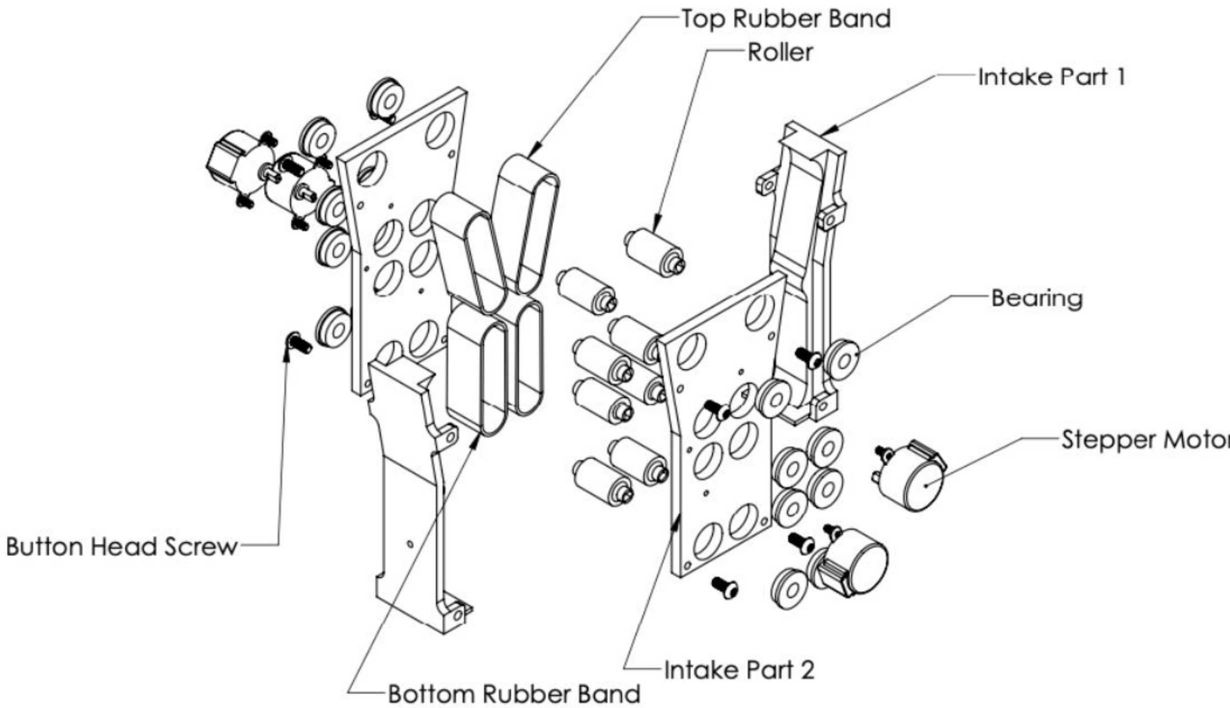

Wisper Report Paper

10.15.2020

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Team: D.A.D (Dirt Automatic Disposal)
Class: ME4320
Instructor: Prof. Stabile

Introduction

This report is to describe the mechanism of a designed Wisper under the cooperation with iRobot. The company was developing a new version of roomba; they had solutions for dispensing different debris types onto the belt in front of the cleaning system for all but furious pet hair type debris. Therefore, iRobot required a solution for processing bulk cotton and then dispensing small fibers onto a conveyor belt surface to simulate pet hair on a carpet in customer homes, as well as an embedding mechanism to press the fibers conveyor belt carpet to simulate foot traffic driving the hair deeper into the carpet. The team goal was to create a device that could transfer bulk cotton into wisps in the use of testing roomba's functionality on different types of debris.

Background

The product was mainly used in industrial use -- in the use of creating fiber wisps as simulation of pet hair to test functionality of iRobot roomba. The product was mainly made of PLA so the use environment should mainly be indoor not to expose it under the sunlight.

Evolution of Designs

Circle Sketch

Each of the team members came out with a different design and put it into the circle sketch, with a total of four to five designs. Initially, most designs were using the ideation of squeezing. Shown in the figure below, two designs on the top of the picture prefered using heavy weight to press the bulk cotton and squeeze it out from the exit at the bottom. Another design used two moving parts with nail boards which simulates humans using two hands tearing down bulk cotton. Such a design could complete the task well in theory, but it was against the original requirement of safe to use. The last sketch at the bottom left stood out and became the initial idea of the design, which used a conveyor belt one side and a roller at the other to help rolling down the bulk cotton.

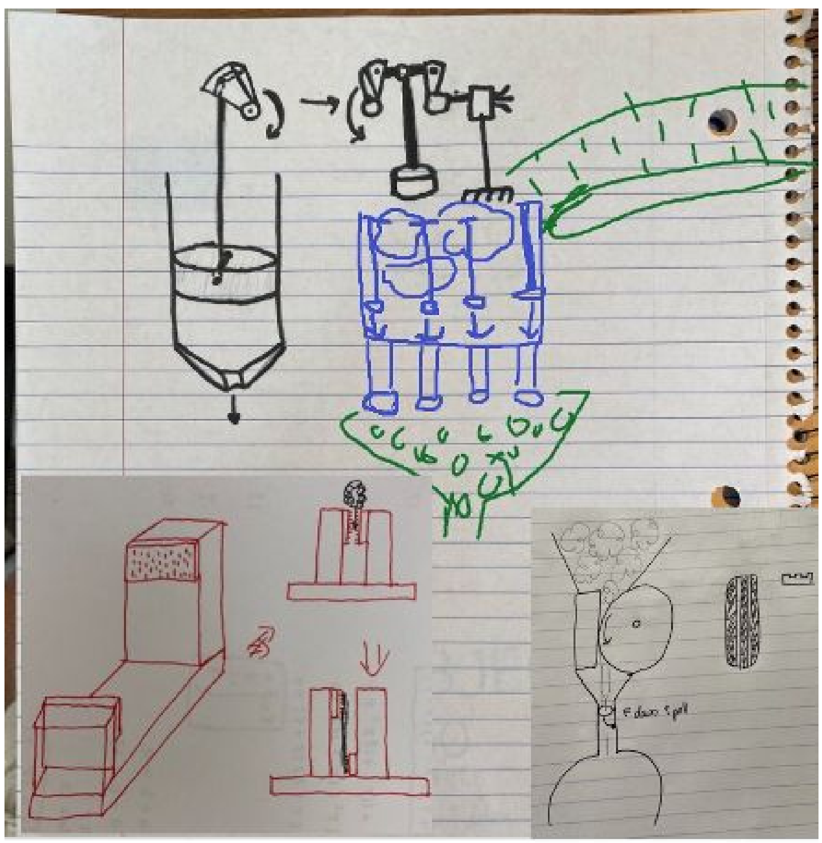


Figure 1. Circle Sketch

Mini Challenge

The mini challenge model was the first CAD model that had been made in the project; it was a hand-hold model. In the early ideation, there were three gears on each side with different sizes to drive four conveyor belts that were going downward. The problem with that design were the gears -- error tolerancing for gears were too low to have the 3D printers to implement. But the ideation had been decided.

