TOMOGRAPHY APPLIED TO LAMB WAVE CONTACT SCANNING NONDESTRUCTIVE EVALUATION

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Abstract

The aging world-wide aviation fleet requires methods for accurately predicting the presence of structural flaws that compromise airworthiness in aircraft structures. Nondestructive Evaluation (NDE) provides the means to assess these structures quickly, quantitatively, and noninvasively. Ultrasonic guided waves, Lamb waves, are useful for evaluating the plate and shell structures common in aerospace applications. The amplitude and time-of-flight of Lamb waves depend on the material properties and thickness of a medium, and so they can be used to detect any areas of differing thickness or material properties which indicate flaws. By scanning sending and receiving transducers over an aircraft, large sections can be evaluated after a single pass. However, while this technique enables the detection of areas of structural deterioration, it does not allow for the quantification of the extent of that deterioration. Tomographic reconstruction with Lamb waves allows for the accurate reconstruction of the variation of quantities of interest, such as thickness, throughout the investigated region, and it presents the data as a quantitative map. The location, shape, and extent of any flaw region can then be easily extracted from this tomographic image. Two Lamb wave tomography techniques using Parallel Projection tomography (PPT) and Cross Borehole tomography (CBT), are shown to accurately reconstruct flaws of interest to the aircraft industry. A comparison of the quality of reconstruction and practicality is then made between these two methods, and their limitations are discussed and shown experimentally. Higher order plate theory is used to derive analytical solutions for the scattering of the lowest order symmetric Lamb wave from a circular inclusion, and these solutions are used to explain the scattering effects seen in the tomographic reconstructions. Finally, the means by which this scattering theory can be used to develop Lamb wave tomographic algorithms that are more generally applicable in-the-field, is presented.