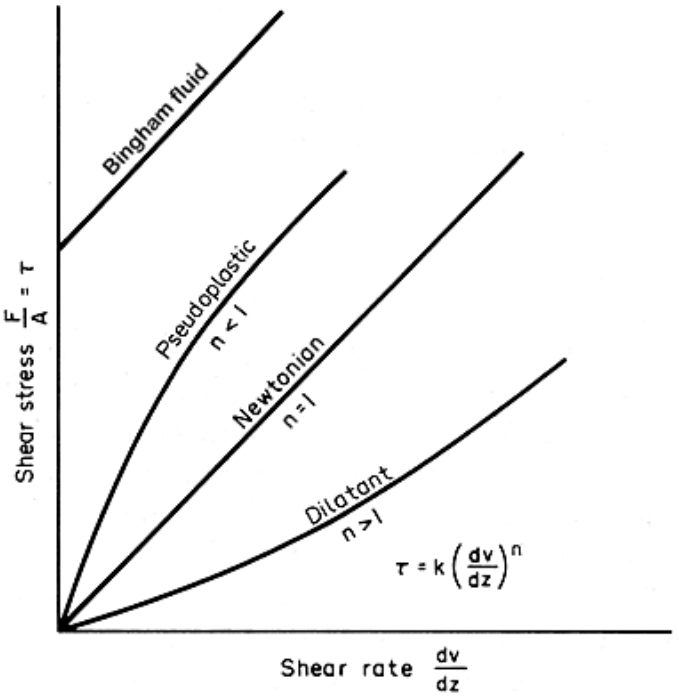


Figure 3.6. Shear stress/shear rate relationships in liquids.

In many instances in practice non-Newtonian characteristics are important, and they become obvious when materials that it is thought ought to pump quite easily just do not. They get stuck in the pipes, or overload the pumps, or need specially designed fittings before they can be moved. Sometimes it is sufficient just to be aware of the general classes of behaviour of such materials. In other cases it may be necessary to determine experimentally the rheological properties of the material so that equipment and processes can be adequately designed.

VISCOCITY

- Dilatant - Dynamic viscosity increases as the rate of shear increases (shear thickening -)
- Pseudoplastic - Dynamic viscosity decreases as the rate of shear increases (shear thining - milk)
- Rheopexy - Shear stress increases with time of shear at a given shear rate – starch
- Thixotropix - Shear stress decreases with time of shear at a given shear rate – honey, bread dough

Non-newtonian fluid

The relationship in a non-newtonian fluid between shear stress (τ) and velocity to diameter ratio ($^{V}/_{D}$) is given as $\frac{\Delta P.D}{4L} = \tau = K\left(\frac{8V}{D}\right)^n$. We can determine, graphically, the viscous coefficient and the velocity index using a capillary viscometer?

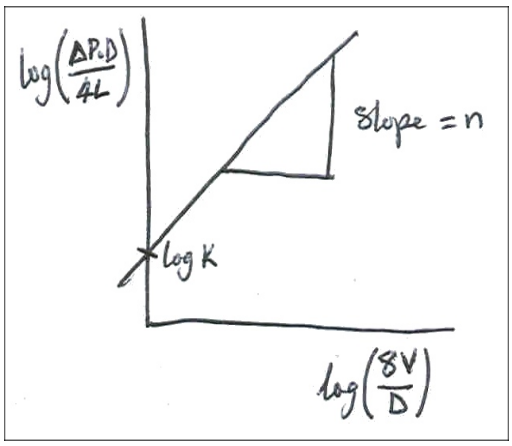
$$\frac{\Delta P.D}{4L} = \tau = K\left(\frac{8V}{D}\right)^n$$

Taking log of both sides

$$\log\left(\frac{\Delta P.D}{4L}\right) = \log K + n\log\left(\frac{8V}{D}\right)$$

$$\log\left(\frac{\Delta P.D}{4L}\right) = n\log\left(\frac{8V}{D}\right) + \log K$$

This implies y = m x + c



Diagram

In a viscometer, varying the velocity and noting the pressure difference results in a record useful for plotting a curve as shown below

From the graph

logK = the intercept on the y axis, hence

K = $\log^{-1}$(intercept on y-axis) = Viscous coefficient

n = the slope of the graph = velocity index

Useful in solving a flow problem in a food processing industry

An idea of the K and n obtainable by experimentation using a viscometer can assist in determining the appropriate pipe diameter or pipe length for a particular type of pipe which gives the K and n that will cope with the speed of operation required. A knowledge of the K is also useful in determining the power requirement for lifting or pumping the fluid hence the selection of appropriate pump for the factory operations.