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Novel Concepts and Technologies to Enable Future Building Blocks in Space Exploration and Development (3)

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FULL-SCALE TERRESTRIAL DEMONSTRATOR FOR LUNAR ILMENITE REDUCTION WITH CONCENTRATED SOLAR POWER

Abstract

LUNAR OXYGEN: The in-situ production of resources on the Moon could significantly reduce the amount of mass needed to be launched from Earth. The most needed and abundant resource on the Moon is oxygen. The main problem is that oxygen release requires high temperatures due to the strong chemical bonds in the minerals. The process with the most benign operating conditions is hydrogen reduction of ilmenite (1) and subsequent water electrolysis (2):

(1): FeTiO3+H2=>Fe+TiO2+H2O

(2): H2O=>H2+O2

FLUIDIZED BED: A chemical reactor for reaction (1) must work in continuous mode, be able to heat and process large amounts of lunar regolith, and offer the solids a long residence time and a good mixture with the gaseous reactant. All these conditions can be satisfied by a low expansion fluidized bed reactor. Fluidization is the operation by which solid particles are transformed into a fluid like state through suspension in a gas.

SOLARTHERMAL REACTOR: The Plataforma Solar de Almería (PSA) is a public research center for concentrated solar power in Spain. A fluidized bed reactor powered by concentrated solar radiation was developed, assembled and tested here for the hydrogen reduction of ilmenite. The goal was to build a full scale reactor to carry out tests on Earth, coming up with solutions for as many challenges it could face on the Moon as possible.

The center-piece of the reactor is a fluidized bed with capacity for 25kg of lunar regolith. Feeding and removal of the solids is done in continuous mode by auxiliary fluidized pipes. The concentrated solar power enters the reactor vertically through a quartz window on the top, directly heating the particles. Special attention was given to the off-gas treatment. This includes cooling, hot gas cleaning from remaining fines, and efficient separation of the desired product water from the gas stream.

SYSTEM TESTING: All primary goals were successfully achieved: Identification of the gas flow demand of the main fluidized bed in the reactor as a function of temperature, reactor operation at 800-1000°C solely heated with concentrated solar power, and demonstration of water production from the reaction of ilmenite with hydrogen. Further (secondary) goals like the demonstration and control of the continuous particle feed/removal from the reactor, or the off-gas treatment, were also accomplished.

The PAPER/PRESENTATION will provide an overview of the system's design, the testing results, and the prospects of future activities and developments.