Heraeus

Technical Information

Choosing the Right Brookfield Viscometer, Spindle and Cup for Paste Viscosity Measurement

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Choosing the right Brookfield viscometer model (LV, RV, HA or HB) and spindle/cup combination plays a major role in obtaining reliable and repeatable viscosity measurements while minimizing measurement error.

Purpose: To describe the various factors involved in selecting the most appropriate viscometer for a given paste viscosity measurement application in order to minimize measurement error. For a basic overview of the principles of thick film paste viscosity measurement, refer to Heraeus Engineering Note #203.

Choosing the "Right" Model of Brookfield Viscometer:

Brookfield Engineering Laboratories Inc. (Stoughton, MA) sells 4 basic models of viscometers (LV, RV, HA and HB). The latter 3 find wide use in the viscosity measurement of thick film pastes. The difference between these models is the calibration spring torque which enables different ranges of viscosity to be measured using the same spindle and container. For example, with the SC4-14 spindle and 6R small sample adapter combination (see figure 1), the following viscosity ranges can be measured at a spindle rotation speed of 10 rpm:

RV: 0 – 125 Pa-sec (Kcps)
HA: 0 – 250 Pa-sec
HB: 0 – 1000 Pa-sec

The obvious question that comes to mind is why not use the HB model for the measurement of all thick film pastes from low viscosity end terminations (which typically have 10 rpm viscosities of 30-60 Pa-sec) to much more viscous via fill pastes where the 10 rpm viscosity can exceed 500 Pa-sec. The answer to that question is covered in the next section on viscometer measurement error.

Figure 1: Brookfield SC4-14 spindle with the 6R small sample adapter

Measurement Error with a Brookfield Viscometer:

Analog (dial reading) model Brookfield viscometers have a rotating dial with units from 0-100 representing the deflection on the unit's calibration spring. The viscosity of the fluid measured on an analog viscometer is calculated as follows:

(Dial Reading) x (Factor) = Viscosity in centipoise

The value of the factor is unique for each viscometer model (LV, RV, HA and HB) and combination of spindle and speed. They are calculated using a viscosity calibration fluid in a specified container or small sample adapter and are listed in the viscometer manual.

With the more modern digital models, the factors are built into the software of the unit and the viscosities are automatically calculated once the appropriate spindle number is entered. In addition to providing a read-out of the paste viscosity, the digital models of Brookfield viscometers also provide a read-out of the % torque on the calibration spring. It is very important to be aware of this percent torque value when setting up a viscosity test since its value has a direct impact on the amount of measurement error.

Ideally, a viscometer model/spindle/speed combination should be selected which produces percent torque readings (or dial readings for Analog models) between 15 and 85 percent. As will be illustrated shortly, the higher the value, the lower the error associated with the measurement. For tests that will be run at a variety of speeds, a viscometer model/spindle combination should be selected which enables a full range of speed settings to be used without the percent torque exceeding 100%.

Brookfield viscometers are guaranteed to be accurate to within +/- 1% of the full scale range. Since the factor is equal to 1/100 (1%) of the full scale range, the factor (in units of centipoise) is also equivalent to the tolerance associated with any viscosity value measured. Therefore, by knowing the factor for the measurement conditions being used, the percent error for a given measurement can be easily calculated as will now be illustrated.

Returning to the earlier illustration for a SC4-14 spindle with a 6R small sample adapter, the following factors (in centipoise or cps) have been established for the RV, HA and HB model viscometers:

RV: 12500/N
HA: 25000/N
HB: 100000/N

where N equals the speed in rpm

A typical viscosity at 10 rpm for a conductor paste is 120 Pa-sec (120000 cps). The viscosity of this paste could be measured on all 3 models listed above. However, the percent error for the measurements will vary significantly as shown in the following table:

Percent Error = [(tolerance) ÷ (measured viscosity value)] x 100%

Viscometer Model	Factor (tolerance) at 10 rpm	% error for a measure - ment of 120000 cps.
RV	1250 cps	1.04%
HA	2500 cps	2.08%
HB	10000 cps	8.33%

To minimize the percent error for this particular measurement, the RV model viscometer is the best choice. However, the HA model may prove to be a more versatile choice since lot-to-lot variations may result in some lots having a viscosity >125000 cps which would result in off-scale readings on an RV model viscometer.

Summary:

The general principals reviewed in this document should enable the best choice of viscometer model to be made based on the percent error which will be present in the measurement.

It is important to consider the viscosity specification of the paste to be measured to be certain that a portion of the specification will not result in off-scale viscosity readings for a particular model of viscometer and spindle/speed combination.

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References:

Brookfield Engineering Laboratories publishes a very helpful booklet entitled "More Solutions to Sticky Problems: A Guide to Getting More From Your Brookfield Viscometer". This is an excellent publication which provides a wealth of helpful information on viscosity measurement.

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