Rheology - Basic Flow Curves

Introduction

Rheology is the study of flow; most rheometers are based on the relative rotation about a common axis of one of three tool geometries: concentric cylinder, cone and plate or parallel plates (figure 1a, b and c respectively). The type of measuring geometry used is specific to the nature of the sample and the flow conditions generated.

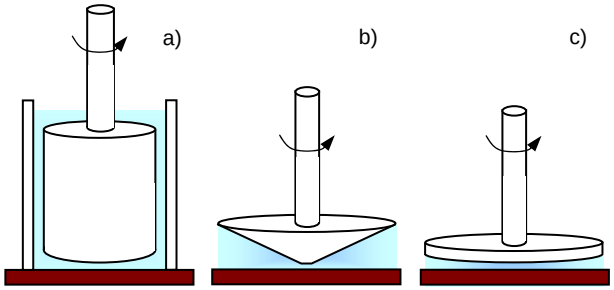

Figure 1: Measuring geometries for the rotational rheometer

The cup and bob geometry is used for low viscosity material; the large surface area gives greater sensitivity at lower shear rates. It can often be used for measuring particulate material, since the gap between the bob and the base is non critical. For higher viscosity samples, a cone and plane or parallel plate is generally used; the latter is insensitive to gap setting but care must be taken due to a shear rate gradient across the sample. A cone geometry eliminates this problem and is generally the choice for highly viscous pastes, gels and concentrated suspensions.

Experimental

A flow curve or rheogram is a graphical representation of the behaviour of flowing materials whereby a sample is subjected to ascending or descending shear rates, with the corresponding shear stress and viscosity calculated from instrument parameters. The shape of the flowcurves indicates the type of flow behaviour exhibited by the sample and is generally of one of 4 types indicated in figure 2.

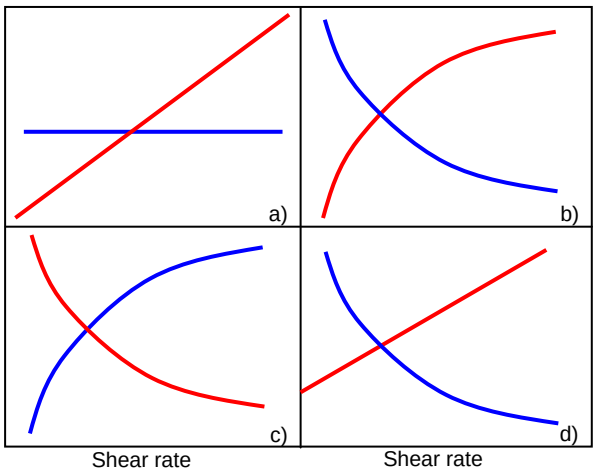

Figure 2: Flow types (blue line = viscosity, red line = shear stress)

a) **Newtonian**: Viscosity is constant over the entire shear rate range
b) **Shear thinning**: Viscosity decreases as shear rate is increased
c) **Shear thickening**: Viscosity increases as shear rate is increased
d) **Bingham plastic**: Viscosity appears to be infinite until a certain shear stress is achieved (until a yield stress is overcome)

The type of flow will have serious consequences for the application under scrutiny. A shear thickening material will not pump well, a shear thinning paint is desirable but with thixotropic properties so that it will stay on the wall (see Application Note: Thixotropy)

Measurement conditions

Samples: Pastes, gels, suspensions, emulsions, oils *etc*.

Geometry: 4˚/40 mm cone and plate or cup and bob

Rheology option: Viscometry

Shear: Table of shears, 1-10 Pa

Delay time: 60 seconds

Maximum timeout: 30 seconds

Conclusion

A simple flowcurve may be generated by applying a series of shears and recording resulting viscosity. The shape of the curve may be used to predict flow behaviour in a variety of applications. The value of viscosity may be interpolated if the desired shear rate is known.

Escubed Ltd

Leeds Innovation Centre
103 Clarendon Road
Leeds LS2 9DF UK
tel +44 (0)870 126 3200
fax +44 (0)870 126 3201
www.escubed.co.uk