Two methods to accomplish paint viscosity measurement are discussed by **Vinnie Hebert**, Brookfield Engineering Laboratories

A guide to measuring paint viscosity vs temperature

Fig 1. Brookfield DV-II+ Pro Rotational Viscometer

The necessity of measuring paint viscosity is well known and there are several methods using a rotational viscometer, such as ASTM D2196, for accomplishing this (see **figure 1**). The objective is to characterise the shear sensitivity and time dependent behaviour of paints during their application and recovery on different types of surface.

An additional consideration when measuring paint viscosity is to evaluate how it behaves as the temperature varies. Certainly, the cooler the temperature, the higher the viscosity of the paint; conversely, the warmer it is, the lower the viscosity.

But to truly get a firm grasp on how paints will perform at any given temperature, they should be tested at both low and high shear rates to assess overall performance. Two methods for accomplishing this are discussed.

Why is it important to test paints at different temperatures and at low and high shear rates? It is needed to determine behavioural characteristics such as how the paint will perform under the heat of summer outdoors in Arizona as compared to a cool spring in New England? What are its shear-rate dependent characteristics at these temperatures? A profile needs to be done to realise how the paint will perform at these various temperatures and shear rates so that additives, if needed, can be used to thin or thicken the paint. A paint viscosity vs temperature profile would be similar to what is shown in **figure 2**.

First, let us define low and high shear rates for this application. Low shear would be applicable for hand stirring paint, pouring, how it drips from a roller or brush and recovery after application to form a smooth finished surface. In order to accomplish low shear rate testing, different types of accessories, such as the small sample adapter (see **figure 3**), are available for use with standard rotational viscometers. These types of accessories utilise coaxial cylinder geometry (a cylindrical spindle rotating in a cylindrical chamber) to give defined shear rates.

Unfortunately, testing paint in a 600ml beaker with standard disc spindles will not give defined shear rates. Coaxial cylinder geometry accessories are an extremely cost-effective way to test paints for low shear because the sample size is significantly smaller and the time required to come to temperature is minimised.

High shear would be defined as brushing, spraying through a nozzle or rolling. Cone/plate spindle geometry is the appropriate choice of instrument to test for high shear applications. An added benefit is that this gives rapid tem-

Fig 2. Example of viscosity vs temperature curve for paint

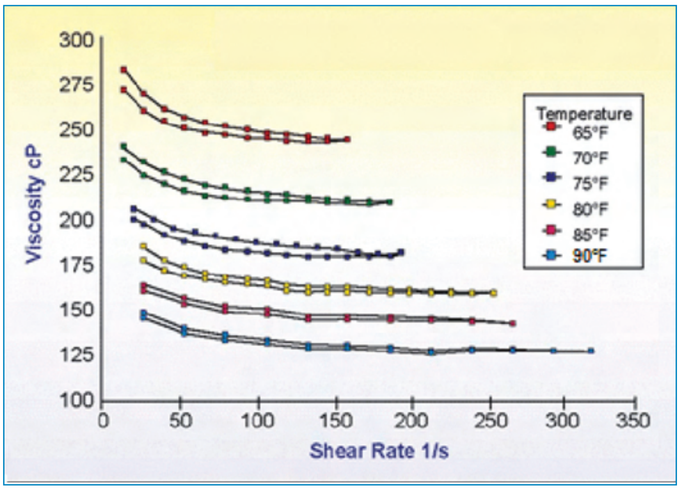

Fig 3. Brookfield small sample adapter for low shear rate testing

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Fig 4. Right: Brookfield CAP 2000+ Cone/Plate Viscometer

perature control on very small sample volumes of 2ml or less. Cone/plate type instruments can be more costly but that cost is justified by the ability of these instruments to test at high shear and perform viscosity vs temperature testing quickly. For example, **figure** 4 shows an instrument specifically designed for high shear rate applications of up to 13,000 sec^{-1}.

For this article, it is explained how to perform the low shear rate application. The procedure for a high shear rate application is the same as for the low shear rate application.

