Ultrasonic Vibration-Assisted Direct Energy Deposition 3D Printing of Aluminum Alloy 7075

L. Mutswatiwa[1], J. A. Todd[1], E. W. Reutzel[2], B. Sawyer[2], C. D. Jamieson[2], C. M. Kube[1]*

[1]Engineering Science and Mechanics, The Pennsylvania State University, 212 Earth and Engineering Sciences Building, University Park, 16802, PA, USA.
[2]Applied Research Laboratory, The Pennsylvania State University, 230 Innovation Blvd, University Park, 16802, PA, USA

Abstract: Additive manufacturing (AM) offers advantages, including geometric flexibility and material grading capabilities over conventional fabrication techniques. However, the range of printable alloys is restricted due to solidification cracking and intolerable microstructures. Direct energy deposition (DED) 3D printing of Al7075 alloy results in composition gradients, porosity, and liquation and solidification cracking because of the vaporization of low melting temperature alloying elements such as zinc and magnesium. In addition, components fabricated via DED are known to have columnar grains along the build direction, resulting in mechanical property anisotropy. Solidification manipulation through ultrasonic melt processing presents a promising solution for microstructural refinement and defect reduction in DED AM. Through Al7075 direct energy deposition 3D printing on substrates vibrated at an ultrasonic frequency, we explored the influence of vibration amplitude and intensity on melt pool surface dynamics and solidification structure. We custom-designed an Al7075 rectangular substrate, equipped with a high-power ultrasonic transducer, for installation in the DMG MORI LASERTEC65 Hybrid AM system. The substrate was engineered to excite the second transverse bending vibration mode at 19.3 kHz. Additionally, a high-speed phantom camera was used to capture the influence of ultrasonic vibration on melt pool surface dynamics. Single tracks, single-layer, and multiple-layer specimens were deposited on the substrate at several different ultrasonic vibration amplitudes and excitation powers. This research correlates the effect of ultrasound on melt pool dynamics with microstructural development, detailing the roles of ultrasonic parameters.