Ultrasonic Nondestructive Characterization of Hybrid Additively Manufactured 420 Stainless Steel

Luz D. Sotelo[1], Cody S. Pratt[2], Haitham Hadidi[2], Michael P. Sealy[2], Joseph A. Turner[2]

[1]School of Mechanical Engineering, Purdue University, USA, [1]Department of Mechanical and Materials Engineering, University of Nebraska - Lincoln, USA

Additive Manufacturing (AM) is ideal for creating customized high-value components, which are often made in low volumes. An added benefit of the Directed Energy Deposition (DED) process is the ability to make functionally graded materials. This expansion of the design and manufacturing parameter spaces presents a challenge for the nondestructive evaluation (NDE) of AM parts. Hybrid AM components are an example of functionally graded materials for which the variation in microstructure and material properties is achieved through a synergized combination of manufacturing processes and/or energy sources. In this work, a hybrid 420 stainless steel coupon was made by combining the DED process with a cyclic surface laser treatment. A separate coupon was made in the same DED system without undergoing the hybrid process. Additionally, a wrought coupon was acquired to compare the AM and hybrid AM samples to a conventionally manufactured sample of the same material. Micrographs of all the samples were obtained using optical and scanning electron microscopy. Furthermore, the hardness profile and phase velocity, attenuation, and backscatter responses were measured across the axial (build) direction of the hybrid AM, AM, and wrought coupons. The results show excellent agreement between destructive and nondestructive measurements, highlighting the potential of ultrasonic methods for the efficient characterization of hybrid AM components. The potential limitations of these characterization approaches are discussed. [Research support by the United States National Science Foundation].