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Quantitative Estimation of Nonlinearity Parameter of Noised Lamb Waves using a Chaotic oscillator

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Abstract: Because of the difficulty in quantifying weak nonlinear Lamb waves in strong noises, the second harmonic generated by material nonlinearity or microcontact crack is detected using the Duffing-Van der Pol oscillator (DVPO), and its relative intensity is quantified based on the periodic trajectory area exponent (PTAE) of the oscillator output. In this paper, the windowed harmonic is amplified by different magnification factors and then fed into the DVPO. The linear fitting relationship between the amplification factor and the PTAE is established, from which the absolute amplitude of the second harmonic is estimated. The simulations on aluminum plates with different sizes of contact microcracks validate that the PTAE can quantify the intensity of the second harmonic generated by contact microcracks. Moreover, the experimental data of aluminum plate also demonstrate that the proposed method can more accurately quantify the material nonlinearity in a noisy environment than other conventional denoising methods.

Key words: nonlinear Lamb waves; nonlinearity parameter; Duffing-Van der Pol oscillator; periodic trajectory area exponent

1. Introduction

Material nonlinearity (e.g., degradation of material property, material microstructural change, residual stress, and plasticity induced by dislocation) and various material microdefects (e.g.,