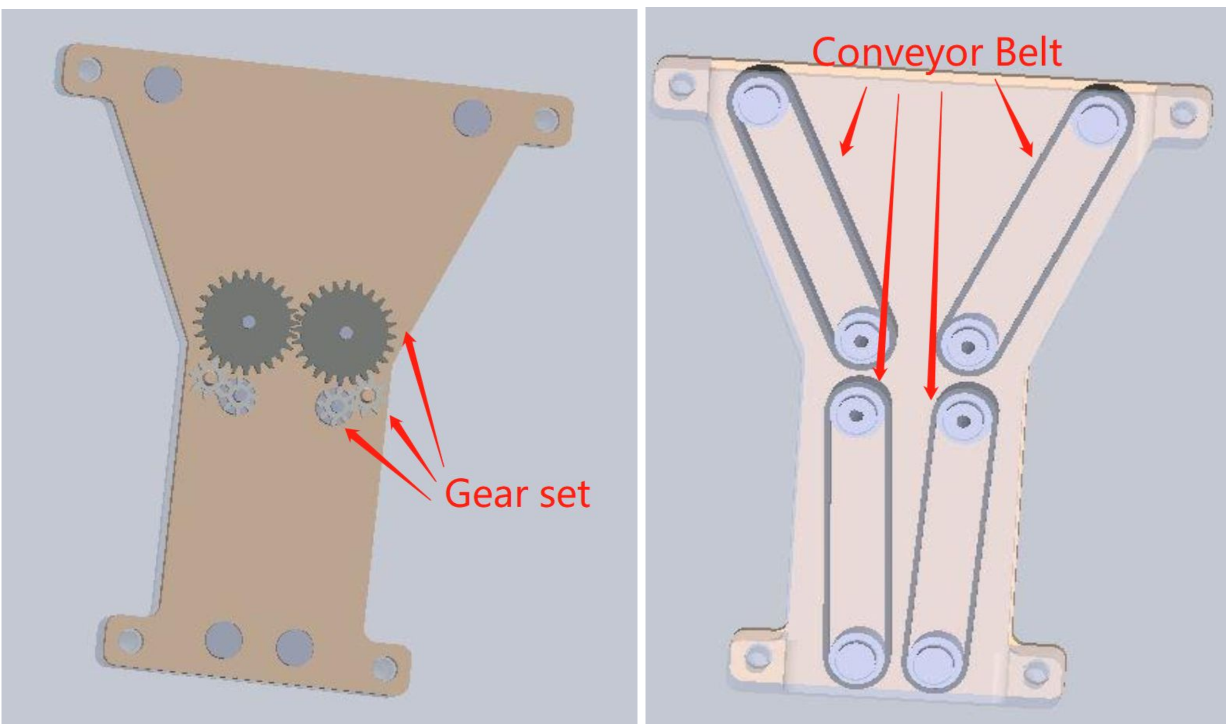


Figure 2 & 3. Mini Challenge CAD Model

First Iteration of Design

There were two parts in the first iteration: input and exit. The input part stuck with the idea from the mini challenge. Differences were that in the full-scale model, instead of using gears, 4 sets of bearings were added acting as connections of each conveyor belt, as well as a funnel for cotton intake. The team also designed a round-shape exit. In this part, silicone scrapers were installed in the exit acting as comb to scrape cotton off of conveyor belts and to drive wisps of hair out from the device in the exit at the left corner. The overall design was well enough theoretically, but what was left was error tolerancing -- this design was not easy for 3D printers to print out, and if there were any small mistakes during the printing process, its effect could be amplified and impact the entire model.

