Extruder Cooling Line Team

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ABSTRACT

Trine University's School of Engineering and Technology offers a plastics minor with machines and tools for the students to gain experience with in a lab environment. One machine is a polymer extruder which mixes plastic pellets and any filler the students wish to add and extrudes the hot material through a die forming a 2D profile part, Figure 1.

Figure 1: Plastic Extruder

The current setup has no cooling unit at the die end, so when the hot plastic is extruded, it falls straight down into a bucket making achieving a standard sample difficult. The design team is tasked with designing a simple cooling system that catches the extruded plastic upon emerging from the die and cools it to a temperature which is safe to handle. A mechanism to pull and guide the plastic is required and must match the speed of the extruder. With these requirements, the design team came up with the design of a water trough system supported by a frame with a mechanical puller device to guide the extruded plastic and provide sufficient cooling. The two main factors of the project were cost and overall size.

CUSTOMER NEEDS/SPECS

Trine University's plastics lab needs cooling line for the polymer extrusion machine students use for coursework. Current commercial solutions are too costly, so a design team will develop a low-cost solution that will cool extruded materials in a cost-effective manner. Tables 1 and 2 show the needs and some specifications for the project.

Tables 1: Needs

Customer Needs
Cool polymer for safe to touch
Puller system speed matches the extruder
Motor runs off standard wall outlet
Corrosion resistance
Mobile
Product looks neat and professional

Table 2: Specifications

Specifications
Trough length 3-4 feet
Max temp. 450°F
Cool polymer to 110°F
120 volts
Motor 1/4 HP max

DESIGN CONCEPTS

The design process included sub-problems for a cooling trough, pulling system and frame. The team developed several different designs for the shape of the trough as shown in Figures 2-4. The team had to consider how much water would be needed to sufficiently cool the plastic parts and not over heat the water too quickly. Also, material selection was critical as the trough would hold water and needed to be corrosion resistant. The team decided to go with stainless steel for the trough, this is for its corrosion resistance and professional look.

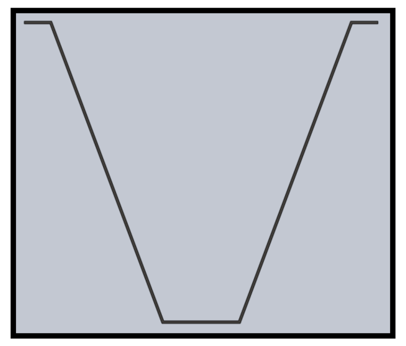

Figure 2: V Shape Trough

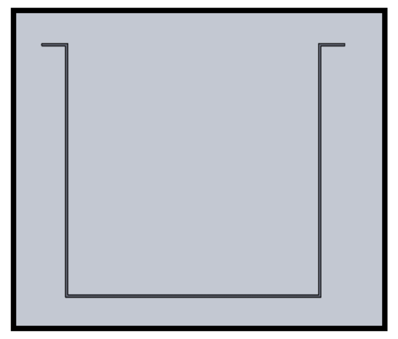

Figure 3: Large Box Trough

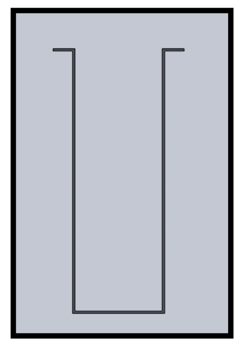

Figure 4: Skinny Trough

The team also generated several different designs for the frame. The frame designs are shown in Figures 5-8. For the frame design, the team looked at stability and ease of access for the operator as the major factors. The team considered two different materials for the frame: 1-inch 8020 aluminum and 1-inch stock tubing. The team went with stock tubing for the frame to save money, but still used 8020 for the puller device.

