

# Measuring Viscosity of Pastes

by Len Thibodeau

Rotational viscometers have been used for many years for measuring fluid viscosity. Standard disk spindles are the most commonly used spindle geometry and require large, 600-mL sample containers. Other measurement geometries, such as coaxial cylinder or cone-and-plate geometry, provide options for measuring viscosity with limited sample volumes. Nevertheless, there are samples that present problems even with these techniques.

Gels and thick pastes are two such samples. It can be difficult to immerse a disk spindle into very thick samples without trapping air. Furthermore, during spindle rotation there can be wall slip of the sample at the spindle surface, resulting in unstable, inaccurate readings. Two useful accessories have been developed to overcome these obstacles: the Helipath accessory and the Spiral adapter (both from **Brookfield Engineering Laboratories**, Middleboro, MA).

The Helipath accessory consists of a motorized drive that slowly lowers then raises the viscometer head so that a slowly rotating T-bar spindle sinks into the sample to a preset depth, then rises back to the sample surface. *Figure 1* shows the Helipath setup. The crossed T-bar on the spindle shaft cuts a spiral path down through the sample as it descends. The advantage of this technique is that wall slip is eliminated because the spindle is continuously cutting its way through fresh sample during measurement. If the sample has any gel structure, the measurement is made as the gel is penetrated; thus any gel structure contributes to the torque sensed and, consequently, to the measured viscosity.

*Figure 2* shows a graph of two duplicate measurements made with the Helipath at 4 rpm of a very stiff glycerin-based paste (sample A). Because of the glycerin, the paste has a slippery feel and exhibits significant wall slip during measurements made with disk spindles. The graph shows that approx. 15 sec after data collection was started the spindle began penetrat-



*Figure 1* Helipath accessory with T-bar spindle.

ing the sample. By 35 sec the spindle is completely immersed and the measurement stabilizes at approx. 180,000 cP. The small “blip” appearing at 60 sec is caused by the Helipath reversing direction. At approx. 95 sec the spindle is again nearing the surface of the sample, after which the measurement drops to zero. These two curves demonstrate the repeatability of Helipath measurements. It is characteristic of the T-bar spindle to provide a somewhat “noisy” plateau rather than a smooth, flat curve.

*Figure 3* shows a comparison between very similar glycerin samples (A and B). This graph, in con-

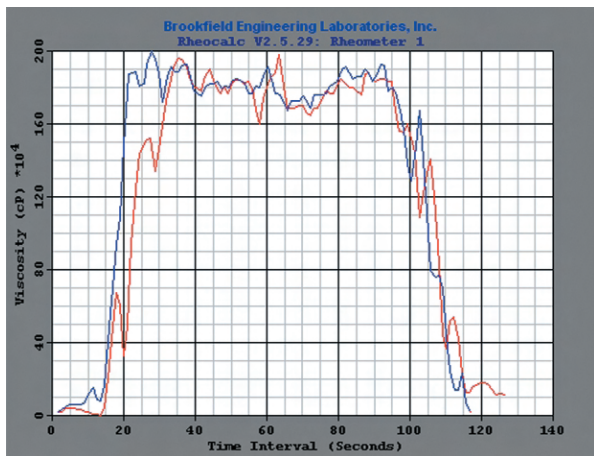


Figure 2 Viscosity data for glycerin paste made with Helipath accessory and T-bar spindle.

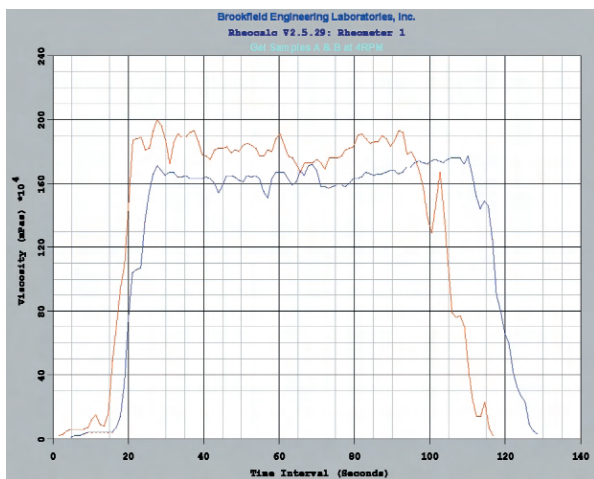


Figure 3 Comparison of viscosity data for two glycerin pastes made with Helipath accessory and T-bar spindle.

