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IN-SPACE MANUFACTURING BY PHOTOPOLYMER EXTRUSION: INVESTIGATION OF DIFFERENT PHOTOPOLYMERS UNDER HIGH VACUUM CONDITIONS

Abstract

In this paper, experiments are presented in which various photopolymers are exposed to vacuum in their liquid state. Thereby, a method is shown to observe how the material behaves in vacuum on a macroscopic level. More precisely, it is observed whether volatile components of the resin evaporate by measuring the mass loss and how it can be avoided to introduce air into the system during filling procedures. In additional, it will be investigated how the resin behaves under high vacuum when it is extruded through a nozzle. The experiments are based on identified artefacts observed from photopolymer specimens that have been recently manufactured in space. A variety of photopolymers are compared in order to assess their usability under vacuum influence. Photopolymers have a great potential to be used as materials for in-space manufacturing but also for human spaceflight and planetary exploration. The reason for this is the simplicity of its use: No high temperatures are required for processing, which simplifies cooling in vacuum. In addition, the curing of the polymer requires little energy and since it is a liquid it can be stored very compactly. However, the material must be able to withstand the influences of space what includes high vacuum, weightlessness, strong temperature fluctuations and harsh UV-radiation. The Munich University of Applied Sciences is conducting research on an additive manufacturing process for in-space manufacturing called direct robotic extrusion of photopolymers (DREPP). Extensive laboratory tests have been carried out for this purpose, and the technology has already been tested in weightlessness during parabolic flights and on a sounding rocket in space. In-space manufacturing will be a key technology in the future for the manufacturing of large structures for satellite applications. These can be structures for solar arrays, antennas or satellite booms. Structures manufactured in space do not have to withstand high launch loads but can be designed for the mission loads in orbit. It is therefore expected that this will result in a lower overall mass and high packing efficiency compared to conventional deployable structures. By using additive manufacturing in space, the freedom in design is increased, which is expected to lead to more rigid structures and better scalability for future missions.