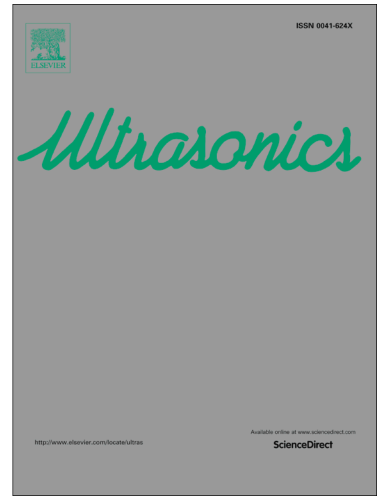

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A new wave front shape-based approach for acoustic source localization in an anisotropic plate without knowing its material properties

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ABSTRACT

Estimating the location of an acoustic source in a structure is an important step towards passive structural health monitoring. Techniques for localizing an acoustic source in isotropic structures are well developed in the literature. Development of similar techniques for anisotropic structures, however, has gained attention only in the recent years and has a scope of further improvement. Most of the existing techniques for anisotropic structures either assume a straight line wave propagation path between the source and an ultrasonic sensor or require the material properties to be known. This study considers different shapes of the wave front generated during an acoustic event and develops a methodology to localize the acoustic source in an anisotropic plate from those wave front shapes. An elliptical wave front shape-based technique was developed first, followed by the development of a parametric curve-based technique for non-elliptical wave front shapes. The source coordinates are obtained by minimizing an objective function. The proposed methodology does not assume a straight line wave propagation path and can predict the source location without any knowledge of the elastic properties of the material. A numerical study presented here illustrates how the proposed methodology can accurately estimate the source coordinates.

KEY WORDS: acoustic source localization; anisotropic structures; elastic wave propagation; wave front shape; elliptical wave front; non-elliptical wave front

1. Introduction

Structural health monitoring (SHM) has now become an integral part of infrastructure engineering in order to detect and mitigate the damage occurring in a structure at any point of its lifetime. Various events such as impact of a foreign object, formation of cracks, failure of a structural element, etc. can act as an acoustic source in a structure that generates acoustic signals which propagate through the system. An important step towards the passive health monitoring of structures is the prediction of the acoustic source location by capturing and analyzing the wave-signals generated by the source and recorded by a group of ultrasonic sensors installed at specific locations of the structure. Several studies in the past have proposed methods for acoustic source localization in isotropic structures [1–13]. A large portion of modern infrastructure elements, however, exhibit anisotropy, and development of techniques for acoustic source localization in such anisotropic structures has received attention only in the recent past. Nakatani et al. [14,15] considered the beamforming technique which is commonly applicable to isotropic plates and extended the concept to be applicable to anisotropic plates. They modified the expression of beamforming array by incorporating direction dependent wave speed and proposed a source localization technique using delay-and-sum algorithm. This method requires the knowledge of the direction-dependent velocity profile in an anisotropic plate. Kundu et al. [16,17] proposed an optimization-based technique that uses minimization of an objective function containing time difference of arrival of waves between sensors and direction-dependent velocity information. For anisotropic materials with unknown material properties (and therefore unknown direction-dependent velocity profiles), Kundu [18] and Kundu et al. [19] proposed a

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