Proceedings of the 8th World Congress on Mechanical, Chemical, and Material Engineering (MCM'22)
Prague, Czech Republic – July 31, 2022 - August 02, 2022
Paper No. HTFF 162
DOI: 10.11159/htff222.162

3D Printing Of Lunar Soil Simulant towards Compact Structures

Yiwei Liu[1,2], Xian Zhang[2], Qinggong Wang[2], Chao Wang[2], Jian Song[2], Xiong Chen[1], Wei Yao[2]
[1]School of Mechanical Engineering/Nanjing University Science and Technology
No. 200 Xiaolingwei Road, Xuanwu District, Nanjing, China
liuyiweihebuter@163.com; chenxiongnjust@njust.edu.cn
[2] Qian Xuesen Laboratory of Space Technology/China Academy of Space Technology
No. 104 Youyi Road, Haidian District, Beijing, China
zhangxian@qxslab.cn; wqg1804@163.com; wangchao@qxslab.cn; songjian@qxslab.cn; yaowei@qxslab.cn

Extended Abstract

Building an outpost on the moon has become a new frontier in deep space exploration [1-3]. The moon contains rich mineral and energy resources [4], provides 715,000 tons of helium-3, 70 trillion tons of TiO_2 and other mineral resources, and has important location resources such as space communication, exploration, and scientific experiments. However, due to the high Earth-to-Moon launch cost, the transportation of large amount of materials from Earth for the construction of lunar base is unfeasible. In-situ resource utilization (ISRU), which can make the exploration of the Moon much more sustainable by dramatically reducing the cost, has become a focal point of research targeted to developing technologies in support of the long-term on-site exploration. Solar energy and lunar soil are in-situ resources directly available on the lunar surface. The effective use of solar energy and lunar soil can greatly reduce the construction cost of the lunar base. In addition, the harsh environment of the moon, such as high vacuum, low gravity and large temperature difference, requires an unmanned and autonomous method to build infrastructure. The additive manufacturing (AM, also known as 3D printing) system can meet the above requirements. Combined with ISRU technology, it is regarded as a promising solution for building a lunar base. Recently, the feasibility of SLM forming technology for lunar in-situ resource additive manufacturing is verified by using lunar soil simulant (LRS). The lunar soil simulant particles in the powder bed melt under the irradiation of high-energy beam laser, and then solidify forming the target objects. Unfortunately, the objects possess numerous defects, for instance porosity, crack and balling, which cannot realize the construction of load-bearing compact structures.

An experiment was conducted to investigate the effect of remelting times on the densification of single melt track. The variation of density of single melt track with remelting times under different power are researched. The single melt track scanning experiments indicate that there is a certain threshold of melt pool width and depth where the remelting track is uniform. If this threshold is exceeded, the track will be damaged. This is highly undesirable and is known as the balling effect. Morphological characteristics of single melt track samples, including surface and porosity, are studied by using SEM. Evaluations of dimensional and microhardness tests are also performed to uncover the print quality of the samples. The EDS and XRD results characterize the elements and compositions of the single melt track samples. SLM process parameter research is carried out to realize high-precision block forming of lunar soil simulate. The block samples with certain mechanical properties meet the requirements of external bearing structure.

We'd like to present the latest results of this work in this conference.

References

[1] C. Zhou, R. Chen, J. Xu, L. Ding, H. Luo, J. Fan, E. Chen, L. Cai, B. Tang. "In-situ construction method for lunar habitation: Chinese Super Mason", Autom. ConStr., Vol. 104, pp. 66-79, 2019.
[2] T. Patrinos. "Artemis Moon Program Advances–the Story So Far", pp. 3-5, 2020.
[3] Agencia Espacial Europea. "Building a Lunar Base with 3D Printing", pp. 1-7, 2013.
[4] N. Lovegren. "Chemistry on the Moon: the quest for Helium-3", 21st Century Science and Technology, pp. 1-14, 2014.