Extruder for Production of 3-D Printer Filament

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Problem Statement and Requirements

The Civil and Mechanical Engineering Department at Purdue University Fort Wayne houses multiple 3-D printers for student and faculty use. Waste is inevitably generated in the form of 3-D printed objects due to a variety of reasons including overall changes in design, poor finish quality of the part, or the part not properly integrating into an assembly.

The specific goal of this project is to recycle failed 3-D printed parts that are otherwise wasted by transforming them into a new spool of filament.

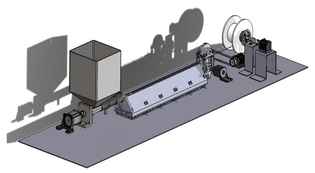
The following requirements were determined for the device:

- The extruded filament must have a diameter of 1.75 mm with a tolerance of ± 0.05 mm.
- The temperature of the nozzle should be capable of reaching 300°C.
- The extruding temperature of the device should be adjustable.

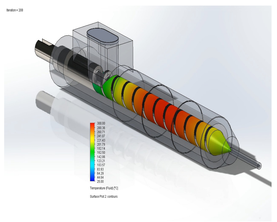
Design Concepts and Evaluation

The device was divided into six subsystems to ensure proper functionality:

- Material Input
- Heating
- Extrusion
- Cooling
- Postprocessing / Spooling
- User Interface and Control System



Solution concepts were generated for each subsystem and the final conceptual design was selected for each. This process was completed using a weighted decision matrix.



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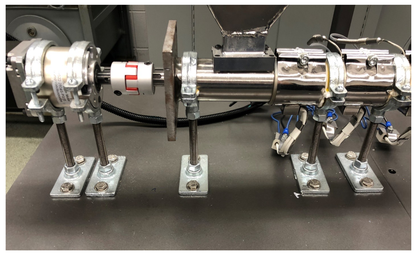
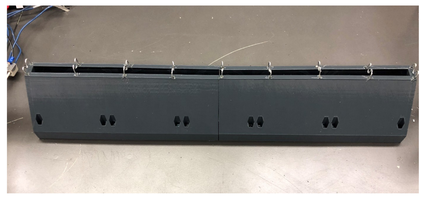
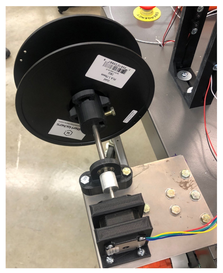
Detailed Design and Construction

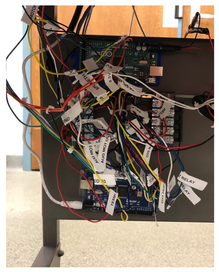
The device is mounted on a cart to allow for simple transportation. The extruding barrel and auger motor are mounted using clamps and threaded rods fed through the cart to allow for simple height adjustments. A hopper was created from sheet metal and mounts to the barrel, the extruder's auger screw is driven by a NEMA 23 stepper motor, and three band heaters were mounted to the barrel.





The spooling subsystem was mounted to a sheet metal extension of the cart. This consists of a motor, bearing, shaft, and 3-D printed spool holder.





Three thermocouples were mounted between the band heaters to allow the heating system to be a closed loop system. The live readouts of the temperatures at each of the thermocouples are displayed on an LCD screen.

The 3-D printed duct was slotted into the cart and mounted to five cooling fans. This was paired with a fan and blowers pointing directly at the nozzle to complete the cooling subsystem.

The control systems are separated into two parts, heating and motor control, each of which has their own Arduino controlling the functions. Both motors are controlled with on/off switches and have potentiometers to adjust their speed in real time. The temperature at the extrusion exit is controlled by an on/off switch and a potentiometer.

Testing and Verification

Testing was performed for each of the three requirements. The temperature of the device was increased incrementally from room temperature to a maximum test temperature of 325 °C. The temperature at the nozzle was verified using a thermal imaging camera and the thermocouple function of a multimeter.

Once material was input into the device and a constant stream of filament was being output, the final requirement was partially achieved. A continuous 29-foot strand of filament with sections varying in diameter near the 1.75 mm goal was created.

Concluding Remarks

Testing and evaluation indicated that the temperature of the nozzle was successfully able to reach 300 °C and be controlled by the user, satisfying the last two requirements. The extruder was able to produce filament with a 1.75 mm diameter under certain combinations of correct temperatures, extrusion speeds, and cooling conditions, but was unable to maintain the required tolerance of ± 0.05 mm.

Acknowledgments

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