OCT News
Optical Coherence Tomography News

Feature Of The Week 2/10/13: Cranfield University Researchers Investigate Using OCT For Adhesive Cure Monitoring

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Monitoring the progress of cure in an adhesive enables changes in behaviour to be studied under differing conditions of temperature, humidity or illumination, and allows the importance of other factors, such as variability between production batches, volume of adhesive or altered composition due to aging, to be assessed. Detailed knowledge of the cure process minimises the time that must be allowed before further processing.

For exothermic reactions, it is possible to track progress via measurement of the temperature at one or more positions within the cure region. More generally, acoustic sensors, which detect the material modulus, and dielectric measurement methods are commonly used. Optical monitoring techniques include fluorescence methods, near-infra-red spectrometry and optical-fibre Bragg gratings embedded into the adhesive cure zone for both strain and temperature measurement. Most of these techniques produce a spatially integrated output signal. In other words, the value of the measurand, at any point in time, corresponds to an average either over the entire cure region or over an extended zone within that region.

We are proposing the application of image-correlation in OCT to create a useful addition to the suite of methods available for adhesive cure monitoring. The advantage of the proposed technique is its ability to pinpoint, with a spatial resolution of a few tens of um, the locus of a particular degree of cure within a sample area having dimensions of the order of one millimeter. A time-series of images results depicting the movement of a “cure front” within a small volume of adhesive; something that is not accessible from currently-available cure-monitoring techniques. Using a fast data acquisition system, images for post-processing can be acquired at rates from several Hertz up to many tens of Hertz, dependent on the number of pixels required in the image. For live imaging, on-line processing and display implies a somewhat lower update rate.

The OCT processing method involves cross-correlation of small areas within image pairs separated by a ‘correlation interval’, to identify and locate regions of movement within the OCT image (J. Enfield, E. Jonathan and M. Leahy, Biomed. Opt. Exp. 2 (2011) 1184-1193). Similar techniques have been used in the past, in which sub-surface velocity in diffuse objects was encoded as a contrast reduction in speckle images, and OCT now enables the extension of the method to depth discrimination within images. Altering the time interval between two cross-correlated images will affect the degree of correlation, as the positions of particles moving more rapidly within the sample de-correlate faster than those of slow-moving particles. Where there is no

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- Cranfield University

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- Helen D. Ford

pressure gradient within the fluid, the physical quantity detected by the OCT measurement is the displacement of scattering particles caused by Brownian motion, which is, in turn, related to the local viscosity.

Cross-correlation of OCT images is here applied to internal imaging of PVA paper glue, and a two-part epoxy adhesive, during cure, providing information on relative viscosity at different positions within the sample volume. Spatial resolution of a few um is obtained in the original OCT images, and a few tens of um in the correlation images, enabling the progress of cure to be mapped in fine detail within a small cure volume. Evidence of phase separation is seen in the OCT and correlation images of a partially-cured PVA emulsion. Mixing structure, and regions of poor cure, can be observed in a poorly-mixed two-part epoxy, as well as the presence of bubbles and other internal flaws, indicating where possible positions of weakness might arise in a supposedly fully-cured sample.

For more information see recent Article. Courtesy Helen Ford from Cranfield University.

- Ralph P. Tatam

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