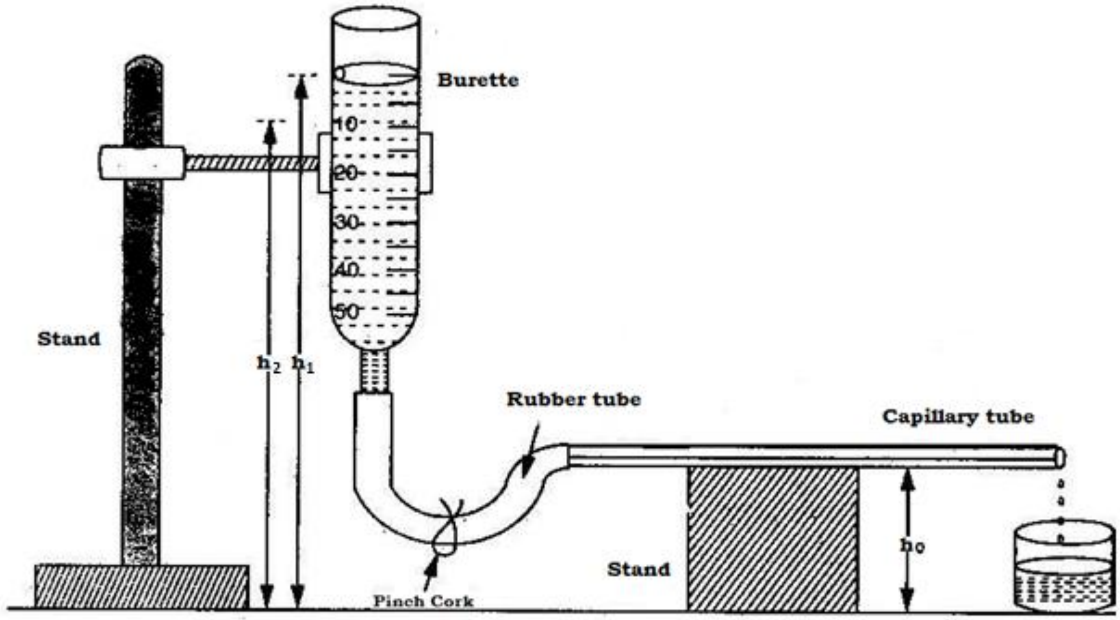

Figure 4.1 Experimental arrangement of Poiseuille's Method

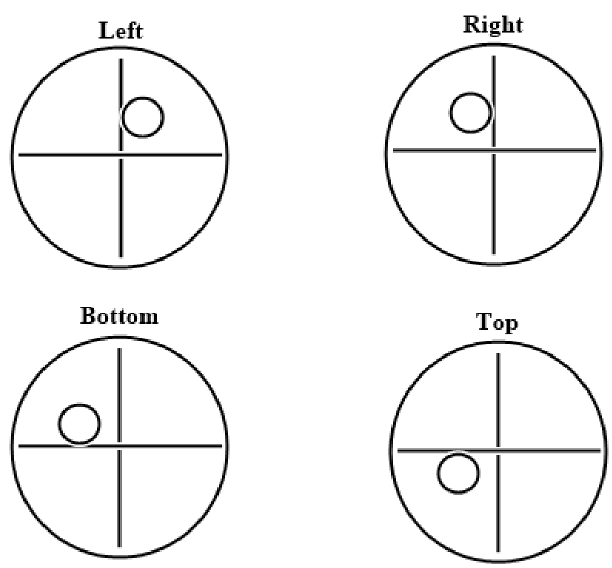

Figure 4.2 Calculation of radius of the capillary tube

Viscosity of a Liquid -Poiseuille's Method

Expt. No: Date:

AIM

To determine the coefficient of viscosity of the given liquid by Poiseuille's method.

GENERAL OBJECTIVE

To assess the viscous behavior of the given liquid by Poiseuille's method

SPECIFIC OBJECTIVES

1. To determine the driving height of the liquid level
2. To find the time taken for the uniform flow of given volume of the liquid
3. To measure the internal radius of the capillary tube
4. To calculate the coefficient of viscosity of the given liquid using the formula

APPARATUS REQUIRED

- Burette
- Rubber tube
- Capillary tube
- Pinch cock
- Traveling microscope
- Stop clock
- Metre scale
- Beaker

TABLE - I

To find time of flow (t) and height

Burette reading (10^{-6} m^3)	Time taken (s)	Height of burette reading from the table H (10^{-2} m)
0		
10		
20		
30		
40		
50		

TABLE - II

To find 'ht'

The height of the axis of the capillary tube from the table (h_0) = **……….** × 10^{-2}m

S. No.	Volume of the liquid (10^{-6} m^3)	Time of flow t (s)	h_1 (10^{-2} m)	h_2 (10^{-2} m)	$h=[(h_1+h_2)/2]-h_0$ (10^{-2} m)	ht (10^{-2} ms)
1	0 – 10					
2	10 – 20					
3	20 – 30					
4	30 – 40					
5	40 – 50					

