Shippensburg University of Pennsylvania
School of Engineering – Civil and Mechanical Engineering Department

Project No. 04

3D PEEK Printer

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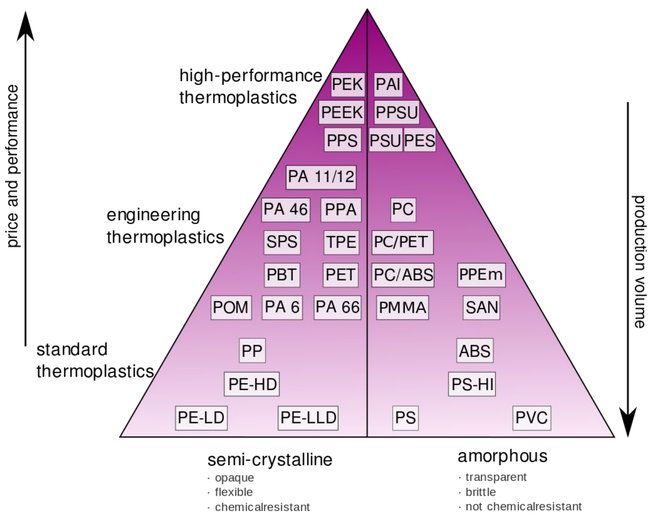
Introduction

3D printers are becoming a viable consumer product for decentralized manufacturing. Low-temperature filaments like PLA and PETG limit the applications 3D printed designs to low-temperature and strength applications. All commercial printers on the market capable of printing engineering-grade thermoplastics either cost in the 5-figures or have a limitingly small build volume. The 3D PEEK Printer solves these issues by being able to print some of the hottest thermoplastics, like PEEK, while having a build volume of 300mm x 280mm x 1330mm (roughly 1'x1'x5') and costing less than $2,500.



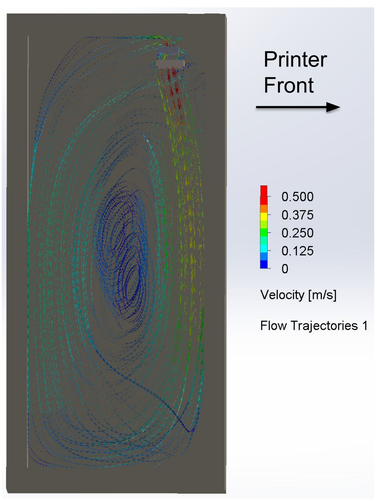
High-temperature thermoplastics

Features

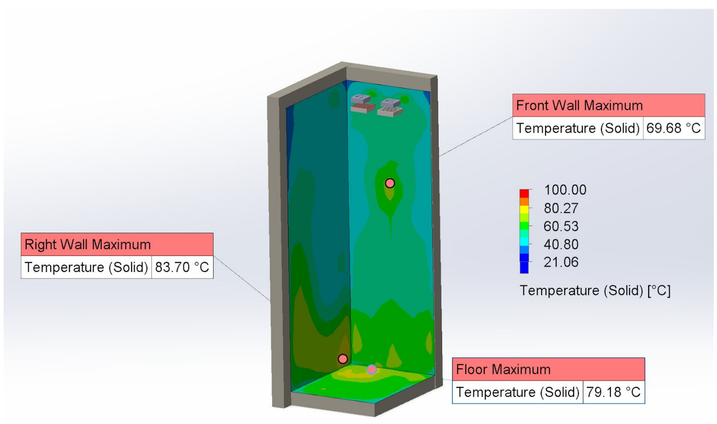
- 300x280x1300mm build volume
- Up to 450°C hotend, 200°C bed, and 80°C chamber
- Print all common filament types (PLA, ABS, PETG)
- Print PEEK objects
- Able to operate at maximum chamber temperature for 3 days continuously
- User can monitor and control movement and temperature through an LCD or through a web-interface
- Able to operate on a single 15A circuit without the heated chamber and operate on three separate 15A circuits with the heated chamber on
- Thermal protection for the hotend, heated bed, and chamber
- Fused connections in the event of a short circuit
- Hosts live view of a camera inside the print chamber

Simulations

- Air velocity simulation – visualizes the location of the airflow used to distribute heat evenly throughout the printer, allowing tall prints to be placed optimally in the heated chamber so they do not get disturbed by the airflow.



