Report Name: App Note 006-OLR

Measurement of printing inks using the OnLine Rheometer

The rheological properties of various lithographic printing ink and varnish samples were measured using the Rheology Solutions OnLine Rheometer.

A genuine process monitoring and control rheometer which can be operated in-line or on-line and measure the viscoelastic properties in a flow environment and in real-time has the potential to improve product quality and reduce processing costs.

The OLR delivers fast, accurate results with a single measurement over a range of frequencies. Its simple geometry and stainless steel construction allow for easy cleaning.

ONLINE RHEOMETER

To date, the control of the properties of process flows has been attempted by the use of capillary viscometers, vibrating probe viscometers, and slit rheometers. In-line process viscometers by their very nature yield only viscosity data, and hence provide an incomplete analysis of viscoelastic fluids. All of the instruments mentioned above operate only at a single shear rate (or frequency), thereby potentially limiting the usefulness of the data.

If more detailed knowledge of the viscoelastic properties of the fluid is required test volumes must be removed from the process stream and measured using an off-line laboratory rheometer. However, this is a time consuming procedure that may require the process line to be shut down until the results are available to confirm, or otherwise, the quality of the product. Alternatively, the process flow may continue with the potential loss of product. In some cases, the volume of lost fluid could be large and this could be particularly problematic when processing high- value materials (such as pharmaceuticals), products that cannot be reprocessed or products that incur a disposal cost (for example, an environmental levy).

Thus a genuine process monitoring and control rheometer which can be operated in an in-line or on-line configuration and measure the viscoelastic properties of a process fluid in a flow environment, and in real time, has the potential to improve product quality and reduce processing costs. The Rheology Solutions OnLine Rheometer (OLR) is such an instrument, and uses a patented multi-frequency squeeze flow technique that allows the viscoelastic flow properties of a material to be measured over a wide frequency range in a very short time. The measured rheological parameters can be used as process controls in a feedback system to control the process, and hence the quality, of the final product

LITHOGRAPHIC INK MEASUREMENTS

The lithographic printing process is a harsh environment and its success depends largely on the rheological properties of the ink used. If the rheological properties of the ink can be determined and controlled during processing the characteristics and quality of the final product can be dictated.

The rheological properties of a number of lithographic printing ink and varnish samples

Lithographic inks must operate in a wide range of flow conditions during its journey through a printing press. The ink must coat the image areas of the printing cylinder, transfer to the blanket cylinder and coat the paper without spreading or tearing the paper. The ink must then set while retaining its colour intensity and gloss and be suitably hard and “rub-resistant“

were measured using the OLR. The samples involved in this study were as follows; three magenta ink samples labeled M1, M2 and M3 (the same ink with slight compositional variations), two magenta ink samples labeled M1P and M1M where M1P is premixed and the M1M is the same ink that has been milled, and a sample of varnish labeled V1. The inks labeled M1, M2 and M3 were all within the manufacturer's specifications but behaved quite differently under routine factory testing.

The storage moduli G' (elastic component) of samples M1, M2 and M3 as a function of frequency are shown in Figure 1. There are obvious differences in theses curves indicating that the levels of elasticity within the inks vary. The elasticity of a lithographic ink influences misting, ink transfer and film splitting.

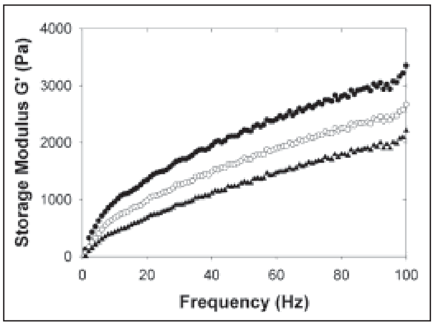

Figure 1 Storage modulus as a function of frequency of SRM2490.

The loss moduli G" (viscous component) of samples M1, M2 and M3 as a function of frequency are shown in Figure 2. These curves are quite similar indicating that the viscous flow characteristics of the three inks are very similar. It can be concluded that the compositional variations influenced the elasticity to a greater extent than the viscous properties.

The complex viscosity η* of samples M1, M2 and M3 as a function of frequency are shown in Figure 3. The decreasing viscosity with increasing frequency (or shear rate) is known as "shear thinning" behaviour and is very common to viscoelastic materials. The OLR could easily differentiate the ink samples on the basis of their rheological properties.

The measurement of the varnish sample V1 indicated the ability of the OLR to measure a sample with very high values of elasticity and viscosity. The maximum values of G' was just under 25000 Pa, G" over 50000 Pa and complex viscosity just under 300 Pas. These values do not represent an upper limit but are merely representative of the capabilities of the OLR due to its stiff design. The varnish is a critical component in designing a good ink as it can determine the flow properties.

The premixed ink sample M1P and the milled ink sample M1M were compared using the OLR and significant differences in the rheological properties were observed. Milling is necessary to disperse the pigment particles but it is an energy intensive and expensive process. If the rheological parameters can be correlated to the milling time this process can be optimised leading to energy and cost savings

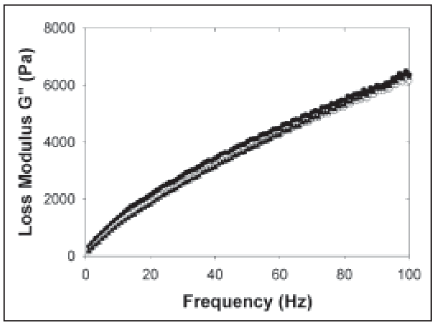

Figure 2 Loss modulus as a function of frequency of 490 where the symbols (•), (◦) and (▲) represent inks M1, M2 and M3 respectively.

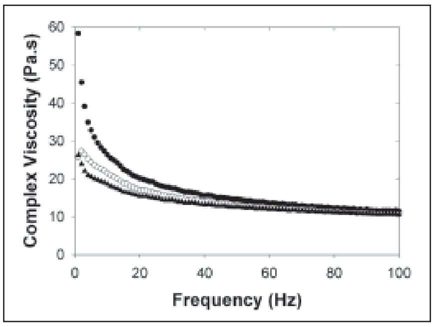

Figure 3 Complex viscosity as a function of frequency of 90 where the symbols (•), (◦) and (▲) represent inks M1, M2 and M3 respectively.

Rheology Solutions

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