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ADDITIVE MANUFACTURING OF LUNAR REGOLITH VIA RESIN-BASED BINDER AND MATERIAL EXTRUSION METHOD FOR HIGH-PERFORMANCE IN-SPACE MANUFACTURING ON THE MOON

Abstract

With the continuous advancement of lunar exploration missions by countries such as the United States, Europe, and China, lunar exploration and the utilization of lunar resources have become hot research topics. In particular, the utilization of lunar regolith for in-situ construction on the lunar surface has emerged as a technical challenge among in-space manufacturing field. In-situ construction using lunar regolith as raw material has the potential to reduce the demand for Earth resources in lunar missions, while providing increased flexibility and maintenance support for lunar tools, facilities, and base construction activities. This study proposes a lunar regolith manufacturing method based on high-performance resin bonding, characterized by high regolith content and forming strength. Firstly, a composite resin material with both thermosetting and photosetting properties is developed, which is then mixed with lunar regolith to prepare regolith slurry. This slurry can be directly molded by compression or extrusion-based additive manufacturing. The prepared material can self-cure under high temperatures and ultraviolet radiation during lunar daytime, reducing energy requirements and meeting lunar construction needs. The study extensively investigates material formulation and forming processes, examining the effects of different additives types and contents, regolith mass ratios, and process parameters on the properties of the prepared slurry and formed specimens. The mechanical performance, dimensional accuracy, microstructure, thermal insulation properties of the forming samples and its tolerance of harsh lunar environmental conditions were further investigated. The maximum lunar regolith mass ratio achievable is up to 90 wt%, with compression strength of cast specimens exceeding 60 MPa and mechanical strength of printed specimens surpassing 30 MPa. Experimental results also demonstrate that the proposed technological approach exhibits good resistance to vacuum, high-low temperature cycling, and ultraviolet irradiation of lunar environment. This technology holds promise for playing a significant role in future lunar regolith based in-site construction on the moon.