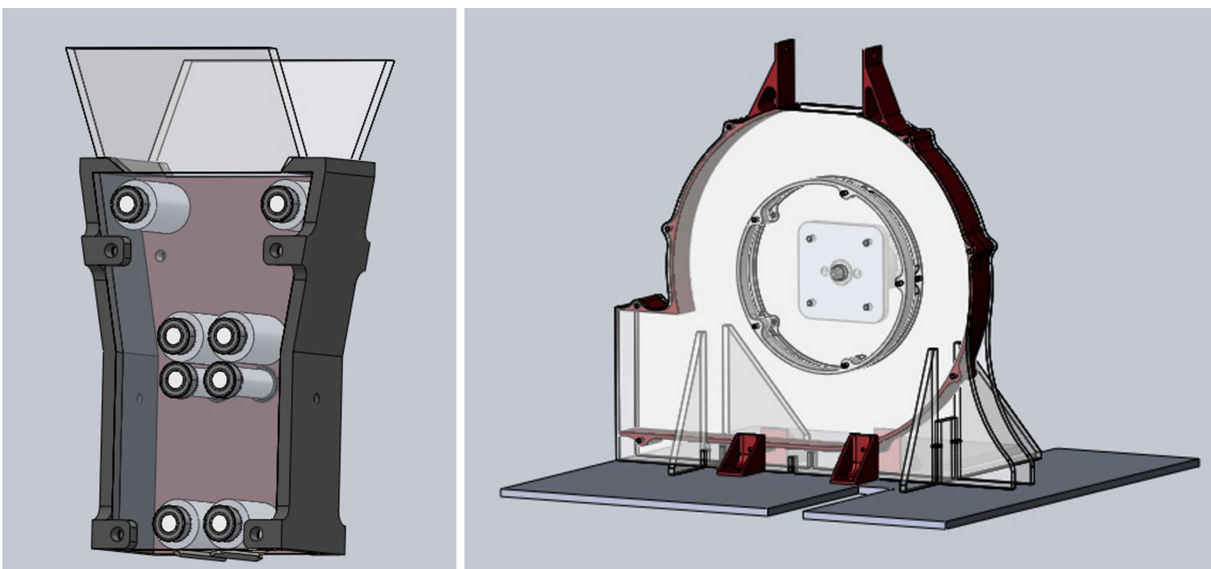


Figure 4 & 5. Intake & Exit Mechanism

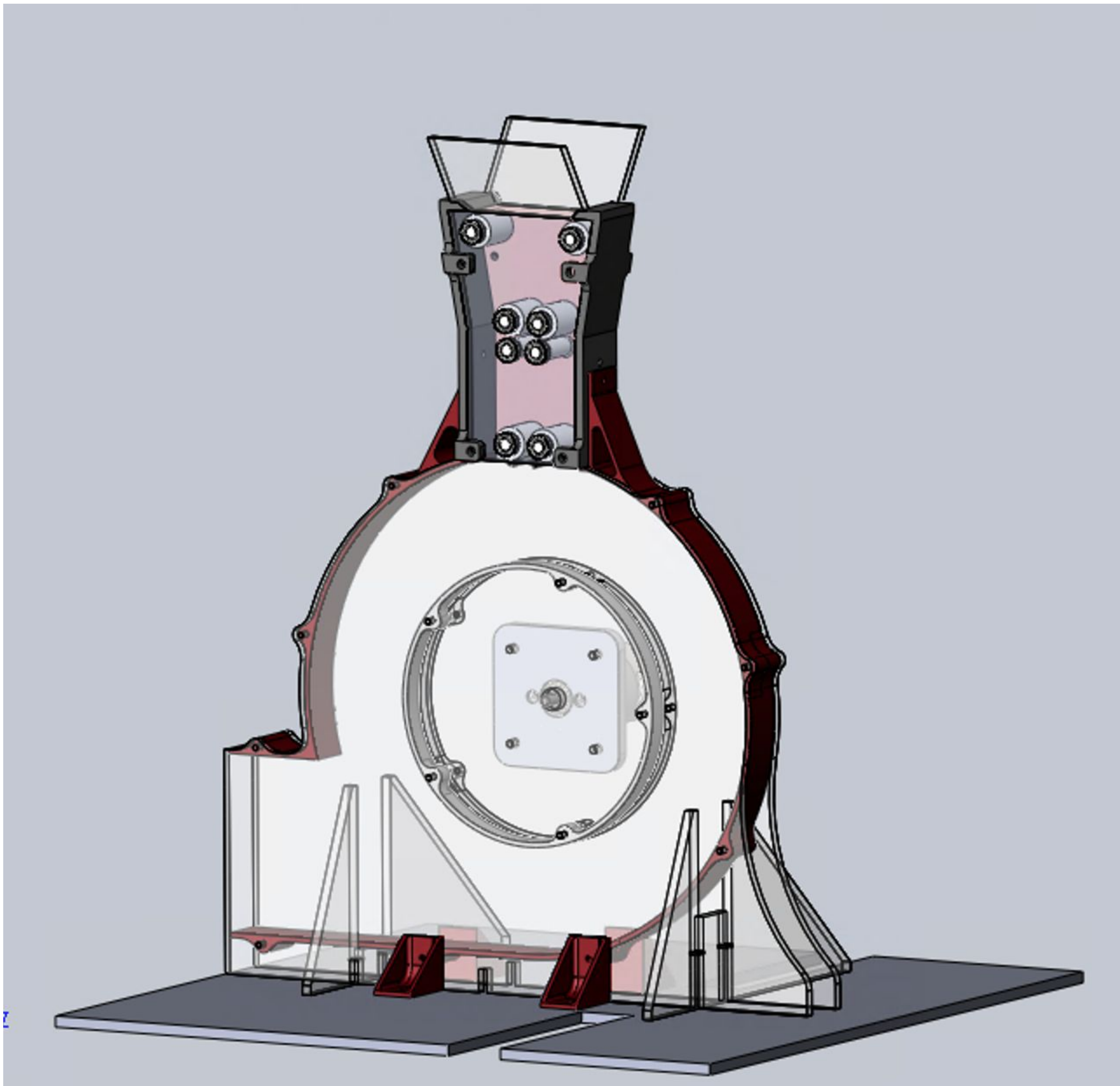


Figure 6. First Iteration of Design

Initial & Final Prototype

The initial prototype was quite close to finished. The team changed a funnel design, making it large enough so that bulk cotton can be fed in smoothly. Also added four independent stepper motors to drive each conveyor belt installed externally at two sides. In detail, four conveyor belts were divided into upper and lower pairs. Theoretically, conveyor belt rolling speed should be adjustable, but due to technical reasons it was not applied in the real product. For the exit part, four silicon combs changed into two, and a motor was added to drive silicone scrapers as well.

