



# SPE Automotive Composites Conference and Exhibition SMC Consistency Test Methods- Viscosity Methods

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## Abstract

This presentation will look at the study of available viscosity test methods to minimize variation associated with testing equipment. The test methods include the current industry standard, HBT viscometers, and Brookfield's new Soft Solids Tester SST 2000 which are compared for performance in SMC matrix samples.



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## SMC Consistency Test Methods- Viscosity Methods

In order to improve on product consistency, material consistency is continually reviewed with Sheet Molding Compound, SMC. Molders and compounders of the product strive to produce the most consistent material and processes which has been demonstrated in numerous papers and presentations.

One of the largest concern for material property consistency is the viscosity of the SMC matrix. The first step towards making improvements in a given property is to study the correct method for used for measurement.

This presentation focuses on testing methods for measuring SMC matrix viscosity and determining the more consistent method amongst them.



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## SMC Consistency Test Methods- Viscosity Methods

- Two Viscosity Test Methods Studied
  - HBT Helipath Time Stop Viscosity Industry Standard
  - Soft Solids Tester SST 2000 Applications- Silicone Sealants, Cement, Plaster and Putty, Ceramic Slurries



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## SMC Consistency Test Methods- Viscosity Methods



- Brookfield HBT Viscometer
  - Capabilities
    - Helipath Travel
    - Industry Standard
    - Controlled Rate Method- High Shear Rate
    - T Spindle Configuration
  - Measurement Variables
    - Viscosity
    - Time Stop- Industry Standard



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## SMC Consistency Test Methods- Viscosity Methods

