Evaluation and locating of plasticity damage using collinear mixing waves

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Background, Motivation and Objective

Metallic materials are widely used in engineering components, while the plastic deformation is one of the main damages in such structures that will cause an early failure within the structures. To ensure structural safety, it is important to evaluate and locate the plastic deformation at an early stage. In this study, the possibility of evaluation and locating the plasticity damage using collinear mixing waves was first demonstrated based on a finite element model; and experimental measurement was conducted to evaluate and locate the plasticity damage in Q235 steels specimens with different plastic damages.

Statement of Contribution/Methods

The collinear wave mixing method was numerically studied using the commercial finite element software ABAQUS. Dimension of the finite element model is 72.3 mm × 20 mm. Four cases were considered. Case 1 is a linear elastic material without plastic damage. Case 2, case 3, case 4 have localized plastic damage at different position. The transverse wave with 5 cycles was excited by imposing tangential displacement on the left side, and the longitudinal wave with 10 cycles was excited by imposing longitudinal displacement on the right side. Collinear wave mixing experiments were carried out for Q235 steels with plastic deformations at different locations. In the measurements, transverse waves with frequency of 2.5 MHz and longitudinal waves with frequency of 11.09 MHz were excited from the left and right side of the specimens, respectively. The received resonant signals were processed using fast Fourier transform.

Results/Discussion

The simulation results show that when two waves mix at the linear elastic zone, there are no resonant wave; when they mix at the plastic damage zone, a resonant transverse wave will be generated with difference frequency. The amplitude of resonant wave in the plastic damage zone is higher than that in linear elastic zone at same position. The results of scanning experiments show that the distribution of plastic deformation within each sample agreed well with the simulation results. The locations of the plastic zone can be identified clearly.