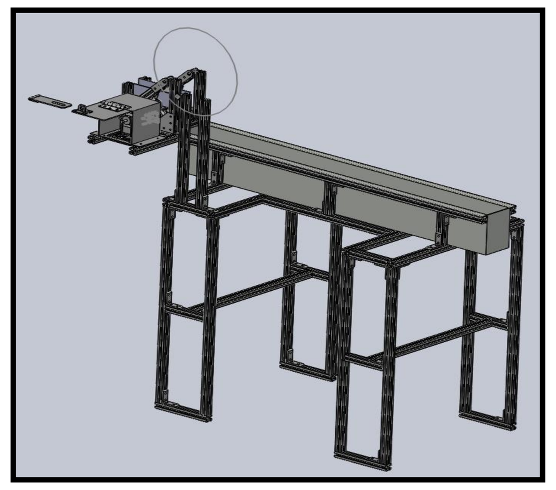

Figure 5: Design Concept 1

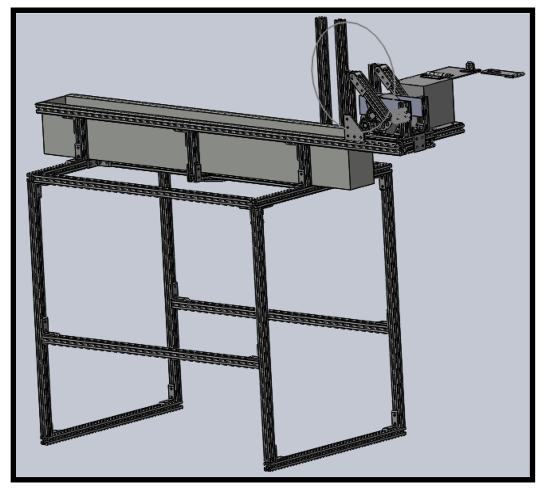

Figure 6: Design Concept 2

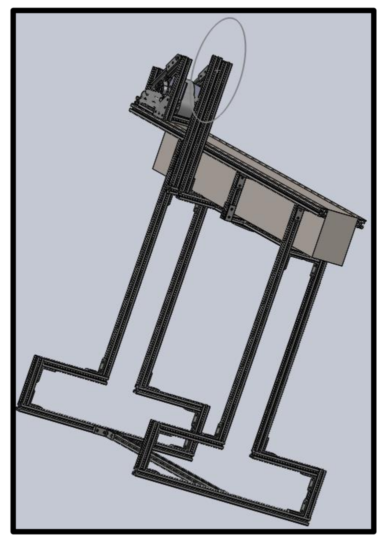

Figure 7: Design Concept 3

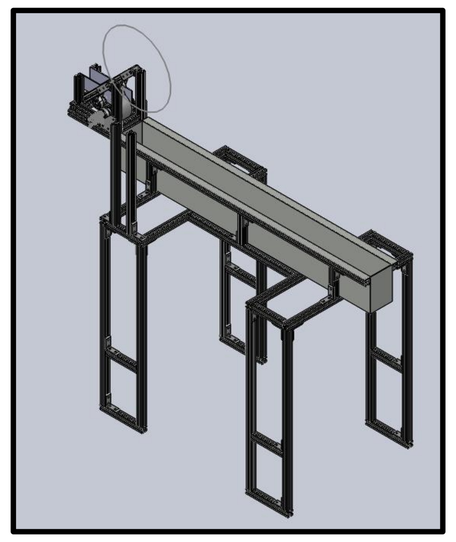

Figure 8: Design Concept 4

TEST RESULTS

SolidWorks was used to perform an FEA analysis on the trough and the frame to verify that the design would be adequate for the amount of water in the trough and the components of the puller system. Each test had a simulated water weight of 50 lbf and another 50 lbf to simulate a student pushing on the side. The test was done with two fixed constraints and two rolling constraints to accurately represent the frame being on casters. The factor of safety for this final design was 3.294 as seen in Figure 9. The displacement was 1.855 mm as seen in Figure 10.