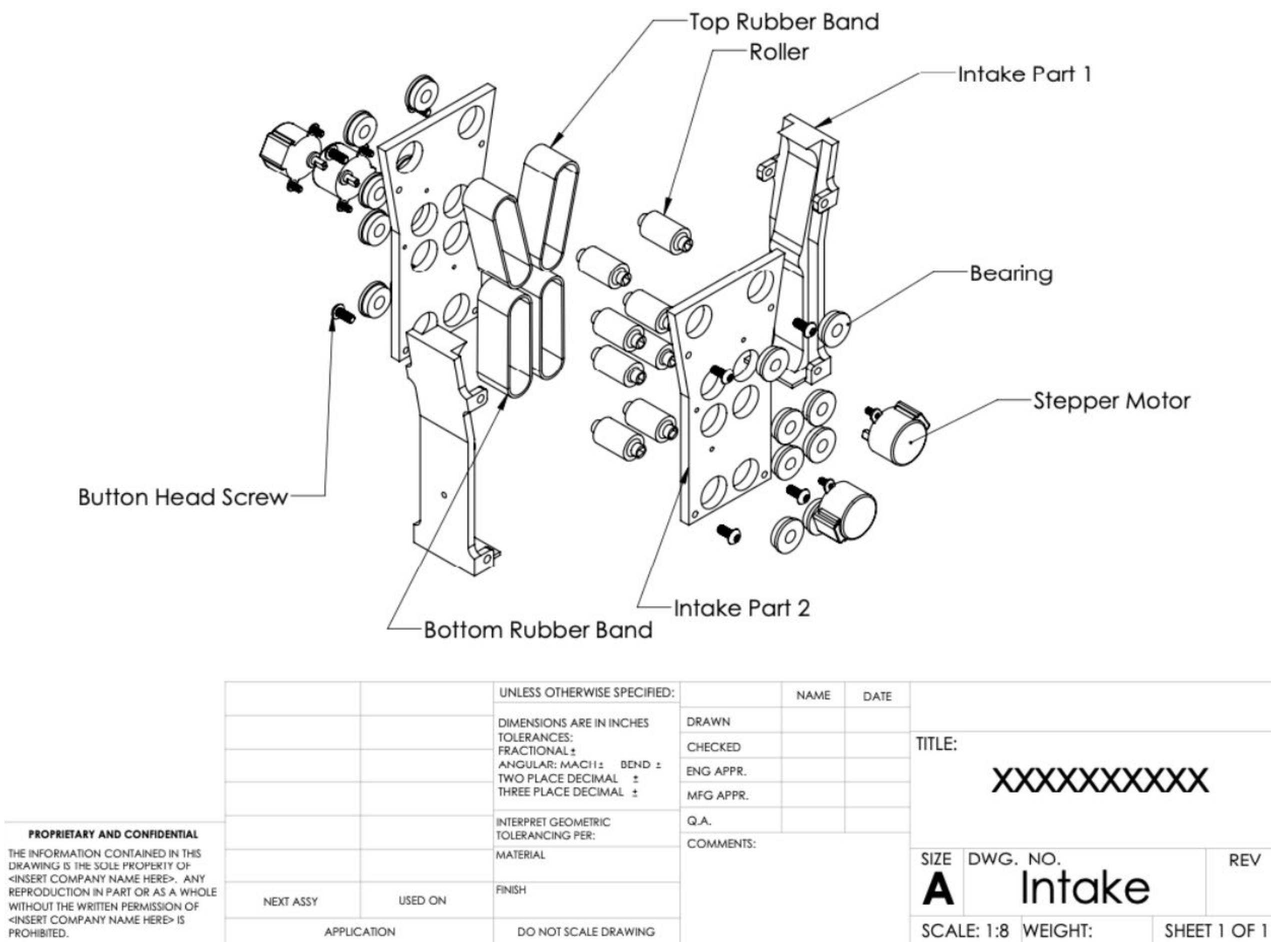


Figure 7. Intake Exploded View

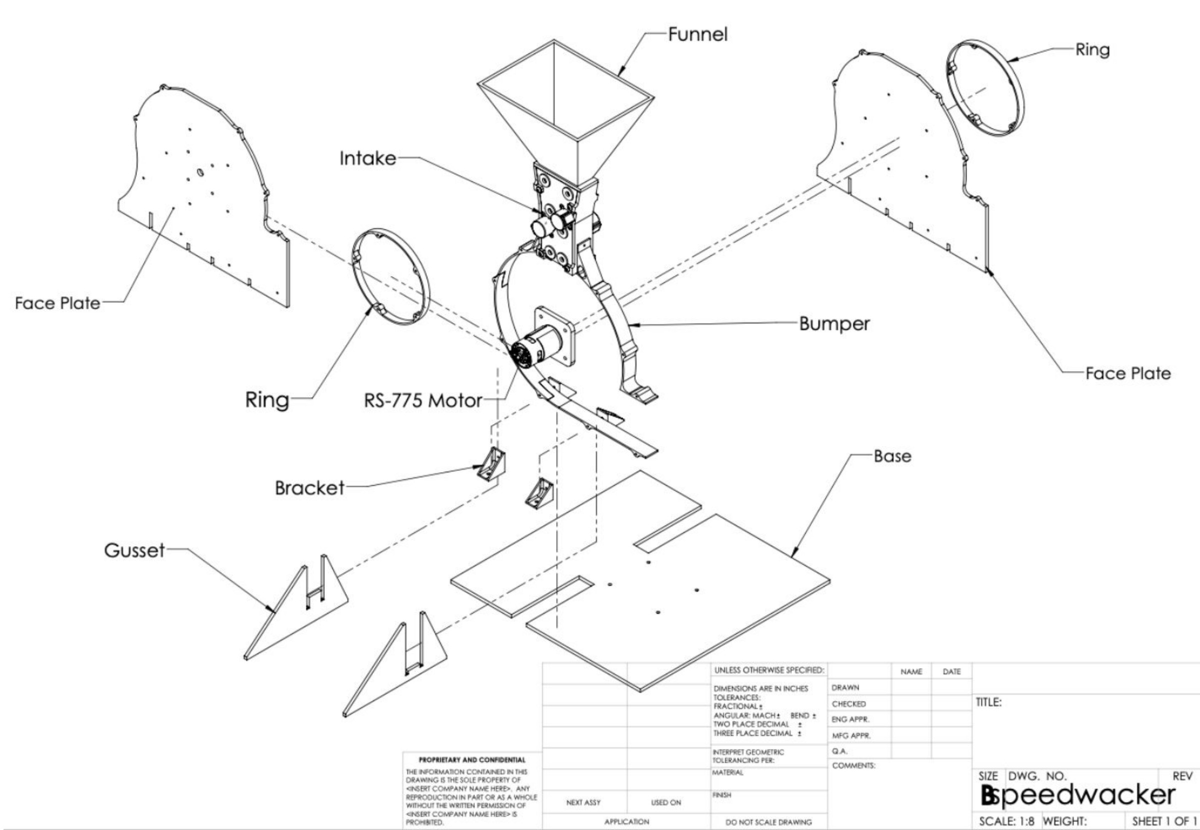


Figure 8. Exploded View of Final Prototype

Features

Operating features mainly located in the intake part, including four stepper motors, four pairs of rollers with a total of 8, two pairs of conveyor belts with length of 2 inches. There was also an RS-775 stepper motor installed on one of the face plates to drive two silicon scrapers to rotate and to scrape any cotton coming out of the sandpaper turning it into small wisps of fibers.

Non-operating elements included every part other than what were mentioned previously. Most of the non-operating parts were mainly for fixing -- base plate mounted the entire device;

two gussets, brackets, bumpers, rings, and faceplates were all used for securing the output device.

Manufacturing Sequence

The graph below showed the sequence of how the entire device was fabricated and assembled. Basically all parts were designed in Solidworks and printed out by 3D printer at school. For holes on acrylic plates of the intake and bigger face plates and gussets of the output exit, laser cutting was the technique that the group had used. Meanwhile, Arduino boards, motors, wires, and other electronic elements were all ordered online and shipped to the school.

Ordering parts, laser cutting, and 3D printing were working parallelly due to there other groups also in line waiting for printers and laser cutters. Starting to build the model after every part and electrical elements were ready, either through hole tapping, sanding, or gluing. Once the device was built, the team started testing for further results and analysis.

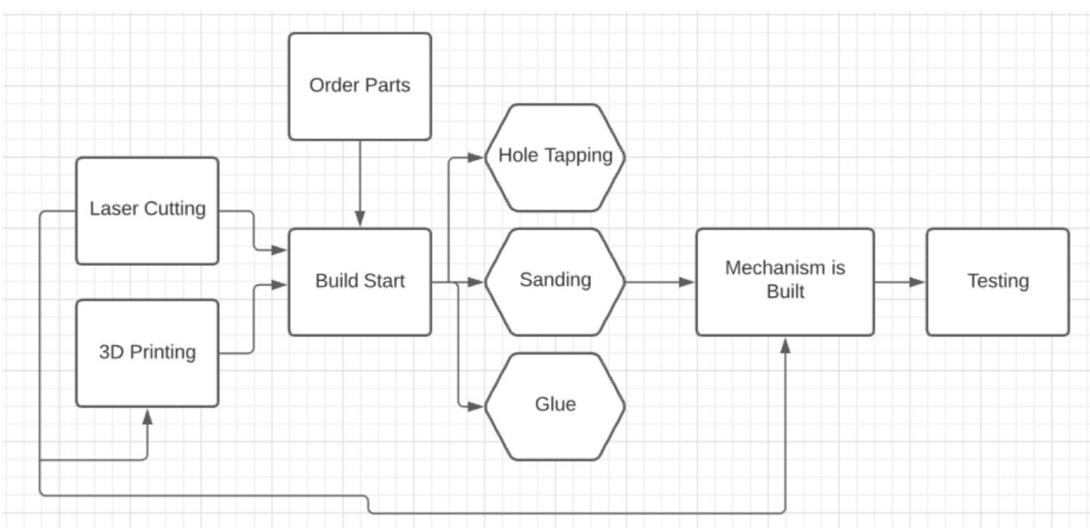


Figure 9. Manufacturing Sequence

Testing & Analysis

The team had run some tests on the conveyor belt in order to know which material of it was most ideal. There were two choices -- rubber band or sandpaper, if sandpaper, how much grip should it be to get a good result. There were also tests on the laser cutting parts because that was where most rollers, screw holes, and motors were attached. A good design on the error tolerancing and accurate cuts would significantly improve the performance of the product.

As a result of the first problem, sandpaper would perform better than rubber band. However, the feeding speed was not stable -- it relied much on bulk cotton's weight. And for laser cutting results, dimensions of holes started to have errors. The solution to that was to increase the dimensions of holes to allow errors and therefore put less stress on bearings so that rollers could run more freely as well. The chart below showed the specific difference between CAD model and laser cutting dimension.

Hole Size	CAD Diameters (Ideal)	Laser Cut Diameter (Real)
Big Hole	0.8''	0.813''
Medium Hole	0.15''	0.160''
Small Hole	0.093''	0.115''

Conclusion

Generally the goal has been reached; the team has come up with an idea of turning bulk cotton into wisps and realized it. The mechanism worked well -- inputting bulk cotton, spitting out wisps, and the wispocity remained between 1 to 2. If the users are mainly used for creating small pieces of fibers, the current version of the product is just enough to reach their goal.

Additionally, due to various reasons, four motors were all running at the same speed, which did not satisfy the initial idea of upper and lower conveyor belts running at different speeds (upper conveyors run slower than the bottom ones).

In the future design, a stronger motor would be required just to perform better; same as conveyor belts, because of the sizes and grip limitations, many rubber bands and sandpapers were not applicable to this project, if it's possible, 3D printing conveyor belts in Ninjaflex would be helpful in the implementation step. Another future plan was to build a better machine guarding system to the device -- the plan was to add cover to the output end so wisps wouldn't be flying all over, also use press-fit bearings, and to add a push button to the device for safety reasons.

