

## Rheology Laboratory Capabilities

### VISCOSITY DATA FROM CAPILLARY RHEOMETRY

#### APPLICATION

Polymers and viscous fluids up to 400°C.

#### USE

The viscosity of a melt or fluid describes its resistance to flow when a force is applied to it. It is possible to simultaneously measure the shear and extensional viscosity of a viscous fluid or a polymer melt (both filled and unfilled) using a capillary rheometer.

The **shear viscosity** of a polymer melt depends primarily on the chain lengths, whilst the extensional viscosity (sometimes called the tensile viscosity) is more sensitive to the polymer chain structure i.e. whether or not branches and/or entanglements and/or crystallinity are present.

Knowledge of the shear viscosity behaviour is essential in the understanding of polymer flow in processes such as injection moulding, and shear viscosity data is extensively used in computer flow simulation packages. Manipulation of the shear viscosity data into the relevant coefficients for **Cadmould** and **Moldflow** is available.

**Extensional viscosity** values are used to understand behaviour in processes where stretching and/or compression are significant (i.e. fibre spinning and film formation). It is common for two or more polymers to exhibit similar or identical shear behaviour (and therefore MFI) but have radically different extensional viscosity (and therefore processing) behaviour.

A laser **die swell** facility is also available for direct measurement of extrudate diameter and provides information on the elasticity of the sample under test.

**Thermal stability**, and **wall slip** velocities can also be assessed.

#### LIMITATIONS

Flow rates attainable in capillary rheometers are usually comparable to those experienced in many industrial processes. The maximum shear rate range available is  $10\text{s}^{-1}$  to  $1000000\text{s}^{-1}$  but is dependent

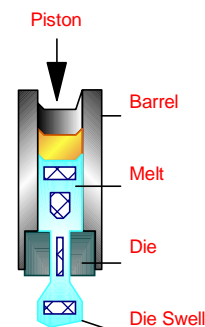
upon the viscosity of the system under study. Comparatively longer preheat times (10 mins) may result in degradation.

#### SAMPLE REQUIREMENTS

100 g of sample per test temperature is required. This would ideally be in granular form for thermoplastic polymers. Fluids can be handled as supplied. A typical test would cover 3 decades of shear rate.

#### PRINCIPLE

This type of rheometer works on the principle that the volume flow rate through an orifice is proportional to a pressure drop. A screw driven ram is used to force the fluid or melt out of a heated reservoir, at constant volume displacement, through a cylindrical die. The pressure drop through the orifice is measured.



By utilising orifices of different lengths but the same diameter, it is possible to isolate the shear and elongational viscosity components of flow.

#### EXAMPLES

1. Injection moulding / Extrusion.  
Surface finish, mould filling, flashing, clamping pressure, weld lines, sink marks, warpage.
2. Tapes, Films, Fibres, Blow moulding.  
Surface finish, fibre breakage, excessive draw, melt strength, edge curl, shrinkage, fibre coalescence, splitting, uneven width / thickness, bubble breaks, die drool.

## VISCOELASTICITY DATA FROM ROTATIONAL RHEOMETRY

### APPLICATION

Polymer melts, viscous fluids, dispersions, emulsions etc from ambient (-30°C for shear stress rheology) to 400°C.

### USE

The viscoelasticity of melts, fluids, and dispersions may be characterised in dynamic oscillation. The measured **loss and storage moduli** plotted as functions of oscillation frequency provide a viscoelastic "fingerprint" of the material. This fingerprint may be interpreted in terms of molecular architecture.

**Temperature sweeps** are used to study processing window, **gelling** or **curing** in **reactive systems**

**Thermal stability** may be assessed in air or nitrogen.

By using a complex waveform whereby more than one sine wave is superimposed together, the time needed for testing is greatly reduced allowing unstable or reactive systems to be usefully characterised.

Complex or steady shear viscosity and normal stresses are provided as a function of shear rate between  $10^{-2}\text{s}^{-1}$  and  $100\text{s}^{-1}$ . This data may be correlated with shear viscosity data generated by capillary rheometry to extend the range of the flow curve. This is particularly useful in the characterisation of reinforced systems.

A steady state melt modulus can be calculated.

**Shear stress controlled** rheometry is used to determine structural behaviour such as **yield stress** in dispersions or the presence of flocculated structures. Accurate low shear data may be produced as a shear stress is applied to the sample allowing the yield stress to be measured directly.

### SAMPLE REQUIREMENTS

Liquid or solid (shape dependent on test geometry selected).

Approximately 5 – 10g required per test.

### PRINCIPLE

1. Dynamic oscillation. A sample is held between two plates, one of which is

oscillated at a given frequency and the response is measured on the other plate. The in-phase and out-of-phase response equates to the storage and loss moduli. A complex viscosity may be calculated from the moduli.

2. Steady shear. A sample is held between two plates, one of the plates is rotated at a fixed angular velocity and the torque is measured on the other plate. The steady shear viscosity is calculated from the torque. Normal forces are measured directly.
3. Controlled stress. A sample is held between a cone and plate or in a concentric cylinder geometry. A stress is applied and the resulting motion is measured.

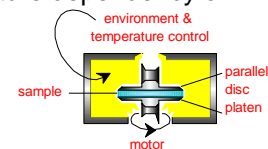
### EXAMPLES.

Yield stress, recovery, thixotropy, flocculation of multi-phase systems.

Prediction of polymer melt processing behaviours e.g.

Surface finish, weld lines, sink marks, warpage, fibre breakage, excessive draw, melt strength, edge curl, shrinkage, fibre coalescence, splitting, uneven width / thickness, bubble breaks, die drool.

Gel Point Determination, Relaxation behaviours, Time/temperature dependency of



Thermosetting, Thermoplastic and adhesive materials

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