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REAL-TIME DAMAGE IDENTIFICATION USING ROTATING FIELD ANALYSIS

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ABSTRACT

This paper proposes a real-time damage identification method based on the disturbance of the rotation field, which are measured using shearography technique. A particular case of phase modulation method is applied to the interference pattern in order to improve the spatial resolution of the rotation field. A program was developed in Matlab® platform for digital recording the information capture by CCD camera and post-processing the data using dedicated image techniques. The phase filter and unwrapping algorithms were optimized to allow the visualization at video rate the full-field rotations fields. For small internal damages in laminated composite plates, the results show a superior performance of the proposed technique when compared with the classical raw fringe analysis.

Keywords: multi-damage localisation, laminated plate, rotation field, speckle shearography.

INTRODUCTION

The low damage tolerance of laminated composite structures and the lack of effective and global non-destructive inspection techniques have recently motivated the development of new methodologies. The perturbation or discontinuity analysis of the rotation field and their spatial derivatives has been referred in literatures as the most promising techniques for damage localisation (Pandey, 1991; Abdo, 2002). Moreover, the accurate measurement of full-field rotation fields is required to identify small internal damages. On the other hand, the speckle interferometry techniques, such as Electronic Speckle Pattern Interferometry (ESPI) and the shearography prove to be the most suitable techniques for damage localisation (Seinchen, 2003). In particular, the shearography technique allows full-field, non-contact and high resolution measurement of the rotation field. Their low sensitivity to external perturbations makes this technique suitable to industrial applications and being the rotation measurement unaffected by rigid body movements, the discontinuities and perturbations in the rotation field, associated to the internal damages, can be rapidly identify. The classical approach for internal damage localization is based on the detection of anomalies in the raw fringe spatial distribution. Since damage localisation is supported recognition and classification of fringe patterns, the identification process fails when there aren't enough fringes produced by the external loads. This scenario can occur for small internal damages or when they are located deeply inside of the structure. Instead of the fringes pattern disturbances recognition, this paper proposes the real time analysis of local perturbation or discontinuities of rotation field for damage localisation. The rotation field is obtained by filtering and unwrapping the phase map. The phase map is obtained by the correlation of light phase from a reference and deformation states. Generally for static deformations, the determination of the light phase

requires the digital recording of four intensity interferograms with different phase step (Kreis, 2005). In our case, the phase map is obtained by recording the four intensities at the reference stated, with constant phase step of π/2, being intensity interfererogram of deformation subtract to each of reference intensity. A program was developed in Matlab® platform to digitally acquire the intensity pattern created optical interferometer and post-processing the phase maps. The phase filter and unwrapping algorithms were optimized to allow at video rate the visualization of the rotation field.

RESULTS AND CONCLUSIONS

The rotation field was measured in a carbon fibre laminated plate with two different size damages, using speckle shearography technique. The plate is fixed in one edge to a high rigidity support and mounted on an optical table, in order to impart greater stability to the assembly and experimental measurement.The thermal load was applied on one side of the plate, by heating surface during 5 seconds with a 100 W halogen lamp, rising the surface temperature in 2 ºC. The reference state was recoded after the thermal load was applied and the rotation field was monitored during the cooling process. The figure 1 shows the rotation field obtained 10 seconds after removing the thermal load. The two damages location and their difference in size can be identify through the perturbation analysis of the rotation field.

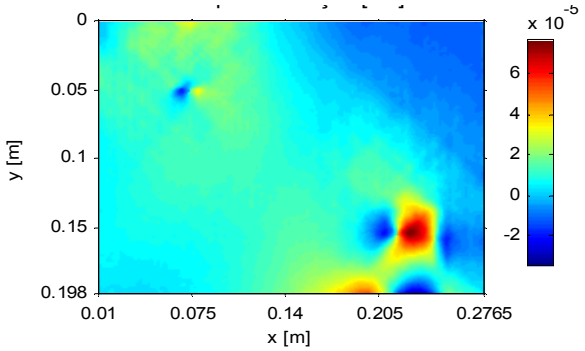

Fig. 1 - The rotation field measured during the cooling process (10 s).

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