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EXPERIMENT (2)

viscosity

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The properties of fluids are:-

- ♣ viscosity
- ♣ surface tension
- ♣ compressibility

Viscosity is an internal property of a fluid that offers resistance to flow. Viscosity determine the fluidity of fluids, it's useful property in petroleum production refining and transportation , it is used in reservoir simulators to estimate the rate of oil or gas to flow and their production, and it is needed in calculation of power required in mixers or to transfer fluid, the amount of pressure drop in pipe or column, flow measurement devices and design and operation of oil/water separations, A high viscosity implies a high resistance to flow while a low viscosity indicates a low resistance to flow. The load carrying capacity also increases as operating speed of the lubricated machinery is increased

Two methods for measuring viscosity are commonly employed: shear and time. When viscosity is determined by directly measuring shear stress and shear rate, it is expressed in centipoise (cP) and is referred to as the absolute or dynamic viscosity. In the oil industry, it is more common to use kinematic viscosity, which is the absolute viscosity divided by the density of the oil being tested. Kinematic viscosity is expressed in centistokes (cSt). Viscosity in centistokes is conventionally

Factors affecting viscosity:

Among the most important factors affecting the viscosity: the change in temperature, the rate of change of shear stress, the state of flow and flow of the fluid, the properties of the fluid and other factors that affect the viscosity:

1. Temperature:

The viscosity decreases with the increase in the temperature because the increase in the temperature increases the movement of the particles, so the attractive forces between the molecules are relatively reduced

2. Molecular Weight:

Viscosity increases with increasing molecule size (molecular weight) in homogeneous compounds for example, in hydrocarbons, the viscosity of compound C_8H_{18} is greater than that of $C_7 H_{16}$.

3. Attractive forces:

The forces of attraction between molecules are a basic measure of the viscosity of liquids. The greater the attraction between the molecules, the more difficult the movement of the molecules, and thus the viscosity of the liquid increases. For example, liquids with polar molecules have higher viscosity.

4. Presence of dissolved substances:

The substances dissolved in the liquid affect the viscosity, for example the presence of sugar in the water increases the viscosity of the water, while the presence of ionic salts in the water reduces the viscosity of the water. The presence of suspended substances in the liquid increases its viscosity, for example blood is more viscous than water due to the presence of proteins and platelets stuck in it.

5. Pressure:

In liquid: high pressure also affects fluid viscosity; As the energy required for the relative motion of the particles increases; Therefore, viscosity increases with increasing pressure. This property enables use of thin oils to lubricate heavy machinery.

Application of viscosity :-

1. Transparent and storing facilities for fluids i.e., pipes, tanks
2. Bitumen used for road construction.
3. Designing of the sewer line or any other pipe flow viscosity play an important role in finding out its flow behavior.
4. Drilling for oil and gas requires sensitive viscosity.
5. To maintain the performance of machine and automobiles by determining thickness of lubricating oil or motor oil.

To maintain the performance of machine and automobiles:-

Oil viscosity needs to suit the right ambient temperatures. If it's too thick when the engine is cold, it won't move around the engine. And if it becomes too thin when the engine is hot, it won't give the right protection to the engine parts. Optimizing an oil's viscosity, or thickness, helps maximize energy efficiency while avoiding component wear. Viscosity modifiers increase the viscosity of your oil at high temperature but have little effect on low- temperature viscosity. These enable your oil to flow properly when cold and also to remain thick enough to protect your engine components at high temperatures. Lower-viscosity grades of oil such as Shell Helix Ultra, make it easier for your engine to start from cold because they present less resistance to moving parts and hence take less power from your engine. This also means that you get enhanced fuel economy.

Equipment and procedures

Several instruments have been developed for measurement of viscosity; they depend on the pressure of the liquid being tested to provide the force to drive the liquid through the instruments providing a measure of the kinematic viscosity, which is expressed in centistokes (cS = cm ^{2}/100 s). The Cannon-Fenske viscometer equipped with a clear, liquid-controlled temperature bath, provides a method for determining viscosity at several temperatures (Figure A5.1). The Saybolt viscometer contains brass viscometer tubes set in a temperature-controlled oil bath with a calibrated orifice placed at the outlet of the viscometer tube.

U-tube Viscometer

Principle of Method

U-tube glass viscometers allow an accurately reproducible volume of liquid to pass through a capillary at a constant temperature by the application of an accurately reproducible force. The time taken for a liquid to flow is proportional to the ratio of the dynamic viscosity to the density of the fluid, hence to its kinematic viscosity. The constant of proportionality for the instrument is obtained by carrying out a determination in the viscometer with a fluid of known viscosity.

The kinematic viscosity of a fluid of viscosity greater than 10 centistokes is given by the expression

$v = C\,t$

where C is the viscometer constant, and t is the time of flow in seconds. When the fluid has a viscosity of 10 centistokes, or less, a second coefficient is used to correct for changes in kinetic energy at the exit to the capillary. The expression then becomes

$$v = Ct - \frac{B}{t}$$

where B is the coefficient of kinetic energy, which may be determined experimentally, or eliminated by choosing long flow times

The viscometer constant is determined by use of standard solutions of known kinematic viscosity, e.g. 40% sucrose: v = 4.39 cS at 25°C. Centistokes are still widely used.

Determination

A filtered sample of the oil under test is introduced into the viscometer by suction or by pipetting into the wide tube (DE in Fig.) so that air bubbles are absent and the level of oil stands a few millimeters above the level E. The viscometer is then placed in a thermostat, maintained at the required temperature, and adjusted so that it is exactly vertical. After a time, varying from 20min for temperatures near the normal to 30min at 100°C, the oil is blown or sucked into the tube A to a point 1 cm above the etched level B. The oil is then allowed to flow freely back down the capillary, taking the time of fall from the mark B to the mark C by means of an accurate stopwatch reading to 1/5 sec. The experiment is repeated until duplicate tests are repeatable within 0.2%.

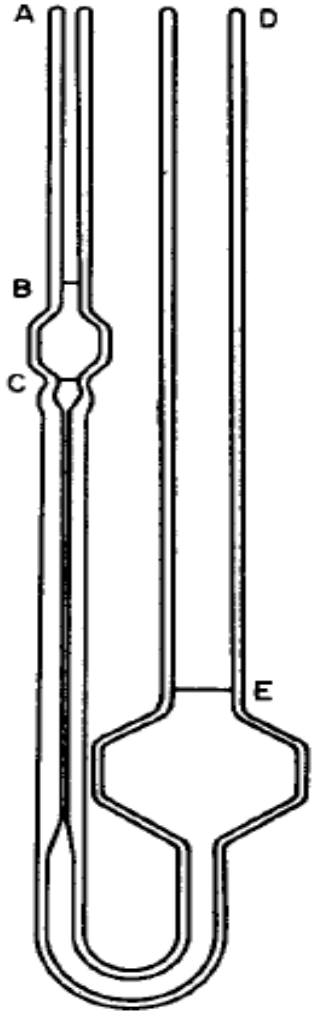

FIG. 62.3 U-tube viscometer.

Viscosity Index and what you need to know

The viscosity of an oil decreases as temperature increases. The degree to which the viscosity decreases determines the Viscosity Index (VI). The **higher** the viscosity index, the **lower** the change in viscosity. That is, oil with a high VI will retain their viscosity over a wider temperature range. A higher VI is important when your machine will experience a big change in operating temperatures. Oil needs to flow when cold, but not get too thin and runny when it's warm. If you know the viscosity of your oil at 40°C and 100°C (100°F and 212°F) you can easily calculate its Viscosity Index.