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Titel des Beitrags: Experimental setup and results for a simulated solar cavity receiver for thermal processing of lunar regolith

Abstract: Solar wind impingement deposits are very fine layer of hydrogen and nitrogen into the lunar regolith grains on the lunar surface. These solar wind implanted particles (SWIP) have been discussed as a potential resource for lunar exploration. Experimental data on Apollo samples have shown the potential to release these components by thermal desorption in the temperature range between 400(°C) and 1200(°C). A conceptual in-situ thermal extraction experiment, thermally powered by a solar concentrator, has been proposed. This concept envisions a double walled cavity, with regolith filled into the space between the cavity walls. Concentrated solar radiation is collected in the cavity receiver, resulting in an inside-out heating. Thermal analysis performed on this concept has shown a complex interaction between material parameters, especially regolith thermal conductivity, solar irradiation from the concentrator and thermal coupling of cavity walls. Optimistic estimations have led to the conclusion that such a design could allow for small thermal gradients (ΔT <100K) inside the regolith layer, although gradients cannot be completely avoided. The envisioned solar cavity receiver and its surrounding regolith processing chamber were approximated in an experimental
setup through two nested cylinders. An electrical heater located in the innermost cylinder represents the solar energy input. The thermal behavior of the integrated system was tested under high-vacuum (10−5 mbar) with the JSC-1A regolith simulant, in layers of 5 and 15mm. The inner cylinder wall aperture was increased stepwise from 20(°C) to 250, 500, 750 and 900(°C). The thermal connection between the inner and outer cylinder (‘cavity’) was also altered. This allowed for better understanding, model correlation and measurement of the thermal conductivity of the lunar regolith simulant JSC-1A in vacuum. Our results show extremely high thermal gradients between 250 and 500 K within the regolith, limiting the useful and possible thickness of heated regolith to very thin layers if a non-stirred bed reactor approach is used. A low gradient heating of larger amounts of regolith with this approach is not feasible. Recommendations for improved concepts using solar-thermal and electrical heating, and an updated cavity and reactor bed design are proposed based on the analytical and experimental results of this study.

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