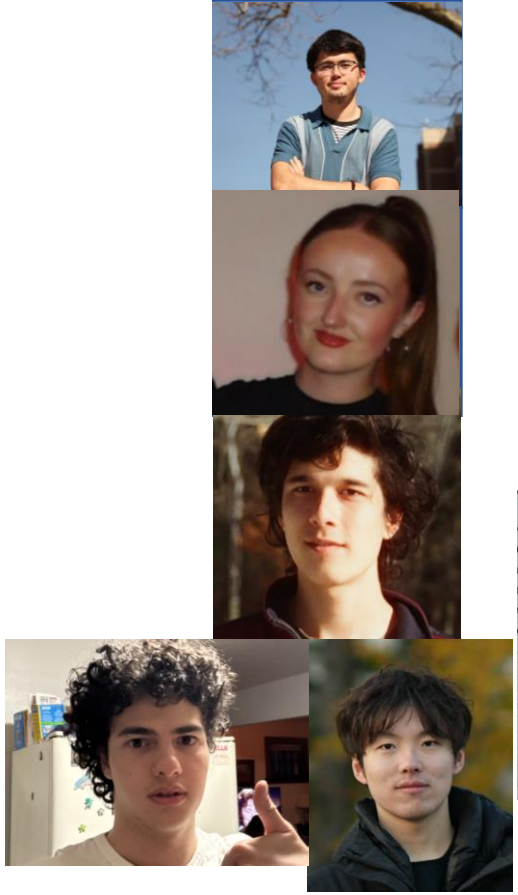
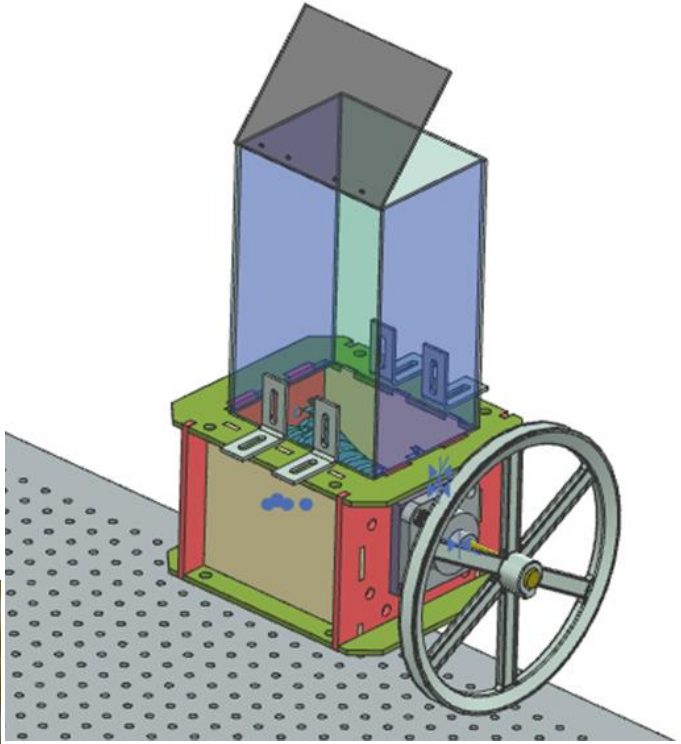
Small Scale Plastic Shredding and Recycling





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Customer:
University of Rochester, Prof. Muir

Project Overview

We set out to create a system that would divert the large amount of plastic that is thrown out and recycled each day at the University of Rochester by demonstrating that small scale recycling is feasible. To do this we adapted an open-source shredder design from the nonprofit company Precious Plastic and powered it using an available motor and a belt-driven reducer. We are currently in the process of manufacturing an injection mold and collecting plastic to injection mold dice.

Problem Statement

Problem Statement: Every day, massive amounts of plastic are thrown out across the University of Rochester Campus. A sustainability problem is created by the waste of usable material, an environmental problem is created when this waste fills landfills, and an aesthetic problem when it is left uncaringly across campus. This plastic is in need of a destination that will prevent it from creating a negative impact and will properly utilize it for the useful resource that it is

Goal: Create a closed loop recycling system that is compatible with the University of Rochester campus resources.

Areas of Opportunity:

- *Environment*
- *Sustainability*
- *Aesthetics*

Starbucks Cold Cup Data:
- 1500 grande
- 600 venti
- 200 tall
- 40 trenta

= 2340 cold cups daily

Deliverables, Requirements and Specifications

The deliverables, requirements and specifications define what will be done
and how to be objective about what it means to have a “successful” project.

