Hydramotion
innovators in fluid measurement

Viscosity: getting technical

viscosity **1. c.** In scientific use, the tendency of a liquid or gas to resist by internal friction the relative motion of its molecules and hence any change of shape; the magnitude of this, as measured by the force per unit area resisting a flow in which parallel layers unit distance apart have unit speed relative to one another; also called ***absolute*** or ***dynamic viscosity***; ***kinematic viscosity***, the dynamic viscosity divided by the density of the fluid. — *Oxford English Dictionary*

VISCOSITY is a measure of the resistance of a fluid to flow. This resistance arises from the attractive forces between the molecules of the fluid. A fluid will only flow if enough energy is supplied to overcome these forces.

For a body to be able to move through a fluid, the fluid has to flow around or across it. Therefore, the energy required to move a body through a fluid is directly related to the degree to which that fluid resists flow, *i.e.* its viscosity.

Newton defines viscosity

The English physicist Sir Isaac Newton (1642 – 1727) was the first to define viscosity scientifically. He derived a mathematical formula relating the viscosity to the resistive (drag) force experienced by a thin flat plate "cutting" its way ("shearing") through the fluid. The definition was based on two quantities:

(1) "Shear rate": this is the speed of the thin plate divided by its distance from some reference surface, such as the wall of the container.

(2) "Shear stress": this is the drag force experienced by the thin plate divided by its surface area.

Viscosity is defined as the ***shear stress*** divided by the ***shear rate***.

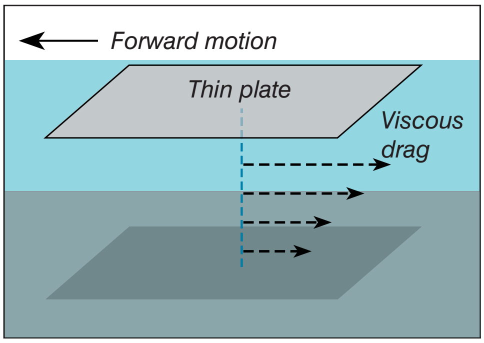
Non-Newtonian fluids

Newton knew that viscosity changed with temperature. He also assumed that viscosity was always independent of shear rate, *i.e.* the viscosity would remain the same no matter how quickly the plate was shearing through the fluid. Fluids which exhibit this type of behaviour are now called "Newtonian".

Water, alcohol and thin motor oil are typical Newtonian fluids. Many fluids, however, are "non-Newtonian" — at a given temperature, the viscosity depends on the shear rate and/or the length of time during which the fluid is subjected to shear.

There are several types of non-Newtonian fluid. They are classified on the basis of the way in which their viscosities change.

(*i*) *Pseudoplastic* (shear-thinning): the viscosity falls as the shear rate increases.



Newton's view of viscosity. *He saw that viscosity was related to the distance between the thin plate and a reference surface such as the wall of the container*

Examples: paints, shampoo.

(*ii*) *Dilatant* (shear-thickening): viscosity rises as the shear rate increases.

Example: mixtures of sand and water.

(*iii*) *Plastic* (Bingham): behave as a solid until a certain force (the "yield value") is applied, after which they may display either Newtonian or non-Newtonian flow characteristics.

Example: ketchup (catsup).

Thixotropy and rheopexy

The viscosity of some fluids changes over time even if the shear rate remains constant. If the viscosity falls, the fluid is said to be "thixotropic"; if it increases, the fluid is said to be "rheopectic". Both thixotropy and rheopexy may occur together with other flow characteristics, or only at certain shear rates.

While rheopectic fluids are rare, thixotropic fluids are very common. The best-known examples are non-drip paints and heavy printing inks.

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