Rheology Solutions
for the Polymer Industries

Explanation and Evaluation of Processability

RHEO290

Company Profile

Rheology Solutions Pty Ltd is a specialist sales and service organisation dedicated to the science of materials characterisation and are the exclusive Australian distributor for the brand names HAAKE, NESLAB, PRISM and CAHN from Thermo Fisher Scientific, Optical Control Systems, Schleibinger Gerate and Marimex Industries Corporation range of equipment and instruments, and they also distribute the Shimadzu range of tensile testers and texture analysers.

Rheology Solutions recognises the importance of specialisation and dedication to a specific science and as such provides full technical support and service throughout Australia. The company goal is to integrate industry experience and materials characterisation techniques to provide practical solutions for customers.

Rheology Solutions has an established applications laboratory equipped with a comprehensive range of instruments to meet the requirements of material characterisation. Specialist contract testing services are also available and contracts can be tailored to suit discrete tests or protracted testing requirements involving a series of tests over a period of weeks or months.

A range of seminars and application specific workshops as well as product launches and demonstrations are provided throughout Australia. The seminars and workshops are designed to meet the needs of specific customer and industry applications. Rheology Solutions has its head office in Victoria and works with a team of specialist sales and factory trained service personnel throughout Australia. The combined experience of this team ensures that Rheology Solutions are able to provide their customers with access to the products to ensure that the right technical support and service is provided.

Contact Details

Rheology Solutions Pty Ltd
Address: 15 -19 Hillside Street, Bacchus Marsh, Victoria, 3340
PO Box 754, Bacchus Marsh, Victoria, 3340
Phone: 03 5367 7477
Fax: 03 5367 6477
Email: info@rheologysolutions.com
Website: www.rheologysolutions.com

Disclaimer

Written by Dr. T. Kealy
Technical Manager
Rheology Solutions Pty Ltd

Rheology Solutions

Tim's Top Tips: Rheology Solutions for the Polymer Industries

Explanation and Evaluation of Processability

Key Words: *Processability, rheology, rotational, liquid, melt, viscosity, thixotropy, yield stress, viscoelasticity, force and displacement measurements, pilot scale, instrumented mixer, extruder.*

About The Author

Tim has a background in engineering and specifically in rheology, with a B.Eng and Ph.D. in Chemical Engineering and has held postdoctoral research positions in engineering rheology. Tim's research has continued for the last seven years and recent interests and publications include the application of rheology and rheometry to mineral, food, polymer and surface coatings systems. His current position encompasses the managment of customer contract testing and also includes customer focussed education and training. Additionally he is available to provide technical input for existing or proposed materials characterisation systems for both laboratory and production.

Table Of Contents

Introduction

Often the polymer industries must overcome problems related to (and often dominated by) the flow properties of their product, though the relationships between these properties and production related issues are not always immediately apparent. It is the purpose of this series of articles, "Rheology Solutions for the Polymer Industries", to help illuminate the issues faced by the industry, how they relate to the flow properties of problem materials and how they can be successfully measured and controlled with a view to better processing.

Definitions

Processability is related to the amount of energy required to perform the relevant production steps for a product. Elements of processability can be measured relative to the various physical properties of the polymer in deformation and flow. They can be measured in absolute or relative terms.

Background and Discussion

Traditionally, processability has been measured on a large scale, using full scale mixers, extruders etc for relative processing data, and using flow cups, Brookfield-type viscometers etc for low temperature, smaller scale (but still relative) data. Increasingly sophisticated and sensitive measurement techniques and equipment now allow much of this work to be conducted using scientific instruments, which can allow direct comparison of material behaviour for mixing and extrusion in the laboratory, reducing the requirement for expensive full-scale trials. Additionally, newer generation rheometers and viscometers can allow the direct measurement of fundamental physical properties of the materials, at elevated temperatures if necessary, for proper equipment design and sizing. In the case of the relationship between processability and flow properties, the important variables may include some, or all, of extensional viscosity, the elastic and viscous moduli, the complex viscosity, shear viscosity, thixotropy etc.

Note: Working definitions are provided at the end of the paper.

