NextManufacturing
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# Fatigue and damage tolerant performance of wire and arc additively manufactured austenitic stainless steel

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## ABSTRACT

The viability of modern engineering structures and materials requires actively designing against cyclic damage, which accounts for the largest majority of mechanical failures. While additive manufacturing (AM) offers numerous advantages to conventional manufacturing techniques, the cyclic behavior of AM parts must be characterized before they can be safely used in areas such as the aerospace and biomedical industries. Directed energy deposition (DED) wire and arc additive manufacturing (WAAM) of austenitic steel components and their behavior under cyclic loading was investigated. Damage tolerant design parameters were determined from experimental testing in an effort to deduce location-dependent properties and to compare to published data for the conventional material. Further scanning electron microscopy (SEM), light optical microscopy (LOM), x-ray diffraction (XRD), and electron backscatter detection (EBSD) investigation showed compressive residual stress, texture and large grain sizes resulting from high thermal gradients in the AM process. Additionally, "Safe Life" analyses were undertaken for WAAM austenitic steel. Experimental results of the cyclic response match closely with literature for wrought austenitic steel, with differences possibly due to strengthening mechanisms such as deformation twinning or austenite to martensite transformation. From this research it was primarily discovered that continuum scale analysis of DED AM components can be reasonably utilized to characterize their performance; however more accurate understanding of complex material behavior is only possible via micromechanical experiments and modelling. This finding motivates further investigation of the deformation response of additively manufactured metals using multiscale efforts such as crystal plasticity modeling and probabilistic simulation techniques to develop optimized microstructures.

## BIOGRAPHY

Jerard Vincent Gordon obtained his B.S., M.Eng and Ph.D in mechanical engineering from Lehigh University. For his doctoral research, he studied the cyclic behavior of wire and arc additive manufactured of type 304L stainless steel. He is currently a CMU President's Postdoctoral Fellow in the NextManufacturing Center and College of Engineering at Carnegie Mellon University.