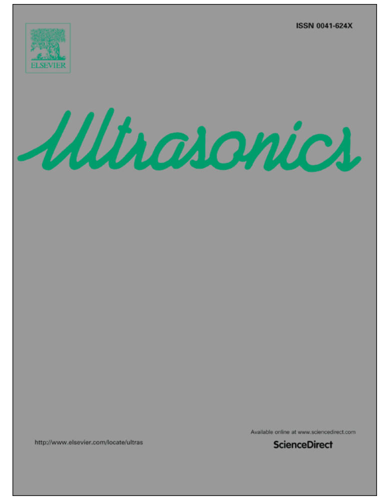

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A model assessment method for predicting structural fatigue life using Lamb waves

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Abstract: This paper presents a study on model assessment for predicting structural fatigue life using Lamb waves. Lamb wave coupon testing is performed for model development. Three damage sensitive features, namely normalized energy, phase change, and correlation coefficient are extracted from Lamb wave data and are used to quantify the crack size. Four data-driven models are proposed. The average relative error and the probability of detection (POD) are proposed as two measures to evaluate the performance of the four models. To study the influence of model choice on the probabilistic fatigue life prediction, probability density functions of the actual crack size are obtained from the POD models given the Lamb wave data. Crack growth model parameters are statistically identified using Bayesian parameter estimation with Markov chain Monte Carlo simulations. The model assessment and the influence of model choice on fatigue life prediction are made using both coupon testing data with artificial cracks and realistic lap joint testing data with naturally developed cracks.

Keywords: Lamb wave; crack size quantification; probability of detection; POD model assessment; probabilistic fatigue life prediction.

1. Introduction

Structural health monitoring (SHM) is of critical importance to the safety, reliability, and affordability of structural systems [1-3]. As one of the most common failure modes in aviation structures, fatigue damage greatly impacts the long-term durability of structures; therefore, fatigue damage diagnosis and prognosis play an important role in SHM [4, 5]. Studies have shown that guided ultrasonic waves have great potentials for diagnosis and prognosis in SHM [6-9]. As a form of elastic perturbation, Lamb wave can be used to interrogate the structural integrity [10, 11]. In particular, it is very suitable to detect material discontinuity on components with a simple geometry, such as aircraft riveted lap joint components, pipes, and thin-wall structures. Grondel et al. [12] designed an integrated experimental platform based on

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