Processability analysis using pilot scale torque mixers and compounders

Rheology Solutions Instrument
PolyLab OS – Extruder

Small-scale equipment for measuring the flow and deformation of polymers under process conditions

Rheology Solutions Instrument
PRISM 36 PC

Small-scale equipment for measuring the flow and deformation of polymers under process conditions

The efficiency and suitability of a blending configuration can be examined from the standpoint of processability. Processability is a relative measure and can be designated qualitatively using laboratory or pilot scale compounding equipment. This equipment measures relative processability only - extruder torque (usually through the electric current), rpm, temperature etc - as a function of the agitator arrangement and material being processed. Usually this type of equipment can be arranged in a similar way to the process equipment eg co-rotating twin screw and gives basic processing data, allowing the potential for different materials to be assessed in terms of their processabilities under this regime.

More sophisticated equipment can include variable configuration instrumented processing devices (mixer, single-, or twin-screw etc), offering direct determination of the torque (torsion bar or similar) and providing relative (qualitative) data. A further development has been the addition of rheology dies to extrusion equipment, in which not only processability, but also fundamental flow properties (shear viscosity, viscoelastic properties) of each material can be scientifically, quantitatively measured. These properties have a direct impact on the processability of the material since highly viscous materials are difficult to transport by pipe or to mix, and highly viscoelastic materials will also be difficult to mix and pump. Potential problems which may occur for laboratory scale or pilot scale equipment are generally similar to those experienced for the full-scale equipment, they are:

- *Too high torque/energy consumption for the compounder:*

Increasing temperature or rpm of the extruder can alleviate the problem, but either may impact on the final properties of the processed material, and the latter also impacts on the residence time of the material in the compounder. Another solution is to alter the agitator configuration, removing some of the high energy mixing or reversing elements and replacing them with conveying elements. This solution may compromise the degree of processing of the materials in the machine. Rheological analysis of the final product can help clarify this.

- *Residence time too low or too high:*

Changing the screw configuration by adding or removing reversing elements may be a solution, provided that the degree of mixing remains acceptable. Alternatively, changing the feed rate of the material, or the rpm of the agitators directly impacts residence time (increase either of them for reduced residence time).

- *Which is the correct set-up?*

Rheology Solutions Instrument

PRISM Change Bowl Mixer

The best pilot scale configuration is the one closest to the process conditions

There is a large variety of different mixing blade configurations. This is not itself a problem, and may in fact help to solve problems, but care must be taken that the most appropriate one is chosen for the purpose, in general this will be the one most closely approximating the full scale application. Similarly for extrusion applications – a single screw extruder is best mimicked using a single screw in the laboratory equipment, and so on.

- *Repeatability:*

More than a single test is often necessary in order that a statistically relevant measurement is made. This is particularly true of materials with a highly heterogeneous nature.

- *Which is the best test method?*

Similar to the case of choosing the optimal equipment configuration, the best method for relative testing is usually the one that most closely approximates the conditions under which the process occurs. For example actual process temperatures, mixing rates etc can be chosen to compare the performance of different materials prior to full scale processing.

- *The tests are, in general, relative:*

The complexity of the flow field during the displacement, and the heterogeneity of the test material means that the dissipation of the forces through the materials is difficult to fully predict. As a result, it is not possible to collect absolute data. On the other hand, relative data is usually sufficient for many applications.

- *Stiff materials can be difficult to measure:*

Solid materials can cause problems during measurements because of their high rigidity. Care should be taken that the materials will not damage the equipment, higher torque motors and hardened screws or mixing blades may be necessary, and if possible the temperature can be further elevated to aid in melting and softening the material. It is usually better to isolate processability problems such as this on laboratory equipment, avoiding more costly repairs and prolonged shut-down of production equipment.

- *Melt properties in spec for MFI (melt flow index) but material not performing as expected:*

MFI is a single point measurement on a curve. It is common for MFI measurements to be misleading because in general MFI is a measure (inaccurate/relative) of the shear viscosity of the material at a single shear rate. The solution is to generate a curve, preferably of shear or complex viscosity vs. shear rate, or to examine the viscoelastic crossover point as an alternative QC criterion.

