



Viscosity vs Elasticity

Liberty Engineering Perspective



Background

Why Do We Need Viscosity?

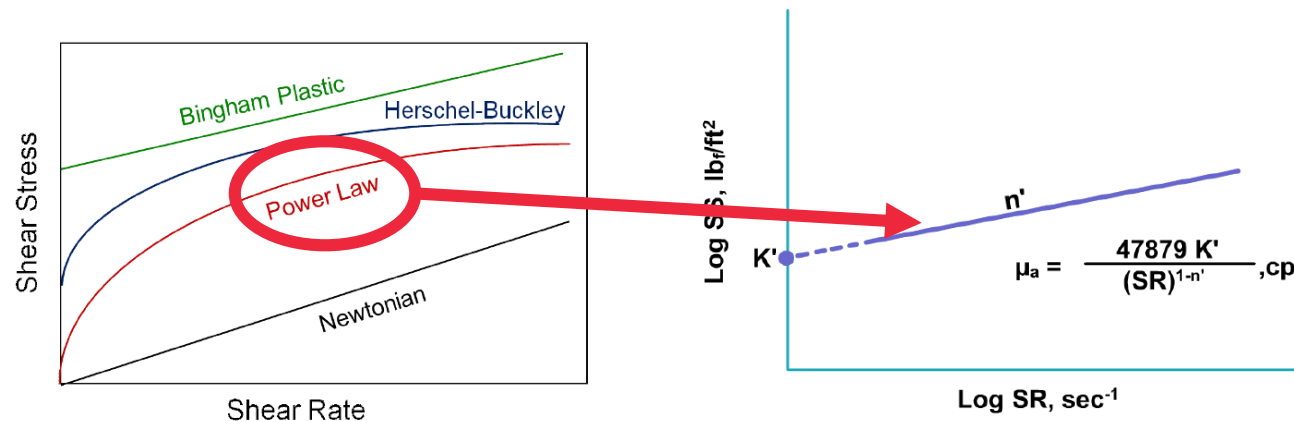
- Viscosity is important in many industrial applications
 - In hydraulic fracturing, viscosity is important because one of the primary goals is to place particles we call proppant deep into the target formation.
 - Viscosity measurements are typically used as the main tool to judge and optimize the fluids ability to transport proppant of polymer based frac fluids.
 - The minimum viscosity needed is often overestimated.
 - Excessive viscosity increases costs,
 - Raises treating pressure
 - Can reduce fracture conductivity since many of the chemicals used to increase viscosity leave residue which damages the proppant permeability or conductivity

Viscosity vs Elasticity

Viscosity Concept Overview



- What's the difference between viscosity and elasticity?
 - Viscosity is the more common concept in our industry
 - Viscosity is simply a measurement of how thick or thin a fluid is.
 - Frac fluid viscosity traditionally uses the Power Law model to describe viscosity
 - For this rheological model, the shear stress vs shear rate data give a linear relation on log-log scales.
 - > The slope of this log-log line is denoted by n' , and this is labeled the Flow Behavior Index.
 - > $n'=1$ implies a Newtonian fluid
 - > The shear stress at a shear rate of "1" is labeled the Consistency Index and is denoted by K'



Viscosity vs Elasticity

Viscosity Measurement Instrumentation

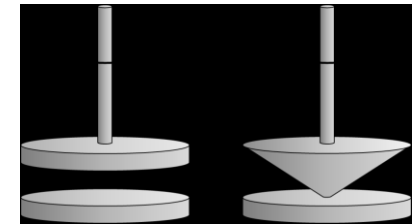
- Traditionally, a rotating “cup and bob” viscometer known as a “Couette” viscometer is used to make these viscosity measurements.
 - API standard RP39 and ISO 13503 fully describe the current testing procedures used by the industry.
 - Below are some images of some common instruments traditionally used to measure viscosity in our industry.



Viscosity vs Elasticity

Elasticity Measurement Instrumentation

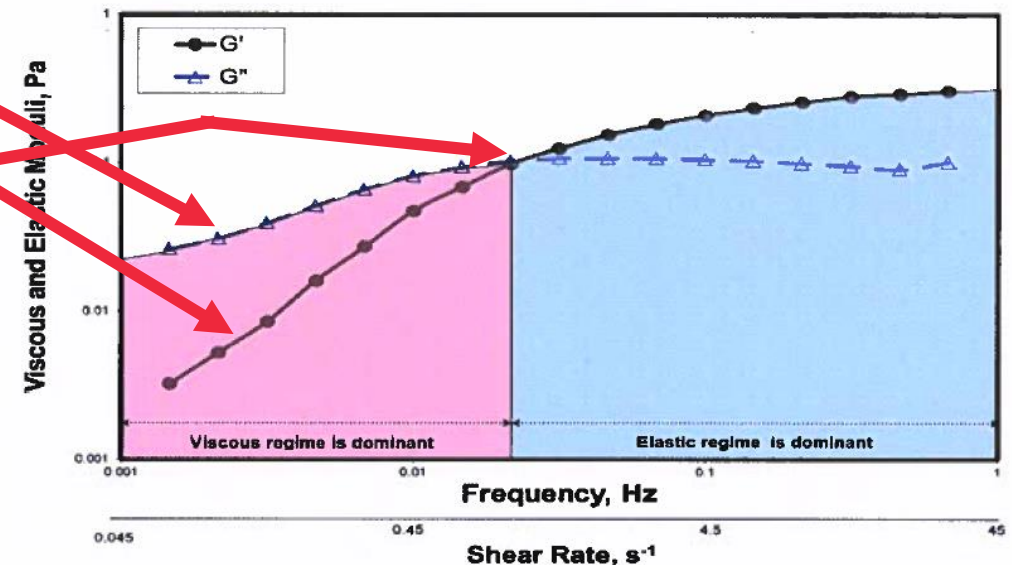
- Different instrumentation is required to measure fluid elasticity
- While rotational viscometers are suitable for measuring ‘weak’ viscoelastic properties, they can’t be used to measure ‘strong’ viscoelastic properties
 - This is primarily due to the tendency of the fluid to climb (known as the Weissenberg effect)
- An oscillatory rheometer is required to accurately measure a fluid’s elastic properties.
 - Below are images of an oscillatory instrument used to measure elasticity in our labs.



Measurement Techniques

Elasticity Concept Overview

- Elasticity is a newer or less frequently utilized concept in the frac industry
 - Viscosity alone doesn't have good correlation to proppant transport tests
 - This is because viscosity measurement rational only accounts for Stokes law settling
 - There is a strong correlation between a fluid's elasticity and it's ability to transport proppant
 - Viscoelastic frac fluids such as crosslinked gels and HVFRs have properties that are partly viscous and partly elastic.
 - G' – storage modulus
 - G'' – loss modulus
 - If $G' > G''$ (storage ratio > 1) the fluid is considered to be elastic
 - Elasticity is needed to investigate and determine the minimum rheological properties required for efficient proppant transport.



SPE-173323

Viscosity vs Elasticity

Summary

- In summary, two fluids can have the same or similar viscosity and power law parameters, but have substantially different proppant transport characteristics.
 - Elasticity data can be used to determine the minimum required polymer loading
 - Liberty uses an oscillatory rheometer to select products that have superior elastic properties
 - It is possible to use this technique to test your frac fluid properties to ensure that your frac fluid meets the minimum requirements to transport proppant efficiently



LIBERTYFRAC.COM