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Author: Ms. Hanna Läkk
European Space Research and Technology Centre, ESA-ESTEC, The Netherlands

Dr. Aidan Cowley
ESA, Germany
Ms. Lauren Vasey
University of Stuttgart, Germany
Ms. Maria Yablonina
University of Stuttgart, Germany
Prof. Achim Menges
University of Stuttgart, Germany

FIBROUS HABITAT STRUCTURE FROM LUNAR BASALT FIBRE

Abstract

Most of the current state-of-art in-situ resource utilization (ISRU) technologies for planetary manufacturing of habitats and other civil engineering structures focus on the automated additive construction (AAC) systems. AAC enables the usage of a variety of materials found locally in a low-fidelity large-scale compressive structures. Different methods exist from slurry extrusion to sintering to melting techniques, with varying levels of difficulty, costs and technological readiness. However, when using additive construction methods in space environment a number of challenges arise, such as construction in a vacuum or low atmosphere as well as under reduced or zero/ milli-gravity. To bypass many of these issues the usage of in-situ produced fibres in manufacturing processes might provide a potential alternative to additive construction technology.

The objective of this study is to identify and develop promising fabrication methodology for a fibre based in-situ robotic fabrication process for potential use in a lunar habitat as an alternative to existing additive manufacturing technologies. One of the key advantages of using fibres in construction is a higher-fidelity of the manufacturing process due to the use of continuous filament and absence of powders and liquids. It also enables the possibility of orienting and locating each fibre in the structure allowing local differentiation of material properties, and manufacturing of not only compression but also tensile structures.

The first part of the study discusses the production method of a basalt fibre from lunar regolith using microwave furnace. Loose regolith that is deposited into the furnace is melted under a number of microwave heaters and transported to a bushing, from where the fibres are extruded. The material properties of the fibres are specified through mechanical and thermal testing. The application of these fibres in a cyber-physical robotic fabrication process of a habitat structure is discussed in the second part of the study. The construction sequence begins with a manufacturing of bending active frames which act as a support for the rest of the structure. A number of climbing robots connect the frames by winding the filament in between and anchoring it to the frames. The created shell is then covered with a layer of sprayed chopped fibres to seal the surface. The second layer is added following the same sequence resulting in a bilayer structure that is filled with regolith for radiation and thermal protection.