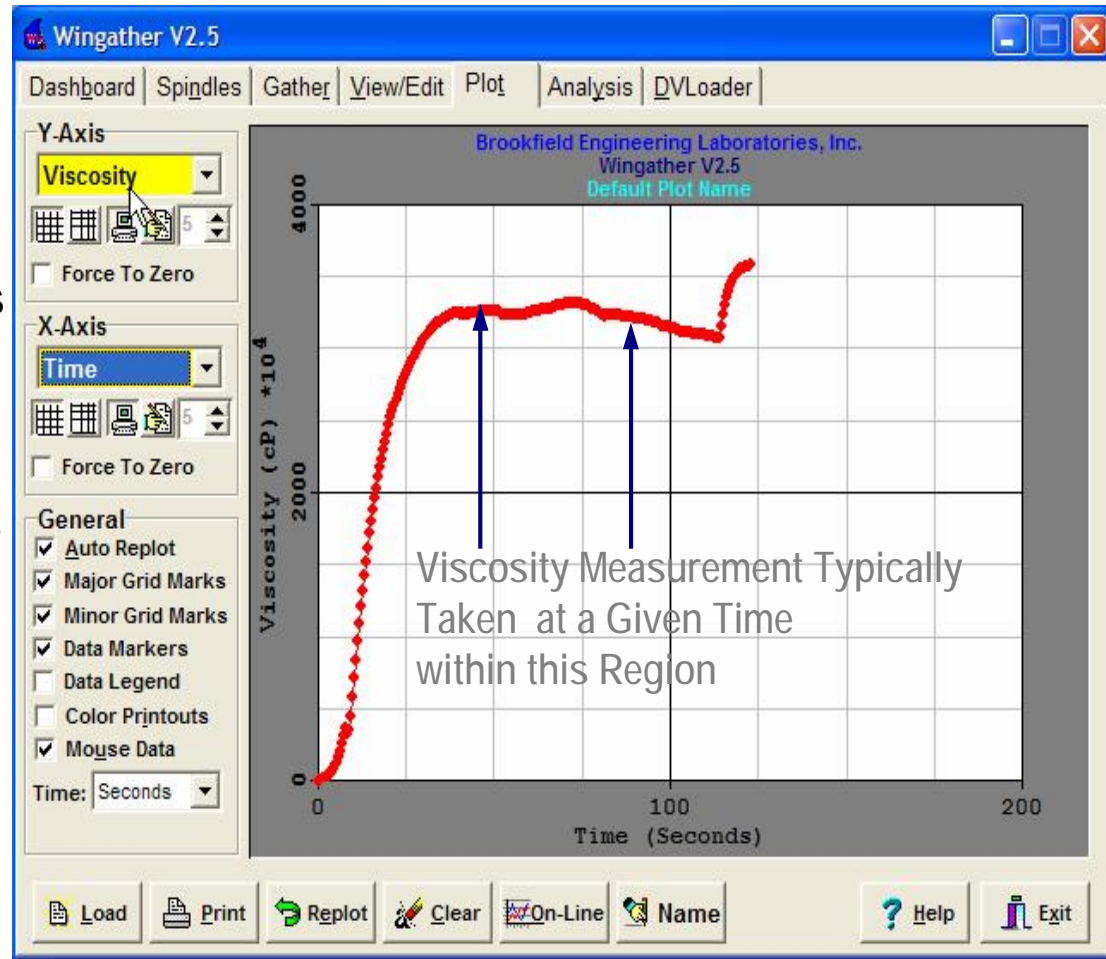
- Brookfield HBT Viscometer

Typical Viscosity versus Time Graph

Method involves a “Time Stop” Value to be obtained.

Utilizes Standard Method

- T Spindle
- Helipath Profile for Viscometer
- Slow RPM Setting 0.5-1.0 RPM



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## SMC Consistency Test Methods- Viscosity Methods



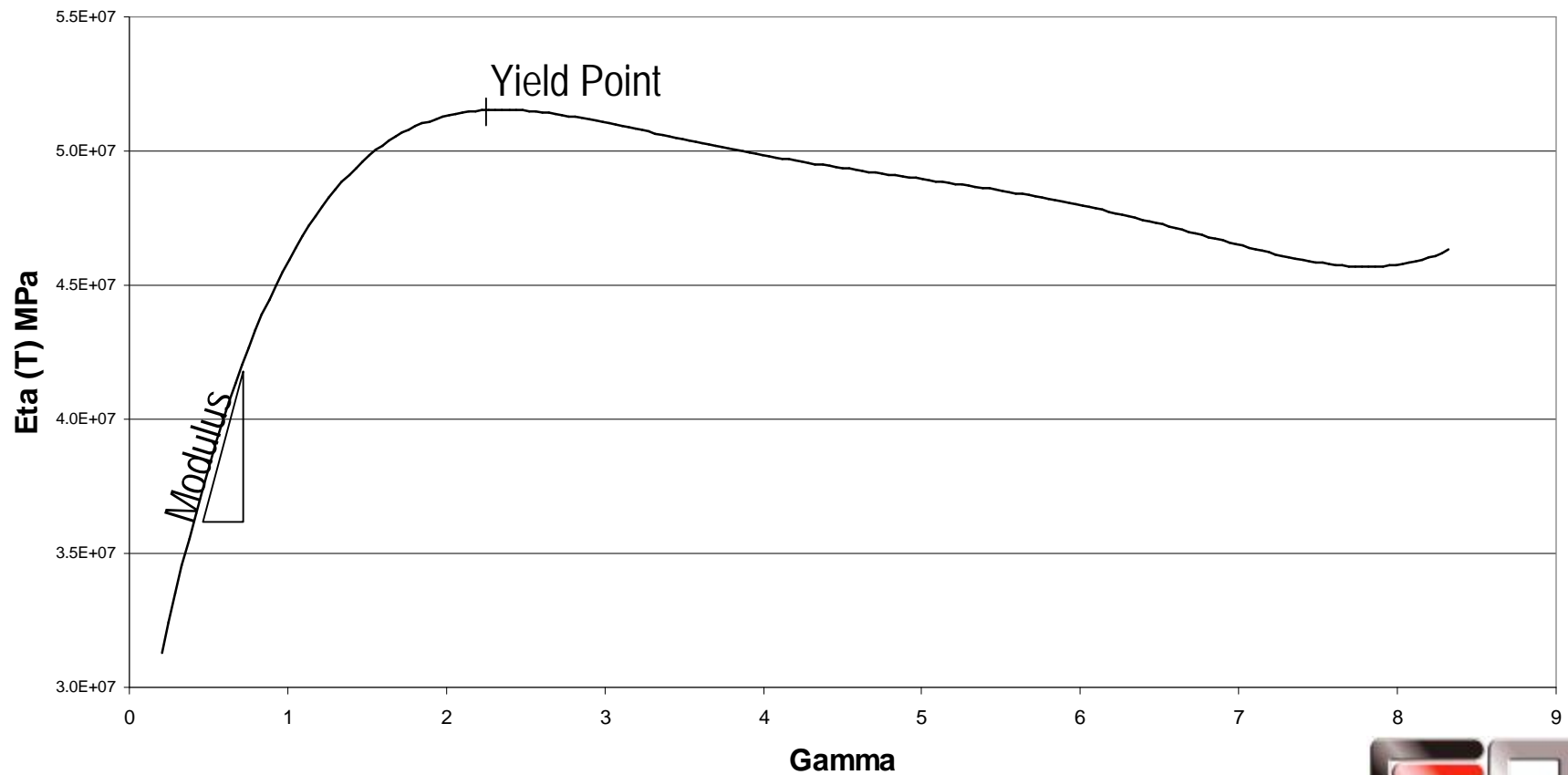
- Brookfield Soft Solids Tester
  - Capabilities
    - Vane Spindle Design
    - Low Shear Rates- Allows Material Flow
    - Controlled Rate and Controlled Stress Methods
  - Measurement Variables
    - Yield Stress –  
Stress Required to Break Elastic Structure
    - Shear Modulus-  
Stiffness of Structure prior to Obtaining Yield Stress
    - Creep Viscosity  
Viscosity at Very Low Shear Rates and Stresses



