Design of a Cooling Printer Attachment

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Introduction

The Mueller group works with 3D extrusion printing, especially with polymers that exhibit different properties when chilled. Chilling printing material can be useful for industry applications. 3D extrusion printing of edible paste can be used to form novel food products. This additive manufacturing application can repurpose food that would otherwise go to waste. However, to expand this concept, some foods need to be kept cold to prevent health issues.[1] Similarly, 3D printing of drugs and biomaterials has the potential to deliver tailored, customizable solutions in terms of product shape; however, temperature affects rheological and biological properties of the extruded material, with some materials needing special temperatures.[2]

Objective

The main goal of this design project is to create an inexpensive 3D printer attachment to chill extruded material for advancing research in the Mueller lab.

Materials and Methods

A casing for a 3D extrusion printing chamber was created in SolidWorks or physically constructed using Styrofoam board and insulation tape. CAD-designed casings were printed using polylactic acid (PLA) or acrylonitrile styrene acetate (ASA) filament. Styrofoam, PLA, and ASA were chosen for their insulating properties.

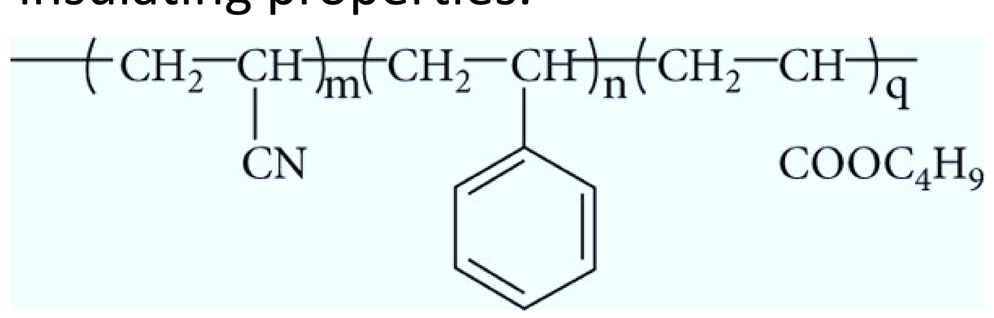

Figure 1—Chemical structure of ASA.[3]

The casing has holes for the material chamber to fit in, and a fan and Peltier cooling element that are powered by 9V batteries. Copper tape was used to connect wires. An Arduino Uno kit was used in conjunction with a DS18B20 temperature sensor to determine ambient temperature, and a Taylor digital thermometer was used for temperature monitoring closer to the cooling module. Temperature was collected after 15 minutes. Subsequently, the CAD design was updated to fit the Mueller Group's equipment.

Results

Figure 2—ASA casing model. The casing made from ASA was able to cool down the air inside the chamber slightly.