- Temperature distribution simulation – helps verify that no hotspots exist in the printer and the heat distribution is even.



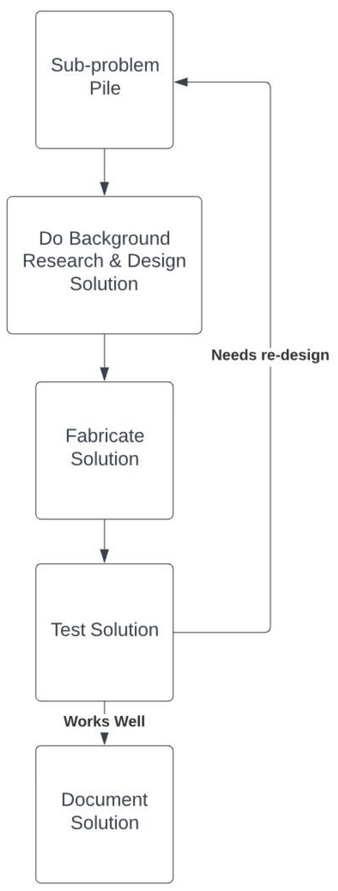
Design and Fabrication

The 3D PEEK Printer was designed from the ground up with cost in mind. Every design choice in the movement and thermal systems balanced cost vs. functionality.

Some of the main design decisions are:

- Movement system is guided by V-wheels on aluminum extrusions
  - A belt/pulley system moves the X/Y-axes
  - Lead screws move the Z-axis
- The chamber is heated by 2 1500W space heaters (simulations show they can generate enough heat)
- All parts not originally rated above 80 °C are either replaced with high-temperature versions or a solution was implemented to reduce their temperature
  - Stepper motors are cooled with a Peltier plate, heatsink, and fan combination
- The insulation is 3" thick foil-faced polyisocyanurate rigid foam

The design phase consisted of many small engineering cycle loops. To maximize efficiency, normally two of us worked on the design solution, while the other worked on the fabrication of completed design solutions. Then we would all test the fabricated solution.



The solutions that needed the largest re-designs (along with the failure reasons) included:

- Z-axis movement – a belt/pulley system with a counterweight that counteracted the force of gravity was tried but was too complicated to work reliably.
- Space heater mounts – the temperature and high-voltage nature of the space heater elements prevented the use of a 3D printed mount and a metal mount created a short to ground.
- Heated bed mount – the temperature at the base of the printer is hottest, causing the belt-to-bed mount to keep melting.
- Power cable solution – standard AC outlet receptacles were originally used for the AC power, but this required male-male power cables to use, which were incredibly dangerous and eventually redesigned for safety.

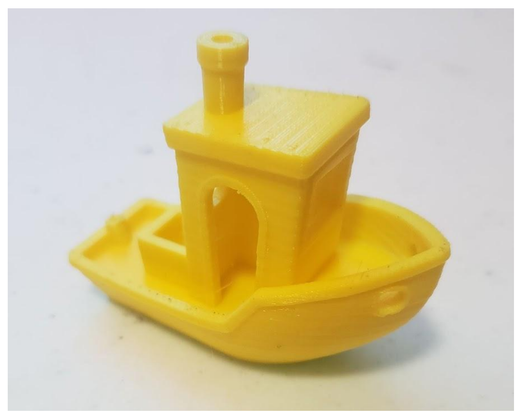
Finished 3D PEEK Printer

Results

- Prints of a standard 3DBenchy out of different materials yielded similar results, regardless of the material used.
- A static mixer was printed out of PLA to demonstrate the 3DPPs height capabilities
- A tall test print out of PEEK was not done due to filament cost, but given the similarity of the benchys, it stands to reason a tall PEEK print will have similar results as well

PEEK "Benchy" Test Print

PPS "Benchy" Test Print



PLA "Benchy" Test Print

Tall PLA Test Print of a Static Mixer

Acknowledgments

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