Unit 6: Flow of fluids

Streamline flow:

A stream line flow is defined as the steady flow where the velocity of the fluid particle does not change with time. It is only possible if the velocity of the fluid is less than the critical velocity.

Turbulent flow:

If the velocity of the liquid exceeds the critical value, the flow become irregular and turbulent is called turbulent flow.

Equation of continuity:

When there is a steady flow of an incompressible fluid through a tube of non uniform cross section, the product of the area of cross section and the velocity of flow remain same at every point in the tube. $a_1 v_1 = a_2 v_2$

1. Velocity of the fluid is independent of the nature of the liquid.
2. Velocity is greater where the area is smaller.
3. When a liquid flow through a tube which end with a jet, the velocity of the flow become very large due to the small area at the end.
4. When water falls continuously from a tap, the velocity increases with distance under the action of gravity. Then the cross section of the streaming water becomes narrower as it comes down.

Energies associated with fluids:

Kinetic energy:
This is the energy possessed by the fluid due to the velocity of the flow. It can be found by the equation$KE = \frac{1}{2}mv^2$

$$Kineticenergyperunitmass = \frac{1}{2}v^2$$

Potential energy:

If a fluid of mass m is situated at a height h from a reference level, its potential energy can be found by the equation $PE = mgh.$

$$potentialenergyperunitmass = gh$$

Pressure energy:

The energy possessed by a fluid by the virtue of its pressure is called pressure energy. If P is the pressure, d is the density and m is the mass, $pressureenergy = \frac{mP}{d}$

$$Pressureenergyperunitmass = \frac{P}{d}$$

Bernoulli's theorem:

The sum of the kinetic energy, potential energy and pressure energy of an incompressible and non viscous fluid in steady flow remain constant throughout the flow.

If P1/d, gh1, v12 and P2/d, gh2, v22 are the pressure energy, potential energy and kinetic energy per unit mass of the liquid flowing through a tube at two different positions,

$$\frac{P_1}{d} + gh_1 + \frac{v_1^2}{2} = \frac{P_2}{d} + gh_2 + \frac{v_2^2}{2}$$

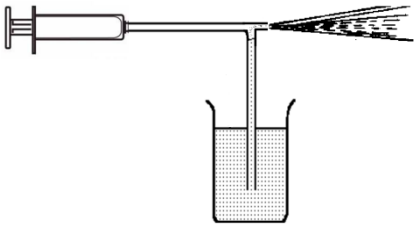
For a horizontal tube, h remain constant,

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

Ie, when the velocity of the fluid is large, the pressure small.

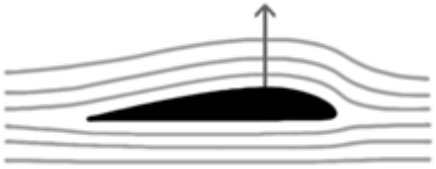
Applications of Bernoulli's theorem:

Atomiser:



The sprayer or atomiser works on the basis of Bernoulli's principle. The figure shows the essential parts of an atomiser. C is a cylindrical barrel which terminates in a small constriction T. The constriction is connected to the vessel L containing the liquid to be sprayed. P is the piston which can move be moved in the barrel. When the air in the barrel is pushed by the piston, the speed of the air increases considerably at the narrow region. According to the Bernoulli's principle, this causes reduction in pressure. Consequently, the liquid in the vessel rushes up through the vertical tube dipped in it. The impact of the high speed air breaks the liquid into fine spray.

Airfoil:



An air foil is a device which is shaped in such a way that to cause a force at right angles to the direction of its motion through the air. The wing of an aeroplane is an example for airfoil. Its upper surface is more curved and longer than the lower surface. Hence the air move faster over the upper surface compared to the lower surface. According o the Bernoulli's principle, pressure over the wing is decreased than the pressure below the lower surface. This pressure difference causes an upward lift on the wing.

From Bernoulli's principle, $\frac{P_1}{d} + \frac{v_1^2}{2} = \frac{P_2}{d} + \frac{v_2^2}{2}$

By re arranging, $P_2 - P_1 = \frac{d}{2}(v_1^2 - v_2^2)$

The above equation gives the upward lift of aircraft due to pressure difference above and below the wings.