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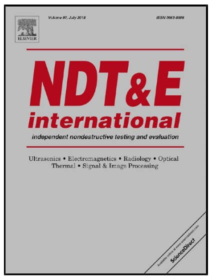

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Nonlinear Lamb Wave Mixing for Assessing Localized Deformation during Creep

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Abstract

Nonlinear ultrasonic is known to be a promising technique to characterize the microstructural degradation in engineering materials. This work demonstrates the use of nonlinear Lamb wave mixing technique to assess the localized deformation in modified 9Cr-1Mo steel during creep. Two Lamb wave modes of different frequencies (ω_1 & ω_2) are allowed to mix within the material under certain resonant condition to generate third type of harmonic waves of frequencies ($\omega_1 \pm \omega_2$). This new generated wave carries the information of material nonlinearity from the mixing site and independent of the other extraneous nonlinear factors. Amplitude of the generated third wave depends on the third order elastic constants of the material. This study reveals that nonlinear Lamb wave mixing technique could be used to assess the localized deformation much prior to its failure.

Keywords: Lamb wave mixing; Nonlinear ultrasonic; Localized deformation; Modified P91 steel

1. Introduction

Nonlinear ultrasonic (NLU) technique has shown to be a potential NDE tool due to its ability to characterize damage much prior to the failure. It uses the interrogation signals at frequencies other than the excitation frequency to detect changes in structural integrity and characterization of material degradation [1]. It relies on the nonlinear stress-strain behavior or nonlinear Hooke's law that is dominated by higher order elastic constants in isotropic elastic solid. Initial sinusoidal elastic wave gets distorted and generates higher order harmonics in presence of nonlinearity within the materials. This NLU technique assesses the average nonlinearities over the region between transmitter and receiver; so, spatial resolution is limited. But the major problem in NLU technique/ harmonic generation is to distinguish the causes of nonlinearity. Because, there are multiple extraneous sources that generate higher harmonics beside material nonlinearity and these may be the instrumentation of the measurement system, coupling media or other external factors [2]. So, the measured nonlinearity includes the material nonlinearity along with the nonlinearities generated from extraneous sources.