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## SMC Consistency Test Methods- Viscosity Methods

SST 2000 Rheometer- Stress versus Strain Curve



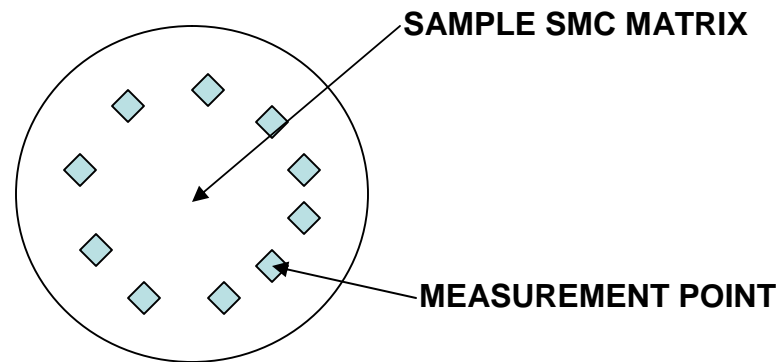
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## SMC Consistency Test Methods- Viscosity Methods

- **Reproducibility**  
Measurement System Accuracy

Study Involved Measuring SMC Matrix Retain over Ten Repetitions

Evaluated for Coefficient of Variance



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## SMC Consistency Test Methods- Viscosity Methods

System	Test Method	SMC Matrix Description	Mean	$\sigma$	Coefficient of Variance
A	HBT Viscosity Timed Stop MM cP	High Glass Low Filled System  30-50 pHR Filler	32.524	3.028	9.310%
A	Yield Stress MPa		559.64	50.397	9.005%
A	Modulus		2490.3	229.9	9.233%
B	HBT Viscosity Timed Stop MM cP	Typical Class A SMC System 180-210 pHR Filler	50.319	3.142	6.243%
B	Yield Stress MPa		1907.49	72.02	3.766%
B	Modulus		3288.0	190.6	5.796%
C	HBT Viscosity Timed Stop MM cP	Higher Viscoelastic SMC System 170-210 pHR Filler	35.758	5.259	14.708%
C	Yield Stress MPa		2378.19	102.06	4.291%
C	Modulus		2549.9	103.0	4.039%



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- **Conclusions- Reproducibility  
Measurement System Accuracy**
  1. Yield Stress as measured by SST shows improvements in reproducibility- Coefficient of Variance is reduced by 3 to 70% depending on system.
  2. Yield Stress improvements were more apparent in higher filled systems.
  3. Modulus measurements determined a difference in elastic properties of the SMC matrices studied.



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SMC Consistency Test Methods- Viscosity Methods

- Correlation Studies

Objective:

To determine if SST and HBT viscosity testing correlate to one another

Can we use what we already understand for a new test method?

