Study of Material Consolidation at Higher Throughput Parameters in Selective Laser Melting of Inconel 718

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Selective Laser Melting (SLM) is a powder bed fusion additive manufacturing process used increasingly in the aerospace industry to reduce the cost, weight, and fabrication time for complex propulsion components. SLM stands poised to revolutionize propulsion manufacturing, but there are a number of technical questions that must be addressed in order to achieve rapid, efficient fabrication and ensure adequate performance of parts manufactured using this process in safety-critical flight applications. Previous optimization studies for SLM using the Concept Laser M1 and M2 machines at NASA Marshall Space Flight Center have centered on machine default parameters. The objective of this work is to characterize the impact of higher throughput parameters (a previously unexplored region of the manufacturing operating envelope for this application) on material consolidation. In phase I of this work, density blocks were analyzed to explore the relationship between build parameters (laser power, scan speed, hatch spacing, and layer thickness) and material consolidation (assessed in terms of as-built density and porosity). Phase II additionally considers the impact of post-processing, specifically hot isostatic pressing and heat treatment, as well as deposition pattern on material consolidation in the same higher energy parameter regime considered in the phase I work. Density and microstructure represent the “first-gate” metrics for determining the adequacy of the SLM process in this parameter range and, as a critical initial indicator of material quality, will factor into a follow-on DOE that assesses the impact of these parameters on mechanical properties. This work will contribute to creating a knowledge base (understanding material behavior in all ranges of the AM equipment operating envelope) that is critical to transitioning AM from the custom low rate production sphere it currently occupies to the world of mass high rate production, where parts are fabricated at a rapid rate with confidence that they will meet or exceed all stringent functional requirements for spaceflight hardware. These studies will also provide important data on the sensitivity of material consolidation to process parameters that will inform the design and development of future flight articles using SLM.