New Helical Spindle for Mixing and Measuring Viscosity of Tyre Rubber Modified Binders

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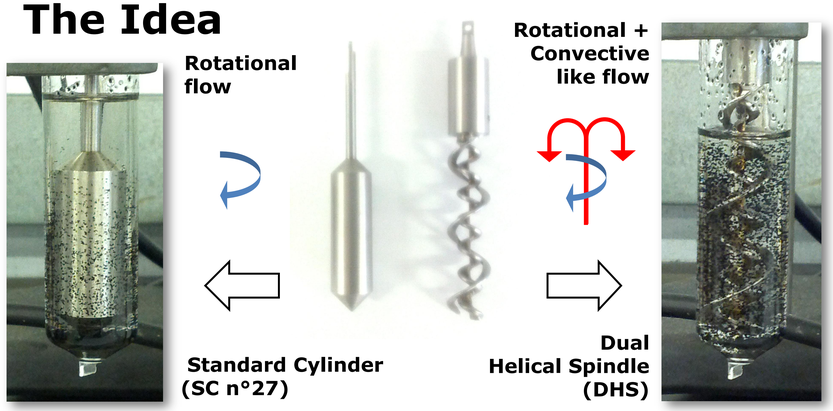
Background

The production of tyre rubber modified bitumen requires an appropriate process design where the temperature, time, shear stress, bitumen/rubber ratio are the principal factors. Rotational viscometers offer the potential to perform low shear mixing of bitumen-rubber blends with accurate control of the above mentioned conditions. Furthermore, this system could allow an accurate monitoring of the modification and its optimisation through real-time viscosity measurements.

Nevertheless, the measurement of rheological properties of these modified binders is challenging due to phase separation during measurements. In fact, tyre rubber particles react with bitumen only at temperature above 160°C and in this state the system is a non-homogeneous blend of a thin fluid matrix (bitumen) containing suspended solids (tyre rubber particles) that tend to settle.

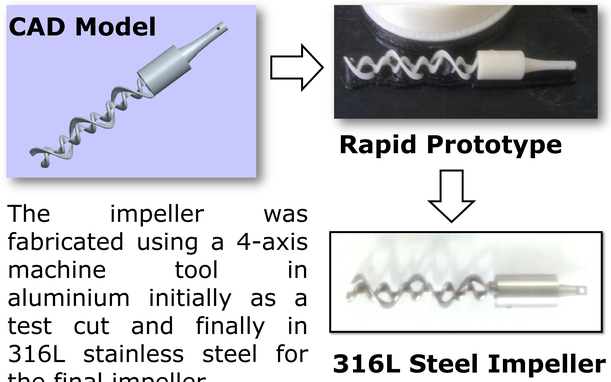
The Idea



Common systems for measuring viscosity of bitumen, Concentric cylinders with Standard cylinders (SC) as impellers, are not able to prevent phase separation. This does not allow for an even distribution of tyre rubber particles within the bitumen matrix, so neither mixing process nor viscosity measurements will be accurate.

This study presents a new impeller, the Dual Helical Spindle (DHS) that has been designed to perform viscosity measurements on blends of fluids containing suspended particles. The DHS can be used with a Brookfield rotational viscometer to optimise the production of tyre rubber – bitumen blends.

Design & Manufacture



The impeller was fabricated using a 4-axis machine tool in aluminium initially as a test cut and finally in 316L stainless steel for the final impeller.

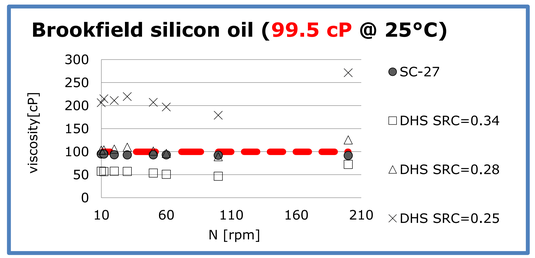
Calibration with fluids of known viscosities

The average shear rate in the measuring vessel is assumed to be independent of the rheology of the fluid and proportional to the impeller speed N and to the shear rate constant (SRC), which is determined for each impeller geometry.

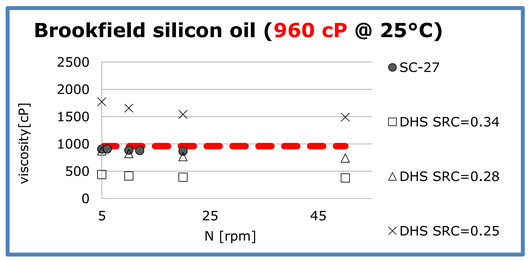
The Brookfield viscometer measures the applied torque (τ), and automatically calculates the applied shear rate (Eq.1) and the viscosity (Eq.2)

$$\dot{\gamma} = \mathrm{SRC} \cdot \mathrm{N} \qquad \text{(Eq.1)}$$

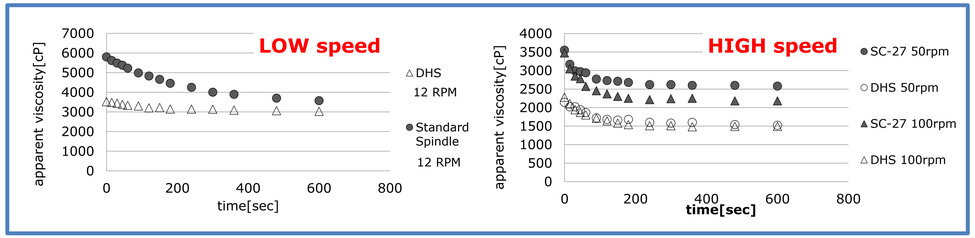
$$\eta = \tau / \dot{\gamma} \qquad \text{(Eq.2)}$$



Robustness Analysis ⇨ • 10% accuracy • SRC = 0.28



Validation of results with TR-MB



- More stable viscosity measurements at low speed
- Minor shear thinning behaviour at high speed (NO phase separation)

Future developments

- Understanding the flow patterns - DHS Shape optimisation
- Application with Dynamic Shear Rheometer