3D Printer Die and Winder

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ABSTRACT

Trine University was founded in 1884, with the mission to "… promote intellectual and personal development through professionally focused and formative learning opportunities, preparing students to succeed, lead and serve." Trine University's Design Engineering Technology department owns 3D Printers that are used for furthering the education of students and faculty. To aid in 3D printing, the senior design group was assigned the task of creating a system for extruding, cooling, and winding 3D printer filament. This machine will be comprised of a special extruder die, cooling fans, and a winder. The specifications given were that the filament must be 1kg spools of PLA or ABS with a 1.75mm diameter and a tolerance of +/- 0.03mm. After research, development and testing the design meets these requirements. This system adapted existing equipment to save the university money while allowing students to produce filament.

Figure 1: Extruder and Cooling Assembly

CUSTOMER NEEDS/SPECS

The target specifications were based on the needs of the sponsor. The sponsor made these requirements based on the desires of the consumer and industry standards. With industry standards such as the tolerances for the filament, the team was able to create specifications shown in Table 1.

Table 1: Customer Needs/Specs.

Metric	Value
Filament Diameter Size	1.75mm
Filament Diameter Tolerance	+/- 0.03mm
Maximum Occupied Floor Space During Use	3ft X 20ft
Maximum Occupied Floor Space When Stored	8ft X 8ft
Spool Weight When Full	1kg
Material Printing Capability	ABS, PLA
Able To Disassemble And Reassemble	Number Of Sections: 4≤
Assembly Frame Material	Steel, Aluminum, Sheet Metal
Maximum Budget	$3000.00

DESIGN CONCEPTS

The created three concepts to present to the sponsor. Figures 2 – 4 shown these concepts. Each provides unique capabilities.