- *Final melt properties out of specification?*

Measuring melt flow properties, such as viscoelastic, shear and extensional viscosity can be achieved in-line using rheological piezo actuators (viscoelastic properties) and dies (extensional and shear flow). These properties are a measure of the molecular structure of the melt and relate to process properties, for example in compression, blow moulded or extruded parts. They can provide precise scientific data for comparing the effects of changing process variables on the properties of a melt. If it is not possible to install rheological dies in-line, rheological measurements may be made off-line, on a rheometer. Most modern rheometers can provide the user with simple measurements giving absolute measures of shear and viscoelastic flow properties.

Processability analysis using rotational viscometers and rheometers, and extensional rheometers

Rheology Solutions Instrument

HAAKE ViscoTester VT550

CR viscometer (ViscoTester) for measuring the flow properties of polymers

Rheology Solutions Instrument

HAAKE MARS

CS rheometer (MARS) for measuring the flow properties of polymers

Rheology Solutions Instrument

HAAKE CaBER 1

Extensional rheometers for measuring the flow properties of polymers

Small sample volumes are required for most rheometers and viscometers, unless they are in-line. In the case of a laboratory viscometer or rheometer, the material is placed in a gap between a holding cup or a flat plate and a cylindrical, conical or flat plate sensor. The sensor moves (rotates or oscillates), resulting in a measured force and displacement of the sensor and sample. The force and displacement are used to measure the flow properties of the material. These flow properties – yield stress, shear viscosity, extensional viscosity and viscoelastic properties – can be related to some of the processability properties of polymer suspensions or melts, for example optimising the duties for pumps, piping and mixing all rely on a good knowledge of the flow properties of the materials in them. Potential issues surrounding these types of tests may include:

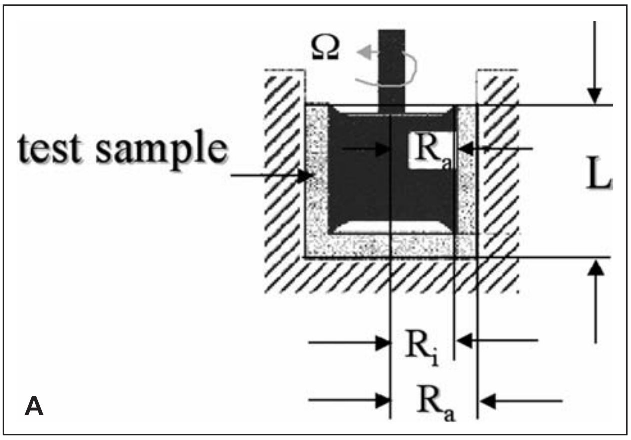
- *Relative vs absolute data:*

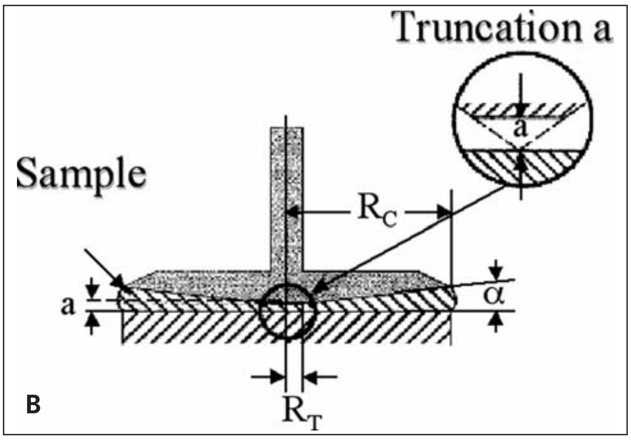
Rheology Solutions Instrument

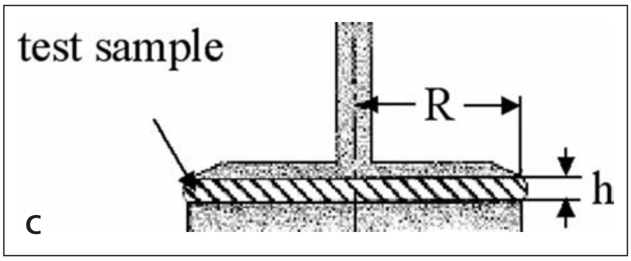
HAAKE ViscoTester VT7L Plus

Relative viscometer for QA/QC measurements (large gap between sensor and holding cup)

Some of the early model instruments, for example those meeting the 'Brookfield' standard, ISO 2555, for testing provide the user with relative data for most materials, because the gap between the holding cup and the rotating sensor is large.



