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TRADE-OFF AND OPTIMIZATION FOR A THERMAL LUNAR WATER EXTRACTION SYSTEM

Abstract

Water is an essential resource for both robotic and human space exploration. In the future, this resource can be used to produce rocket propellant. This Space Resource Utilisation (SRU) would reduce the cost of spacefaring significantly. Especially considering the development of multiple (commercial) lunar landers currently, the lunar economy will soon become more accessible, which further drives the need for water extraction equipment. Multiple methods to thermally extract and capture water from lunar regolith from the lunar south pole are already envisioned, and this research aims to select the most promising concept based on the optimization of parameters. The first step will be to design a set of different concepts to a degree after which they can be compared to each other.

Both a quantitative as well as a qualitative trade-off will be performed, since the fidelity of the designs is likely not enough information to accurately compare them to each other by quantitative measures alone. Also, factors like complexity are hard to define in numbers, but should not be excluded in a selection. For the preliminary design, the following 3 parameters will be initially fixed, and then later varied during a sensitivity analysis:

- Fixed surface coverage (or volume, in the case of drills) of the heating elements in the system.
- Fixed state of the water (different wt.% of water).
- Fixed power available in the system.

Alternatively, the power could be an output of the design rather than the input, and the power is dependent on the amount of energy required to sublimate the accessible water. The outputs of such a comparison would then be:

- The mass (an estimate of components, considering the low fidelity of the design).
- The accessibility of the water extractor to the water-ice and the ability to heat water-ice to the sublimation temperature at sub-surface depth.
- The time and energy required to get a certain yield. A sensitivity analysis can be performed on the time factor and the concept of operations to find an optimal scenario.
- The complexity and the added failure modes, increased risks, and potential losses.

The resulting design of this trade-off will be tested in a dedicated TVAC test.