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FFC CAMBRIDGE PROCESS AND METALLIC 3D PRINTING FOR DEEP IN-SITU RESOURCE UTILISATION - A MATCH MADE ON THE MOON

Abstract

Most in-situ resource utilisation (ISRU) techniques proposed to date are focussed on the extraction of consumables requiring minimal processing for the support of human missions to the Moon or Mars. Water in particular has been the beguiling jewel to which we have been drawn. We define this as shallow ISRU to illustrate that its extraction requires minimal processing. We are interested in deep ISRU – investing in the hard problem of extraction and processing of material that permits us to create physical infrastructure on the Moon. We submit that a new approach to space exploration beckons in which deep ISRU permits the robotic construction of an entire automated infrastructure on the Moon at low cost. By leveraging the enormous resources available of the Moon, the cost of human lunar missions can be reduced substantially. Our hypothesis is that following resource acquisition by bucket wheel, comminution and electrostatic/magnetic beneficiation, lunar regolith can be subjected to the FFC Cambridge process followed by 3D printing using either selective laser sintering or electron beam freeform fabrication. The FFC Cambridge process is an electrolytic technique that can extract near pure metals from their oxide and silicate forms. The two lunar minerals on which we have focussed are anorthite (common in the highland regions) and ilmenite (common in the maria regions). From these two minerals, an entire suite of metals can be extracted in alloy form, or if subjected to prior purification methods, in pure form – Al, Ca, Si from anorthite and Fe and Ti from ilmenite in alloy forms, or pure Al from alumina, pure Ti from rutile and pure Si from silica. The CaCl2 electrolyte is recycled requiring only Cl import from Earth in salt form to replenish small losses. Furthermore, the output of the FFC Cambridge process is powder (or wire) suitable as input for powder metallurgy and metal 3D printing by electron beam freeform fabrication and selective laser sintering. Essentially, only two processes – FFC Cambridge and metal 3D printing – converts beneficiated raw material into final products. These two methods offer unprecedented capabilities in deep ISRU.