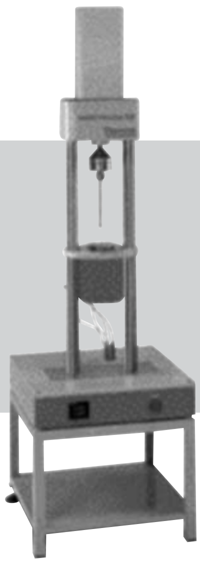




Fully defined (viscometric) measuring geometries (a) concentric cylinder, (b) cone & plate, (c) parallel plate for rheometry and viscometry

In contrast, most modern viscometers can provide absolute data because the measuring gap is small and the sensor geometry is fully defined. For any given material at the same temperature, a measurement made using a cone/plate sensor geometry gives an absolute measurement, and the same answer as one made with a concentric cylinder apparatus. For absolute measurements, or those needing to be reliably comparable between two different polymer systems, viscometric geometries should be used.

- *Shear properties difficult to measure on a rotational instrument*



Rheology Solutions Instrument
HAAKE RheoCap S

Capillary measurements can provide high shear data which may not be available from rotational measurements

Rotational instruments have some limitation for measurements in steady shear. The motors with which they are equipped, though of a high specification can not always rotate through highly viscous polymer melts. There are several potential solutions for this issue:

- Cox-Merz rule: The Cox Merz rule basically states that the complex viscosity (measured using dynamic, oscillatory techniques) is quantitatively equal to the steady shear viscosity (by rotational techniques) when the shear rate, g', and angular velocity, w, are plotted together against the viscosities. This is the case for many polymer melts, and where steady shear rotational measurements can provide data up to 10-100s-1, oscillatory data can increase this to over 600s-1.

- Capillary measurements: Capillary viscometers have long been used for rheological data collection in the polymer industries, primarily because of the high shear rates attainable with these instruments. Capillaries measurements are more time consuming and difficult than oscillatory or steady shear and cleaning can be an issue.

Rheology Solutions Instrument
HAAKE ProFlow - On-line Melt Rheometer

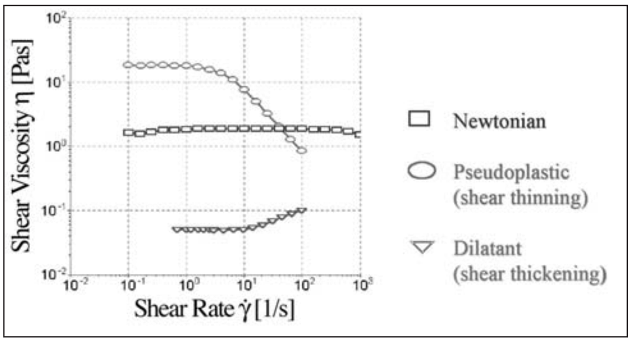
Capillary measurements can be made on-line with a melt pump and appropriate data collection

If used in conjunction a PC, software and with a melt pump to ensure steady, surge free flow, capillaries can be used directly on the end of, or in a side stream from, an extruder for direct continuous measurements.

In addition to the problem of the low torque available from rotational instruments, relative to capillary ones, there also exists the problem that highly elastic materials will not remain in the measuring gap, even at low shear. This is known as the Weissenberg effect and is quite common, especially for high molecular weight materials. As soon as the measuring geometry has begun to empty, the measurements are no longer valid. It is difficult to overcome, and can not be completely avoided. It's onset can be retarded by using smaller cone angles for measurements.

- *Shear properties difficult to comprehend.*

Shear viscosity is simply the resistance of the material to flow. Except for a few materials, shear viscosity is a function of shear rate, and should be measured at a variety of shear rates in order that a clear picture of the behaviour of the material as it changes can be obtained (a single point can usually not fully define the viscosity curve).



