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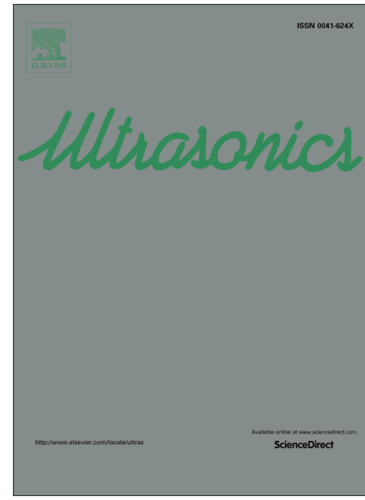

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Dynamics of Ultrasonic Additive Manufacturing

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Abstract

Ultrasonic additive manufacturing (UAM) is a solid-state additive manufacturing technology for joining similar and dissimilar metal foils together near room temperature by scrubbing them together with ultrasonic vibrations under pressure. Structural dynamics of the welding assembly and work piece influence how energy is transferred during the process and ultimately, part quality. To understand the impact of structural dynamics during UAM, a linear time-invariant model is used to relate the inputs of shear force and electric current to resultant welder velocity and voltage. Measured frequency response and operating performance of the welder under no load is used to identify model parameters. Using this model and in-situ measurements, shear force and welder efficiency are estimated to be near 2000 N and 80% when welding Al 6061-H18 weld foil, respectively. Shear force and welder efficiency has never been estimated before in UAM. The influence of processing conditions, i.e., welder amplitude, normal force, and weld speed, on shear force and welder efficiency are also investigated. Welder velocity was found to strongly influence the shear force magnitude and efficiency while normal force and weld speed showed little to no influence. The proposed model is also used to describe high frequency harmonic content in the velocity response of the welder during welding operations and coupling of the UAM build with the welder.

Key words:
A. ultrasonic additive manufacturing (UAM), B. ultrasonic welding, C. LTI modeling, D. frequency response function (FRF) estimation, E. piezoelectrics, F. in-situ measurements

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