* Viscosity & their measurements :-

The force of friction which one layer of the liquid exerts on another layer of the liquid is called viscosity.

Let us suppose the velocity of three successive layers is $(u+du)$, u and $(u-du)$ respectively. The distance between two adjuscent layers is dz. Thus the velocity of the layer at the distance dz is changed by a value of du.

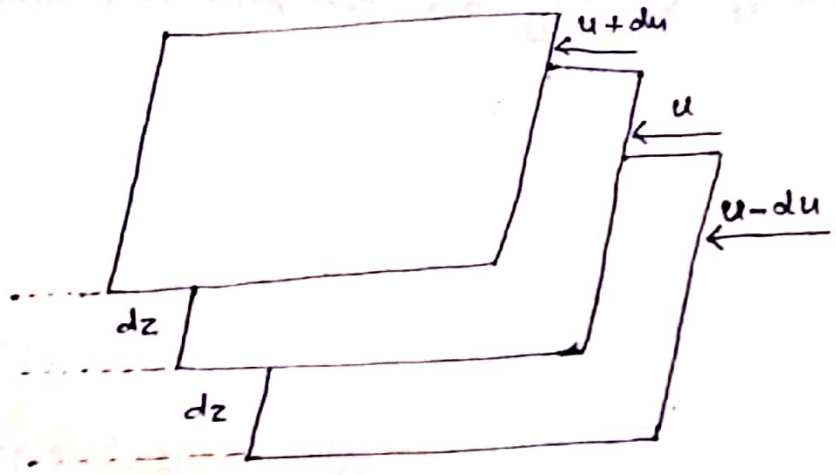
The velocity gradient is given by $\frac{du}{dz}$. (du = m/sec, dz = meter, $\frac{du}{dz} = sec^{-1}$).

A force is required to maintain the flow of layers. This force (f) is probotional to the area (A) of contact of layers and velocity gradient $\left(\frac{du}{dz}\right)$.

$$\therefore f \propto A \cdot \frac{du}{dz}$$

$$\text{or} \quad f = \eta A \cdot \frac{du}{dz}$$

Where, η = proportionality constant called Coefficient of viscosity.



When, $\frac{dv}{dz} = 1\ sec^{-1}$

$A = 1\ cm^2$

then $\boxed{f = \eta}$

Thus, Coefficient of viscosity may be defined as the force when velocity gradient is unity and the area of contact is unit area.

Unit of Viscosity :-

In CGS system :-

$$f = \eta A \frac{dv}{dz}$$

$$\therefore \quad \eta = \frac{f \times dz}{A \cdot dv} = \frac{dynes \times cm}{cm^2 \times cm\ sec^{-1}} = dynes\ cm^{-2}\ sec.$$

The quantity dynes cm^{-2} sec is called One poise.

In SI Unit :-

$$\eta = \frac{f \times dz}{A \cdot dv} = \frac{N\ m}{m^2 \times m\ sec^{-1}} = N\ m^{-2}\ sec = Pa\ s.$$

Common units of viscosity are centipoise and millipoise.

* Factors affecting viscosity of liquids:-

(1). Effect of temperature on viscosity :-

The viscosity of a liquid generally decreases with rise in temperature. The decrease is appreciable, being about 2% per degree rise of temperature in many cases.

The relationship between coefficient of viscosity of a liquid and temperature is expressed mathematically as:

$$\eta = A e^{Ea/RT}$$

Where, A and Ea are constants for a given liquid. Ea is called the activation energy for viscous flow.

(2). Effect of Pressure on viscosity :-

The viscosity of liquids, however, increases with increase in pressure. This is attributed to decrease in the no. of holes as the pressure is increased. Consequently, it becomes more difficult for liquid molecules to move around and thus it becomes more difficult for them to flow.

* Reynolds Number :-

The flow of a liquid (fluid) through a pipe of radius 'r' has been associated with a number called Reynolds Number, and defined as:

$$N_R = 2R\bar{v}\rho/\eta$$

Where, $\bar{v}$ is the average bulk velocity of the fluid, 'ρ' is the density and η is the coefficient of viscosity.

If N_R is greater than 4000, the flow is turbulent and if it is less than 2100, the flow is laminar. In a laminar flow, a velocity profile is given by —

$$\bar{v} = \frac{\Delta P (R^2 - r^2)}{4\eta l}$$

Where, 'ΔP' is pressure drop over a length 'l' and 'r' is the distance from the axis of the pipe of radius 'R'.

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