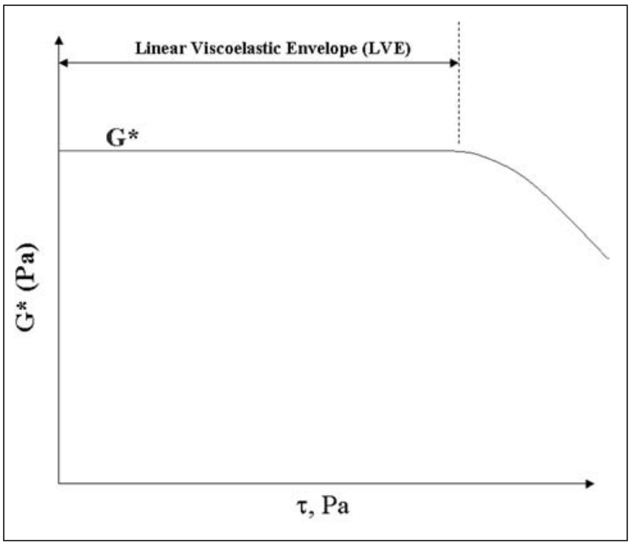
Knowledge of a single point viscosity for shear thickening or shear thinning materials can not fully define their behaviour

The primary shear properties of interest are viscosity and yield point which dictate how a material can spread, flow etc. Extensional viscosity is conceptually similar to shear viscosity, except that the direction of the applied forces are different. Extensional properties are not directly related to those in shear, and so may need to be measured separately, especially if the property of interest for the material is apparent in extension.

- *Flow properties within specification for relative viscosity but material not performing as expected:*

Usually the Brookfield-type viscometers measure a single (relative) point on a curve. It is common for these measurements to be misleading because in general the information is a measure (relative, not absolute) of the shear viscosity of the material at a single shear rate. The solution is to generate a curve, preferably of shear or complex viscosity vs. shear rate as an alternative QC criterion.

- *Viscoelastic properties not repeatable:*

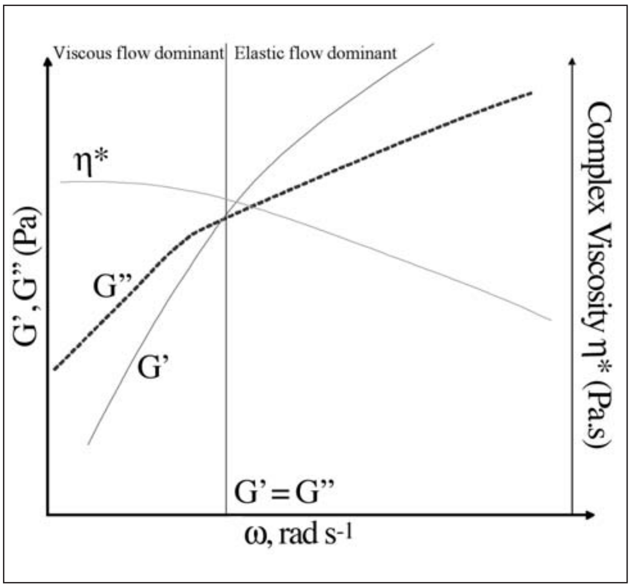


In the LVE, properties are independent of the amplitude or force applied during oscillatory measurements

Viscoelastic properties are generally measured by means of a frequency sweep (oscillating a sensor at different rates in the sample) in the Linear Viscoelastic Envelope (LVE).

Measurements not carried out in the LVE are not repeatable, and are probably not comparable for different materials.

- *Viscoelastic properties difficult to understand:*



Viscoelastic flow properties tell us about the undisturbed (in the LVE) structure of the material

In general the properties measured are the viscous (G'') and elastic (G') moduli and the complex viscosity. The complex viscosity is a measure of the resistance of the material to flow and the comments made for shear viscosity are valid here also. Higher viscosity materials will require higher forces to initiate and continue flow. At low frequencies, for polymeric systems, the viscoelastic moduli show the contribution of high molecular weight (MW) species, the crossover point (where G'=G'') of the moduli shows the point at which the moduli are equal and is often used as a quality control point for materials. Changes in the magnitude of the moduli at the crossover point imply changes in molecular weight distribution, and changes in the frequency at which the crossover point occurs implies a change in the mean MW of the system. Some practical and theoretical training can often help nervous operators overcome the perceived complexity of viscoelastic measurements and assessing the data.

