Auger Based Water Extraction System for In-Situ Resource Production

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Purpose and Design Problem

In situ resource production is an essential part of extending deep space exploration missions. The lunar surface has sections that are permanently shadowed that contain regolith with frozen water in the pores of the rock. Extracting this water from the substrate would be able to add to the robustness of human space travel for future missions. This capstone proposes a theoretical design and proof of concept for an auger-based system to extract water from the icy lunar regolith.

Lunar Surface

- **Agglutinates**: rock and mineral fragments cemented together with glass
- **Rock Chips**: broken off pieces from impact or planetary weather
- **Impact Glass Beads**: generated from large scale collisions on the lunar surface

Water content dictated by porosity within the rock. As the regolith matures and has more exposure, the grain sizes decrease, and distribution of agglutinates increase. Rock chips and agglutinates have highest porosity.

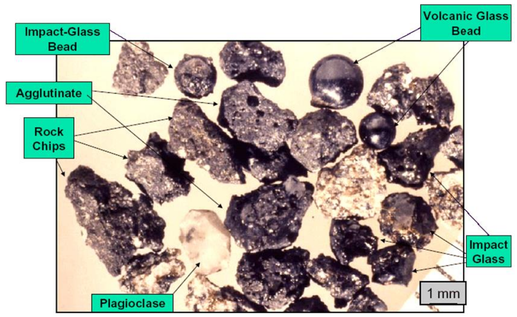


Figure 1. Components of Lunar Soil [1]

Final Concept

Heated **auger-based system** designed to agitate regolith on surface and evaporate or sublimate water from porous rock

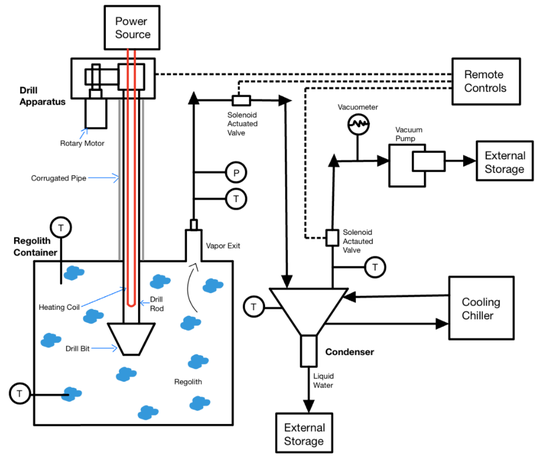


Figure 2. Schematic of Full-Scale Conceptual Design

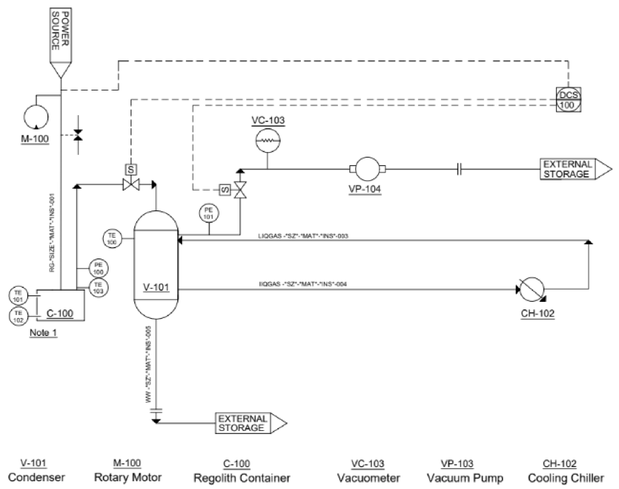


Figure 3. Piping and Instrumentation Diagram for Full-Scale Conceptual Design

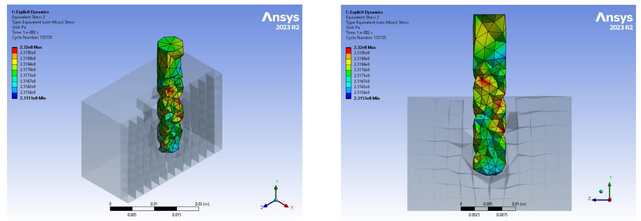
Discussion

The auger-based design does show promise in its ability to generate heat to extract water and separate volatile compounds from lunar surface regolith. Design requires adjustments to be suitable for extreme vacuum conditions as well as intense temperature fluctuations. The system is also dependent on the design of the larger plant and must include considerations for the power supply and piping.

Future Research

- Impacts of space conditions such as cryogenic temperatures, extreme temperature fluctuations, and vacuum
- Wear of materials and maintenance requirements due to abrasion
- Heat transfer methods within the auger such as alternative working fluids
- Alternative extraction methods such as microwave heating and ilmenite-based reactions

CAD Design



Figures 4 and 5. ANSYS Stress Analysis of Auger Drill to Optimize Feed and Rotational Speeds

Prototype

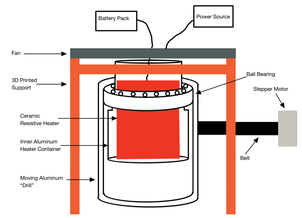


Figure 6. Schematic of Heated Auger Tabletop Prototype

References

[1] S. Noble, "The Lunar Regolith", NASA, https://www.nasa.gov/wp-content/uploads/2019/04/05_1_snoble_thelunarregolith.pdf
[2] "Evolution of the lunar regolith," NASA, https://www.nasa.gov/wp-content/uploads/2019/04/mckay.pdf
[3] L. He, C. Wang, G. Zhang, Y. Pang, and W. Yao, "A novel auger-based system for extraterrestrial in-situ water resource extraction," Icarus, vol. 367, p. 114552, Oct. 2021. doi:10.1016/j.icarus.2021.114552
[4] Y. Liu et al., "Water extraction from icy lunar regolith by drilling-based thermal method in a pilot-scale unit," Acta Astronautica, vol. 202, pp. 386–399, 2023. doi:10.1016/j.actaastro.2022.11.002

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