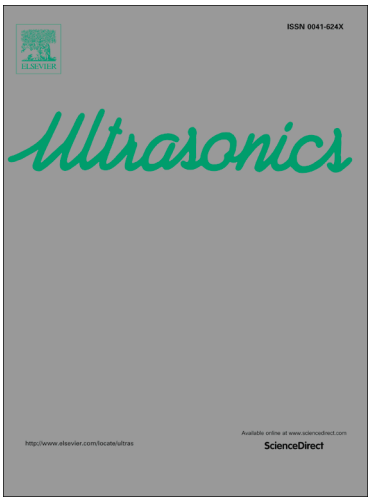

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Dispersion Curve Estimation via a Spatial Covariance Method with Ultrasonic Wavefield Imaging

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ABSTRACT

Numerous Lamb wave dispersion curve estimation methods have been developed to support damage detection and localization strategies in non-destructive evaluation/structural health monitoring (NDE/SHM) applications. In this paper, the covariance matrix is used to extract features from an ultrasonic wavefield imaging (UWI) scan in order to estimate the phase and group velocities of S0 and A0 modes. A laser ultrasonic interrogation method based on a Q-switched laser scanning system was used to interrogate full-field ultrasonic signals in a 2-mm aluminum plate at five different frequencies. These full-field ultrasonic signals were processed in three-dimensional space-time domain. Then, the time-dependent covariance matrices of the UWI were obtained based on the vector variables in Cartesian and polar coordinate spaces for all time samples. A spatial covariance map was constructed to show spatial correlations within the full wavefield. It was observed that the variances may be used as a feature for S0 and A0 mode properties. The phase velocity and the group velocity were found using a variance map and an enveloped variance map, respectively, at five different frequencies. This facilitated the estimation of Lamb wave dispersion curves. The estimated dispersion curves of the S0 and A0 modes showed good agreement with the theoretical dispersion curves.

Keywords: Ultrasonic wavefield imaging, laser ultrasonic, covariance matrix, covariance mapping, dispersion curves

1. INTRODUCTION

Ultrasonic Lamb waves are popular in non-destructive evaluation and structural health monitoring applications because they can offer an effective, relatively long range/area method to estimate the location, severity, and type of damage in structures. Lamb waves are dispersive and multimodal elastic waves that propagate along a plate of relatively small thickness. The dispersive profile of Lamb waves is typically characterized by phase and group velocity curves.

Many studies have employed Lamb waves dispersion curves themselves for damage detection and localization strategies [1-5]. Numerous group velocity measurement methods are introduced to improve the accuracy of the damage detection and localization. One of the methods, time-of-flight (ToF) measurement [6-11], has a rich history for group velocity estimation. Particularly, threshold crossing techniques [8, 10, 11] and temporal cross-correlation techniques [6, 9, 12] are typical