RHEOLOGY

Rheology is defined as the flow of complex liquids. Liquids are different from solids because liquids continuously distort when applied pressure, figure 1(b), while solids distort and then stop, figure 1(a). Solids give an ‘elastic’ response, when applied pressure, while liquids do not give an elastic response, anddistort continuously under pressure. The distinction between liquids and gases is less fundamental from a macroscopic point of view, even though they are very different at the molecular level. Both liquids and gases give a qualitatively similar response when applied pressures. Gases have a higher distortation rate for pressure than liquids.

The aim of rheology is to know the liquid flow that is generated due to applied pressure. The applied pressure could be of different forms. In channels and pipes, for example, the applied pressure is due to the pressure difference across the ends of the pipe, figure 2(a). In reactors, the applied pressure is due to the rotation of the impeller, figure 2(b). The applied pressure could also be natural in origin, such as the gravitational pressure in falling liquid films, figure 2(c). Applied pressure is necessary for causing liquid flow because a liquid resists distortation, and this ‘liquid friction’ has to be overcome in order to generate a flow.

The variables used to narrate liquid flow are the density, the velocity, and the pressure. These variables are considered as ‘continuum fields that are continuously varying functions in space and time.

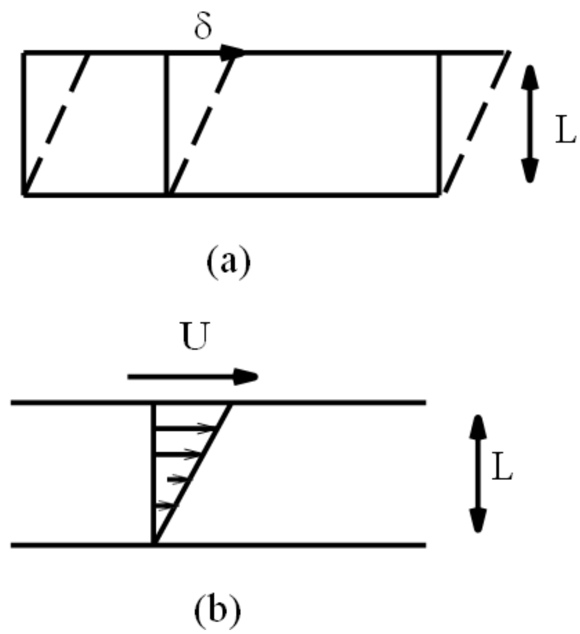


Figure 1: Solids and liquids.

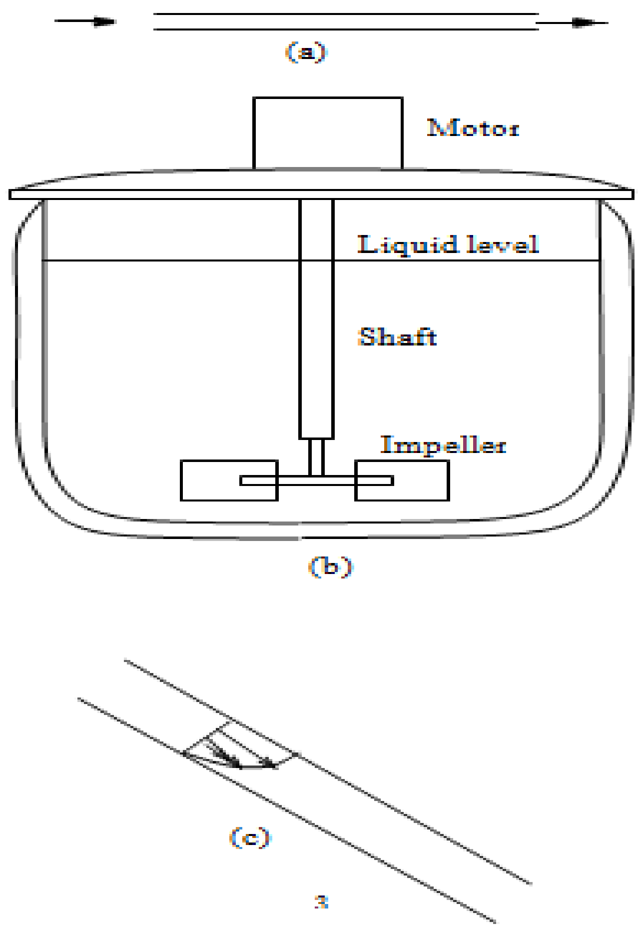


Figure 2: Types of external pressure.

