NASA SBIR 2019 Phase I Solicitation

Z12.01 Extraction of Oxygen from Lunar Regolith

Lead Center: JSC

Participating Center(s): GRC, JPL, KSC, MSFC

Technology Area: TA7 Human Exploration Destination Systems

NASA has a strong interest in technologies that enable In-situ Resource Utilization (ISRU), where commodities such as propellant and breathing air are made from lunar materials to enable exploration beyond low earth orbit.Â Several categories ofÂ technologies related to the extraction of oxygen from lunar regolith are sought in the following subtopic.Â These include solar concentrator technologies, molten oxide electrolysis, and beneficiation/size sorting.

Solar Concentrator Technologies for Oxygen Extraction and In-Situ ConstructionÂ

Solar concentrators have been used to successfully demonstrate multiple ISRU technologies including hydrogen and carbothermal reduction, sintering of surfaces pads, and production of blocks for construction. Terrestrial state of the art solar concentrators are heavy, not designed for easy packaging/shipping and assembly/installation, and can be maintained and cleaned on a periodic basis to maintain performance. For in-situ resource utilization (ISRU) space applications, NASA is interested in solar concentrators that are able to be packaged into small volumes, are light weight, easily deployed and set up, can autonomously track the sun, and can perform self-cleaning operations to remove accumulated dust. Materials, components, and systems that would be necessary for the proposed technology must be able to operate on the lunar surface: up to 110 C (230 F) during sunlit periods and survive temperatures down to -170 C (-274 F) during periods of darkness. Systems must also be able to operate for at least one year with a goal of 5 years. Each of the following specific areas of technology interest may be developed as a standalone technology, but proposals that address multiple areas are encouraged.

Lightweight Mirrors/Lenses - Proposals must clearly state the estimated W/kg for the proposed technology. Phase I efforts, if prototyped, can be demonstrated at any scale, but must be scalable up to 26 kW of reflected solar energy assuming an incoming solar flux of 1000 W/m^2. Phase II deliverables include prototype(s) that must be deployed and supported in Earth 1-g (without wind loads) but should include design recommendations for mass reductions for lunar gravity (1/6-g) deployment. Proposals should address the following attributes: high reflectivity, low coefficient of thermal expansion, strength, mass, reliability and cost.

Dust Repellent Mirrors/Lenses - Dust particles that cling to the surface of a mirror or lens will degrade the performance of a solar concentrator. Proposals must demonstrate a scalable means to remove or repel dust from mirrors and/or lenses without the use of consumables.

Efficient transmission of energy for oxygen/metal extraction - While the solar concentrator will need to move to track the sun, reactors requiring direct thermal energy for oxygen extraction will be in a fixed position and orientation. Concentrated sunlight must be able to be directed to a single or multiple spots to effectively heat or melt the regolith. Options, such as adjustable mirrors and fiber optics, must be included in the proposed development effort as well as the expected transition losses from collection to point delivery. For carbothermal reduction, surface temperatures of

>1600Â° C are required.

Sintering end effector - Concepts must produce a focal point temperature of 1050Â° C for the purpose of sintering lunar regolith with a fiber optic interface efficiency of greater than 90%.

Molten Oxide ElectrolysisÂ

This particular method of oxygen extraction has the potential to provide relatively high yields of oxygen per mass of regolith. Proposals must specify the expected wear and replacement rate of Anodes/Cathodes. Proposals must also specify the expected loss and replacement of any additives such as flux or ionic liquids. Phase I demonstrations may be any scale. Phase II demonstrations should be scalable up to 1.6 kg/hr oxygen. Multiple units are acceptable if required but need to be specified. Specify which metals will be extracted during oxygen removal and how the metals will be separated and captured.

Beneficiation/Size SortingÂ

Mineral beneficiation and size sorting systems can greatly improve the effectiveness of oxygen extraction techniques such as hydrogen reduction. Proposals should demonstrate a means to remove particles larger than 1 mm and increase the concentration of minerals such as FeO, Fe_2O_3 and $FeTiO_3$. Phase I demonstrations can be at any scale, but Phase II demonstrations should be scalable up to 80 kg/hr of bulk regolith at the inlet of the device.

Relevance to NASA

Each of these technologies are considered key for ISRU processing.Â There is currently an ISRU project being funded by AES/STMD, and the last time NASA was focused on lunar ISRU, solar concentrators were used for multiple applications, and both molten oxide electrolysis and beneficiation of minerals was being demonstrated at a small scale.

References:

Solar Concentrator Technologies for Oxygen Extraction and In-Situ Construction

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Molten Oxide Electrolysis

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Beneficiation/Size Sorting

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