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PROGRESS TOWARDS A 3U-CUBESAT PAYLOAD FOR IN-SITU RESOURCE UTILISATION (ISRU) DEMONSTRATION AT NEAR EARTH ASTEROIDS

Abstract

The idea of exploiting space resources, and commonly known as In Situ Resource Utilisation (ISRU), has been around since the Apollo era. However, among the ISRU techniques being developed, the actual in situ demonstration of ISRU has not yet been achieved. The first in situ ISRU demonstration payload, Mars OXygen In-Situ Resource Utilization Experiment (MOXIE), is planned to be launched as part of the NASA Mars 2020 rover payload and is designed to demonstrate molecular oxygen production from Martian atmospheric carbon dioxide. Cranfield University's Space Group has been working on developing CubeSat compatible payloads that have the capability to perform in situ cost-effective and early stage demonstration and de-risking of key steps and processes for various types of ISRU. This paper aims to update recent progress in the development of a proposed CubeSat-compatible payload to demonstrate ISRU on the surface of asteroids. Near Earth Asteroids (NEAs), especially C-type are the initial target for this research and on which to demonstrate molecular oxygen extraction.The payload utilises a concept, in the current format, that produces molecular oxygen (and molecular hydrogen) from water extracted from asteroid regolith at low temperatures ($<<+160\,^{\circ}C$). The concept consists of five main sub-systems; a sample acquisition sub-system, a multi-oven carousel sub-system, a condensable volatile trap sub-system, a water electrolysis sub-system and a volatile analyser sub-system. The overall system is intended to fit within a "T-shaped" 3U volume envelope. This paper will present recent progress in the design of laboratory breadboard versions of the preceding sub-systems, their fabrication and initial testing. The focus of the paper will be on the sample acquisition and multi-oven carousel sub-systems. The sample acquisition sub-system consists of a pair of counter-rotating paddles/brushes and Archimedes screws that can be extended from the base of the payload into the asteroid regolith to collect regolith and transfer this sequentially to the ovens. The oven carousel sub-system has in the baseline design five independent volatile extraction ovens with each oven having a nominal internal volume of $15cm^3$. If the ovens are to be used only once, there is the possibility of appropriate ISRU demonstrations with five discreate samples.Note – the volatile analyser sub-system is anticipated to be a CubeSat compatible miniaturised cylindrical ion trap mass spectrometer currently being developed at the Open University, UK and able to analyse the volatiles emerging from the extraction ovens, the condensable volatile trap and the water electrolysis sub-system.