Extrusion Based Ceramic 3D Printing for In-Space Manufacturing

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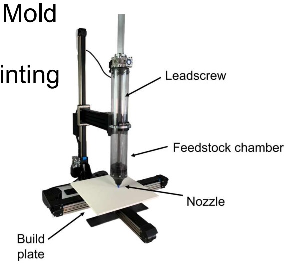
Introduction

Long-duration Martian missions will require on site manufacturing. In situ casting solutions that utilize Martian resources will be essential.

Research Question: Can simulated Martian regolith be extrusion-printed and thermally processed into crack-resistant molds for metal casting?

Hypothesis: Mold cracking will depend on printing and sintering conditions.



3D Potterbot

Objectives

Develop an extrusion-printable regolith feedstock and fabricate self-supporting casting molds.

Quantify dimensional change and defect formation during drying and thermal processing.

Determine how infill architecture influences mold cracking.

Method

Feedstock Material Composition

MGS-1 Mars Global Simulant	Wt.%	MGS-1C Mars Clay ISRU	Wt.%
Anorthosite	27.1	Smectite	40.0
Glass-rich basalt	22.9	Anorthosite	16.4
Bronzite	20.3	Glass-rich basalt	13.7
Olivine	13.7	Pyroxene	12.2
Mg-sulfate	4.0	Olivine	8.2

Printing and Drying

4mm nozzle

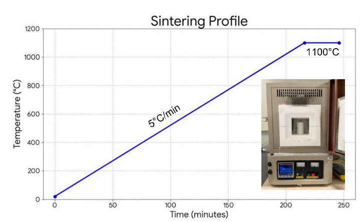
Varying extrusion rates

Achieved 100% extrusion speed

Dry for 3 days

Ambient temperature

Sintering



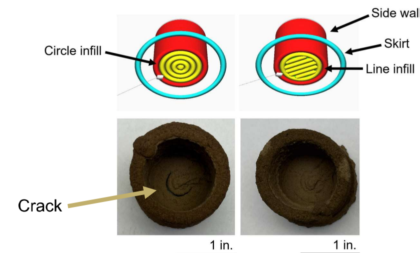
Sintering is a thermal process that transforms a powder aggregate into a dense solid.

Casting

Tin was heated above its melting point (232 °C), poured into the regolith mold, and allowed to solidify.

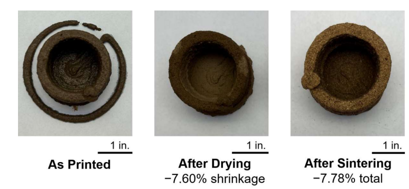
Results/Conclusions

Occasional cracking observed after drying



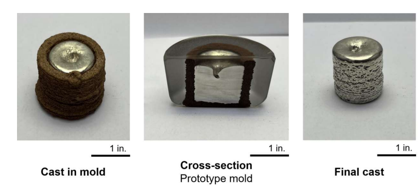
Crack free molds can be achieved with line infill patterns for the base layer.

Dimensional change during processing



More shrinkage occurred during drying compared to shrinkage during sintering.

Investment casting with regolith molds



Crack free molds can be achieved by tuning the infill pattern and extrusion rate. The surface morphology of the final cast depends on the printing parameters of the mold.