Method:

Perform Side by Side Testing of Different SMC Matrix Systems and Determine Correlation

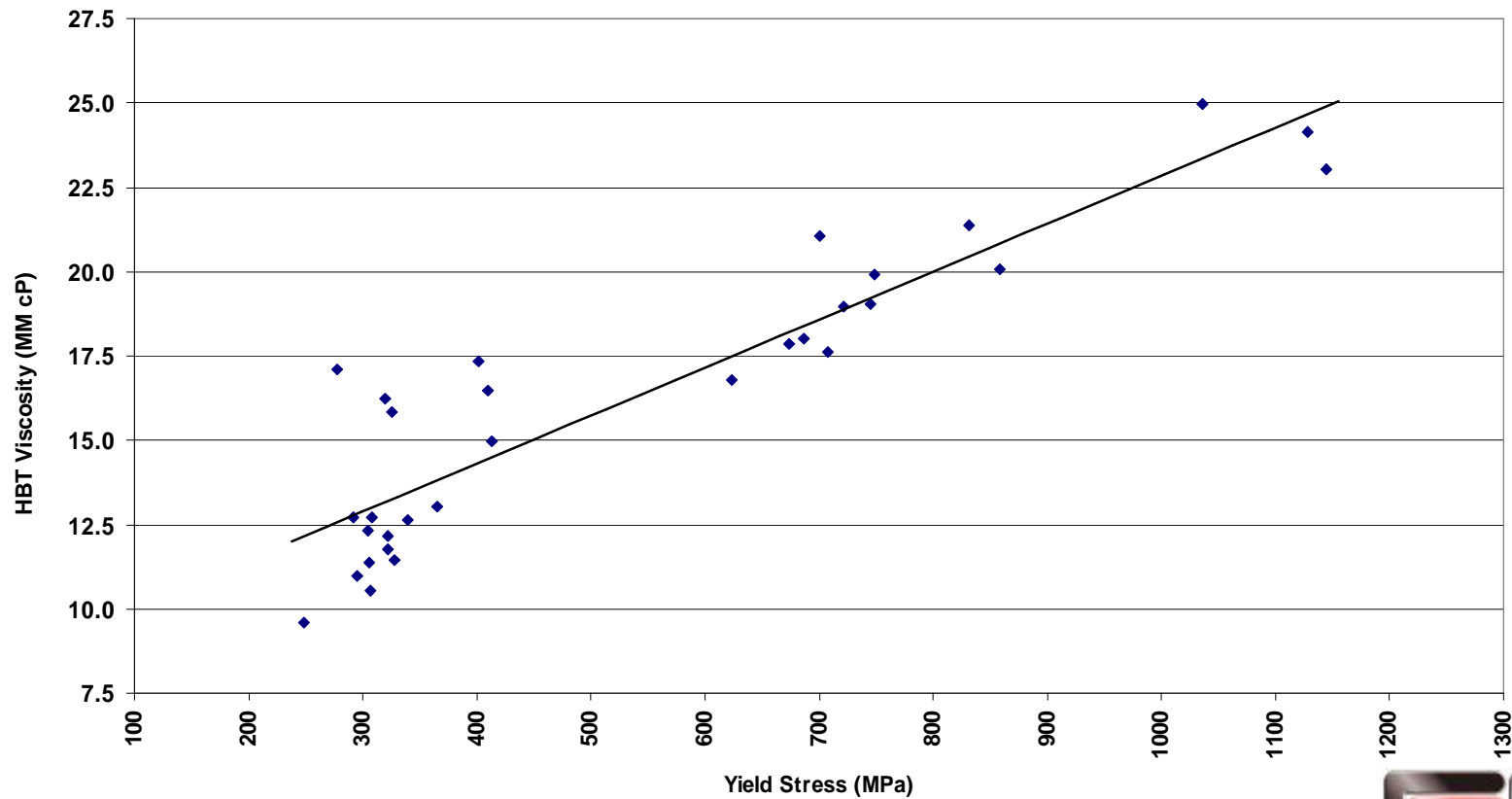


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## SMC Consistency Test Methods- Viscosity Methods