Deliverables:

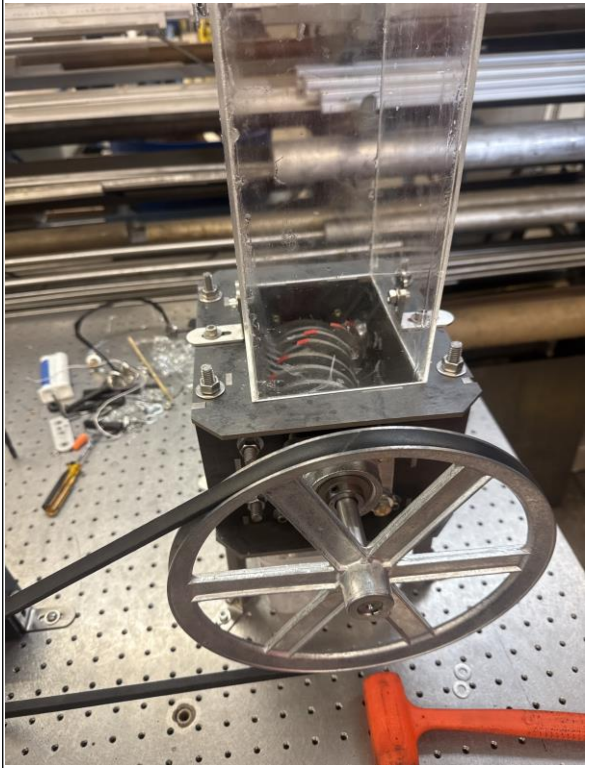
- *Shredder (includes blades spacers and housing)*
- *Injection Mold and molded parts*
- *Theory of operations Manual*
- *CAD layout and Bill of Materials*

Requirements:

- *Shredder must be able to shred used Starbucks cold cups*
- *Must be safe to operate by or under the supervision of a trained technician*
- *Size of shredded material must be compatible with mold*

Specifications:

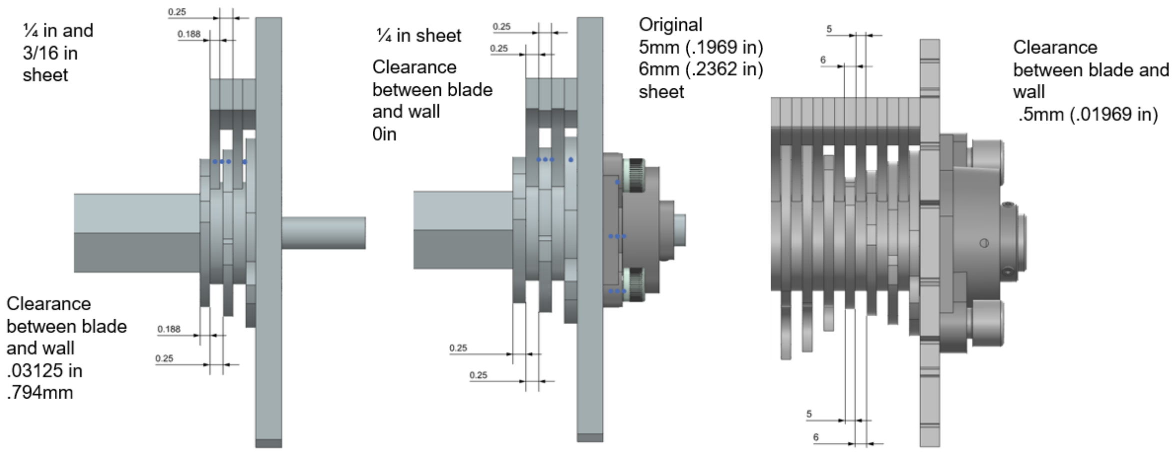
- *Must produce 1000 parts by design day*
- *Mold must be filled by operation of injection mold*
- *Exposed surfaces must not exceed 140 F*



Current Project Status

Preliminary design:

- We decided to adapt PreciousPlastic SHR 3.3, due to the small size and single axis design
- The main challenge was converting crucial thicknesses and fasteners designed in metric to imperial equivalents
- Based on blade geometry and material properties of Starbucks cups we calculated the reducer ratio we would need as well as the motor power and rpm for the setup
- Ultimately we decided to use 0.25” steel for the spacers and wall spacers, and 0.211” ground steel for the blades and wall blades. This ensures a tolerance of 0. 0197“ = 0.5mm as specified in the original design.

