3D Printing with Liquid Silicone

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Abstract

With the ongoing evolution of 3D printing, the task presented in this project offered a unique challenge to explore the mechanics of these devices and the implementation of a new printing material. **The objective of this project was to design and prototype a 3D printer that fabricates parts using flexible silicone.** Through iterative design, the team created a mechanically functional printer. The initial phases of design included creating CAD models and assemblies to be manufactured. These designs translated to the physical product with two main sub-assemblies: a typical 3D printer chassis with X, Y, and Z-axis motion and a dual-piston extruder, which mixes two-part curing silicone as the device's build material. To expedite the curing process, a system was implemented to continuously distribute heated air around the end effector. In the final stages of testing and development, the team continued to refine optimal print settings to ensure quality silicone products.

Previous Work

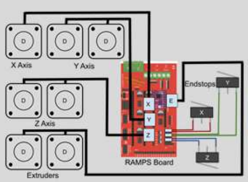
- The 2020-21 project produced the initial silicone 3D printer.
- By operating last year's printer, the team found strengths and weaknesses.
- The previous printer was capable of extruding silicone, but only through a manual mixing process.
- Implementing an updated mixing mechanism, an upgraded chassis design, and a new curing system were major improvements the current team made.

Chassis

- The printer was constructed using Aluminum extrusion, 3D printed parts, and industrial automation equipment
- Tensioned HTD timing belts provide translation for the X and Y axes, while lead screws provide translation in the Z axis
- MGN-12 Linear Rail Bearings are used to constrain motion and prevent backlash
- Each axis is driven by NEMA-17 Stepper Motors

Controls

- The motion of the printer is controlled by an Arduino MEGA and the RAMPS 1.4 Platform. This runs the Marlin 2.0.7 firmware.
- Each axis contains an end-stop, providing a setpoint for the firmware to determine the exact position of each motor.

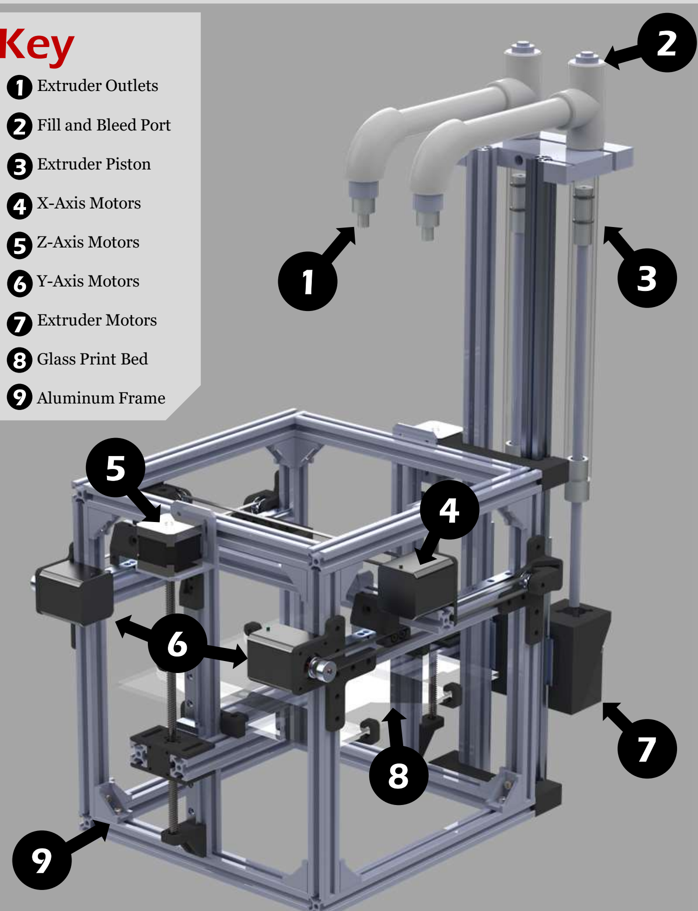


Time of Flight Sensor

- A bed leveling system was implemented using two time-of-flight distance sensors. These allow the printer to compensate for small height inconsistencies between the two Z axis motors.

Key

1. Extruder Outlets
2. Fill and Bleed Port
3. Extruder Piston
4. X-Axis Motors
5. Z-Axis Motors
6. Y-Axis Motors
7. Extruder Motors
8. Glass Print Bed
9. Aluminum Frame

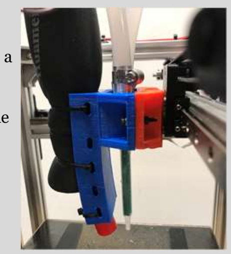


Extruder

- To pressurize the silicone, a dual piston-based extruder system was designed and prototyped. The piston heads are advanced using a threaded rod which is turned using NEMA-17 stepper motors with a 27:1 gear reduction.
- A bleed port is used to fill the extruder and evacuate air from the system.

Silicone Curing

- Silicone is mixed prior to extrusion using a static mixer (green in photo).
- A repurposed soldering heat gun heats the print to expedite the curing process
- Faster curing prevents unintended flow, decreasing print times and allowing for thinner geometry



Results

- Optimizing the print settings has been a nontrivial task and is an ongoing process.
- The current configuration has produced several rough prints, with promising cure time and structural integrity.
- The biggest challenge has been inconsistent mixing and curing; impacting the repeatability of prints.