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Damage detection potential of a triangular piezoelectric configuration

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ABSTRACT

In this work a problem of damage detection and localization was investigated. A new configuration of piezoelectric transducers was proposed. It consists of twelve transducers. It is in a form of an equilateral triangle that has a 2×2 transducer array in each vertex. Transducers of this configuration were used to excite and register guided waves in an aluminum alloy specimen. Due to known sensitivity of these waves to structural defects it was assumed that registered waves, in the form of voltage signals, carry information about the structure condition. A special algorithm was implemented to process these signals and extract features related to damage. This algorithm transfers information from the time domain to the spatial domain. Results are mapped into coordinate system assigned to monitored structure. In this way in the case of damage present outside or inside the configuration its coordinates are highlighted. In order to detect damage on the direct path between triangle vertices a damage index is defined that indicates whether there is damage present or not. Experimental investigation included three scenarios, one for outside and one for inside localization and one for direct path detection. Results showed that this method has a potential for Structural Health Monitoring of a structure made of an isotropic material.

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1. Introduction

This work includes research belonging to the multidisciplinary subject of Structural Health Monitoring (SHM). The particular topic investigated is focused on Lamb waves propagation phenomenon used for damage detection and localization [1–4]. These waves can be excited in structures with various methods, such as angle beam transducers [3], EMATs [5], laser sources [6,7] or piezoelectric elements [8]. Similarly, wave registration can be performed by means of piezoelectric or wedge transducers. However, it seems that most of the information about Lamb wave propagation phenomenon can be achieved using 3D laser scanning vibrometry [9–11]. This method covers monitored structure with a grid of virtual points at which velocity or displacement is measured. In this way wave interaction with defects, notches, edges and stiffeners can be visualized. On the other hand, SHM system is designed to be integrated with a monitored structure. Laser scanning vibrometer method does not comply with this demand. There are also concepts of using vibrothermography in which the sensing element is a thermographic camera [12]. Nevertheless, in this approach the registration is also performed by an external device – the camera. These are the reasons for using piezoelectric transducers in order to generate and register Lamb waves. Mainly their small dimensions, negligible weight and low cost are the motivation for this. Quite recently Macro Fiber Composite (MFC) transducers have gained interest in SHM application

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