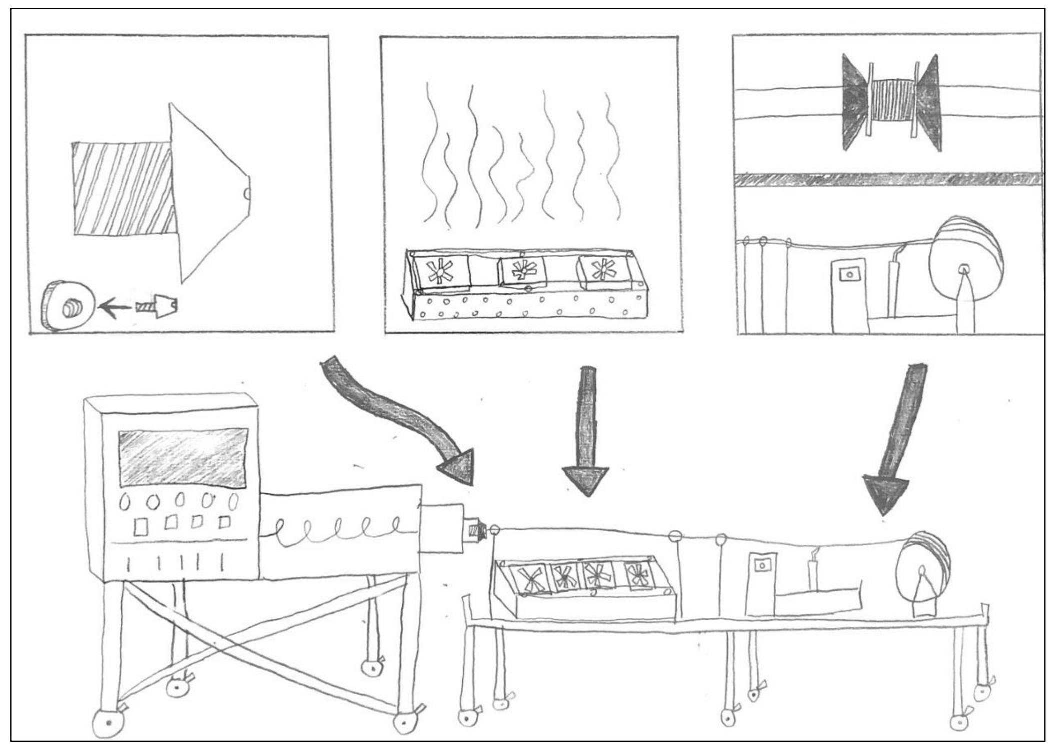


Figure 3: Design Concept I, Nozzle Die, Fan Bar, Tick winder

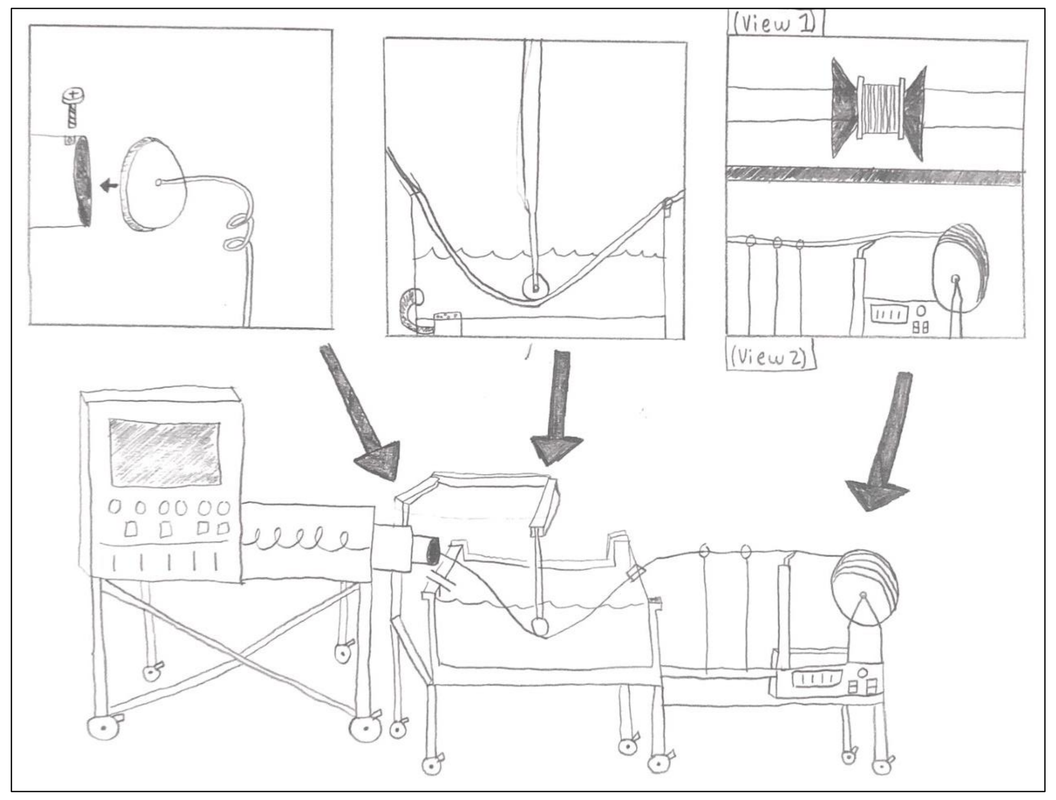


Figure 4: Design Concept II - Traditional Die, Water Cooling, RPM Winder

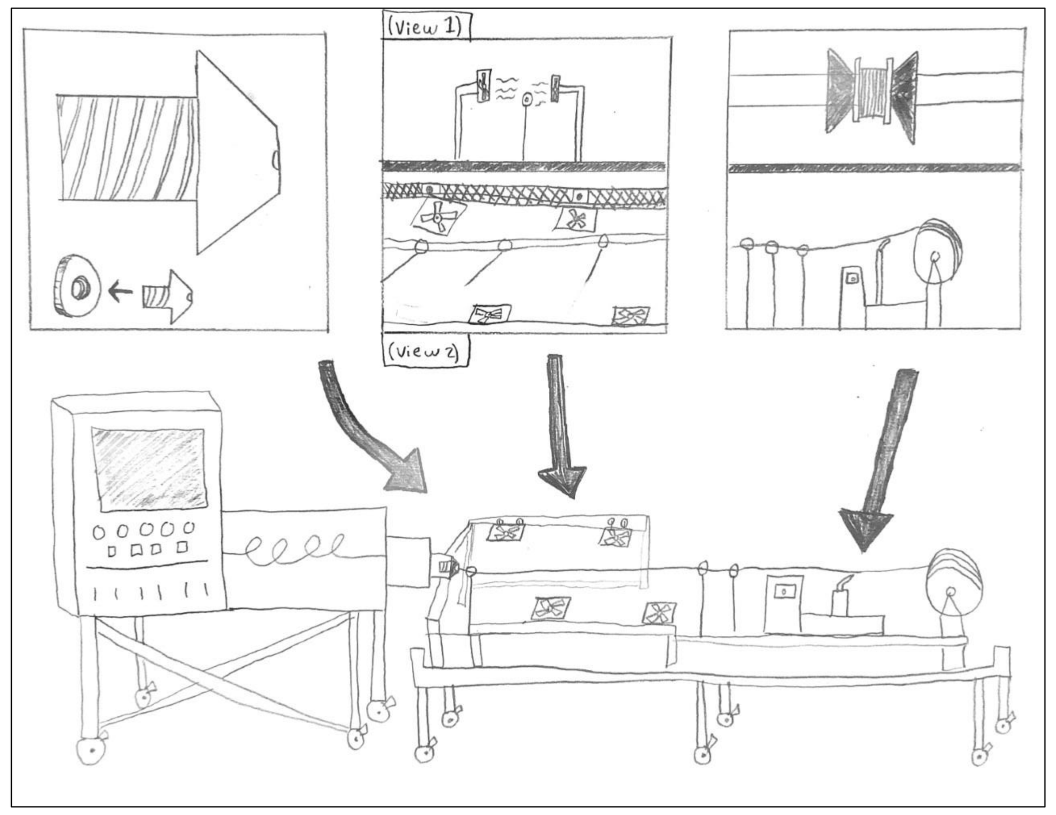
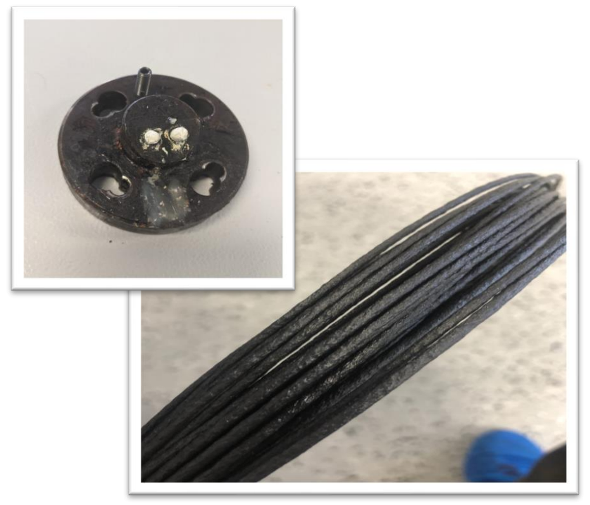


Figure 4: Final Design Concept III - Nozzle Die, Side Mount Fans, Tick Winder

DIE TEST RESULTS

The Steer Model 0/2.2/9.5 Plastic Extruder was used to produce ABS and PLA filament during the team's die testing. The team tested the quality of the filament, as well as the filament diameter and consistency. The team ran many samples with the extruder, while using different extrusion temperatures and dies. The team found the best temperatures to run the extruder at, while producing ABS, was Barrel 2 @ 360°F, Barrel 3 @ 360°F, Barrel 4 @ 365°F and Die Assembly at 370°F. This would create a constant and thorough filament to 1.75 mm +/- 0.03 mm. The fans cooled the material, which the team allowed for material shrinkage before it would be pulled through the extruder and wound through the tick winder and onto the spool. Figures 5-8 show the dies and filament results.



