High frequency and extensional rheology of low viscosity inkjet fluids

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Ink jet fluid rheology is one of the key parameters that affects the whole ink jet process and can interact with other parameters in a complex way. Conventional oscillatory rheometers normally are unable to oscillate above a frequency of 100Hz. Although, this is adequate for many polymer systems and structured fluids, the maximum frequency of the conventional rotational rheometers is too low to detect any viscoelastic effects for the very low viscosity of ink jet fluids. At high frequencies, the inkjet fluid exhibits a low level of non-Newtonian behaviour, which strongly influences the fluid jet-ability

Optimising bulk properties of inkjet inks to printhead specifications during formulation alone are no guide to achieving reliable jetting. During jetting, the ink encounters all forms of extreme rheology - (i) high frequency (~ 100 kHz) in the printhead channel during waveform actuation, (ii) high shear rate (~ 10^6 s^{-1}) at the nozzle during drop ejection and (iii) extreme in-flight filament stretching before jet break up.

Any minor changes in the ink components or batch variations of formulation can drastically change linear high frequency viscoelastic properties of inks in in printhead channel during waveform actuation and subsequent in-flight non-linear extensional viscoelastic properties of the ink during ejection. This affects fluid flow dynamics in the printhead, in-flight jetting and break-up behaviour.

We will present TriPAV high frequency piezo actuator rheometer with 0.1 - 10,000 Hz frequency range and TriMaster extensional rheometer to quantify complex rheological properties of inkjet at conditions similar to those encountered in printhead channel and in-flight during inkjet printing. Real case examples will be discussed where such complex rheological analyses are exploited in (i) the development and quality control of inks to differentiate between apparently identical inks but that resulted in different jetting behaviour and (ii) recommendation of optimum jetting temperature, print frequency and waveform conditions.

Direct rheological measurements of fluids at high frequency with a capability to determine subtle changes in the characteristic relaxation time down in 0.1 millisecond range would be extremely useful in many applications .