Pros and Cons:

Pros:

1. Did not rip or tear cotton
2. Feed rate was adjustable
3. Hopper was strong enough to hold 0.25kg of cotton

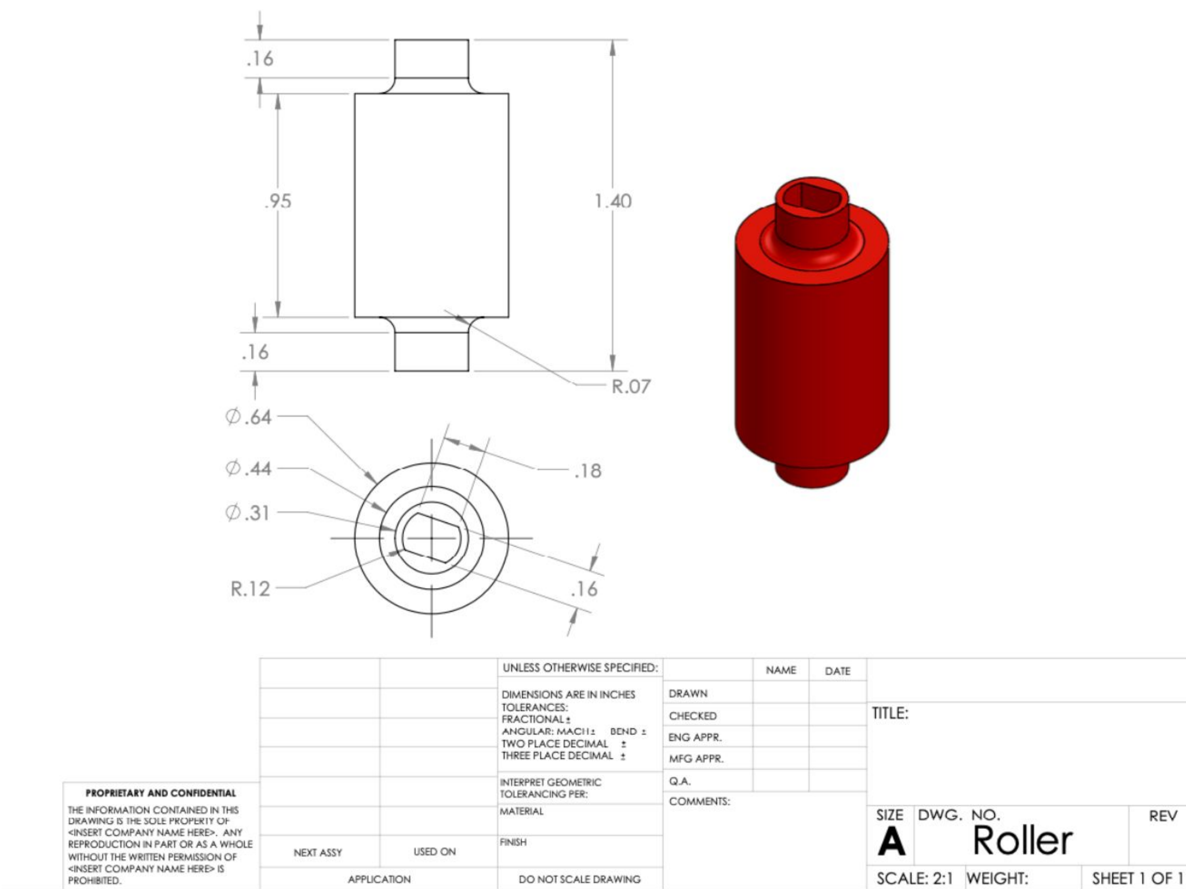
4. Every piece was smooth, which was completely safe to use
5. Final design was within the given size and weight limitation

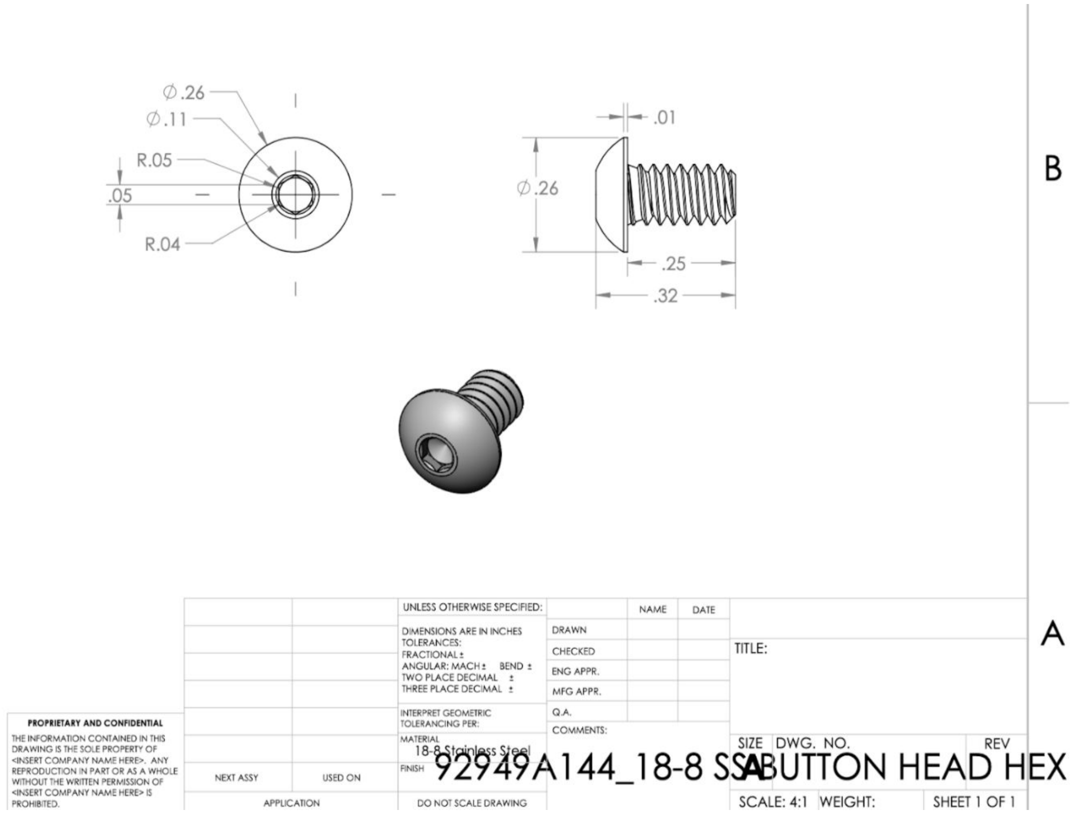
Cons:

1. For objective reasons, motors were limited in power
2. Wires were complex when installing the model
3. Some part, for example conveyor belts, were hard to assemble

Appendix

I. Drawings





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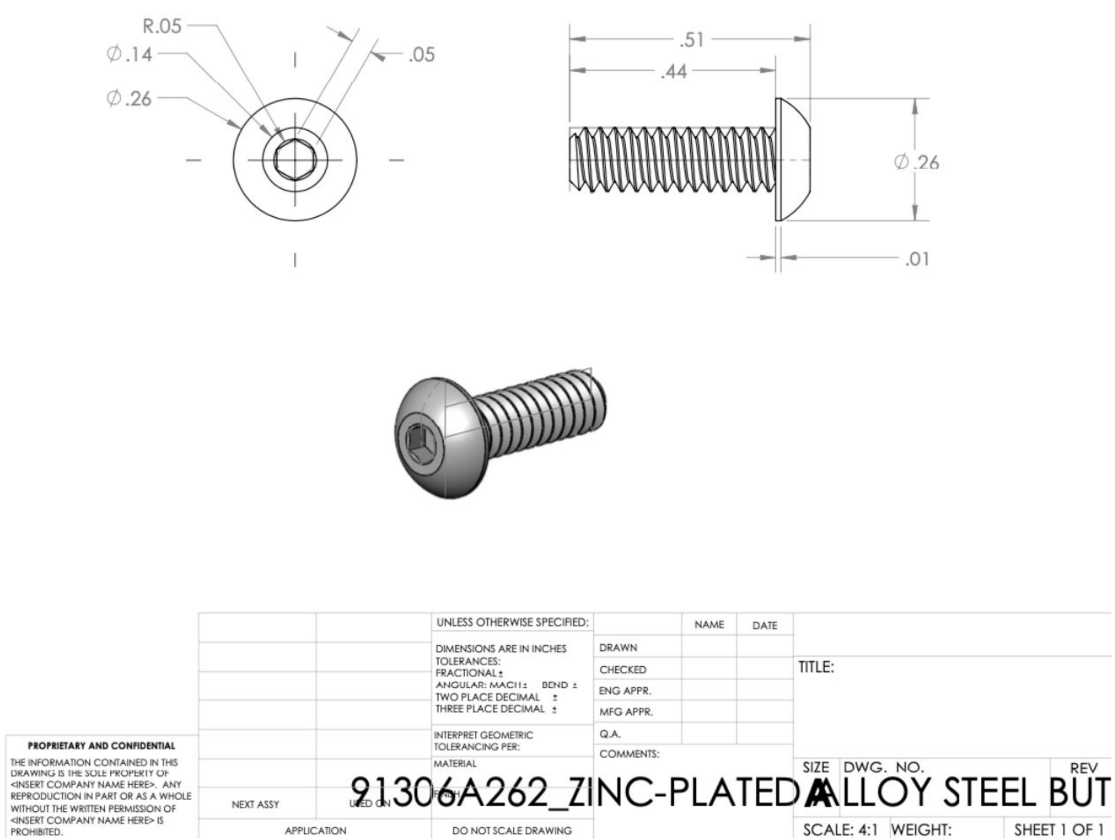

