Nonlinear Ultrasonic Imaging method for Evaluating Fatigue Damages using a Dual Element Transducer

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A contact pulse-echo nonlinear imaging method is proposed for early damage detection and localization in solid materials. A dual element transducer is designed and manufactured, and the transducer is clamped in a fixture device for the purpose of scanning. In order to improve the signal-to-noise ratio of harmonic waves, the nonlinear ultrasonic wave fields are modeled, the effects of driving frequencies on the measured harmonic waves are investigated, and inspection parameters are well selected. The proposed method is introduced for scanning and imaging a stainless-steel specimen before and after fatigue damage (compact tensile test). Experimental results for the specimen in the initial state show that both the fundamental and second harmonic waves are well measured, and the imaging of nonlinear parameters is very stable over the scanning area. The imaging results for the damaged specimen show different behaviors: the amplitudes of fundamental waves decrease near the fatigue crack while the amplitudes of second harmonic waves increase; in the potential growth area of the fatigue crack, the second harmonic waves also vary significantly even though the fundamental waves remain the same. These results indicate that the proposed method is effective for nonlinear ultrasonic imaging and early damage localization. The factors affecting the nonlinear waves in the lab experiments and possible problems in practical applications are also discussed for the proposed method.