Fast Sampling in Oscillation Mode

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ABSTRACT

Conventional oscillatory rheology requires at least one cycle of data to be analysed. This limits the rate at which sample points can be acquired to the frequency of oscillation. TA Instruments have therefore developed two methods of increasing the rate of acquisition of sample points.

INTRODUCTION

The limitations in data acquisition in conventional oscillatory rheology is linked to the actual frequency of oscillation. For example, a frequency of 5 Hz can only provide 5 points per second. Such sampling rates are not always adequate; processes such as the UV curing of coatings occur too rapidly to be captured at this sampling at reasonable frequencies, and so in the past certain practical limitations have existed.

Fast Sampling

Using standard fast oscillation, one of the two new methods of increased data acquisition, introduced in the latest version of TA Instruments Rheology Advantage software, the analysis is conducted at twice the experimental frequency by running two correlators in parallel, offset by 180 degrees. This gives a maximum rate of two sample points per cycle. Figure 1 shows an example of data points acquired using this technique where direct strain control oscillation was used at a frequency of 50 Hz resulting in a data point every 0.02 seconds. The test sample used for this demonstration was polydimethylsiloxane (PDMS) at 20°C.

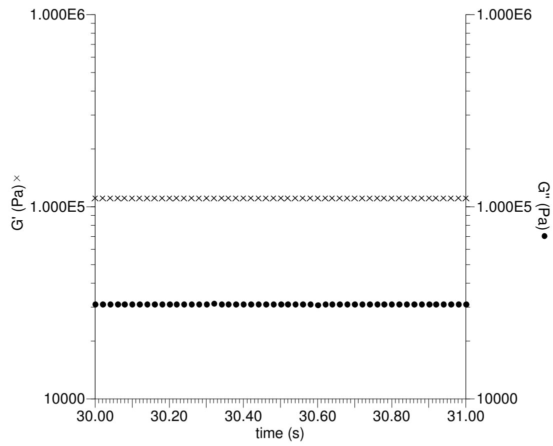

Figure 1: Standard fast oscillation mode, showing data points collected at twice the oscillatory frequency of 50Hz.

As mentioned previously, one area where this new fast sampling mode would be of benefit is in rapidly curing systems such as uv. Figure 2 shows a comparison between a cure made with and without fast sampling and clearly demonstrates the improved definition of the cross over point often used as a unique characteristic value. The test was run at a frequency of 25Hz, providing 50 points per second in fast sampling mode.

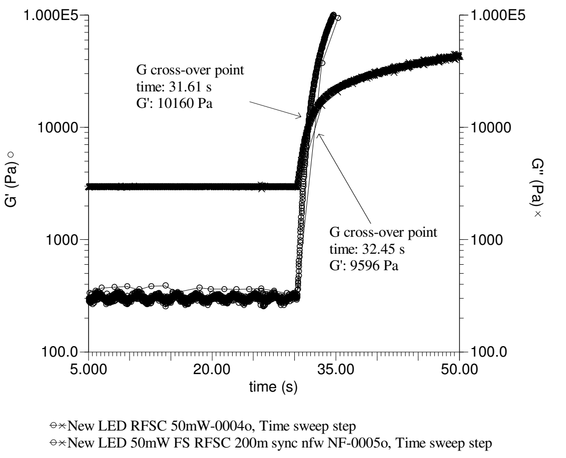

Figure 2: Comparison between standard and fast sampling oscillation mode for UV curing system.

Raw Signal Data Logger

Using a raw signal data logger, which operates in real time, fundamental instrument information such as the torque, displacement, normal force and geometry gap can be logged at just under a kilohertz. The user can access this data and analyse it as required. The raw signal data logger shows rapid transitions occurring during an oscillation cycle that could not be captured using conventional rheology. Figure 3 shows data for PDMS at a frequency of 0.5 Hz and strain of 10000. The asinusoidal form of the torque signal is due to the sample non-linearity at that strain. Note the normal force is seen to fluctuate at twice the frequency of the oscillation, as expected.

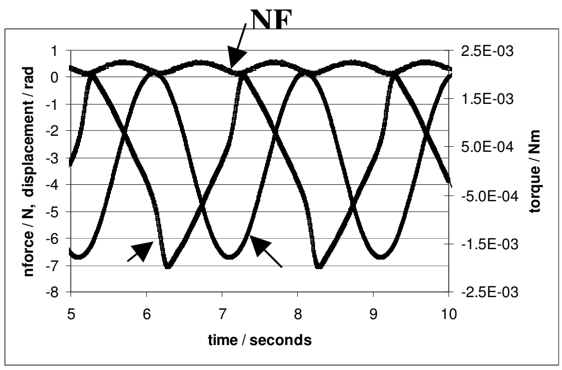

Figure 3: Results obtained using the raw signal data logger. Shown fluctuating at twice the frequency of oscillation, as expected, are the displacement (D), torque (T) and normal force (NF).

Data Storage

A further refinement is for the software to allow the storage of up to 1024 data points per cycle for later analysis. This technique can be used to obtain the higher harmonics of the output signal for a high amplitude sinusoidal input signal, or to plot data as Lissajous figures, for example. Figure 4 shows data plotted in this way for a commercial hair gel at a stress of 10Pa and angular frequency of 6.28 rad s^{-1}.

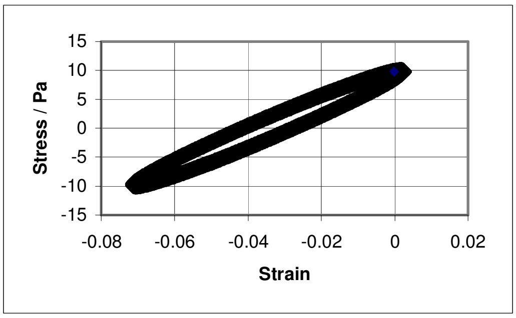

Figure 4: Lissajous figure for a commercial hair gel at an angular frequency of 6.28 rad/s and a stress of 10 Pa.

Harmonic Analysis

As an alternative to a Fourier transform[1] it is possible to perform the harmonic analysis with the correlator used by the rheometer firmware. Figure 5 shows the odd harmonics for a commercial hair gel at 6.28 rad/s^{-1}

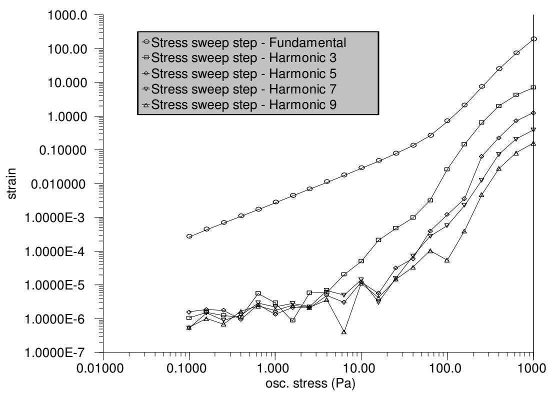

Figure 5: Fundamental and odd harmonics obtained using the AR-G2 correlator for a commercial hair gel at 6.28 rad/s.

Figure 5 clearly indicates that a contribution is being made from the third harmonic prior to the perceived critical stress that may have been suggested from just the fundamental frequency data.

ACKNOWLEDGEMENTS

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REFERENCES

1. M.Wilhelm, D.Maring and H.W.Speiss (1998) "Fourier Transform Rheology" Rheol. Acta. **37**, 399.