

EXPERIMENT NO.:

Title: - Redwood viscometer

Aim: To determine the viscosity of the lubricating oil by using Redwood Viscometer

Objective:

1. Define viscosity of oil.
2. Explain dynamic and kinematic viscosity.
3. Explain the Newton's law of viscosity.
4. Explain with neat sketch 'Redwood Viscometer'.

Apparatus: Redwood viscometer No 1, Measuring flask, Stopwatch, weighing table

Theory:

Viscosity is one of the most important properties of lubricating oil. It is defined as the property of fluid by virtue of it offers resistance to the movement of one layer of fluid over an adjacent layer. The formation of fluid film of a lubricant between the friction surfaces and the generation of frictional heat under particular conditions of load, bearing speed, and lubricant supply is mostly depend upon the viscosity of the lubricant to some extent on its oiliness.(The term “oiliness” is defined as that property of lubricants by virtue of which one fluid gives lower coefficients of friction than another fluid of the same viscosity)

If the viscosity of the oil is too low, the fluid lubricant cannot be maintained between the moving surfaces as a result of which excessive wear may take place. On the other hand, if the viscosity of the lubricating oil were too high, excessive friction due to the shearing of oil itself would result.

Newton’s law of viscosity

Statement: “for a given shear stress acting on a fluid element, the rate at which the fluid deforms is inversely proportional to the viscosity” Or in simple words “the shear stress is directly proportional to the rate of shear strain or velocity gradient”

Where

$$\tau = \text{shear stress in N/m}^2$$

$$\frac{du}{dy} = \text{velocity gradient}$$

$$\tau = \mu \frac{du}{dy}$$

Where μ = coefficient of viscosity or simply dynamic or absolute viscosity

Thus dynamic viscosity is defined as tangential force per unit area required maintaining a unit velocity gradient between two parallel planes in the fluid unit distance apart.

Ratio of dynamic viscosity and density of fluid is called as kinematic viscosity and given as

$$\nu = \frac{\mu}{\rho}$$

Viscosity	CGS	SI
Dynamic viscosity:	dynes/cm ² i.e. Poise (1 Poise=1/10 N-s/m ²) 1 centipoise = 1/100 th Poise	Ns/m ²
Kinematic Viscosity:	1 cm ² /s i.e. Stoke (1 Stoke =10 ⁻⁴ m ² /s) 1 centistoke= 1/100 th stoke)	m ² /s

Difference between kinematic and dynamic viscosity

Dynamic Viscosity is measure a fluid's resistance to flow when an external force is applied. Where Kinematic Viscosity is to measure of the resistive flow of a fluid under the weight of gravity. In another way, kinematic viscosity is the measure of a fluid's inherent resistance to flow when no external force, except gravity, is acting on it.

The measurement of dynamic viscosity is most useful for liquids which change their apparent characteristics as force or pressure is applied. These are known as Non-Newtonian fluids. Non-Newtonian fluids are sensitive to changes in the amount of force exerted on them, and can sometimes even permanently change their viscosity if a constant force has been has been exerted on them over a period of time e.g. tomato Ketchup .

Measurement of kinematic viscosity is used mostly for Newtonian liquids - liquids that do not change viscosity with changes in applied force (shear rate). Testing lubricating oils is a significant application. Using this testing method, changes in viscosity at different temperatures and under differing environmental conditions can be determined. With this information, changes in lubricating effectiveness can be evaluated. Some other products for which the kinematic method is suitable are blood and plasma, paints, polymers, and asphalt

Measurement of Viscosity of Lubricating Oil:

Kinematic Viscosities are measured with the help of an apparatus called the 'Viscometer'. In viscometer a fixed volume of liquid is allowed to flow from a given height through a standard capillary tube under its own weight and the time of flow in seconds is noted. The time in seconds is proportional to true velocities. The results are expressed in terms of time taken by oil to flow through particular instrument. For example, if the time flow of an oil through 'Redwood Viscometer' at temp 20°C is 100 seconds, then its viscosity is '100 Redwood seconds ' at temp 20° C.

Common viscometers used: -

1. Redwood viscometer : Used in commonwealth countries.
2. Saybolt viscometer : Used in U.S.A.
3. Engle's viscometer : Used in Europe.
4. Redwood Viscometer

1. Redwood viscometer No 1

Commonly used for determining the viscosities of thin lubricating oil. Jet Bore Dia. - 1.62 mm, Jet Height = 10mm.

