IAF SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

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SCALED LUNAR ISRU PILOT PLANT FOR OXYGEN EXTRACTION THROUGH CARBOTHERMAL REDUCTION: THE ORACLE PAYLOAD.

Abstract

The medium-long term plans for space human exploration mandatorily requires the crew to be Earth resources independent, capable to exploit local planetary resources for consumables, propellants or construction materials to support the in situ permanence. To this end, the existing technology gap is evident. The crucial role the Moon plays in supporting the key technologies development roadmap, thanks to its proximity, in space and time, being a perfect training asset, appears evident. Among the primary resources to extract, water, oxygen and hydrogen are recognised to be crucial.

Politecnico di Milano, in the recent years, investigated the possibility to use the dry lunar regolith as oxygen source: a low-temperature carbothermal reduction has been studied and characterized using a demonstrator plant built at Politecnico di Milano laboratories, under ESA financed studies. The plant, conceived to process 1 kg of regolith simulant, includes a main and a secondary reactor to get, from regolith oxides, carbon oxides and then water, fluxing a mixture of methane/hydrogen properly tuned. The proposed process is landing site independent, being effective no matter of the feedstock composition; it needs no feedstock beneficiation, keeps the solid by-products sandy, in favour of the plant automation. Thanks to those system level benefits, it turned out to be a valuable candidate for a in situ demonstration, through a scaled demo payload implementation. ORACLE - Oxygen Retrieval Asset by Carbothermal-reduction on Lunar Environment – is the ongoing study, financed by the Italian Space Agency, Politecnico di Milano is carrying on to design, up to phase B1, a feasible ISRU plant for oxygen extraction compliant with a flight on NASA Commercial Lunar Payload Services (CLPS), conceived to deliver small size payloads on the Moon. The paper presents the trade-off run and the solution currently proposed to get rid

of the complex chemical plant miniaturization while preserving the carbothermal process effectiveness. In particular, to get to a viable design run in terms of plant blocks to implement, their technological feasibility, reaction products quantitative measurability, process repeatability and resource demand sustainability by the lander interfaces. Lastly, the whole operation profile, from feedstock loading to solid by-products automatic discharging has been assessed towards feasibility. To support the design process, multiphysics numerical modelling accompanied by lab breadboarding occurred, which are extensively and critically reported in the paper to show the robustness of the proposed solution which is going to enter its consolidation phase credibly by the end of 2024.