Viscometer-on-a-Chip (VSS)

A MEMS Device for Newtonian and Non-Newtonian Viscosities

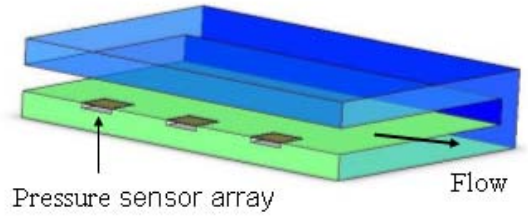
RHEOSENSE INC.

How Viscometer-on-a-Chip Works

The viscometer-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]).

Physical Structure

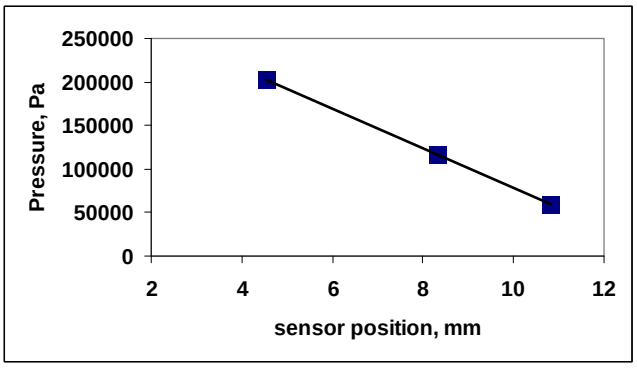
The VSS chip consists of a rectangular slit that is formed with Borosilicate glass and a monolithic Si pressure sensor array. The width of the rectangular slit is far greater than the depth of the slit—the edges of the slit are a negligible contribution to the pressure drop.



Rectangular slit

Usage

When the test sample is pumped to flow through the slit channel, the monolithic pressure sensor array measures 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.

Results Analysis

The measured pressure as a function of position should be linear as shown in the graph. 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:

$$\dot{\gamma} = \dot{\gamma}_{app}\left(1+\frac{1}{3}\left(\frac{d\ln\dot{\gamma}_{app}}{d\ln\tau}-1\right)\right)$$

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.

For additional information, any questions, please contact us: sales@rheosense.com, (925) 866 3802

(1) Reference: K. Walters, Rheometry, Chapman and Hall, London, 1975.

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