Summer 2021

3D-Printing Habitable Structures on Mars

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Project Overview

This project developed technology to 3D-print habitable structures on Mars from in-situ materials, as part of the push to create a self-sustaining colony on Mars.

The team designed a significantly improved printhead over the summer of 2021, expanding on the senior project from the recent engineering graduates. Beyond the print head, the system includes a gantry and XYZ positioning system (below).

Summer goals:

- Improve heating efficiency (reduce energy loss)
- Improve the print quality (consistent and well mixed extrusion with no voids)

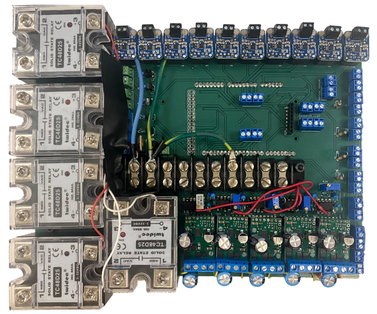
Heating

Controls Method:

- Designed a custom printed circuit board for heating and power control
- Custom derivative controller initialized withg a Simulink model and first-generation test data.
- Thermocouples monitor temps of various zones
- Solid state relays provide power to the heater cartridges to maintain desired temperature

Precision:

- Maintained <4% steady-state error over time



Dosing System

Doser goals:

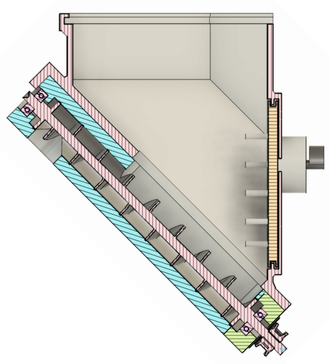
- Portion out the correct ratio of sand and sulfur
- Be able to adjust the ratios of sand and sulfur

Hopper goals:

- Hold enough material to keep the dosers supplied
- Allow material to freely enter to the dosers without clogging

Design:

- Two compartments hold sand and sulfur
- An auger under each compartment carries materials towards the mixer
- A vibrating brush prevents clogging of sulfur



Mixing/Extrusion

Mixer goals:

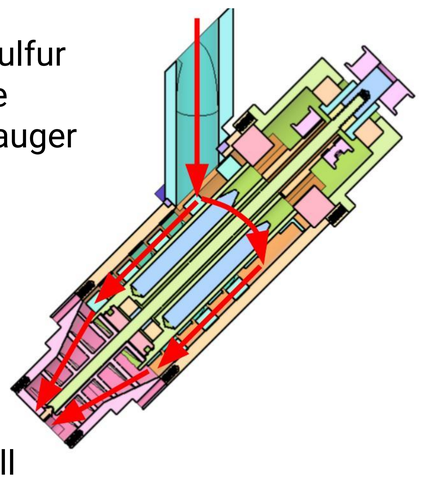
- Evenly mix sand and sulfur
- Efficiently heat mixture
- Advance mixture into auger

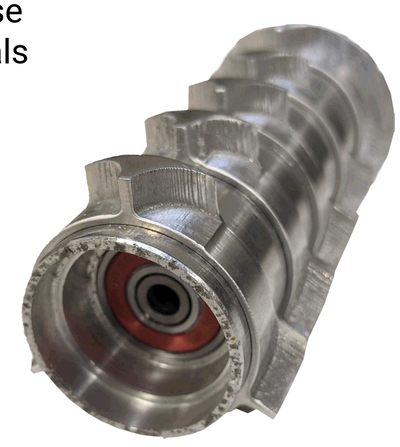
Auger goals:

- Pressurize mixture for extrusion
- Maintain temperature

Manufacturing:

- Except for the auger, all parts were made in-house from a variety of materials
- Auger 3D-printed in stainless steel





Efficiency Test

Method:

- Measured power for heating, mixing, and extruding ~2.2kg of sulfur-sand
- Recorded power usage across multiple 120V phase lines with LABView PM1000+ power analyzers

Results:

- The final test showed the Gen. II sulfur-sand printhead used 43% (0.65 MJ) less energy than the legacy system, well exceeding our initial goal of 15% increased efficiency