

# How Does Manufacturing Take Advantage of Rheology?

Rheology is the science that studies the flow behavior of materials. The ability to mix, blend, pump, store and fill are processes that rely on data from rheological analysis performed by R&D to evaluate material flow behavior. On the production floor and in the QC Lab, rotational viscometers make measurements that confirm the consistency of the material in process. Typically, these devices make a single point viscosity measurement. They work well, but there is lost time grabbing the sample from manufacturing and getting it to the QC lab for analysis. What if the viscosity measurement could be made directly in the mixing tank or on the fill line before product is packaged? Process viscometers have existed for many years, but few companies take advantage. Why? This article investigates the potential benefits to manufacturing that arise from new investment using “in process Rheology”.

R&D performs characterization tests on materials used in new products (ointments, creams, lotions, elixirs, etc.) before they are processed by manufacturing. Typical tests include “flow curves” and perhaps “yield stress determination”. The former describes how a fluid or semi-solid will behave under variable conditions for flow rate and temperature. The latter addresses the startup conditions when the material at rest is pumped or starts to move due to action of a rotating blade in a mixer.

Figure 1 shows an instrument called a “Rheometer” that can perform both types of tests in a lab environment. The type of spindle geometry is called “cone/plate”. With cone spindle in raised position, the material is placed on the plate and brought to temperature. The cone spindle is brought down into contact with the material. The gap is set precisely by the instrument so that, when the spindle rotates, the subsequent shearing action on the material is accurately defined.

The initial test is Yield Stress Determination. The material to be tested is stationary and the structure of the material is therefore undisturbed. Increasing torque is applied to the spindle by the Rheometer until the cone spindle starts to rotate. This moment when rotation commences is called the “Yield Stress”. Figure 2 shows data curves for yield stress on two different creams; the lower yield stress value of 200 Pascals indicates that this material will start to flow more readily than the other one which requires 400 Pascals. These values for yield stress relate to the startup torque needed for the motor driving the pump and mixing blade.



Figure 1: Brookfield RST Rheometer with Cone/Plate Geometry

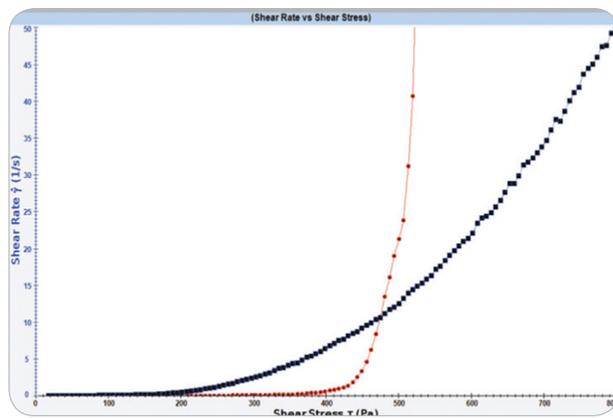


Figure 2: Yield Stress Curves for Two Different Materials

“Flow Curves” for a material are a measure of resistance to shearing action. The Rheometer rotates the spindle from a low speed to a high speed to simulate different shear rates that the material will experience during processing. High shear rates simulate actions such as flow through a pump or high speed mixing. Low shear rates simulate low flow velocity in a pipe when moving material into a storage tank. Medium shear rates might apply to the shearing action on a fill line when material is injected into a container. Figure 3 shows a typical flow curve for a material that exhibits high resistance at low shear rates and significantly reduced resistance at high shear rates. Materials in the pharmaceutical and medical industries will normally exhibit this type of flow behavior.

Process viscometers are selected based on a review of the flow information from Yield Stress Determination and Flow Curve Analysis. Figure 4 shows a type of instrument used on line within manufacturing to continuously measure viscosity. The obvious advantage is that no time is lost in taking corrective action when measured viscosity values start to trend outside of acceptable control limits. Establishing performance boundaries for viscosity is important when the decision is made to use a process viscometer. This may be accomplished initially using the laboratory test data from R&D, but still requires further review once the process viscometer is operating and generating real time data. Performance limits can then be modified appropriately.

With continuing improvements in the technological design of process viscometers, there is every reason to investigate the potential return that this instrument can bring to manufacturing. While the investment is higher than a bench top viscometer in Quality Control, the savings on material that will not require rework can quickly pay back the initial investment.

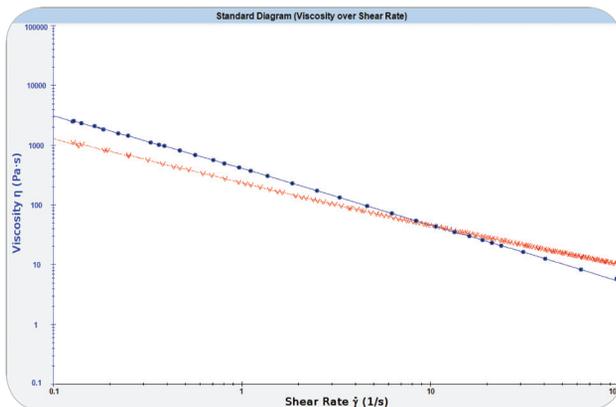


Figure 3: Flow Curve for a Material Provides Data on Viscosity vs. Shear Rate



Figure 4: Brookfield AST-100 Process Viscometer Provides Real Time Viscosity Data

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Author: Robert G. McGregor, General Manager, Global Marketing  
 Brookfield Engineering Laboratories, Inc., 11 Commerce Blvd., Middleboro, MA 02346  
 Tel: 1.508.946.6200 Fax: 1.508.946.6262  
 Email: r\_mcgregor@brookfieldengineering.com Website: <http://www.brookfieldengineering.com>