1.3.47. MONITORING OF FATIGUE IN COMPOSITES USING AIR-COUPLED GUIDED WAVES

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Introduction. The objective of this paper is to develop a non-destructive methodology for remote monitoring of fatigue in fibre reinforced plastics induced by mechanical load. The approach is based on mode conversion of air-coupled ultrasound to flexural waves. Variations in guided wave velocity and attenuation are used as indicators of fatigue state.

Methodology. A single-sided access air-coupled configuration (fig. 1) is used for generation and detection of guided waves in specimens made of non-crimp fabric glass fibre/epoxy composites. The angles of excitation and detection are chosen from the phase matching conditions for the zero-order anti-symmetric (flexural) mode. The specimens are subjected to step-wise fatigue in tension-tension and tension-compression leading to various damage modes due to cracks in different directions and depths. An enhanced Differential Time of Flight (DTOF) method [1] based on the measurements of amplitude and phase of the output signal as functions of the distance between the transducers is used for evaluation of flexural wave velocity and attenuation.

Basic Results. The experiments demonstrate that accumulated fatigue is accompanied by decrease in flexural wave velocity and increase in attenuation of the guided wave, as shown in fig. 2. The change in guided wave velocity indicates fatigue induced stiffness degradation of the composite. The attenuation of flexural waves is influenced by internal interfaces such as cracks due to scattering. Hence, the flexural wave attenuation can be used as a measure of an increase in crack density caused by fatigue. It is shown that the combination of guided wave velocity and attenuation is a distinctive parameter, which enables to determine whether the composite is fatigued in tension-tension or tension-compression mode.

Summary. In summary, a methodology for non-destructive testing of fatigue in plate-like composite components has been developed. The results obtained are promising to stimulate further investigations.

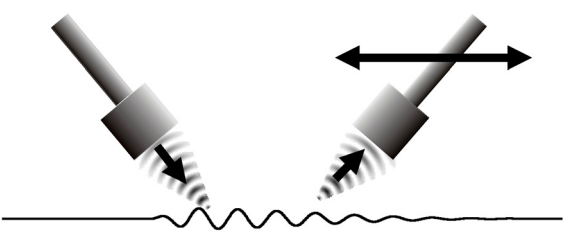

Fig. 1. Single-sided air-coupled DTOF configuration

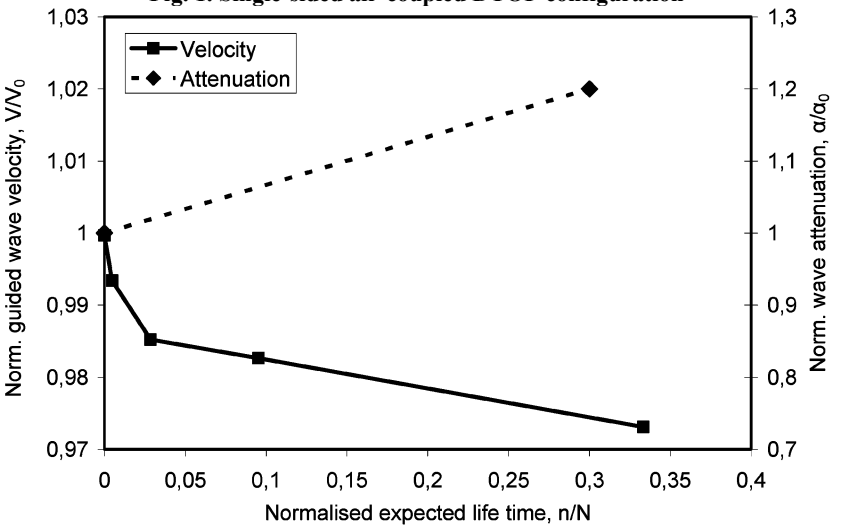

Fig. 2. Guided wave velocity and attenuation versus the number of fatigue cycles (n) normalized to estimated number of cycles at failure (N)

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References:

1. **Döring D., Solodov I., Busse G.** Air-Coupled Surface Acoustic Waves: Opportunities and Limitations for NDT Application. Proc. 4th Workshop NDT in Progress. – Prague, 2007. – pp. 51 – 62.