2. Redwood viscometer No 2.

Used for measurement viscosities of highly viscous oil.
Jet Bore Dia. = 3.8 mm, Jet Height = 15mm.

Components of Redwood viscometer No 1:

1. Oil Cup: It is a silver plated brass cylinder, 90mm in height & 46.5mm in diameter. The upper end of the cup is open. The bottom of cylinder is fitted with a agate jet with bore of dia. 1.62 mm and height 10mm. The upper surface of agate is ground to concave depression into which a small silver plated brass ball attached to a stout wire can be placed in such a way that the channel is totally closed and no leakage of the oil from the cup through the orifice can take place. A pointer indicates the level to which the cylinder is to be fitted with the oil, which is a stout, tapered, upward pointing wire fixed in the inner side of the cylinder. The lid of cup is fitted with a thermometer, which indicates the oil temperature.
2. Heating Bath: Oil cup is surrounded by a cylindrical copper bath containing water. It is provide with a tap for emptying water from it. The water is heated with the help of electrical heating coil. The thermometer is provided to measure the temperature of water.

3. Stirrer: Outside the oil cylinder is a stirrer carrying a four blades for stirring the water in the bath of maintaining uniform desired temperature. The stirrer is provided a circular shield at the top to prevent any water splashing into the oil cylinder
4. Leveling Screw: The entire apparatus rest on assort of tripod stand provided with leveling screws at the bottom of the legs.
5. Measuring flask: For receiving oil from the jet outlet. (Kohlrausch flask)

Using Redwood viscometer, the kinematic viscosity in centistoke is calculated by using the equation

$$v = A.t - \frac{B}{t}$$

Where 'A' & 'B' are the constants of viscometer used, and t is time of flow in seconds.

For the Redwood viscometer No 1, “t” is the time of flow 50ml of liquid and the values of constants 'A' & 'B' are—

Values of t (sec)	'A'	'B'
40-85	0.264	190
85-2000	0.247	65

Practical range of some of the lubricating oils employed is

Applications	Practical range in Redwood No. 1 seconds at 60°C temp.
1. Large marine engines.	200-220
2. Medium size industrial engines.	175-200
3. Small size engines are used in buses.	150-200

Procedure: -

1. Instrument is leveled with the help of leveling screws on the tripod.
2. The water bath is filled with water to the height corresponding to the tip of indicator up to which the oil is to be filled in the cylinder oil cup. (Ensure closing of water outlet tap)
3. The orifice or jet is sealed by keeping brass ball in position.
4. Oil under test is poured carefully into the oil cup up to the tip of indicator.
5. The 50ml flask is placed in position between the jet.
6. Heat the water by electrical heater.
7. Heat the water up to 80-85°C temp.

8. Shut off the electrical supply.
9. The oil and water are kept well stirred to get equal temperature of oil and that temperature is noted.
10. The ball is raised thus opening the orifice for oil flow.
11. Simultaneously a stopwatch is started.
12. When the level of oil dropping into the flask just reaches the 50ml mark, the stopwatch Stopped and the time is noted on seconds. The ball valve is replaced in the original position to prevent the overflow of the oil.
13. Refill the oil cup and repeat the same procedure. The results are expressed in the Redwood viscometer No 1. Seconds at the particular temperature.

Observation Table: -

SR. No.	Temp of oil. 0 ⁰	Flow time for 50ml. t, sec	Weight of empty flask.,gm	Weight of flask With oil. gm
(1)				
(2)				
(3)				
(4)				
(5)				

Calculations

We know that,

Kinematic viscosity is given by: $v = A \times t - B/t$

Also we have, Dynamic Viscosity $\mu = \text{Kinematic Viscosity} \times \text{Density}$

$$\text{Density} = \frac{\text{mass of oil}}{\text{volume of oil}} \text{----- gm/cm}^3$$

Mass of Oil = Weight of flask with oil -- Weight of empty flask , gm

Result Table: -

Sr. No	Oil Temperature.	Kinematic viscosity (Centistokes)	Dynamic viscosity (centipoises)
(1)			
(2)			
(3)			
(4)			
(5)			

Conclusion: -