

Crack detection on aerospace composites by means of photorefractive interferometry.

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Abstract

Aircraft industry requires fast, robust and reliable tools for assessing structural integrity. Linear ultrasonic techniques are among the tools of choice for Non-Destructive Testing. Defects (cracks or delaminations) reflect elastic waves when they manifest as an impedance mismatch. However, no reflection occurs when the fracture is closed. In order to excite and detect ultrasound, contact transducers (piezoelectric transducers, EMATS) are the most popular option because of their flexibility of application, cost effectiveness and ease of use. However, these methods fail to detect a closed defect and can only probe areas accessible by the operator.

The inspection tool presented in this work is based on the detection of defect-induced elastic cross-modulation phenomena using photorefractive interferometry (PRI). This non-contact method is full-field and ultimately, it will allow to inspect large areas at once and enable detection of defects at an early stage.

The novelty of the system lies in both the ultrasonic excitation and in the detection method. Two surface waves are sent along the sample: one of low amplitude and high frequency (probe wave) and one of high amplitude and low frequency (modulating wave). The modulating wave opens and closes the limbs of the defect so that the probing wave experiences a non-linear modulation, thus evidencing its existence.

In order to sense the surface motion and measure its spectrum accurately, we have opted for a PRI setup, which can be configured to detect vibration frequency components of interest without cross-talk from other vibrations, e.g. the high amplitude vibration that opens and closes the defect. Using standard interferometry, frequency mixing between the modulation frequency and the probe frequency resulting from the defect response would be scrambled by the presence of frequency mixing due to the nonlinear relation between the interferometer light intensity and the measured displacements. This work highlights that photorefractive interferometry allows for frequency sensitive detection



and enables to identify the modulated probing signal amid an intense background. [1][2][3]

An important aspect of this study is the aerospace applicability of this tool. Therefore, experimental observations were focused on plausible defects: surface breaking cracks in metallic plates and internal delamination in carbon fibre plates. The samples are observed both under static conditions as well as under a time dependent load (fatigue machine and ultrasonic horn). The results are then compared with previous experimental studies on analogous samples with different techniques [4] and numerical simulations.

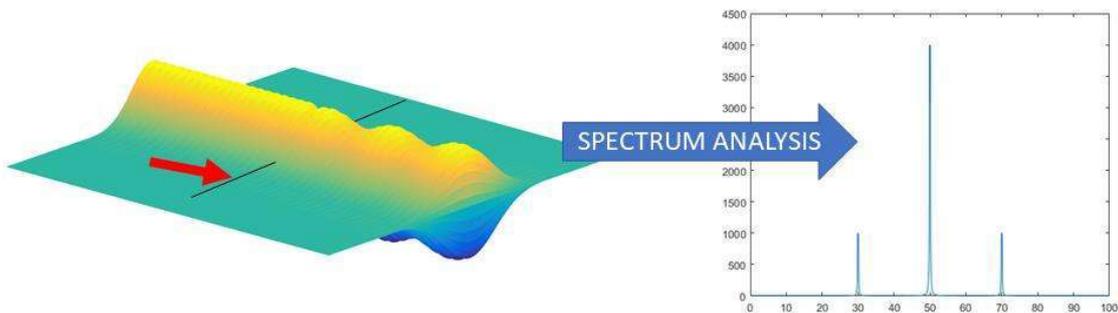


Figure 1. Exemplification of the non-linear modulation experienced by the probing surface waves. The spectrum of the transmitted wave presents two additional lobes because of the clapping effect, as shown in the plot (arbitrary units). The red arrow points at the cracks location

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References

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