Table 1-Results of Temperature Trials After 15 Minutes of Module Run

Material	PLA	ASA	Styrofoam Board
Average Temperature (°C)	19	21	23

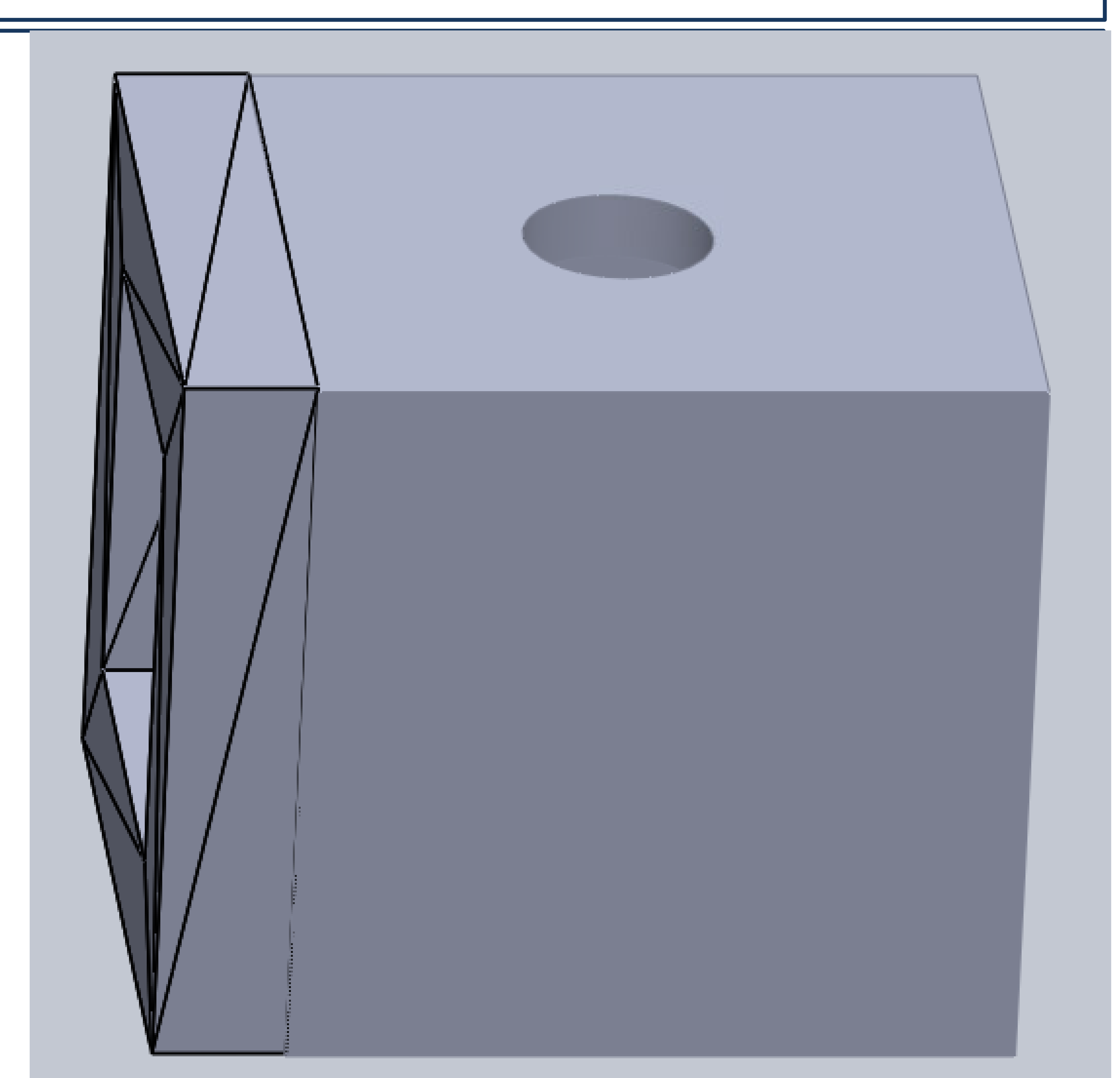

Figure 3—Final design assembly. This is the design used in testing temperature inside 3D-printed casings.

Conclusion

The design process produced the following results:

- Although the Peltier module itself cooled to about 11 °C on the cold side, temperatures within the casing were not significantly lowered.
- PLA and ASA-based designs performed better than Styrofoam board; Styrofoam board did not provide much insulation and was unwieldy. However, PLA and ASA unexpectedly had dissimilar temperatures.
- Ensuring that wires remained connected during the time frame was difficult, which may have affected testing.
- Additionally, after 15 minutes of testing, the battery power source would need replacement and may have failed to provide adequate power during testing.
- The assembly cost roughly $100 and printing time, which was relatively inexpensive based on a $500 budget.

Although the design itself was relatively inefficient, there can be several improvements made that could enhance chilling properties. To eliminate the issue of loose wiring, the components could be soldered. Additionally, different plastic materials for casing could be investigated. Due to the current design's ability to reduce ambient temperature for about 6 degrees, the cooling attachment can be used for the chilling of highly temperature-sensitive materials..

References

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(2)Seoane-Viaño, I.; Januskaite, P.; Alvarez-Lorenzo, C.; Basit, A. W.; Goyanes, A. Semi-Solid Extrusion 3D Printing in Drug Delivery and Biomedicine: Personalised Solutions for Healthcare Challenges. *Journal of Controlled Release* **2021**. https://doi.org/10.1016/j.jconrel.2021.02.027.ferences

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