Lunar Contact Sampling Device

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ABSTRACT

The Moon has played a significant role in shaping Earth's environment and supporting the development of life. Today, efforts like NASA's Artemis program continue to deepen our understanding of its complex history. Artemis Mission III will target the Moon's south pole, where astronauts are set to collect geological samples that could offer valuable insights into lunar evolution. To support this mission, the Space Cowboys team has engineered a specialized lunar contact sampling device. Drawing inspiration from proven soil sampling technologies, the device is designed to ensure safe, efficient collection and transport of lunar regolith. This innovation is a critical step forward in enabling scientific discovery and expanding our knowledge of the Moon.

Project Background

Lunar regolith is a fine, powdery soil composed of dust, small rocks, and glassy particles [1]. Successfully collecting this material without disturbing its natural grain structure is crucial for advancing research into space weathering processes and the Moon's geological history. The Artemis Mission requires an ergonomic and efficient device capable of gathering 1–5 mm of lunar regolith while preserving the integrity of the surface layer. This will help uncover the Moon's untold mysteries that remain beyond our current understanding.

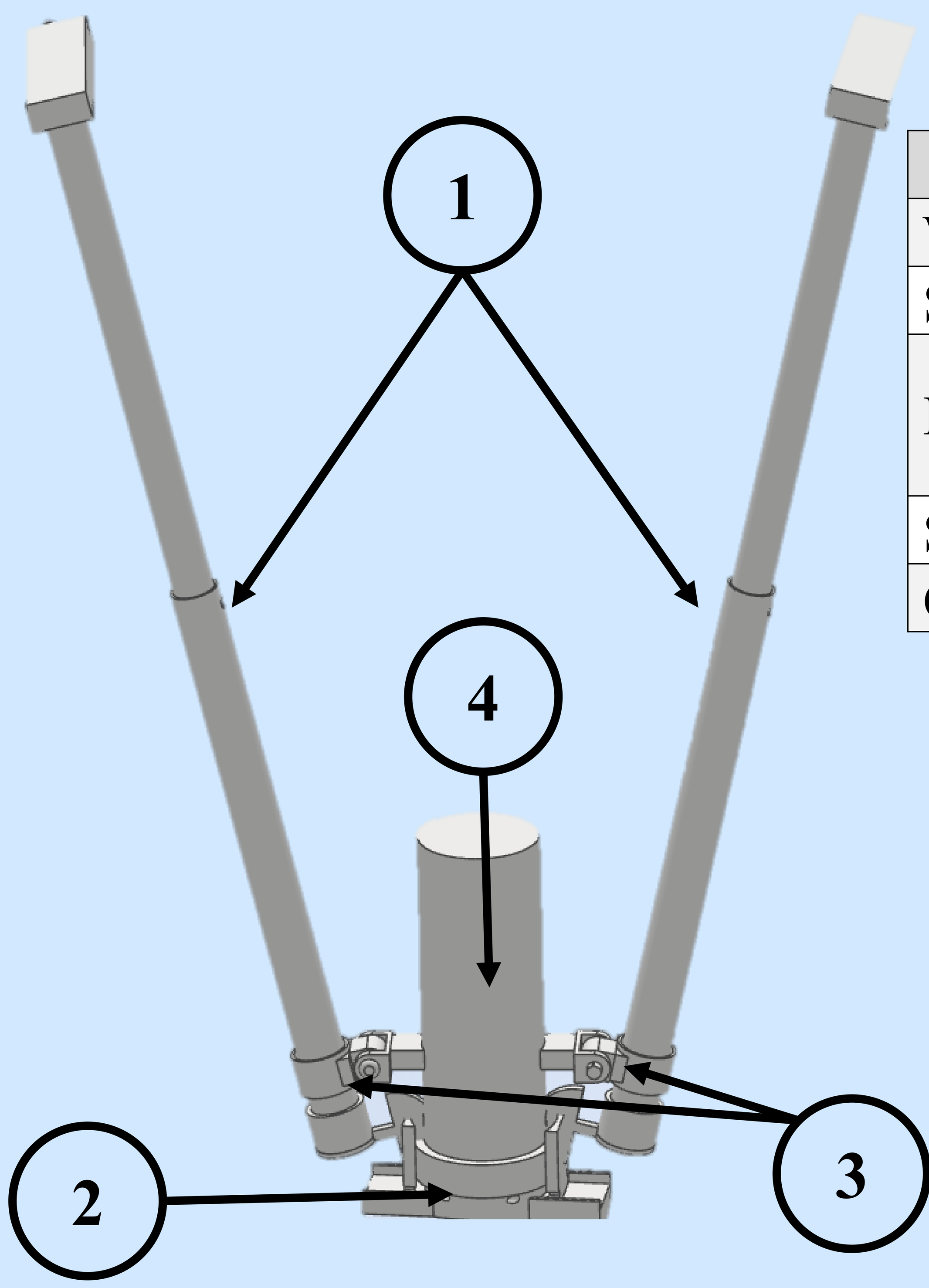
Objectives

The contact sampling device must be specifically designed for use by fully suited astronauts, ensuring it is compact, lightweight, and capable of reliable operation under lunar surface conditions.

