

Psyche Additive Manufacturing

Team 501 - DR 4







Team Introductions



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Sponsor and Advisor



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Objective

The objective of this project is to design a method to utilize hypothesized surface materials of the Psyche asteroid in additive manufacturing.

Psyche Mission





- Psyche is an M-type asteroid hypothesized to be a remnant from a planetesimal.
- In 2023, NASA sent a spacecraft to observe Psyche's surface set to arrive in 2029.
- The surface of Psyche is rich in metallic and silicate materials.
 - o Particularly iron and nickel

Project Overview

Design and demonstrate a proof of concept of intellectual merit

Design full additive manufacturing concept using intellectual merit Integrate system into hypothetical future missions

Assumptions

Print Ready Material

• Surface material will be harvested and refined to necessary specifications

External Power Source

Sufficient power will be provided externally

Repairability

• The system will be maintained by an external system

Product Delivery

• An external mechanism will be responsible for removing print

Functional Decomposition



Critical Targets and Metrics

Function	Target	Metrics
Minimize vibrations	<20 Hz	Frequency
Shield system from radiation	<0.02 rads/s	Allowable Dose Rate
Protects system from particulates	<0.015 µm 0.3 /liter (Electronics) <1.0 µm 10 /liter (Moving Parts)	Particle Size Count per Liter
Regulates temperature	-55 – 125 ℃	Temperature Range
Produces desired output	0.5 mm	Output Tolerance
Design mass	1650 kg	Mass
Print volume	>8 Liters (0.2 <i>m</i> ³)	Volume

Initial Concept Generation



Fused Granulate Fusion

- An adaptation of standard FGF printers
- Uses conventional heating elements to melt extrudate into a filament-like material
- Uses metal powder in place of plastic



Powder Bed Fusion

- Uses powerful laser to selectively melt layers of metal powder
- Use electromagnets keep powder fixed within the print volume

Design Selection

Powder Bed Fusion

- Concept with the most potential for adaptation to Psyche conditions
- Precise

Challenges

- Managing the internal environment of the system
- Compensating for microgravity
- Preventing powder suspension



Powder Bed Fusion in action



Magnet Selection/Sizing

Magnetic Bed

- Reduced field strength and magnetic attraction
- Clumping

Helmholtz Coil

- Uniform Magnetic Field
- Precise Control
- Allows for material adaptability



Magnet Selection/Sizing

$$B = \left(\frac{4}{5}\right)^{3/2} \frac{\mu_0 \boldsymbol{n} \boldsymbol{I}}{\boldsymbol{R}}$$

B : Magnetic Force at midpoint between the coils *B* :

μ_0 : Permeability of free space	μ_0 : Constant
n : Number of coil turns	<i>n</i> :
<i>I</i> : Current through the coils	<i>I</i> : 20 Amps
R : Radius of each coil	<i>R</i> : 0.4 meter

Magnet Assisted Granular Iron Control





Future Work

- Digital Twin
- Physical Prototype
- Power Safety

- Cost Analysis
- Simulations
- Magnet Testing

Contact Us





References

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