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DIRECT EXTRUSION OF PHOTOPOLYMERS (DREPP): INFLUENCE OF MICROGRAVITY AND VACUUM ON AN IN-SPACE MANUFACTURING METHOD

Abstract

Conventional spacecraft design and manufacturing suffers from severe limitations: Long and high-cost development phases in which structures are designed and tested. Structures are oversized due to the high launch loads. Dimensions of antennas and solar panels are constrained by the launch fairing. In Space Manufacturing (ISM) and especially Additive Manufacturing (AM) could be a solution to reduce these limitations. Fundamental investigations on AM in space have already been carried out on the International Space Station (ISS). The numerous performed test prints have shown that Fused Deposition Modeling (FDM) and Stereolithography (SLA) provide satisfactory results under microgravity and controlled environmental conditions. A method for the use in open space utilising Direct Robotic Extrusion of Photopolymers (DREPP) to manufacture structures in a cost- and power-efficient way is examined in this paper. In the presented process a photoreactive resin is robotically extruded through a nozzle and directly cured by UV-light. In opposition to conventional AM methods, which manufacture layer-by-layer, the technology is able to create three-dimensional structural elements in one continuous movement. In order to investigate its feasibility under microgravity conditions, experiments are conducted during parabolic flights. The evaluation shows that the curing zone – the transition area between the liquid and the cured state of the extruded resin – can be larger compared to 1G conditions. This contributes to an increased overall process stability. In addition, a simplified version of the DREPP approach is tested on a sounding rocket. This investigation provides particular insight into the reciprocal influence of vacuum and microgravity on the extrusion and cure of the photopolymer. By conducting and evaluating the various experiments, the process can be better understood and improved on the way to maturity.