Space Cowboys Objectives:

- Device must way less than 5 lbs.
- Must fit within an 8 X 8 X 16-inch volume
- Device must be Mechanically operational not electric components

Assembly Identification



Design Specifications	
Weight (lbs.)	4.77
Stowed Volume (in.)	3.00 x 9.00 x 15.75
Material	6061 T6 Aluminum Tough PLA
Sample Volume (in.^{3})	0.83
Cost ($)	260.99

Number	Assembly
1	Handles
2	Sample
3	Hinges
4	Base

Testing Results

Trial	Mass Captured (g)	Volume Captured (in.^{3})
1	14	0.55
2	8	0.31
3	7	0.27
4	6	0.23
5	11	0.43

Testing Design Practice

- The prototype was tested for sample acquisition and grain preservation
- The sample assembly was pushed in to lunar simulant with 20 pounds of force to simulate usage. Capturing clips secured the sample
- Before and after weight measurements allowed for volume calculation
- Image analysis determined grain similarity was unsuccessful

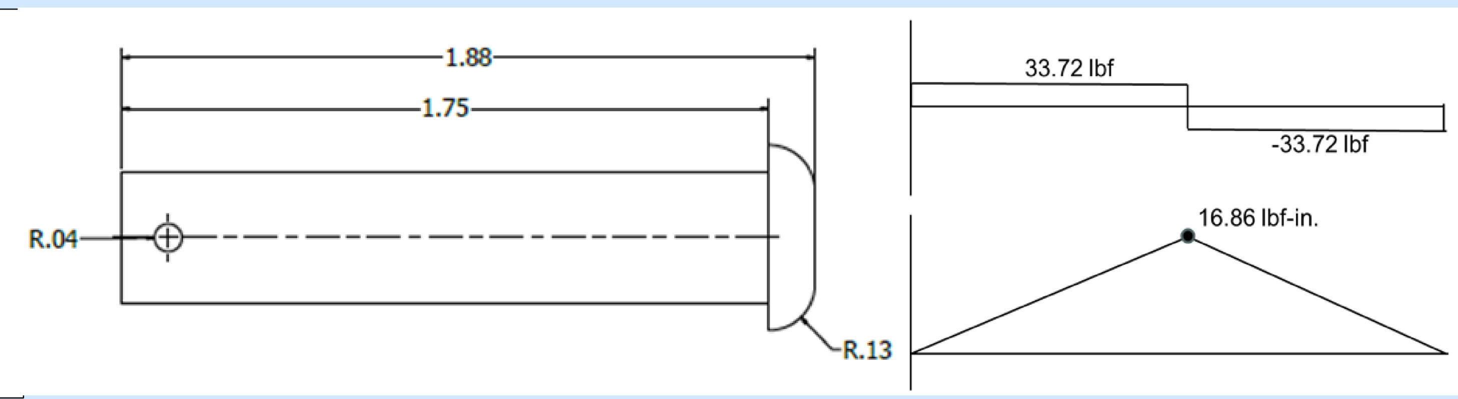
Structural Analysis

The most structurally limiting component is the hinge pin. The diameter of the pin was determined for a required safety factor of two.

$$3985.00 = \frac{(16.86\ lbf - in.)}{2(\frac{\pi D^3}{64})}$$

$$391.22D^3 = 16.86\ lbf - in.$$

$$D = 0.35\ in.$$



FUTURE WORK

Given additional time, more tests would be conducted to verify material manufacture claims and customer requirements. This includes linear and rotational actuation forces, drop tests, detailed grain research, and FEA analysis on all components.

Time would also be alluded to product improvements such as handle capture latches for stowage, ergonomic transportation, multi-sample stowage, and material improvements.

CONCLUSIONS

The Ram Rod is a distinctive and efficient tool specifically designed to support the Artemis Mission (III), particularly in the critical task of safely collecting and storing lunar samples. Its lightweight and compact design, along with its user-friendly features, make it well-suited for the rigorous challenges astronauts face during Extra Vehicular Activities (EVA) on the Moon. The Ram Rod's unique design considers the limited mobility of astronauts, ensuring that it can effectively meet the demands of the mission while standing out among other sampling devices previously designed and manufactured.

Acknowledgements

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References

[1] *Lunar Regolith*, www.nasa.gov/wp-content/uploads/2019/04/05_1_snoble_thelunarregolith.pdf. Accessed 10 Nov. 2024.