Mean 'ht' = **………. ×10^{-2} ms**

FORMULA

Coefficient of viscosity of the given liquid

$$\eta = \frac{\pi \rho g r^4 (ht)}{8LV} \text{ (Nsm}^{-2}\text{)}$$

Symbol	Explanation	Unit
ρ	Density of the given liquid	kg m^{-3}
g	Acceleration due to gravity	ms^{-2}
r	Internal radius of the capillary tube	m
L	Length of the capillary tube	m
h	Driving height of the liquid	m
t	Time taken for the flow of liquid	s
V	Volume of the liquid collected	m^3

PREREQUISITE KNOWLEDGE

1. **Streamline flow**

   It is defined as the flow of a fluid in which velocity is constant or varies in a regular manner.

2. **Shear stress**

   It is defined as the force applied parallel to the liquid layer surface per unit area.

3. **Velocity gradient**

   The difference in velocity between adjacent layers of the fluid is known as a velocity gradient.

4. **Density**

   It is defined as the mass of the liquid per unit volume.

LEAST COUNT FOR TRAVELLING MICROSCOPE

Least Count (LC)	= Value of 1 Main Scale Division (MSD)/ Number of divisions in the vernier
20 MSD	= 1 cm
Value of 1 MSD	= 1/20cm = 0.05 cm
Number of divisions in the vernier	= 50
LC	= 0.05/50= 0.001 cm

TABLE - III

To find the internal radius of the capillary tube

LC = **0.001 cm** *TR= MSR + (VSC × LC)

Position	**Microscope Reading**			**Diameter (2r) = $R_1 \sim R_2$ 10^{-2}m**
	MSR 10^{-2}m	**VSC (div)**	**TR 10^{-2}m**	
Left R_1				
Right R_2				
Top R_1				
Bottom R_2				

Mean diameter (2r) = **………. × 10^{-2} m**

Radius (r) = **………. × 10^{-2} m**

*Note: Total Reading (TR) = Main Scale Reading (MSR) + (VSC × LC)

5. **Coefficient of viscosity**

It is defined as the ratio of applied shear stress to velocity gradient in a fluid flow.

PROCEDURE

1. The burette is fixed vertically in the stand and filled fully with the liquid for which the viscosity is to be measured.
2. At the lower end of the burette, a capillary tube is attached using a rubber tube.
3. The capillary tube is placed on a table such that the tube is in horizontal position. This arrangement allows the liquid to flow freely through the capillary tube without the influence of gravity.
4. The knob in the bottom of the burette is opened and the water is allowed to drain through the capillary tube. When the liquid level reaches zero mark level, the stop clock is started
5. The time taken to reach 10, 20,…..50 cc is noted. Then the time interval for each 10 cc, namely 0-10, 10-20, ………., 40-50 is found and tabulated. The height (H) of each marking namely 0, 10----50 cc is measured from the table. Also the height (h_0) of the axis of the capillary tube from the table is found. Then the actual height of each marking is obtained using the relation ($H - h_0$)
6. The driving height $h = [(h_1+h_2)/2]-h_0$ for every 10 cc namely 0-10, 20-30---40-50 is calculated by taking the height of initial marking as $h_1$and final marking as h_2 for each range.
7. The mean value of (ht/V) is calculated. The diameter of the capillary tube is measured using a travelling microscope and then radius (r = diameter/2) is calculated from it.
8. Substituting the values in the given formula, the coefficient of viscosity can be calculated.

OBSERVATION

Density of the given liquid	ρ	=	....	kg m^{-3}
Acceleration due to gravity	g	=	....	m/s^2
Inner radius of the capillary tube	r	=	....	$\times 10^{-2}$ m
Length of the capillary tube	L	=	....	$\times 10^{-2}$ m
Volume of the liquid	V	=	....	$\times 10^{-6}$ m^3
Mean value of	ht	=	....	$\times 10^{-2}$ ms

CALCULATION

Coefficient of viscosity of the given liquid

$$\eta = \frac{\pi \rho g r^4 (ht)}{8LV} \ (\text{Nsm}^{-2})$$

RESULT

The co-efficient of viscosity of the given liquid **η= ……….………. Nsm^{-2}**

APPLICATIONS

Flow rates of liquids in pipes, selection of proper lubricant oils, paper coating processes, atomization of fuel oils to droplets in boilers for efficient burning, smooth application of paints in walls and flow behavior of adhesives.

VIVA VOCE QUESTIONS

1. Define co-efficient of viscosity.
2. Point out the fluids having viscosity less than and greater than that of water.
3. Comment the various factors that affect co-efficient of viscosity.
4. Why is viscous force dissipative?
5. Compare streamline flow with turbulent flow.

STIMULATING QUESTIONS

1. The inter molecular forces in oil are less than water but still the viscosity of oil is more than water. Justify.
2. If the temperature increases, the viscosity of liquid decreases whereas the viscosity of gases increases. Comment.