In Situ Ultrasonic Measurements During Additive Manufacturing

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As additive manufactured components increase in use, NDE is needed to inspect for measure build height and rate, inspect for flaws, and characterize the microstructures during building. Ultrasonic properties were measured in-situ during direct energy deposition of additive manufactured materials. The measurements were performed on both single material builds of IN625 and bimetallic builds of IN625 with stainless steel. The ultrasonic time of flight and amplitude from the build surface was used to measure the build rate, build height, layer height, and to monitor the melt pool dynamics. The ultrasonic backscattering was used to measure changes to the grain size.

The single material build of IN625 was performed with and without melt pool temperature control to understand the melt pool temperature on sample size and material properties. The in-situ ultrasonic measurements of build rate, build height, and layer by layer height of the sample without melt pool temperature control was 1.5 smaller than the build with melt pool temperature control. In addition, the ultrasonic backscattering was lower in the sample without melt pool temperature control. The ultrasonic measurements corelated with measurements of the microhardness, grains and texture of the materials.

Two of the key needs for NDE of bimetallic materials is to monitor the quality of the fusion between the two materials and continuity of the build rate. Ultrasonic measurements during AM builds of bimetallic stainless steel on top of IN625 clearly showed the transition between the materials and the repercussions of directly transitioning between the metals vs. a gradual transition where the amount of the second material was incrementally increased over three layers. The ultrasonic measurements also showed the build rate and layer height decrease by a factor of 2 for the top layer. Indications of overbuilding, where the materials being deposited adhered to the side of sample rather than the top causing the build rate to decrease, were also evident in the ultrasonic measurements.

Thes data show the feasibility for using ultrasonic measurements to monitor and control the AM machine during building to optimize component properties and microstructure. In the next steps these ultrasonic measurements fed directly into the AM machine to enable used closed loop feedback during the build so that the AM machine can automatically adjust the build parameters based on ultrasonic measurements.