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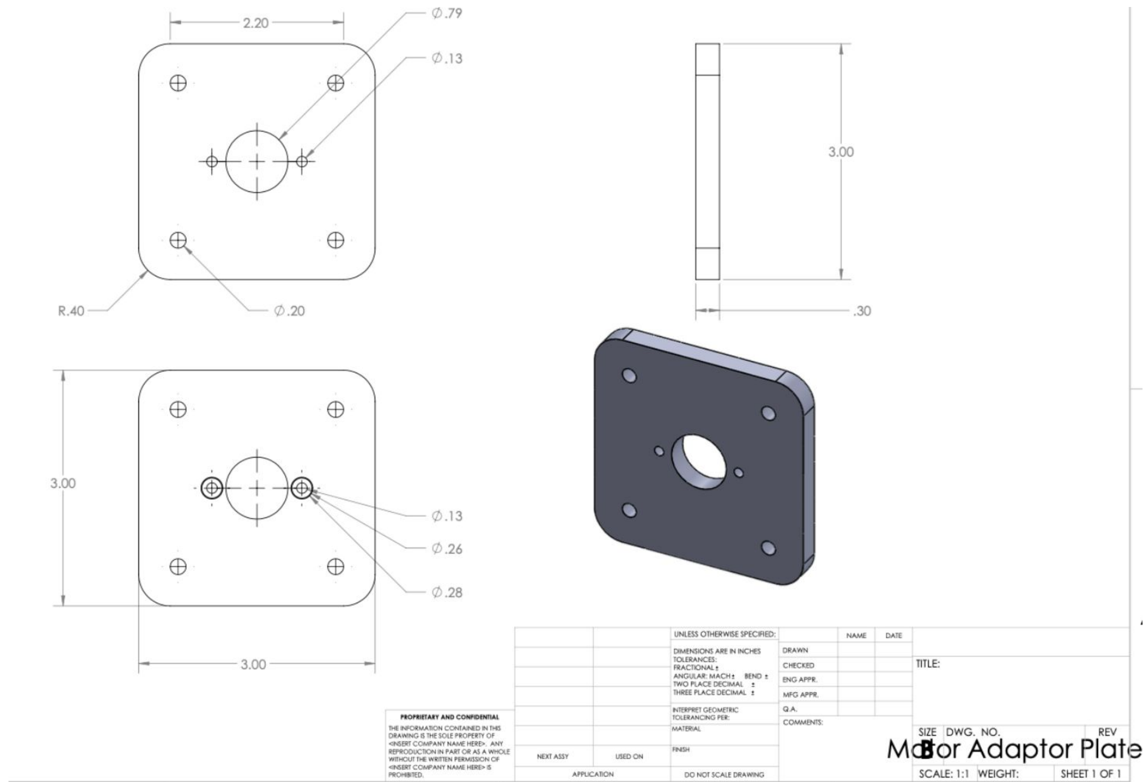
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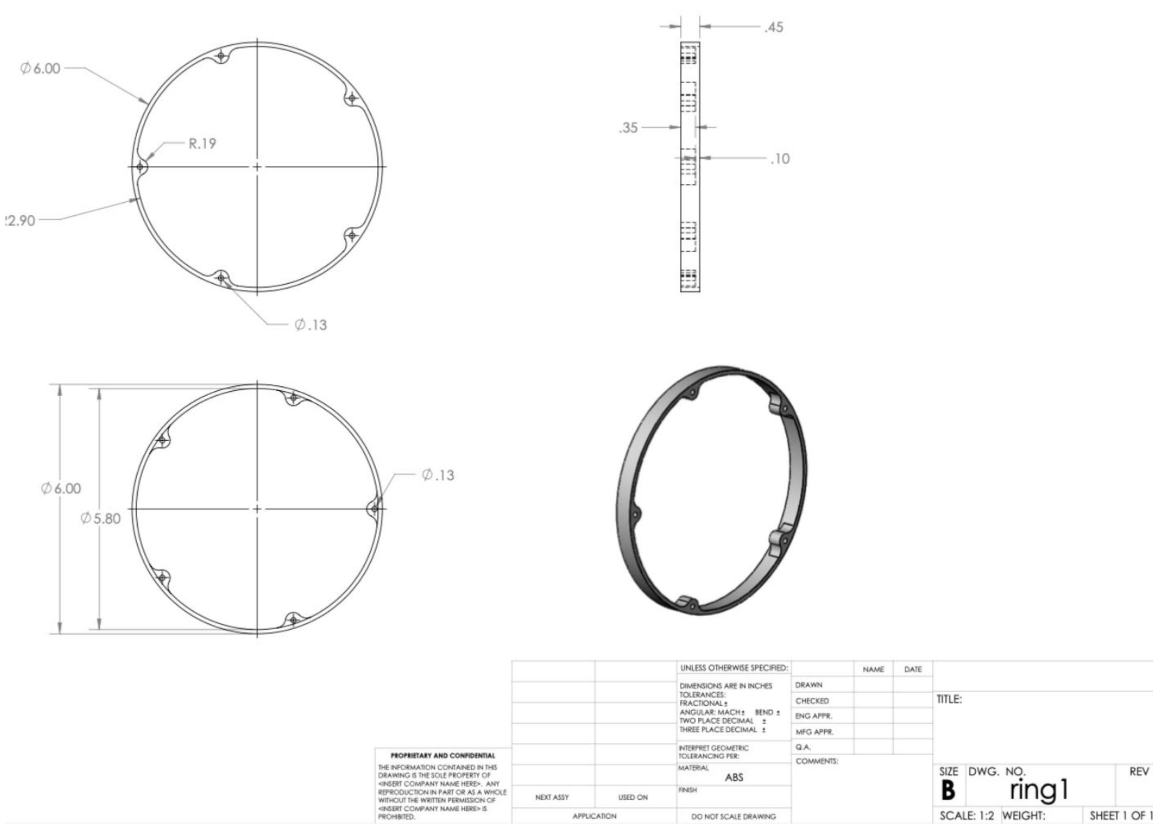
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