- Correlation Studies

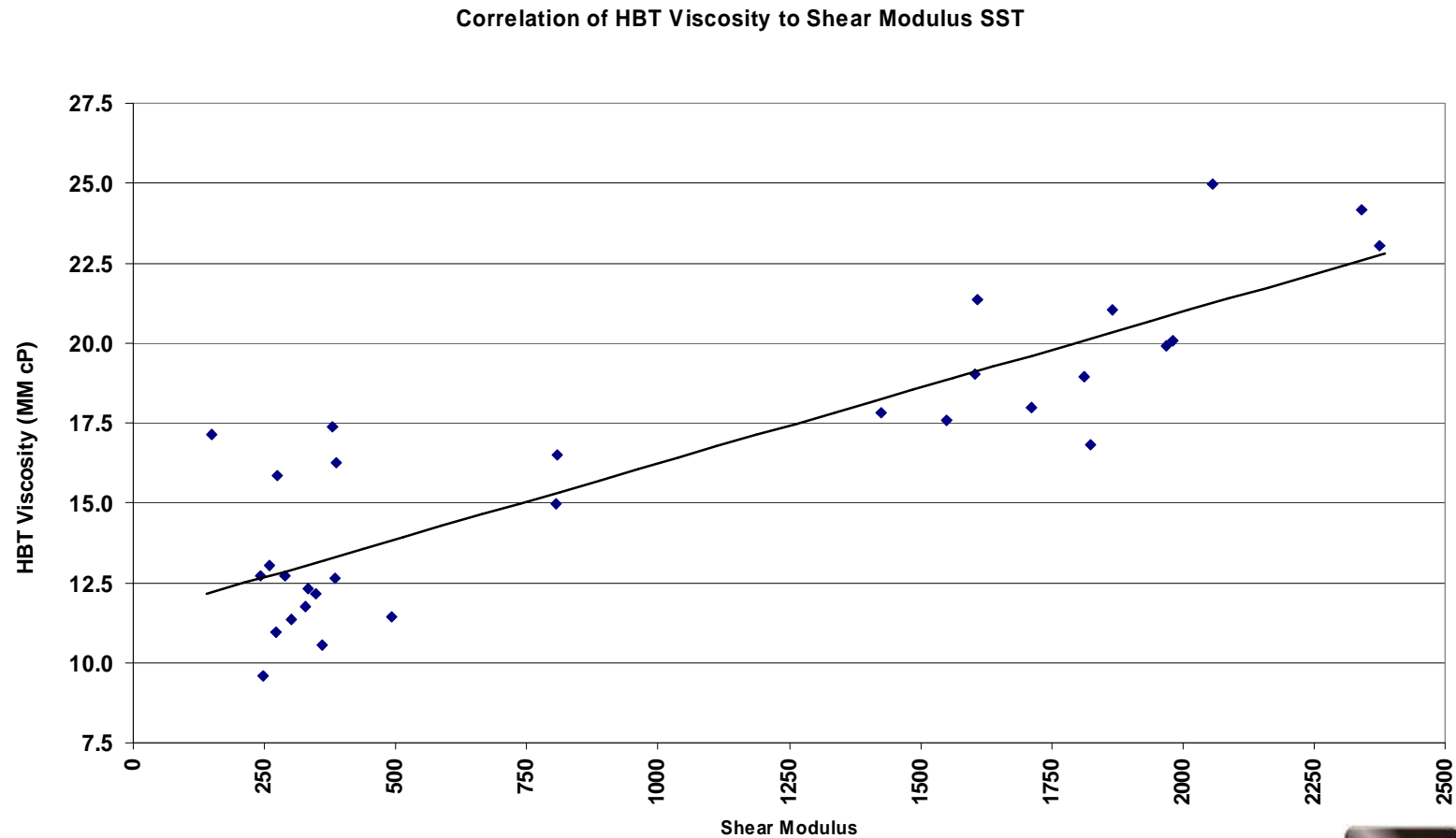
Correlation of HBT Viscosity to Yield Stress SST



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## SMC Consistency Test Methods- Viscosity Methods

- Correlation Studies



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SMC Consistency Test Methods- Viscosity Methods

- Conclusions- Correlation Studies
  1. Correlation exists between Yield Stress and HBT Viscosity-  $R^2 = 0.8276$
  2. Correlation is present Between Shear Modulus and HBT Viscosity-  $R^2 = 0.7564$



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## SMC Consistency Test Methods- Viscosity Methods

- Final Observations

Soft Solids Rheometer appears to be a viable testing method to measure SMC matrix viscosity and the consistency of the SMC compounding process.

SST viscosity testing can minimize the variation in testing and enable the compounder to react to data that is representative to the true rheological properties of the material.



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## SMC Consistency Test Methods- Viscosity Methods

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