

# (1) Capillary viscometer: —

## Principle: —

When a liquid flows by gravity the time required for the liquid to pass bet<sup>n</sup> 2 marks i.e. A & B through a vertical capillary tube determined.

⇒ The time of flow of the liquid under test is compared with the time required for a liquid of known viscosity.

⇒ The viscosity of unknown liquid ( $\eta_1$ ) can be determined by using the equation.

$$\eta_1 = \frac{\rho_1 t_1}{\rho_2 t_2} \times \eta_2 \quad \text{--- (1)}$$

where,

- $\rho_1$  = density of unknown liquid
- $t_1$  = Time of flow of unknown
- $\rho_2$  = density of known liquid
- $t_2$  = Time of flow of known
- $\eta_2$  = viscosity of known liquid

## Derivation

When a liquid is drawn under a tube or viscometer the viscosity  $\eta$  can be determined by Poiseuille's equation i.e.

$$\eta = \frac{\pi r^4 \Delta P}{8 l v} \quad \text{--- (2)}$$

where  $\eta$  = viscosity of liquid

$r =$  radius of inside capillary

$t =$  Time of flow

$\Delta p =$  pressure difference bet<sup>n</sup> liquid

$L =$  length of the capillary

$V =$  volume of liquid flowing

$\Rightarrow$  incase of capillary viscometer <sup>used</sup> actual viscometer the reading, length, and volume liquid are constant

$\Rightarrow$  so this eqn - (2) can be rewritten as

$$\eta = kt \Delta p \quad (3)$$

$\Rightarrow$  The pressure difference depends upon density of the liquid and acceleration due to gravity difference in height in the liquid column.

$\Rightarrow$  The acceleration due to gravity is a constant quantity and this level of the capillary is

$\Rightarrow H$  can be taken constant by taking equal quantity of liquid

$\Rightarrow$  so this eqn - (3) can be rewritten as

$$\eta = kt \times \rho \quad (4)$$

where,  $k =$  constant of the viscometer

incase of ~~non~~<sup>known</sup> liquid and unknown fluid viscosity will be  $\eta_1$  for unknown &  $\eta_2$  for known

$\Rightarrow$  then this eqn - (4) can be rewritten

$$\eta_1 = k t_1 \times \rho \quad (5)$$

$$\eta_2 = k t_2 \times \rho \quad (6)$$

we will get,

$$\eta_1 = \frac{\rho_1 t_1}{\rho_2 t_2} \times \eta_2 \quad \text{--- (A)}$$

If we calculate the kinematic viscosity of either of unknown viscosity then it will be

$$\frac{\eta_1}{\rho_1} = \frac{\rho_1 t_1}{\rho_2 t_2} \times \frac{\eta_2}{\rho_2}$$

$$\frac{\eta_1}{\rho_1} = \frac{t_1}{\rho_2 t_2} \times \eta_2$$

$$\frac{\eta_1}{\rho_1} = \frac{t_1}{\rho_2 t_2} \times \frac{\eta_2}{\rho_2}$$

$$\left. \begin{aligned} \rho &= 1000 \text{ kg/m}^3 \\ \rho &= \frac{F}{A} = \frac{W}{A} \\ &= \frac{V \times \rho \times g}{A} \\ &= \frac{h \times A \times \rho \times g}{A} \\ &= h \times \rho \times g \end{aligned} \right\}$$

$\Rightarrow$  Kinematic viscosity  $\nu =$  unknown fluid  $\times \frac{t_1}{t_2}$ , kinematic viscosity of known liquid.

method

Take a clean & dry, standard, v. cone and fix on a stand at vertical position and with the help of a pipette take fixed quantity of  $H_2O$  and transferred through a wide limb by the help of a rubber tube. water is sucked to this level along the mark A. Then this water is allowed to flow down, when it reaches to mark A stopwatch is started & it will be continued up to the water reaches the mark B. then the stopwatch is

stopped. The time calculated for a unknown & known liquid is measured then the eqn (A)

the viscosity of unknown  
parachol consideration.

The flow of liquid inside the capillary tube should be laminar flow  
→ The pressure head should be maintained to prevent the turbulent flow.  
→ The distinction between the turbulent & laminar flow is provided by a no. called Reynold's number

→ The equation for Reynold's number is expressed as

$$R_E = \frac{Dvd}{\eta}$$

where,  $D$  = inside diameter of the tube  
 $v$  = average velocity of the liquid  
 $d$  = density of the liquid  
 $\eta$  = viscosity of the liquid

### Application:

The ostwald's viscometer is used for quality control purpose in pharmaceutical such as colloids, diffuse suspension, emulsion etc..

→ It is also used for evaluation of light liquid paraffin, heavy liquid paraffin & dextran 40 injection.  
→ The study of flow of liquid through a capillary tube is totally depend upon light the circulation of blood.