The World's First

3D-Printed Plastic Rocket Motor

Matthew Vernacchia, Carlos Garcia and Kelly Mathesius, MIT RocketTeam
Silas Hughes, Markforged

The MIT Rocket Team is collaborating with Markforged, a Cambridge-based 3D-printing startup, to produce and fire a rocket motor printed from plastic.

Printing rocket motors from plastic is a unique accomplishment. Several groups, including SpaceX and NASA, print rocket engines from metal. But metal printers are expensive, costing north of six figures. Our plastic motor is produced on an innovative, lower-cost plastic printer, which has a price accessible to hobbyists and small teams.

Our printed rocket motor fires for the first time.

Printed Ablative Materials

Like most solid rocket nozzles, our nozzle is ablatively cooled. Markforged's fiberglass/Onyx material is a decent approximation of traditional fiber/resin ablative materials.

As the material heats up, the material's nylon binder slowly 'boils', carrying heat away from the remaining surface. The fibers can resist much higher temperatures (2000-3000 degrees Celsius), and remain behind as a porous char. The char layer at the surface insulates the material behind it. This char insulation beneficially slows the rate of ablation.

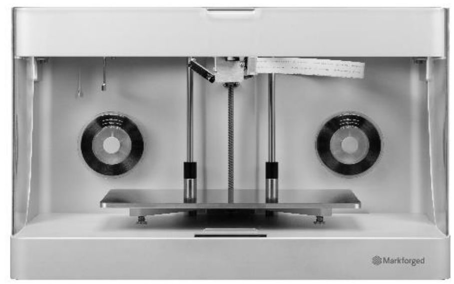
Markforged's unique ability to include fibers in a 3D print is essential to the performance of our motor.

Digital Manufacturing Toolchain

Our rocket design begins in Onshape, a cloud-based CAD program, which allows easy collaboration between MIT and Markforged.

The design is then exported to Markforged's Eiger slicer to lay out the infill and fiber placement required for our design. Then, the files are sent to a Markforged Mark Two printer, which prints the part.

Build times are much quicker than producing a motor via traditional means, and designs can be rapidly iterated without expensive tooling changes.

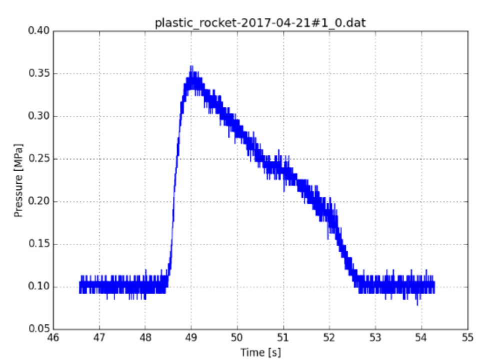


Markforged's Mark Two printer is used to manufacture our motor.

Test Results

Our first static fire achieved a successful 3.5 second burn, reaching a maximum chamber pressure of 340 kPa. The throat eroded at a rate of 0.28 mm s^{-1}.

We are actively working improvements to increase the chamber pressure and decrease the ablation rate.



Pressure trace from our first static fire test, showing a regressive, 3.5 s duration burn.

AEROASTRO MIT Rocket Team Markforged