RheoSense

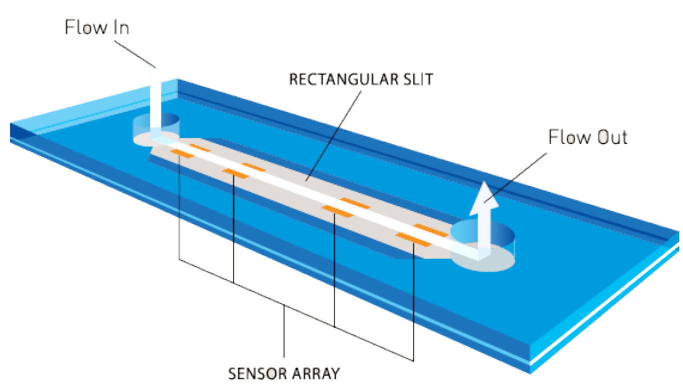
Simply Precise™

How VROC® Works

VROC® (Viscometer/Rheometer-on-a-Chip) measures viscosity from the pressure drop while a test liquid flows through a rectangular slit, a well-known scientific application (K. Walters, Rheometry[1]). VROC technology powered RheoSense viscometers all comply with USP 914.

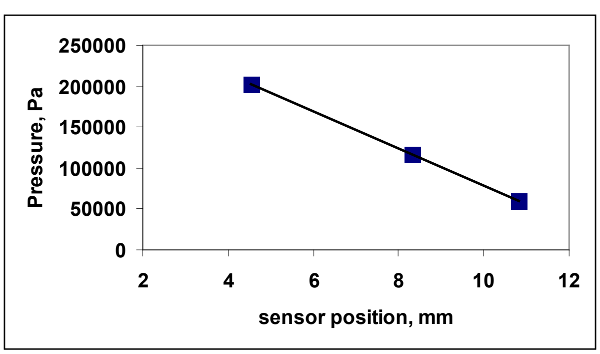
Physical Structure

VROC® chips consist of a rectangular slit that is formed with glass and a Si pressure sensor array. We have developed a unique rectangular slit design that mitigates perturbations at the entrance, sides and exit. This MEMS manufactured low profile silhouette directly contributes to the enhanced accuracy of our sensors and the VROC®'s ability to measure with precision in the presence of variables like high shear.



Usage

When the test sample is pumped to flow through the slit channel, the monolithic pressure sensor array measure pressure at separate locations. As previously described, the flow disturbance is negligible.



Data was obtained for Newtonian Glycerol at 1,220 s^{-1} using a type C Sensor Chip. (1) Reference: K. Walters, Rheometry, Chapman and Hall, London, 1975.

Results Analysis

The measured pressure as a function of position should be linear as shown in the graph if a fully developed flow is ensured in the rectangular slit channel. From the slope, the wall shear stress (τ) is calculated using the formula below. The viscosity (η) of the test sample is calculated as shown below:

$$\dot{\gamma}_{app} = \frac{6Q}{wh^2}$$

$$\tau = -slope\frac{wh}{(2w+2h)}$$

$$\eta = \frac{\tau}{\dot{\gamma}_{app}}$$

Q flow rate
w width of the channel
h channel depth

For the Newtonian liquids, the analysis above is sufficient. However, for non-Newtonian liquids the apparent shear rate does not equal the true shear rate—the true shear rate must be determined. For the rectangular slit flow, the true shear rate is calculated by applying the rigorous Weissenberg-Rabinowitsch correction. To ensure accuracy, our software application applies this correction for non-Newtonian measurements:

$$\dot{\gamma} = \frac{\dot{\gamma}_{app}}{3}\left(2 + \frac{d\ln\dot{\gamma}_{app}}{d\ln\tau}\right)$$

Small Gap Advantage

The small gap of the flow channel provides significant advantages, such as:

- Accurately measure the viscosity of small samples at extremely high shear rates, a service that rheometers cannot provide.
- With the small gap, mimic the lubrication, high speed coating, and inkjet process.

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