Newtonian versus Non-Newtonian Fluids

In fluid mechanics, fluid properties can affect the characteristics of a flow. Viscosity (μ) is a measure of the resistance of a fluid to a shear or tensile stress. Qualitatively, a "thin" (less viscous) fluid will generally flow more easily, while a "thick" (more viscous) fluid will resist flow. A given value of viscosity provides a coefficient for relating the shear stress (τ) experienced by the fluid layers to the velocity gradient ($\frac{\partial u}{\partial y}$) of the perpendicular direction of the flow or the strain rate.

Fluids can be classified by whether viscosity is constant or variable. In a *Newtonian fluid* viscosity is constant for a fixed temperature and pressure. The relationship between the stress and the perpendicular velocity gradient is given by the equation:

$$\tau = \mu \frac{\partial u}{\partial y}$$

Therefore, curves of stress vs. velocity gradient (or strain rate) are linear. Further, the viscosity depends on the temperature and pressure of the fluid, but is independent of the applied forces. Physically, a Newtonian fluid at a given temperature and pressure will behave as a fluid whether it is gently stirred or highly agitated.

In contrast, in a *non-Newtonian fluid* the viscosity can vary according to the applied force. For example, a *shear-thickening* non-Newtonian fluid will "thicken" as the intensity of an applied force increases, and become more resistive to flow. Non-Newtonian fluids can also be *shear thinning*, in which the viscosity decreases with an increase in applied stress. Likewise, viscosity can also be time-dependent in non-Newtonian fluids. In a *rhopectic* fluid, viscosity increases with the duration of stress, while in a *thixotropic* fluid, it decreases.