The two methods that are covered for testing paint viscosity at varying temperatures are fairly straightforward. For the first method, the viscosity vs temperature profile can be determined using a fixed shear rate (running the viscometer at one rotational speed) while varying the temperature and then recording the results. The second method is to test at several discrete temperatures while running a shear rate ramp at each specific temperature and recording the results. As previously mentioned, testing can be done at low to medium shear rates or low to high shear rates depending on the equipment being used.

For low shear viscosity vs temperature profiles, use of the small sample adapter accessory is common. This type of configuration supports defined shear rates and allows for temperature control of the sample through a water jacket into which the chamber is inserted.

To achieve temperature equilibration, the spindle needs to be immersed in the sample material while it is coming to temperature. Once reached, a rotational speed can be set and temperatures ramped accordingly. The choice of rotational speed must provide a reading of >10% on the torque scale in order to obtain accurate viscosity readings.

Due to the thixotropic nature of paints (time dependent shear behaviour), readings must be taken at a specific time interval. Thus, you would ramp to a temperature you wish to test, set a single speed, wait a specific time interval (perhaps a minute or so but this is up to definition by the user) then take a reading. Turn off the motor and increase the temperature to the next level. Repeat the process for defined temperatures and this will generate your profile. Note, that in the case of very thixotropic materials, you may need to change the sample between each temperature change.

For the second method, running a shear rate ramp, first select the rotational speeds based on the shear rates you wish to test and ensure that the torque readings for the instrument will be valid, that is above 10%.

Once this is accomplished, select the temperatures at which you wish to test. Again, make sure you allow the spindle and material to come to equilibration. Set a discrete temperature, allow for equilibration and then run a shear rate ramp test. This consists of selecting three to five speeds, running them from lowest to highest and then back down.

Record the data at each speed after a certain time interval (to be determined by the user but usually a minute or so). Turn off the motor and select the next temperature. You will probably need to check the speeds again to make sure these will meet the minimum torque criteria of >10%. Repeat the speed ramp test. Again, remember if the material is very thixotropic, you may need to change the sample after each temperature/speed ramp test.

To analyse the above data in the second method, consider the viscosity vs shear rate curve for a single temperature (see **figure** 5). Look for potential hysteresis in the data curve, which is indicative of a thixotropic material. Remember, a thixotropic material is time dependent, so to check this when ramping speeds, look for this hysteresis. If the hysteresis in the curve is significant (there is wide separation between the up ramp data and down ramp data), then the material may have a tendency to run or drip when applied at this temperature. If the hysteresis in the curve is too narrow, the material may have a tendency to 'clump' at this temperature.

After running either one of these methods, the user will now have a good picture of how the paint will react to temperature and shear. This information can be used to characterise and define how these paints will perform over a range of temperatures subjected to different levels of low shear. As previously stated, if high shear testing needs to be performed, the methods used for low shear testing as defined in this article are applicable.

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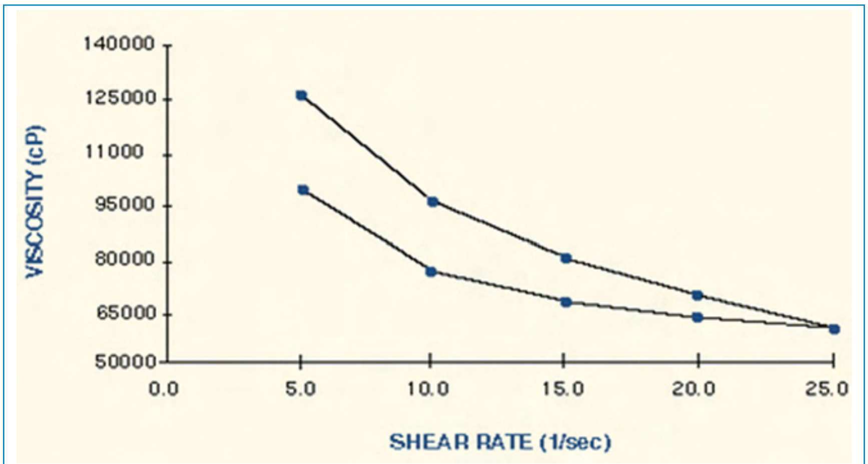
Fig 5. Viscosity vs shear rate curve for data taken at a single temperature showing hysteresis



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