Summary

Table 1 summarises the possibilities for measuring misting using the techniques discussed. Each of the techniques is ranked between 0 and 5 for each of the potential issues and solutions, where:

5=Excellent	4=Good	3=Adequate
2=Possible	1=Difficult	0=Not Possible

Determining the most suitable type of instrument is not simply a matter of adding up the ranking for each. Rather, identify which measurement technique, variable etc is most relevant and appropriate for your application/product. Often, more than one technique is required to ensure consistency, reproducibility and accuracy is achieved.

More and more polymer companies are now including in-line viscosity, pilot scale mixing and compounding and rheology to support, supplement and further direct their R&D and recipe modifications.

Table1: Assessment of strengths/weaknesses for each technique

Technique:	Lab/Pilot Scale Equipment	CR Viscometers	CS Rheometers	Extensional Rheometer
Measures				
Solids	5	0	1	0
Semi-solids	5	4	2	2
Liquids	5	5	5	5
Sensors				
Large variety	5	5	5	3
Rigid samples easily measured	5	0	2	0
Structural disruption on loading avoidable	1	3	3	3
Test Method				
Absolute*	2	5	5	4
Relative*	5	5	5	5
Quickly varied	3	5	5	5
Widely varied	5	5	5	4
Objective measurements	5	5	5	5
Subjective measurements*	0	0	0	0
Rapid test completion	4	4	4	4
Primary Variable Parameter				
Load/Force	5	0	5	1
Displacement	5	5	5	5
Number of Participants				
High*	0	0	0	0
Low*	0	0	0	0
Single operator	5	5	5	5
Results				
Intuitively comprehended	5	3	2	3

* *Depending on the test, these parameters may be viewed alternatively as either a strength or as a weakness*

Contact Details

Head Office Rheology Solutions Pty Ltd

Managing Director – **Pat Griffin**
Email: patgriffin@rheologysolutions.com

Technical Manager – **Dr Tim Kealy**
Email: timkealy@rheologysolutions.com

Service Engineer – **Richard Donaldson**
Email: richardd@rheologysolutions.com
service@rheologysolutions.com

Address: 15 -19 Hillside Street, Bacchus Marsh, Victoria, 3340
PO Box 754, Bacchus Marsh, Victoria, 3340
Phone: 03 5367 7477
Fax: 03 5367 6477
Email: info@rheologysolutions.com
Website: www.rheologysolutions.com

Other Notes Available in the Tim's Tips - Rheology Solutions for the Polymer Industries Series are:

- Explanation and evaluation of Compounding (Rheo289)
- Explanation and evaluation of Sharkskin (Rheo291)
- Explanation and evaluation of Die Swell (Rheo292)

Other Information Available for the Polymer Industries include:

- Rheology Solutions for Polymer Industries Information Kit
- Applications Laboratory and Contract Testing Capabilities Statement for Polymer Industries
- Technical Literature for Polymer Industries

Focused on providing our **customers** with materials characterisation **solutions** through knowledge, experience and support.

Polymer Dictionary

Industry Term: **Absolute.**
Definition: Data which can be compared with another reading colleted under the same conditions. Absolute data is expressed in scientific units.
Governing Properties: N/A.
Rheology Solutions Instrument: HAAKE ViscoTester, VT550, HAAKE RheoStress, HAAKE MARS, HAAKE PolyLab & RheoMex.

Industry Term: **Blending / Mixing.**
Definition: Combining materials to give the desired physical or chemical properties.
Governing Properties: Blending efficiency relies upon the viscosity of the materials at high shear. Matching viscosities often allows better blending. Viscoelastic properties also play a significant role in blending efficiency. An excellent way to assess the potential for blending different materials is using an instrumented extruder.
Rheology Solutions Instrument: HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS, HAAKE PolyLab & RheoMex, PRISM Extruder, Marimex ViscoScope.