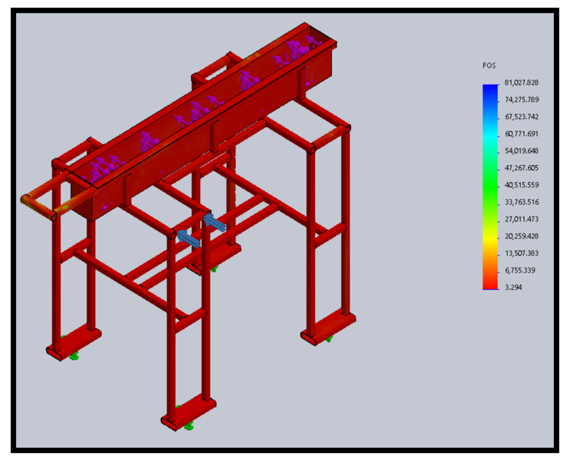

Figure 9: Factor of Safety Test

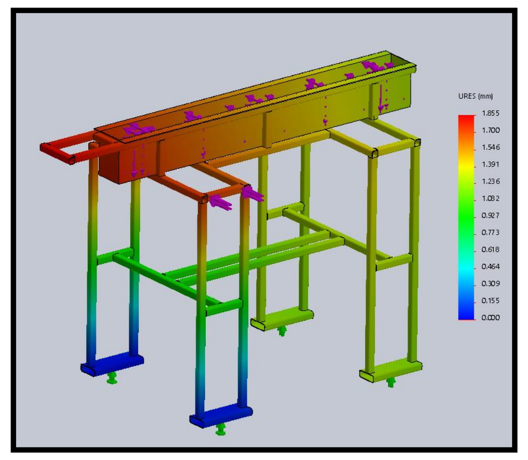

Figure 10: Displacement Test

FINAL DESIGN

After consulting with the polymer science lab instructor and the Design Engineering Technology Department chair regarding the test results and design concepts, changes were proposed based on the design concepts and testing. The design in Figure 11 was chosen for ease of accessibility, lighter weight, and improved stability. Figure 12 shows the actual cooling line machine built for the polymer extruder in the plastics lab in Bock.

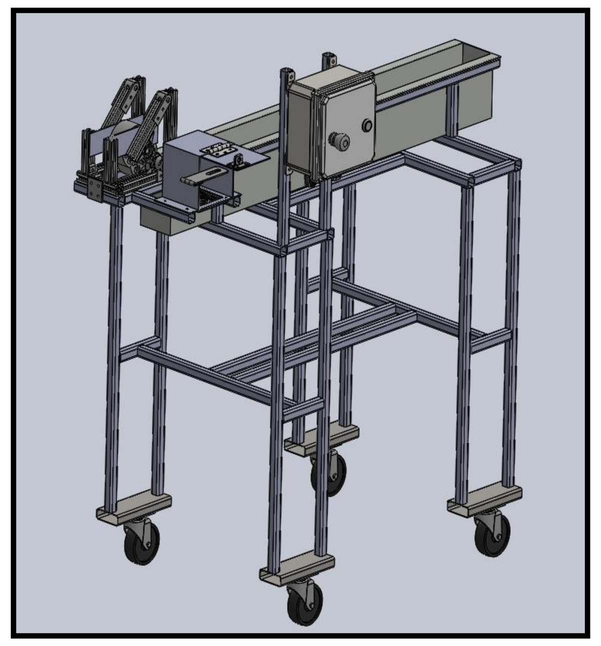

Figure 11: Cooling Line System Final Design

Figure 12: Cooling Line System Actual Machine

CONCLUSION

The team has assembled a functional plastic extrusion cooling line for the Design Engineering Technology department at Trine University. The team used the different engineering design phases to effectively come up with a low cost design for the cooling line. The cooling line allows the molded part to float across the water in the trough to cool the plastic, while the puller system successfully continues to draw the plastic and remain at the same speed as the plastic extruder. Figure 13 shows the cooling line and extruder side by side and the team believes this solution will meet all of the department's needs for lab work.

Figure 13: Cooling Line System Actual Set-up

LESSONS LEARNED

Throughout this project, the team learned:

- The importance of time management.
- Communication is essential to the success of a team-based project.
- The design process is always changing.
- Paying attention to detail in every aspect of the project is crucial.

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