Defect and thickness imaging using laser-generated ultrasonic waves at the thermoelastic regime

Nguyen Tien Dung[1], Yoshio Arai[1]

[1]Graduate school of science and engineering, Saitama University, Japan

Detecting cracks is essential for maintaining structural integrity, preventing potential catastrophic failures, and ensuring the overall safety and reliability of materials and components. Recently, non-destructive testing based on laser ultrasound techniques has been widely applied to evaluate products based on the advantages of non-contact and fast evaluation. The interaction of ultrasonic waves at the defect and the back surface of the sample generates multiple reflected wave modes that can be detected using the receiving laser, providing information that enables the detection of unexpected defects. This study proposes a method to calculate the thickness and location of a defect in the sample without prior knowledge of ultrasonic wave velocities using laser-generated ultrasonic waves at the thermoelastic regime. Firstly, the combination of the skimming longitudinal wave, reflected shear wave, and mode-converted wave from the back surface is used to calculate the thickness and wave velocities. The depth and horizontal distance of the crack tip are then determined using a combination of diffraction signals. Moreover, scanning a 5-mm-thick aluminum sample with an inner crack from the back surface is conducted to create a time-position image of multiple wave modes. An algorithm is used to convert this image into a two-dimensional visualization that shows the location of the crack tip and the thickness of the material. The comparison between the experimental results and the actual geometry of the back surface demonstrates the reliability of the proposed approach.