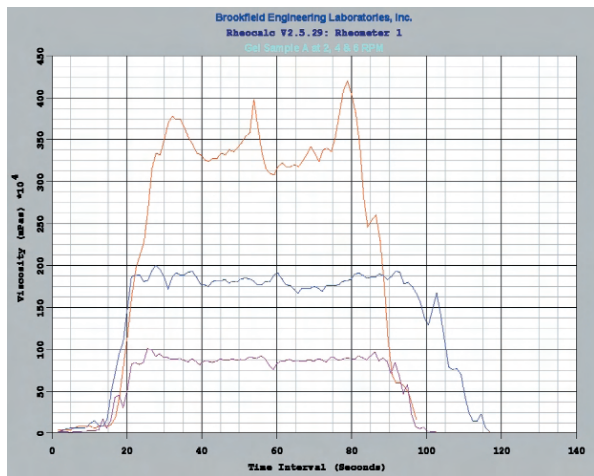


Figure 4 Comparison of viscosity data for a glycerin material made with Helipath accessory at three different rotational speeds.

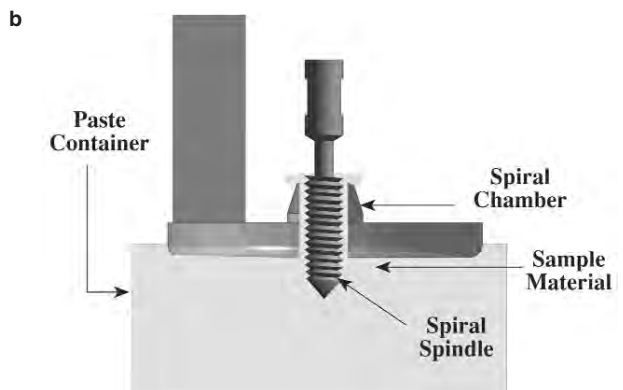


Figure 5 a) Spiral adapter accessory, b) cutaway view.

junction with Figure 2, demonstrates the repeatability of the Helipath and its ability to distinguish viscosity differences in very similar samples.

By varying the rotational speed of the test, the Helipath can determine either Newtonian or non-Newtonian sample behavior. Figure 4 shows three data sets from the same sample used in Figure 2. The data show viscosity plateaus at 2, 4, and 8 rpm. Decreasing viscosity with increasing speed is characteristic of pseudoplastic materials. However, if the non-Newtonian nature of the gel is to be fully characterized, a different test accessory is warranted, such as the Spiral adapter.

Figure 5 shows a cutaway view of the Spiral adapter. The spindle is a spiral-grooved cylinder that rotates inside of a slightly larger cylindrical channel. With the Spiral adapter attached to the viscometer, the head is lowered until the adapter just presses into the sample surface. It is necessary to fill the gap between the spiral spindle and the chamber wall with sample material before the measurement can begin. This is usually done

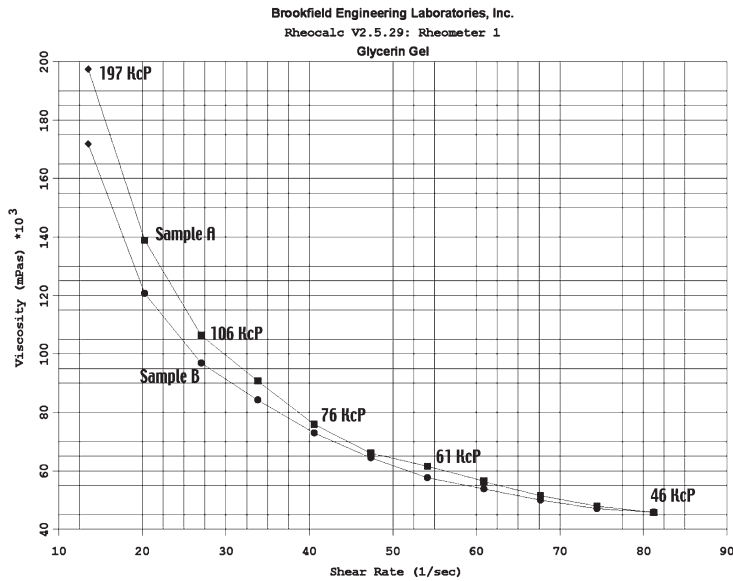


Figure 6 Viscosity data for two glycerin pastes made with Spiral adapter accessory.

at a high rpm until sample material begins appearing at the top of the channel. Then, by varying the rpm, a viscosity profile of the rheological character of the sample can be obtained. Figure 6 shows the viscosity versus rpm curves for both samples A and B, run with the Spiral adapter

over the rpm range shown. Both samples A and B are quite pseudoplastic over the range tested and sample B is slightly lower in viscosity, as was shown in Figure 3.

One advantage of the Spiral adapter is the ability to change speeds quickly during a single test run. This allows the test technician to determine the pseudoplastic nature of the sample material more rapidly compared to the Helipath accessory. Both the Helipath accessory and the Spiral adapter can be used to overcome sample measurement difficulties often experienced with gels and other very thick samples.

Mr. Thibodeau is a Senior Sales Engineer, Rheology and Texture Analysis Products, **Brookfield Engineering Laboratories**, 11 Commerce Blvd., Middleboro, MA 02346, U.S.A.; tel.: 508-946-6200, ext 199; fax: 508-946-6262; e-mail: [L\\_thibodeau@brookfieldengineering.com](mailto:L_thibodeau@brookfieldengineering.com).