

Experimental Analysis of Vibro-Acoustic Modulations in Nonlinear Acoustics Used for Fatigue Crack Detection

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ABSTRACT

The paper investigates experimentally nonlinear vibro-acoustic modulations. Simultaneous high-frequency ultrasonic and low-frequency modal excitations are applied to a cracked aluminium plate. This results in nonlinear wave modulations of the ultrasonic wave. Modal and crack divergence analyses together with vibrothermography are used in these investigations. The study reveals two modulation mechanisms related to nonlinear elasticity and a clear link to coupled thermo-elastic behaviour. The results show that the opening-closing crack movement is not needed when nonlinear acoustic is used for crack detection.

INTRODUCTION

Nondestructive elastic wave propagation has been used for many years to detect material defects. A vast amount of research performed in this area is based on classical and linear wave propagation. There are also some studies on nonlinear wave propagation such as quadratic and cubic stiffness nonlinearities, bi-linear behavior of opening-and closing cracks or delamination. The main problem in these studies is the nonlinear hysteresis mechanism, non-frictional-hysteretic dissipation or thermo-elastic hysteresis mechanism. Various procedures based on elastic wave nonlinearities have been developed for fatigue crack detection. These include the use of ultrasonic waves, resonance frequency shifts, slow dynamics and wave modulations. The vibro-acoustic modulations are used for fatigue crack detection in steel, concrete and aluminium composites. The method investigates ultrasonic wave modulations by modal excitation of a cracked plate. The paper presents the results of the investigation of these modulations in an aluminium cracked plate. However, previous studies demonstrate modulations sidebands in undamaged structures, which are not related to fatigue crack detection. Despite numerous theoretical and experimental investigations, the underlying mechanism behind these modulations is still not well understood.

The paper presents the results of the investigation of vibro-acoustic modulations in an aluminium cracked plate.

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Ключевые слова:

Содержание.

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