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Prediction of Material Behavior for LENS Manufactured Products

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The Laser Engineered Net Shaping (LENS) process is an additive manufacturing process in which a high power laser is used to melt successive layers of metal powder which accumulate to yield a final product requiring little to no rework. In this process a jet of metal is sprayed into the focal point of a laser via nozzles which melt the powder. This melted powder gets deposited on the surface of the subsequent layer and solidifies as it is cooled. The layer by layer addition of metal produces the final three-dimensional component. This process can be used to develop intricate components without the need for costly dies and without the need for additional manufacturing processes. However, the material behavior of the final product is not straightforward to predict due to the varying and complex microstructure [1]. The introduction of oxide inclusions and the process parameter dependent void sizes and distributions cause variability in final product behavior. Herein we use a shear-modified Gurson-Tvergaard-Needleman (GTN) [2] model implemented in LS-DYNA to attempt to predict the behavior of LENS manufactured materials from a void-mechanics point of view. Analysis of the stress-strain behavior and the damage evolution of LENS manufactured products are presented. The primary goal of this research is to one day bridge the knowledge gap between process parameter selection in the LENS process with the final product behavior such that we can use mechanics-based FEA simulations to inform process parameters to yield the most effective final product behavior for specific applications. Included in these product-specific material behaviors may be the hardening behavior, softening behavior or perhaps even fracture toughness [3]. We further hope to use this framework to predict fracture properties and behavior for LENS manufactured products thereby attempting forming a bridge between advanced manufacturing and materials design.

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