Sensitivity of the Excitelet Imaging Algorithm on Material Properties for Isotropic Structures

P.-C. OSTIGUY, P. MASSON, N. QUAEGEBEUR and S. ELKOUN

ABSTRACT

Imaging techniques such as EUSR or Excitelet algorithms used in guided wave damage detection rely on an accurate knowledge of group or phase velocities. The problem is that variability in material properties directly affects the guided wave dispersion curves. Traditional approaches to mechanical characterization are based on ASTM standards. However, most of these techniques require numerous specimens to test and evaluate the properties of a structure within a few percents. The main goal of this paper is to assess a new integrated characterization approach to identify the mechanical properties of an isotropic structure (Young's modulus, Poisson's ratio, density) onto which imaging is performed to detect damage. The integrated characterization approach is based on a modified version of the Excitelet algorithm, where mechanical properties, instead of geometrical features, are set as the variables to be identified. This paper thus aims at evaluating the benefit of using the same array of transducers, and similar signal processing tools, to first identify the mechanical properties of the structure using a modified version of the Excitelet algorithm and then produce an image of this structure using the standard Excitelet imaging algorithm. The experimental setup consists of an aluminum plate with a 2 mm notched hole and instrumented with a linear array of seven circular elements micro-machined from bulk piezoceramic (PZT). Excitelet imaging is performed with the linear array and the characterization uses this same array and an extra PZT transducer located in the near field of the array. In this paper, low order Lamb modes are exploited for both characterization and imaging techniques. The results obtained for the properties identified with the modified Excitelet algorithm are within 1% of properties from the material supplier. Imaging results are then presented using Excitelet with both A_0 and S_0 modes at dispersive frequencies for the localization the notch. This integrated characterization algorithm combined with the Excitelet imaging technique is shown to improve the accuracy of the localization of the damage for isotropic structures.

1. INTRODUCTION

Most guided wave damage detection algorithms are based on estimation of Time of Flight (ToF) which requires knowledge of group velocity at a given frequency. Such approaches have been used within imaging techniques to process signals measured from the elements of sparse and compact arrays [1]. Among them, the Embedded Ultrasonic Structural Radar (EUSR) [2] uses a phased-array approach with a round robin procedure to image defects within the far field of the array. The localization of reflectors or defects relies, for this method, on the compactness of the envelope of the measured signal. Accurate localization can be achieved for non dispersive frequencies. Even if non-dispersive modes are injected in the structure, the accuracy and reliability of this approach can be compromised by mode conversion at discontinuities [3] and also erroneous knowledge of exact material properties, that can however be compensated by using an autofocus approach [4].

To overcome these limitations, few approaches have been proposed to extract mode-related information from time domain signals. Among these, algorithms have been proposed based on the matching pursuit approach [5]. The evaluation of various methods demonstrated that the least error on the estimate of the ToF can be achieved via dispersion compensation [6].

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Ключевые слова:

Содержание.