nevertheless, this forecast is valid if the length scale of flow, that is macroscopic, bigger when compared to the inter-molecular separation and known as averages over volumes that are microscopically small volume under consideration, but large at molecular scales.

Newtonia fluid

Newtonia fluid is a fluid in which the viscous pressure arising due to its flow, at all points, is directly proportional to the species level - the rate of change of its distort over time.

More exactly, a liquid/fluid is Newtonian only if the tensors (an algebraic object) that describes the viscous pressure and the tension rate are related by an unchanged viscosity tensor that does not depend on the pressure state and velocity of the flow. If the fluid is also isotropic (that is, its mechanical properties are the same along any direction), the viscosity tensor reduces to two real coefficients , describing the fluid's resistance to continuous shear distort and continuous compression or expansion, respectively.

Newtonian law of viscosity

It is the resistance of a liquid or gas to deform or movement of adjacent portions relative to one another. Viscosity indicates opposition to flow.

Shear rate is the rate of transform of velocity i.e. one layer of fluid cross over an adjacent layer.

Shearing stress is a force that results in layers to slide upon each other in reverse directions.

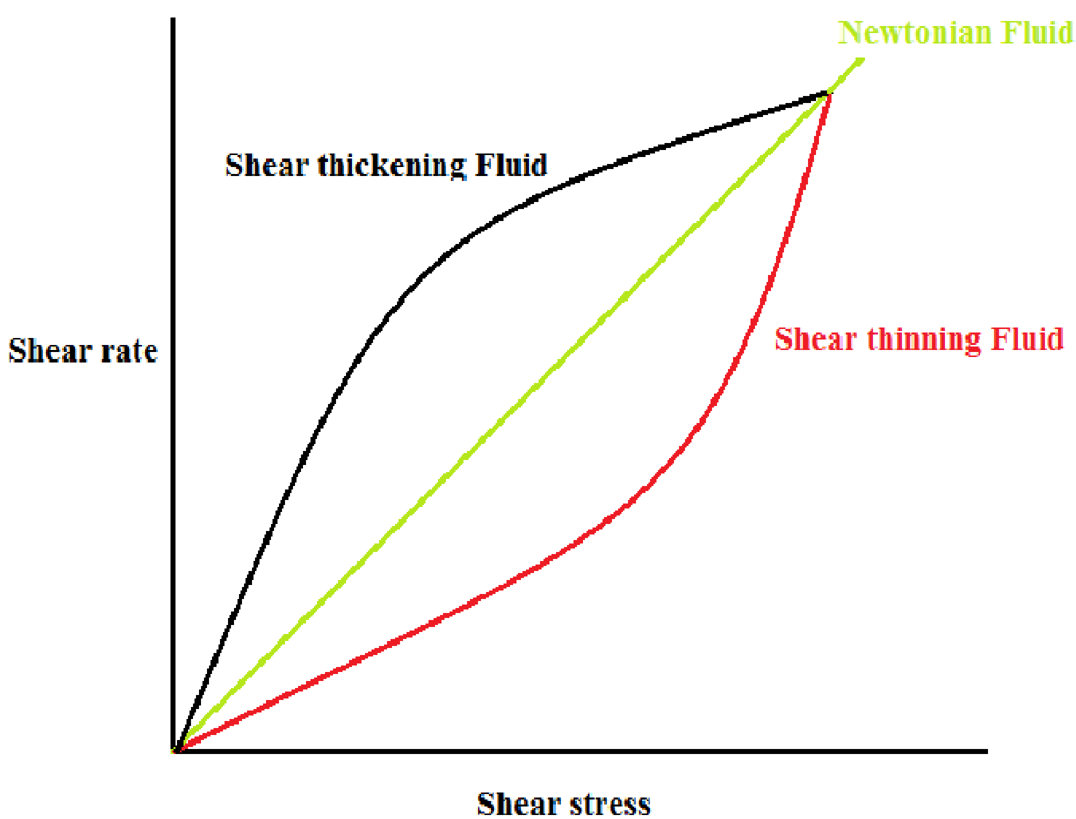
The following equation demonstrates the relation b/w shear rate and shear stress-

$$v = \mu \, du/dy$$

where:

