IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

Author: Mr. Darren Berlein
LIQUIFER Systems Group, Austria

Mrs. Monika Brandić Lipińska
LIQUIFER Systems Group, Austria
Mr. Constantin Schuler
Aalen University of Applied Sciences, Germany
Mr. René Waclavicek
LIQUIFER Systems Group, Austria
Dr. Anna Barbara Imhof
Liquifer Systems Group (LSG), Austria
Mr. Denis Schreider
Aalen University of Applied Sciences, Germany
Dr. Miranda Fateri
Aalen University of Applied Sciences, Germany
Mr. Matthias Wirth
RWTH Aachen University, Germany
Dr. Alexander Niecke
RWTH Aachen University, Germany
Dr. Advenit Makaya
European Space Agency (ESA), The Netherlands

FFLD EVERYDAY HARDWARE FABRICATION TO SUPPORT LUNAR ACTIVITIES: ADVANCING SUSTAINABLE LUNAR EXPLORATION THROUGH FUSED FIBER LAYER DEPOSITION 3D PRINTING USING LUNAR REGOLITH

Abstract

In-Situ Resource Utilisation (ISRU) is an essential strategy for achieving sustainability in lunar exploration, aiming to reduce reliance on Earth-based resources. This paper explores the utilisation of lunar regolith in Additive Manufacturing (AM), specifically emphasising the novel technique of Fused Fiber Layer Deposition (FFLD) within the broader context of Fused Layer Deposition (FLD). Building upon the successful FLD project under the ESA OSIP OFF-EARTH MANUFACTURING AND CONSTRUCTION CAMPAIGN-STUDY SCHEME, this study centres on the optimisation of the existing FLD 3D printer application through the introduction of FFLD. In FLD, parts are fabricated through layerwise melt extrusion of the regolith, which undergoes oven annealing during and after the printing process. Annealing is recognized as an essential step for minimizing cracks in glassy materials, such as lunar regolith.

FLD's concept is then followed by FFLD, a novel approach that involves not only extruded regolith layers but also embedded fibres within the molten regolith matrix material. The fibers, made from lunar material, act as reinforcement for fused layer deposits, promising an improvement in mechanical properties for everyday glassy hardware elements. While processes exist for the integration of fibres and extraterrestrial concrete blocks, there are no proposals for additively manufacturing fibre-reinforced glassy products from regolith feedstock to date. The approach to lunar component manufacturing promises increased autonomy for Moon missions, reducing reliance on Earth's resources.

The FFLD project development strategy revolves around the exploration of different high-temperature resistant fibres, fibre production, the design and integration of a fibre unwinding system and extrusion trials with varied parameters. Mechanical testing of printed samples follows assessing compressive and flexural strength comparing annealed and non-annealed samples to conventional, alternative AM techniques. The strategy concludes with iterative geometry adjustment, resulting in a comprehensive technology roadmap and application scenarios. The approach aims to validate and optimise Fused Fiber Layer Deposition 3D printing for lunar regolith, contributing to sustainable lunar exploration.

This early technology development signifies a stride toward sustainable lunar exploration and development showcasing the feasibility and advantages of FFLD 3D printing using lunar regolith. The paper outlines the technical benefits, development objectives and a comprehensive plan for advancing lunar exploration through innovative AM technologies.