Report Name: App Note 001-OLR

Rheology Solutions OnLine Rheometer (OLR)

An Innovation in Rheometry

"We see how quickly
through the colander
The wines will flow;
on the other hand,
The sluggish olive-oil
delays; no doubt,
Because, tis wrought
of elements more large,
Or else more crook'd
and intertangled."

LUCRETIUS (96 - 55 BC)
FROM "OF THE NATURE OF THINGS"

Unlike other rheometers, the OLR measures the viscoelastic flow properties of fluids within the processing stream. Results are available in seconds. Ideal for process and quality control, and easily adapted for many industrial manufacturing processes.

A TRUE INNOVATION

Developed by CSIRO Industrial Physics and commercialised by Rheology Solutions, this novel instrument delivers fast, accurate results with a single measurement over a range of frequencies. The OLR reduces wastage, saving time and money with potential environmental benefits. Its simple design and stainless steel construction makes it easy to use and clean.

FEATURES

- Measures viscoelastic rheological properties over a 1-100 Hz frequency range (can be extended to 400 Hz).
- Short measurement time makes this instrument suitable for analysis of rapidly changing materials.
- Suitable for measuring shear rate dependent viscoelastic materials.
- Small deformations do not destroy microstructure.
- Simple geometry does not interrupt flow or produce stagnation points.
- Automatic loading and cleaning.
- Real time process monitoring and control.
* Can be configured to communicate with factory PLC systems.

RHEOLOGY

Rheology is the study of deformation and flow of matter, and is most often thought of in conjunction with study of the flow properties (like viscosity) of liquids. Rheometers are devices used to quantify the viscoelastic flow properties of fluids. They measure the force response developed during application of oscillatory deformation to a sample of fluid.

FLOW PROPERTIES

Elastic materials obey Hooke's Law that states that the applied stress τ, is proportional to the measured strain γ, multiplied by a proportionality constant G. An example of a purely elastic material is a metal.

Viscous materials obey Newton's Law that states that the applied stress τ, is proportional to the measured rate of strain d'/dt, multiplied by a proportionality constant η, where η is known as the Newtonian viscosity. Examples of purely viscous materials include water and oil. Most materials are viscoelastic, incorporating both viscous and elastic flow behaviour. Examples of viscoelastic or non-Newtonian fluids include inks, greases and bio-polymers (significant components in the

manufacture of food, personal care and other products).

RHEOLOGICAL PROPERTIES

There are a variety of rheological properties commonly used to describe the flow properties described above.

The elastic (or storage) modulus G' is a measure of the elasticity within the fluid. The viscous (or loss) modulus G" is a measure of the viscous component of the fluid. The complex viscosity η^* is calculated from the storage and loss moduli and contains information about both the elastic and viscous flow behaviour. The viscosity of a material is its resistance to flow. Newtonian materials have a constant viscosity over a range of shear rates. Water and most oils are Newtonian. The viscosity of some materials depends on the shear rate or frequency of the applied oscillation. For example, shear thinning materials exhibit a decreasing viscosity with increasing shear rate. Many inks, paints and greases are shear thinning.

Potential applications of the OLR include the manufacturing of;

- Grease and petroleum products
- Ink and paint
- Food
- Personal care (soaps, pastes, ointments etc)
- Domestic Chemicals (cleaning gels etc)

OPERATING PRINCIPLE OF THE OLR RHEOMETER

The OLR uses a parallel plate geometry with a squeeze flow technique. A multi-frequency displacement signal is applied to the top plate and the force response through the fluid is measured by a load cell beneath the lower plate. The displacement and force signals are analysed to extract a response at each applied frequency. This data is then used to calculate rheological properties such as the storage modulus G', the loss modulus G" and the complex viscosity η^*.

The Rheology Solution's OLR is shown in the image.

The sensor may be constructed with a variety of flange connections and in various diameters, to suit the process pipe system. The sensor has high rigidity to eliminate the flexing of the system that could lead to errors in the measured properties of the fluid. All product-contact parts of the rheometer are constructed from stainless steel. Seal-sets and lubricants can be chosen to suit individual applications, the enclosure is IP 65 rated and the electrical and electronic componentry conform to CE, C-Tick and FCC requirements. The external housing is from FDA compliant grade fibreglass.

The parallel plates are normally 2 cm apart to allow free flow of process fluid. When a measurement is to be made the plates are automatically brought together to a gap defined by a spacer ring, capturing the sample fluid.

The gap is determined in order to maximise the transmitted forces for a particular combination of fluid and flow rate. When the measurement is complete the plates are again separated, the sample fluid is swept away by the flow and replaced with new fluid. The movement of the top plates is controlled electrically, avoiding the requirement for an extra service to the sensor in the case of pneumatic, and the possibility of leakage and contamination in the case of hydraulic systems and a test sequence can be initiated via SOLR (Software for the OLR).

A typical range of measurement frequencies is 1 – 100 Hz (using integer frequencies) though range can be increased to 400Hz if necessary. The measurement time is determined by the lowest frequency. Using 1 Hz as the lowest frequency yields a measurement time of one second. In practice the measurement is repeated ten to twenty times to increase the signal-to-noise ratio. An entire measurement including the time taken for a sample to be captured, measured and released can take less than one minute.