Industry Term: **Complex Viscosity.**
Definition: The viscosity measured by dynamic rheometry, related to both the viscous and elastic portions of flow for a viscoelastic fluid.
Governing Properties: This is a property governed by the viscoelastic properties of the material - elastic and viscous moduli (G' and G"). It is measured on a CS rheometer using a frequency sweep.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Crossover Point.**
Definition: The point at which the viscous modulus is quantitatively equal in to the elastic modulus.
Governing Properties: This is a property governed by the viscoelastic properties of the material - elastic and viscous moduli (G' and G"). It is measured on a CS rheometer using a frequency sweep.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Dispersion.**
Definition: A system consisting of a dispersed substance and the medium in which it is dispersed.
Governing Properties: N/A.
Rheology Solutions Instrument: HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS, HAAKE PolyLab & RheoMex, PRISM Extruder, Marimex ViscoScope.

Industry Term: **Elastic and Viscous Moduli.**
Definition: Many liquids have a solid-like (elastic) component and a liquid-like (viscous) component. The elastic and viscous moduli, G' and G" respectively, are measures of the contribution of these two to the deformation of the liquid.
Governing Properties: These are properties governed by the viscoelastic properties of the material - elastic and viscous moduli (G' and G"). They are measured on a CS rheometer.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Extensional Viscosity.**
Definition: The extensional viscosity of a liquid is the resistance to flow of the liquid as it is being stretched. This is a different property to (and independent of) either the shear viscosity or the complex viscosity
Governing Properties: The extensional viscosity depends on the temperature, the rate of deformation of the liquid. It can be measured on an extensional viscometer.
Rheology Solutions Instrument: HAAKE CaBER.

Industry Term: **Frequency Sweep.**
Definition: This technique is an analysis of the dependency of the rate dependent viscoelastic properties; it is usually carried out in the LVE of the test material.
Governing Properties: N/A.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Linear Viscoelastic Envelope (LVE).**
Definition: The LVE is the region in which the internal structure of a material remains unchanged as the imposed stress or deformation is gradually increased.
Governing Properties: Measured on a CS rheometer using a stress sweep or a strain sweep.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Relative.**
Definition: Data which can be compared with another reading collected under identical test conditions. Units are not scientific and the instrument and conditions also need to be specified with the data.
Governing Properties: N/A.
Rheology Solutions Instrument: PRISM EuroLab, HAAKE VT01/02, HAAKE VT6/7, HAAKE PolyLab, Marimex ViscoScope.

Industry Term: **Rheology.**
Definition: The flow and deformation of matter.
Governing Properties: N/A.
Rheology Solutions Instrument: HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

Industry Term: **Shear Rate.**
Definition: The rate of change of velocity through a cross-section of a flowing system.
Governing Properties: The shear rate is depended on the flow yield of the liquid. It can be measured by a CS rheometer and imposed by a CR viscometer.
Rheology Solutions Instrument: HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

Industry Term: **Shear Viscosity.**
Definition: The shear viscosity is the resistance of a fluid to flow when a shear stress is exerted upon it.
Governing Properties: Shear viscosity depends on temperature and usually shear rate or shear stress. It can be measured on a viscometer or a rheometer, using viscometric measuring geometries.
Rheology Solutions Instrument: HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

Industry Term:	**Thixotropy.**
Definition:	Thixotropic fluids show shear thinning behaviour combined with a time dependency. The viscosity of a thixotropic fluid drops when subjected to a constant shear rate for a period of time. The viscosity of thixotropic fluids often recovers substantially over a period of time after the shearing forces have been removed.
Governing Properties:	Thixotropy depends on the rate of structural recovery in the material. It can be measured using a flow curve on a CR or CS instrument, or by measuring the recovery of the moduli after shearing on a CS rheometer.
Rheology Solutions Instrument:	HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

Industry Term:	**Viscoelasticity.**
Definition:	Materials, which are partly elastic (i.e. solid) and partly viscous (i.e. fluid). When they are deformed some of the energy is stored (solid) while the remainder is lost through flow (fluid).
Governing Properties:	N/A.
Rheology Solutions Instrument:	HAAKE RheoStress, HAAKE MARS.

