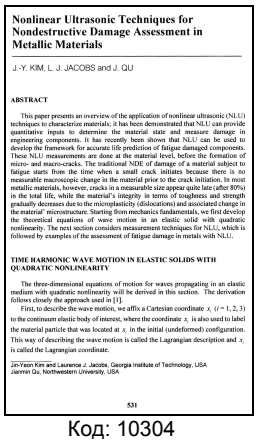

Nonlinear Ultrasonic Techniques for Nondestructive Damage Assessment in Metallic Materials

J.-Y. KIM, L. J. JACOBS and J. QU

ABSTRACT

This paper presents an overview of the application of nonlinear ultrasonic (NLU) techniques to characterize materials; it has been demonstrated that NLU can provide quantitative inputs to determine the material state and measure damage in engineering components. It has recently been shown that NLU can be used to develop the framework for accurate life prediction of fatigue damaged components. These NLU measurements are done at the material level, before the formation of micro- and macro-cracks. The traditional NDE of damage of a material subject to fatigue starts from the time when a small crack initiates because there is no measurable macroscopic change in the material prior to the crack initiation. In most metallic materials, however, cracks in a measurable size appear quite late (after 80%) in the total life, while the material's integrity in terms of toughness and strength gradually decreases due to the microplasticity (dislocations) and associated change in the material' microstructure. Starting from mechanics fundamentals, we first develop the theoretical equations of wave motion in an elastic solid with quadratic nonlinearity. The next section considers measurement techniques for NLU, which is followed by examples of the assessment of fatigue damage in metals with NLU.

TIME HARMONIC WAVE MOTION IN ELASTIC SOLIDS WITH QUADRATIC NONLINEARITY

The three-dimensional equations of motion for waves propagating in an elastic medium with quadratic nonlinearity will be derived in this section. The derivation follows closely the approach used in [1].

First, to describe the wave motion, we affix a Cartesian coordinate x_i ($i = 1, 2, 3$) to the continuum elastic body of interest, where the coordinate x_i is also used to label the material particle that was located at x_i in the initial (undeformed) configuration. This way of describing the wave motion is called the Lagrangian description and x_i is called the Lagrangian coordinate.

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Ключевые слова:

Содержание.

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