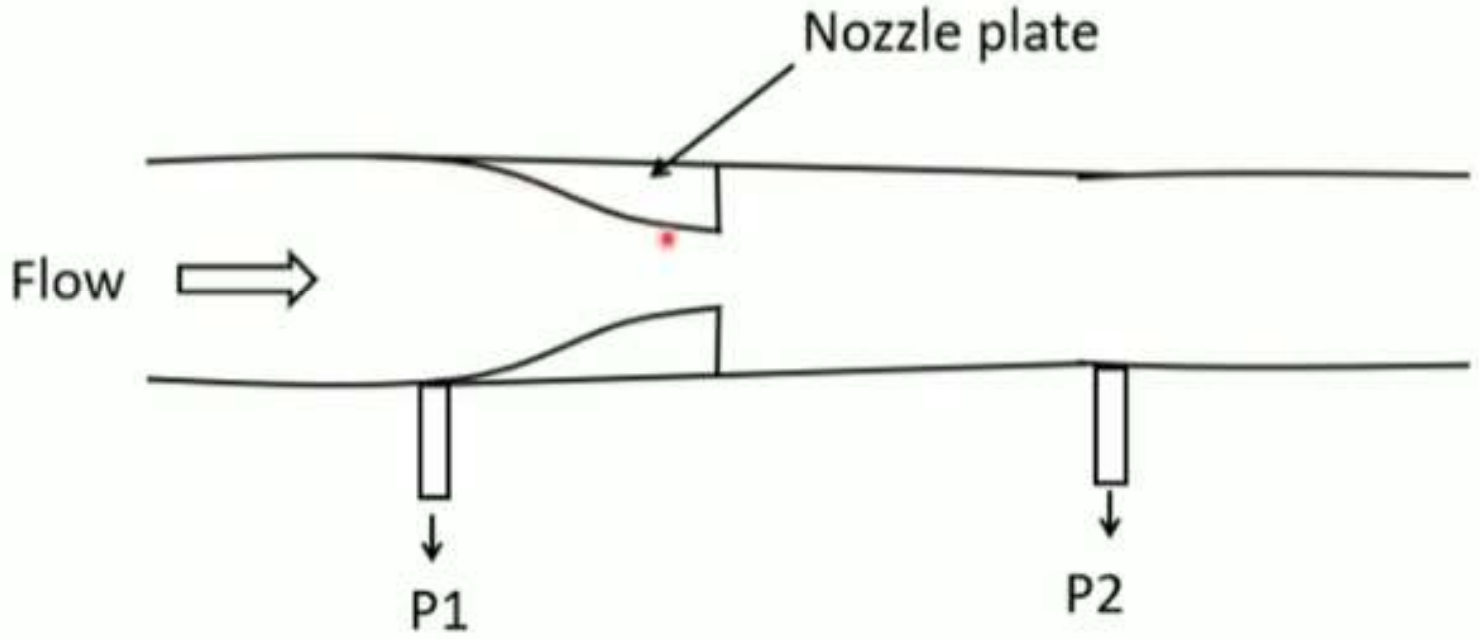
Venturi meter

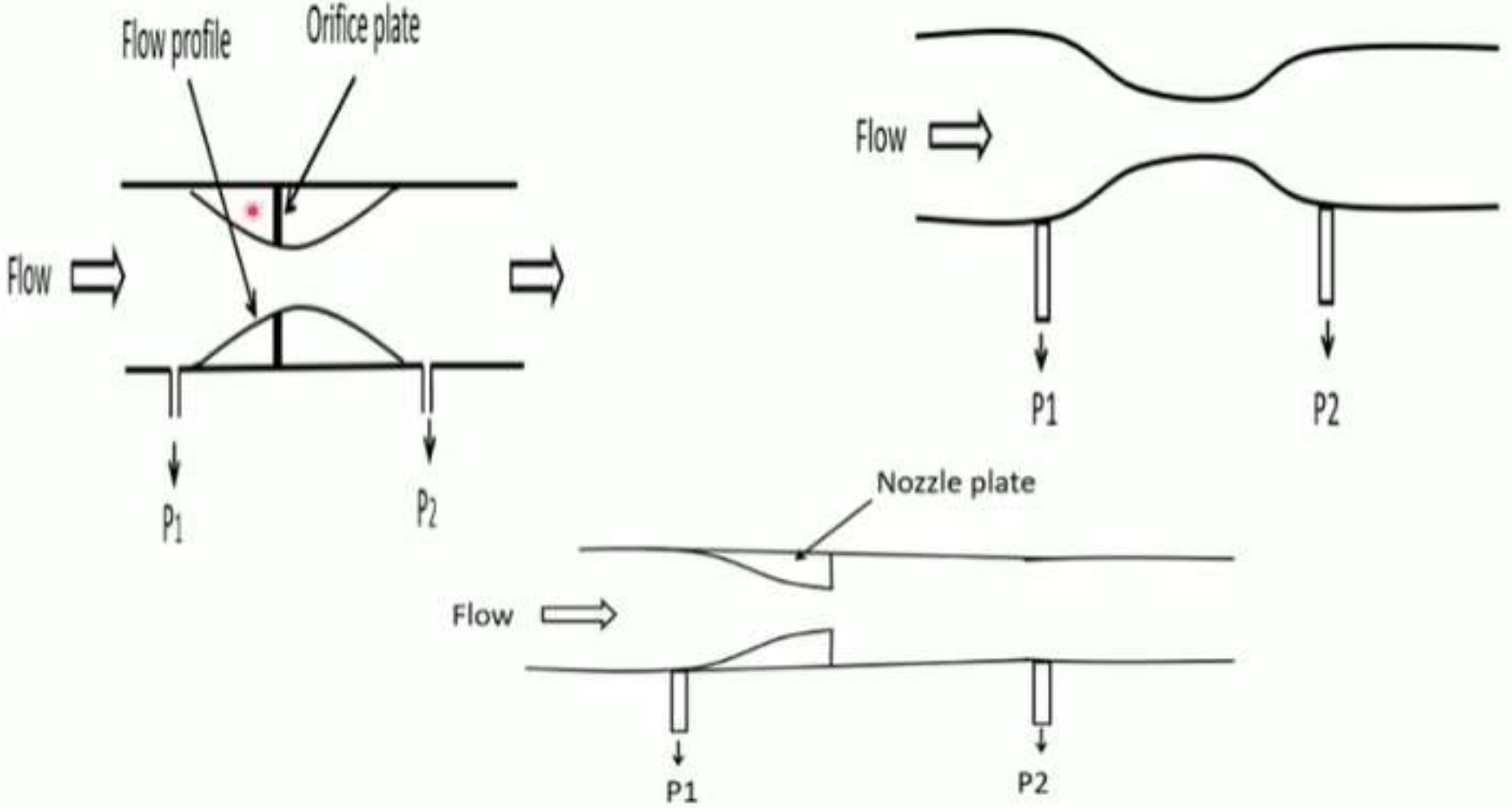
- Venturi meter is a device that is based on Bernoulli's theorem and is used for measuring the rate of flow of liquid through the pipes.
- Here the obstruction is designed in such a way that the change in the flow path is gradual. As a result of gradual path difference, there is no permanent pressure drop in the flow path.



Nozzle Plate

- Its working principle is a combination of Orifice meter and Venturi meter type flow meters.




Flow profile
Orifice plate
Flow
P1
P2
Flow
P1
P2
Nozzle plate
Flow
P1
P2