Paper ID: 84083
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advancements in Materials Applications, Additive Manufacturing, and Rapid Prototyping Manufacturing and Rapid Prototyping (8)

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BINDER JETTING OF LUNAR REGOLITH: 3D PRINTING AND DENSIFICATION

Abstract

The establishment of a human presence on the Moon necessitates the development of sustainable technologies for in-situ resource utilization (ISRU), enabling the conversion of lunar resources into functional raw materials. Binder jetting (BJT) is promising for employing regolith, the material found on the lunar surface, as a feedstock for additive manufacturing (AM). This approach offers several advantages, such as the layer-by-layer creation of complex and customized structures catering to specific needs and functionalities, the potential for automation (minimizing the need for human intervention), and the simple processing of components without the need for high-energy sources as laser or electron beams. However, implementing binder jetting on the Moon presents unique challenges. The lunar regolith, with its extremely fine, jagged particles necessitates the optimization of the printing process and the understanding of densification mechanisms from a loosely packed green body to achieve the desired mechanical properties. In this study, an analysis of the printing parameters, such as layer thickness (50-100 m), binder saturation (70-90%), and drying conditions, on the semi-finished and final components was performed to obtain a consistent and reliable fabrication of parts in terms of packing density and geometrical accuracy. The effect of feedstock granulometry and composition was considered to determine whether it affects the consolidation of parts. Regarding sintering, holding time and temperature were varied to assess the evolution of residual porosity and chemical composition according to the thermal treatment performed. Optical and scanning electron microscopies were employed to determine the distribution of voids, which were revealed to be correlated to the initial layerwise buildup of specimens. Energy dispersive x-ray spectroscopy combined with x-ray diffraction identified the formation and distribution of Al-, Si-, Fe-, and Ti-based oxides. Finally, preliminary mechanical testing (e.g. 3-point bending test) was conducted to determine the strength of the densified components and anisotropic response owing to internal microstructural features.