- τ = shear stress
- μ = viscosity
- du/dy = shear rate

If viscosity remains the same, the fluid is Newtonian.



Fluid model

It is describe the correlation between the shear stress/pressure and shear rate in a shear-thinning liquid which is predicted that these have uncountable viscosity at zero rates of the shear according to fluid model is as follows-

$$\sqrt{\tau} = \sqrt{\tau_0} + S\sqrt{\frac{dV}{dy}}$$

Where

τ_0 = yield stress

$$S = \sqrt{\frac{\mu}{(1 - H)^{\alpha}}},$$

where

α is fully depends on protein constituents and H is the Hct number.

The power-law model

It is used to demonstrate the nature of Newtonian and non-Newtonian liquids/fluids and estimate shear pressure as a role of strain rate.

For the power-law model relationship b/w the velocity slope, shear stress/pressure, and strain rate is –

$$\tau = k(dv/dz)^n$$

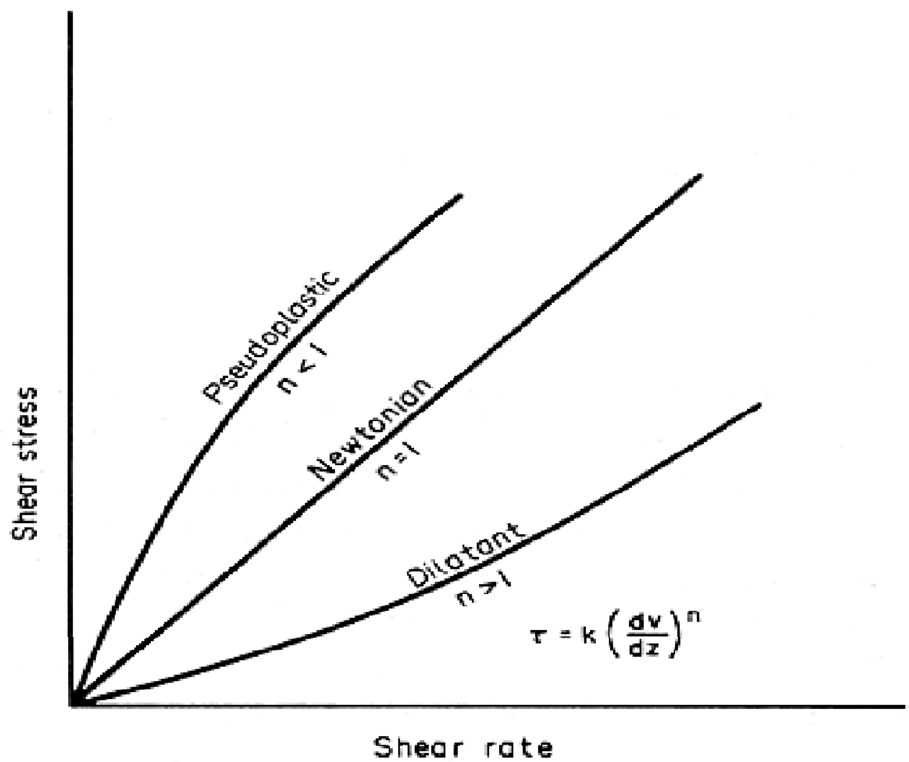
where

- τ = shear stress
- k = constant
- dv/dz = slope of the velocity

- n = power-law index.

If

- $n < 1$ = fluid is pseudoplastic.
- $n = 1$ =Newtonian fluid.
- $n > 1$ = fluid is a dilatant.



Reference

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