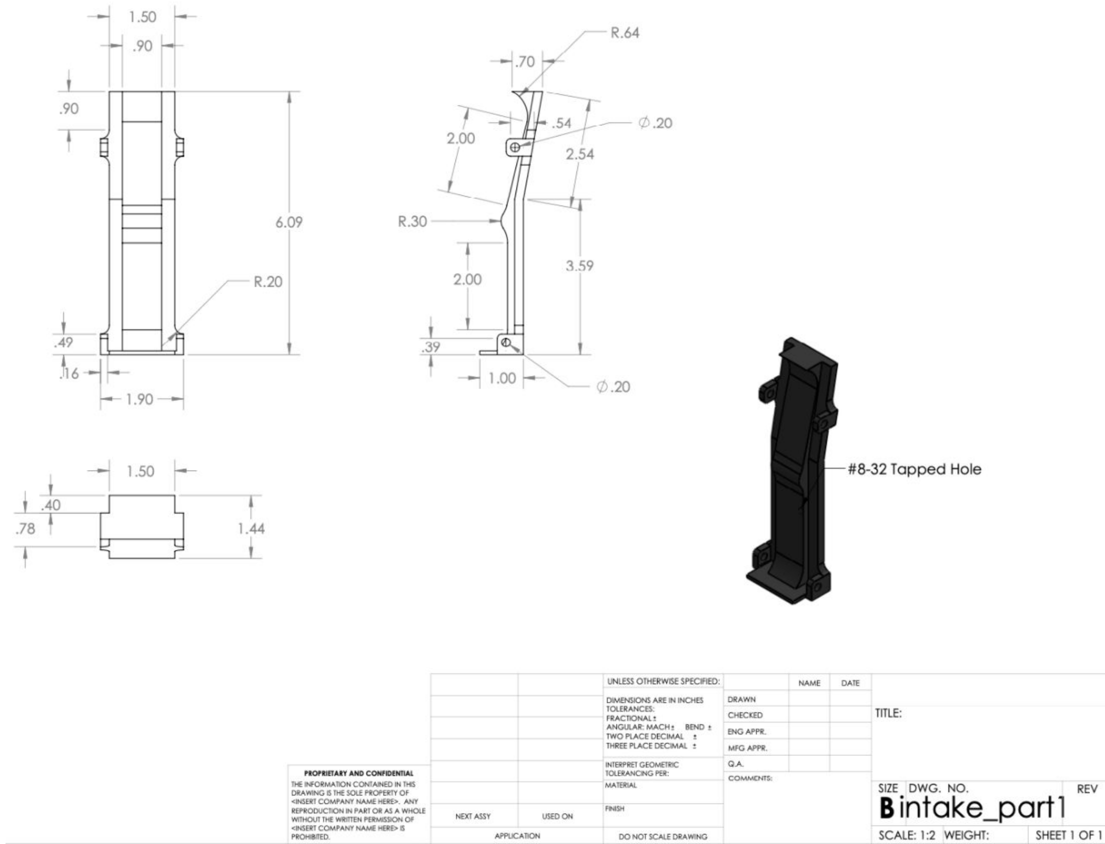
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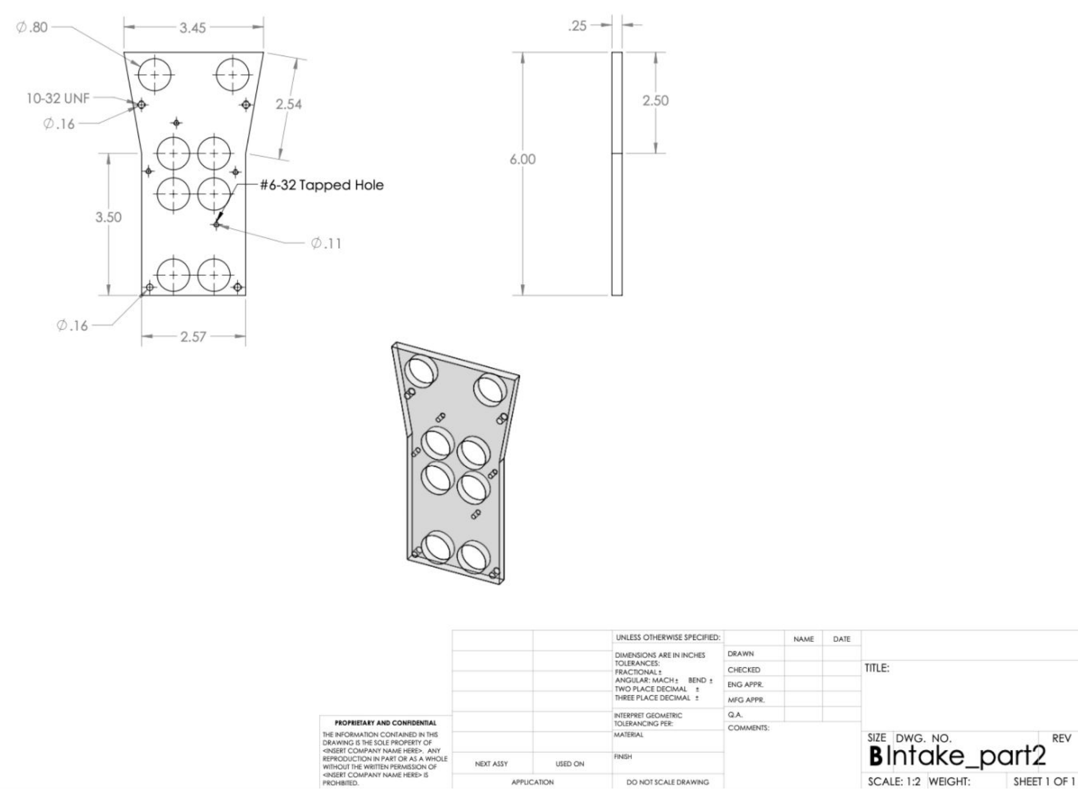
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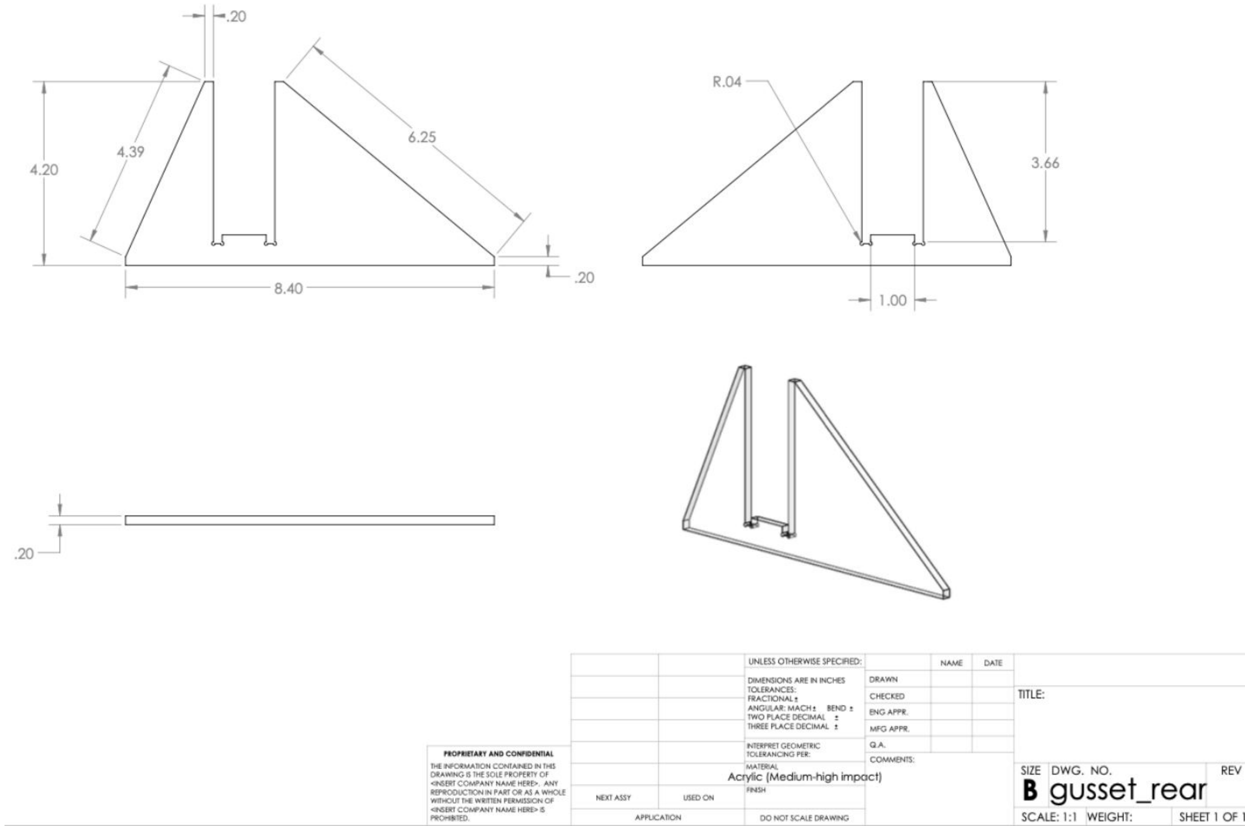