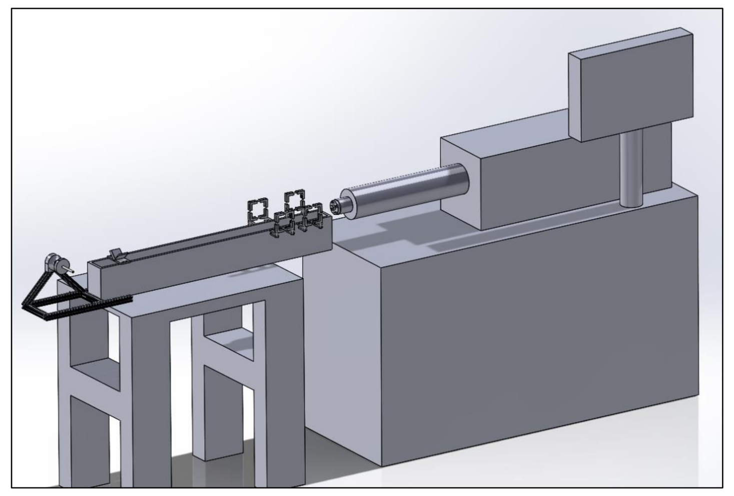
Figures 5 & 6: Original Die & Filament

Figure 7 & 8: 3D Filament Die & Filament

FINAL DESIGN

To decide on the final design, in Figure 9, to move forward with, the team met with the sponsor. In the meeting the team highlighted each subsystem and the options that were developed for each. The team discussed how each subsystem would interact in the complete system and explained the reasoning for each design choice. After the presentation, the sponsor weighed the pros and cons for each design. The team then discussed with the sponsor how to best incorporate as many of the desired features into the system while maintaining the operational meshing of each subsystem. Ultimately the final design chosen included a traditional die, air cooling, and a tick over winder.

Figure 9: 3D Modeled Final Design



CONCLUSION

The team believes the complete machine will meet the expectations of the sponsor and provide a system which can produce 3D printer filament. The Design Engineering Technology Department will now be able to create filament for the 3D printers which will help in future student projects and prototyping. Creating this machine and process in order to facilitate student learning was the main goal of the department and the team delivered on this goal. The machine produces filament at 1.75mm +/- .03mm, cools the material, and then winds it onto a spool.

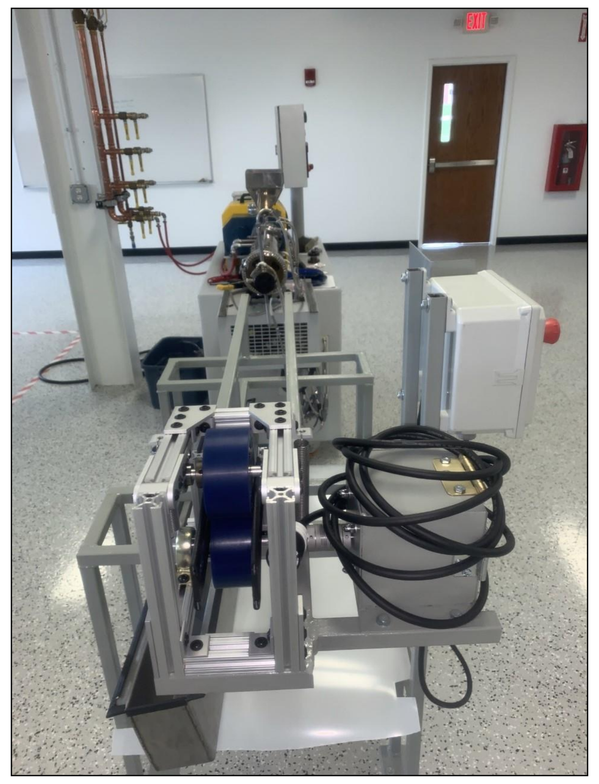


Figure 10: Downstream of the Cooling & Winder

LESSONS LEARNED

Through the Duration of the Project the team learned

- Project and time management is critical to success.
- Assisting teammates with individual tasks is often required, as tasks develop and change.
- The first solution is not always the best or correct solution. Revisions and more brainstorming are often required.
- Working with the sponsor on a regular basis kept the project in line with what the sponsor's end projections were.

ACKNOWLEDGEMENTS

Matt Clark, Owner and Operator of Trihelix
Joe Thompson, Lab Technician, Trine University
Tom Trusty, Associate Professor, Chair Design Engineering technology
Franklin Luchini, Assistant Professor, Design Engineering Technology