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ENDLESS PHOTOPOLYMER TUBE EXTRUSION FOR ON-ORBIT MANUFACTURING OF SATELLITE BOOMS

Abstract

A concept and its challenges for on-orbit production of continuous thin-walled booms for CubeSat applications is presented in this paper. The method is intended for the use in free space, involving an endless photopolymer tube extrusion process to produce satellite booms in a cost-, volume-, and energy-efficient manner. This technology is expected to outperform conventional deployable booms, which generally suffer from severe limitation: long and high-cost development phases, oversized elements to survive the high launch loads, mechanical complexity as well as constraints to the maximum structure size due to the limited volume in a satellite. In-Space Manufacturing (ISM) and especially Additive Manufacturing (AM) offer a solution to reduce these limitations. Fundamental investigations on AM in space have already been carried out on the International Space Station (ISS). Numerous test prints have shown that Fused Deposition Modeling (FDM) and Stereolithography (SLA) provide satisfactory results under microgravity and controlled environmental conditions. The concept proposed in this paper is based on the Direct Robotic Extrusion of Photopolymers (DREPP), which has been under scientific investigation at the Munich University of Applied Sciences (MUAS) since 2017. Experiments on the fabrication of small truss structures in microgravity as well as investigation of the behaviour of photopolymer has been successfully carried out in 2020 as part of the European Space Agency (ESA) student programme FlyYourThesis!2020. In this paper we present the technology, the current problems as well as first successful extrusions of tube segments with a length of up to 100 mm, an outer diameter of up to 23 mm, and a wall thickness of 2-3 mm . Nevertheless, curing the resin without clogging the nozzle is one major challenge of the process. Inhibiting curing of the edge layer of the photopolymer is one investigated solution to reduce the adhesive strength between the resin and nozzle. Another approach is that the curing of the resin is done outside the nozzle, which has already been tested positively. To fulfil future satellite applications, the end of the tube is intended to be connected to a payload (e. g. for flexible solar arrays or sensitive instruments), which is simultaneously deployed while extruding the photopolymer tube. In addition, the goal is to meet CubeSat-dimension standards and to extrude booms longer than 2 m from a 1 U CubeSat.