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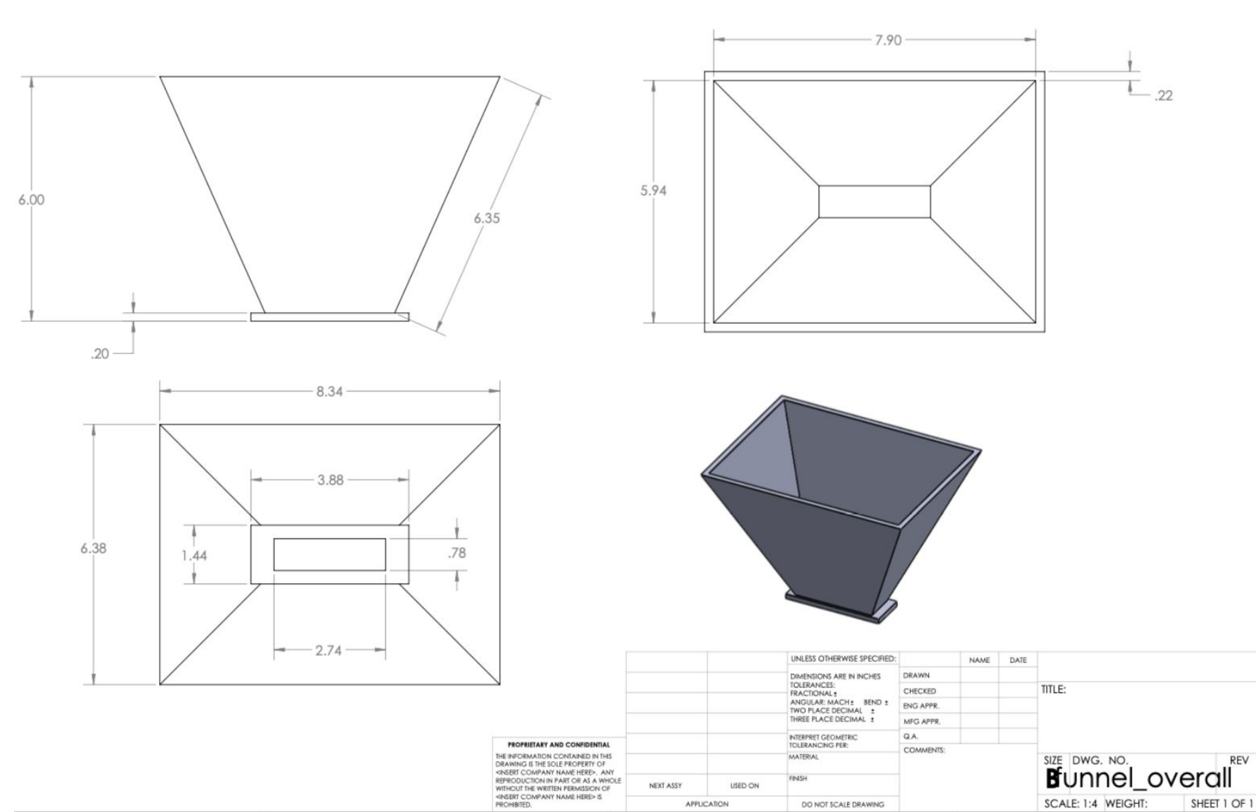
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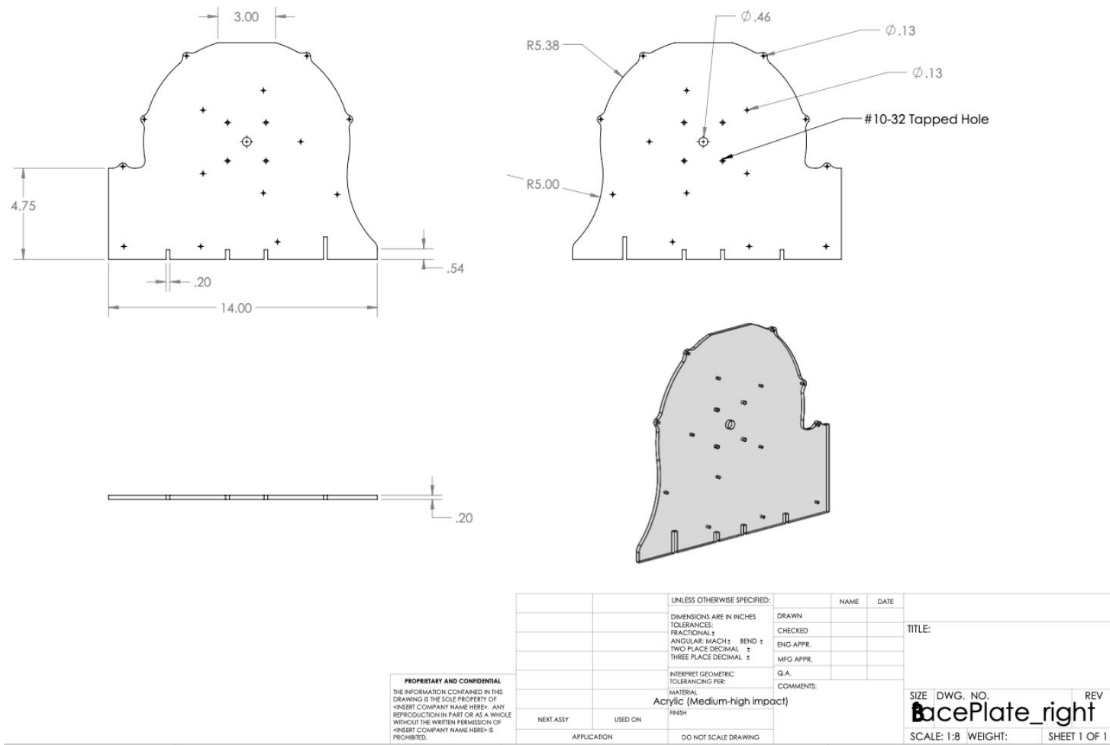
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II. Model