Nonlinear Guided Waves in Plates –

a New Perspective on Dispersion Characteristics Estimation

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Abstract

Guided ultrasonic waves are widely used in Structural Health Monitoring and Non-Destructive Testing techniques. Recently, nonlinear elastic waves gained much interest in this field due to potential advantages of increasing accuracy of damage detection and localization. Regardless of particular application the key idea for the development of a new monitoring strategy is to understand the fundamental phenomena associated with wave propagation. One of the basic characteristics describing wave propagation in waveguides are dispersion curves showing the wave speed (or the wave number) as a function of frequency for various wave modes. Dispersion curves are calculated for nominal linear material parameters and geometrical features of a waveguide to facilitate the development of a monitoring strategy, e.g. adjustment of excitation frequency or improvement of signal processing techniques. This is also the case for guided waves in weakly nonlinear materials. Presented work is devoted to calculation of dispersion properties of nonlinearly-elastic plates. The solution to nonlinear problem is obtained through an analytical approach based on the Lindstedt - Poincare perturbation analysis. As a result, a set of corrections to frequency (or equivalently wavenumber) due to nonlinear forcing, is calculated. It was found that spectral characteristics calculated for linear and nonlinear constitutive relationships differ, especially for high frequency waves. Consequently, the analysis of guided wave propagation phenomena within fully nonlinear framework indicated a need to revisit mode-mode energy flux and higher harmonics generation conditions.

Keywords: guided waves, nonlinear waves, dispersion curves, perturbation techniques