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Application of Ultrasonic Waves Towards the Inspection of Similar and Dissimilar Friction Stir Welded Joints

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ABSTRACT

Crack detection in welded structures of dissimilar material using guided waves is not well developed. This paper scrutinizes the effect of material discontinuity in plate structures and the excessive plastic deformation, within friction stir welded (FSW) joints, on the propagation behavior of guided waves towards their application in weld assessment. Quantifying the scattering, attenuation and group velocities of the guided waves when they propagate across different media, as well as determining the elastic properties of the material within the weld will provide rich information about the behavior of ultrasonic waves.

Three pristine defect free friction stir welded plates were used in this study. The first specimen was a weld of dissimilar materials aluminum/magnesium alloy (AA6061-T6/AZ31B), the second was of dissimilar aluminum alloy grades (AA6060/AA7020-T651), and the third was of the same aluminum grade (AA7020-T651/AA7020-T651). The elastic properties across all the welds were extrapolated using nano-indentation technique. Ultrasonic guided waves were excited and measured using piezoelectric wafers and laser Doppler vibrometer (LDV). Additionally, a sensor network design was implemented on the three specimens using piezoelectric transducers.

Wave reflections, based on the LDV results and the information collected from the sensor network, were observed at the weld zone of the AA6061-T6/AZ31B FSW plate, while no reflections were detected at the weld zones in the AA7020-T651/AA7020-T651 and AA6060/AA7020-T651 plates. The results were correlated with the measurements obtained from the nano-indentation experiment, where a sharp change in the elastic properties of the base metals in the AA6061-T6/AZ31B welded joint were detected, unlike the other two plates that showed constant elastic properties across the weld zones. The results showed that the amount of scattering at the joints is a function of the wave propagation direction. It was noticed that the average wave reflection generated when the wave crossed from the AZ31B to the AA6061-T6 base metal was around 35% of the incident signal, but it reduced to 25% when the wave propagation direction was reversed.

Characterizing ultrasonic waves in FSWs and the behavior of the incident and reflected waves in the welded zones will further improve on the technology used for inspection and monitoring of solid state welded joints.

Keywords: Guided waves, Material discontinuity, Friction stir welding, Frequency-wavenumber filtering technique, CT-scanning.