Localization of Plastic zone in crack tip using the non-collinear ultrasonic waves mixing

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Background

Non-collinear nonlinear ultrasonic mixing has been recently employed to evaluate length and orientation of fatigue crack owing to its sensitivity to material degradation. Evolution of plastic zone in crack tip can predict the propagation of micro-crack. In this paper, plastic zone of crack tip in structural damage was detected and localized using non-collinear ultrasonic wave mixing, in which the method proposed could be used to track the crack propagation.

Statement of Contribution

Three-point bend experiment were carried out on 7075 aluminum alloy specimens using single pressure to prefabricate plastic zone at the tip of sharp notch. Ultrasonic wave signals were excited by RAM 5000 system with a 20-cycles Hanning-windowed sinusoidal tone burst at a frequency of 5MHz. When two shear waves intersect at a certain angle in the plastic zone, a third longitudinal resonant wave at 10MHz would be generated in the intersection region (Fig.1). The mixing nonlinear parameter of different points were measured by changing the position of two transducers with a step of 5mm.Plastic zone could be characterized by these nonlinear parameters at mixing region, and even located by the nonlinear parameter of different points in scanning area of specimens(Fig.2).

Results

The plastic zone was contoured(Fig.3) by the mixing nonlinear parameters using resonant wave signals after fast Fourier transform(FFT). The red region means that the area has the largest nonlinear parameter, and this area fits well with the position of plastic zone in the middle of specimen closed to the tip of sharp notch. The result shown Non-collinear ultrasonic mixing could locate plastic zone in crack tip in the aluminum alloy.

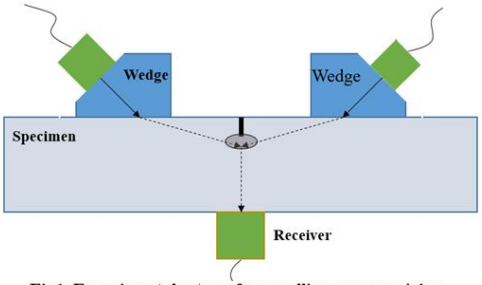

Fig1: Experimental setup of non-collinear wave mixing

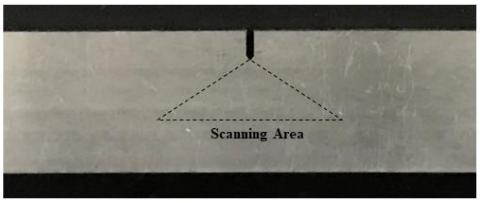

Fig2: The specimen with plastic area

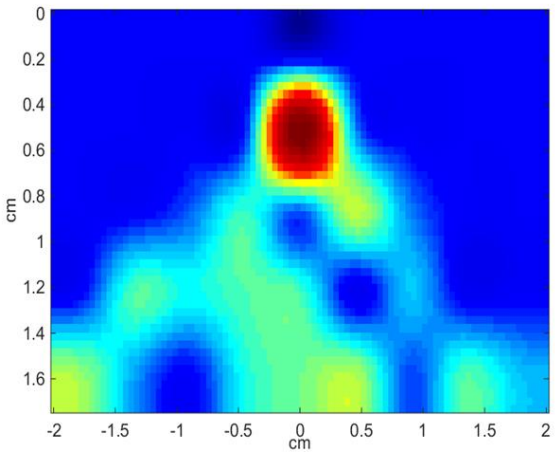

Fig3: The imaging of mixing nonlinear parameter for the specimen with plastic zone