Industry Term:	**Viscosity.**
Definition:	The resistance of a fluid to flow.
Governing Properties:	N/A.
Rheology Solutions Instrument:	HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

Industry Term:	**Yield Stress.**
Definition:	The minimum shear stress required to initiate flow in a fluid.
Governing Properties:	Governed by the structural properties of the material at rest, measured by extrapolation using a flow curve, or using the vane technique, both on a CR or CS instrument. It can also be measured using a CS rheometer by a stress ramp.
Rheology Solutions Instrument:	HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

Notes

- ViscoTester 550 and RotoVisco are controlled rate viscometers, RheoStress is a controlled stress rheometer, MARS is a Modular R&D Controlled Stress Rheometer and CaBER 1 is an extensional rheometer all of which are HAAKE brand names of Thermo Electron Corporation (Karlsruhe, Germany) GmbH.
- ViscoScope torsional motion viscometer is a brand name of Marimex Industries Corporation.
- PolyLab is a torque rheometer, RheoMex is a add on (to the PolyLab) instrumented extruder, Die Swell tester is an add on to the PolyLab and RheoMex and RheoMix is an add on (to the PolyLab) instrumented mixer, MiniLab is a micro rheology compounder, RheoCap is a single bore capillary rheometer, ProFlow is an on-line melt system, MFI - Melt Flow Indexer, pvT - Pressure Volume Temperature, PolyDrive is an instrumented mixer or extruder, all of which are HAAKE brand names of Thermo Electron Corporation (Karlsruhe, Germany) GmbH.
- Pilot Mixer is a small chamber pre-mixer, TSE - twin screw extruder (16mm, 24 mm, 36 mm etc) are PRISM brand names of Thermo Electron Corporation (Stone).

Disclaimer

The information contained in this report is not intended for direct use as a tool for process development. It is a guide only. This document remains the property of Rheology Solutions Pty Ltd, and may not be reproduced or altered in any way without the written permission of the owners.

Information Request Form

Tim's Top Tips – Rheology Solutions for the Polymer Industries

Explanation and Evaluation of Processability

To ensure a speedy response to your enquiry, please take the time to ensure you complete accurately all the relevant sections below.

▶ Contact Details:

Name .... Position ....

Company .... Department ....

Address ....

Suburb .... State .... Postcode ....

Telephone .... Fax ....

Email ....

▶ Please send me more information on the following products:

- ☐ HAAKE RheoStress RS600 – Controlled Stress Rheometer
- ☐ HAAKE CaBER 1 – Extensional Rheometer
- ☐ HAAKE ViscoTester VT6 Plus / VT7 Plus – QA Viscometer
- ☐ HAAKE PolyLab & RheoMix – Pilot Scale Torque Rheometer with Instrumented Mixer
- ☐ HAAKE ProFlow – In-Line Melt Rheometer
- ☐ PRISM Extruders – Twin Screw Extruders
- ☐ Shimadzu AGS-J – Uniaxial Universal Tensile Tester
- ☐ Contract Testing
- ☐ Technical Literature *(Please specify)*

  ....

- ☐ HAAKE VT550 – Controlled Rate Viscometer
- ☐ HAAKE MARS - Modular R&D Controlled Stress Rheometer
- ☐ HAAKE RheoCap S – Capillary Rheometer
- ☐ HAAKE PolyLab & RheoMix – Pilot Scale Torque Rheometer with Instrumented Extruder
- ☐ PRISM Change Bowl Mixer – Instrumented Mixer for Dry Blending
- ☐ Marimex ViscoScope – In Line Process Viscometer
- ☐ Rheology Solutions for Polymer Industries Kit
- ☐ Training & Seminars
- ☐ Other *(Please specify)*

  ....

Comments: ....

....

Please return your completed form to Rheology Solutions Pty Ltd by fax to 03 5367 6477 or post to Rheology Solutions Pty Ltd. PO Box 754, Bacchus Marsh, Victoria 3340 or send an email to info@rheologysolutions.com

Focused on providing our **customers** with materials characterisation **solutions** through knowledge, experience and support.

Rheology Solutions

For all your rheology and service needs please contact:

Tel: 03 5368 7477 **Fax:** 03 5367 6477
Email: info@rheologysolutions.com
Website: www.rheologysolutions.com

RHEO295