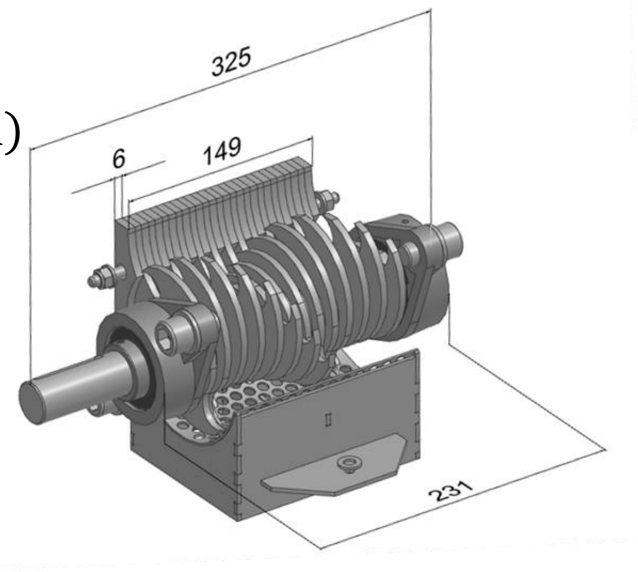


$$T_{out} = (fs * \tau_{\max} * \mathrm{A} * \mathrm{d})$$

$$\frac{N_2}{N_1} = T_{out} * \frac{rev}{2\pi * P}$$

$$\frac{N_2}{N_1} = 8.8$$

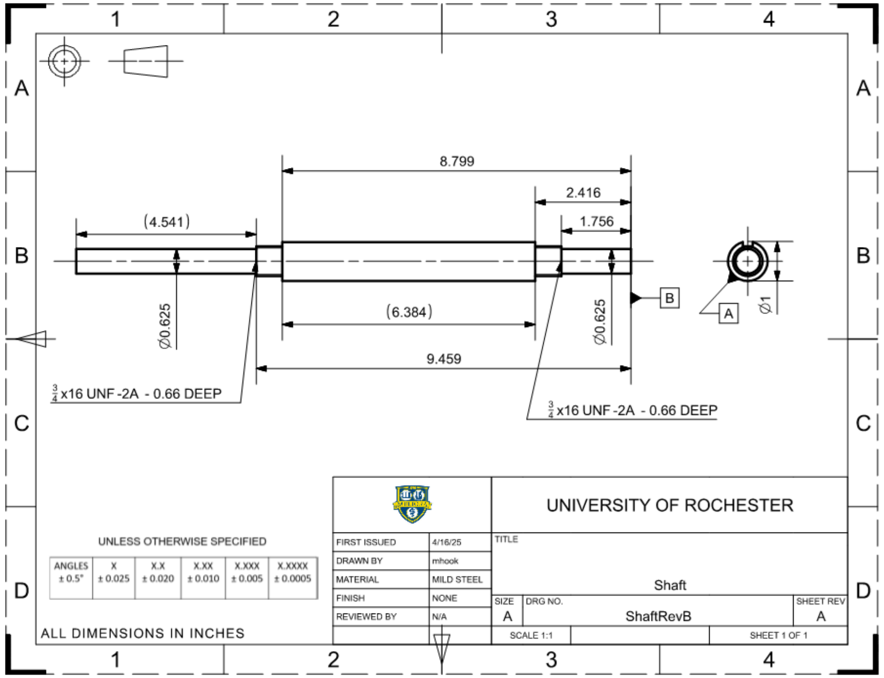
$$\frac{N_2}{N_1}(actual) = 16$$



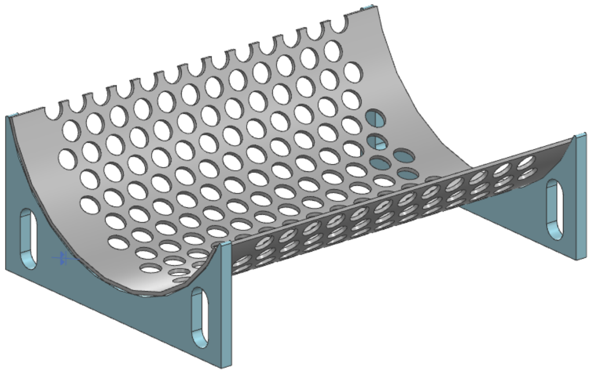
Current Project Status

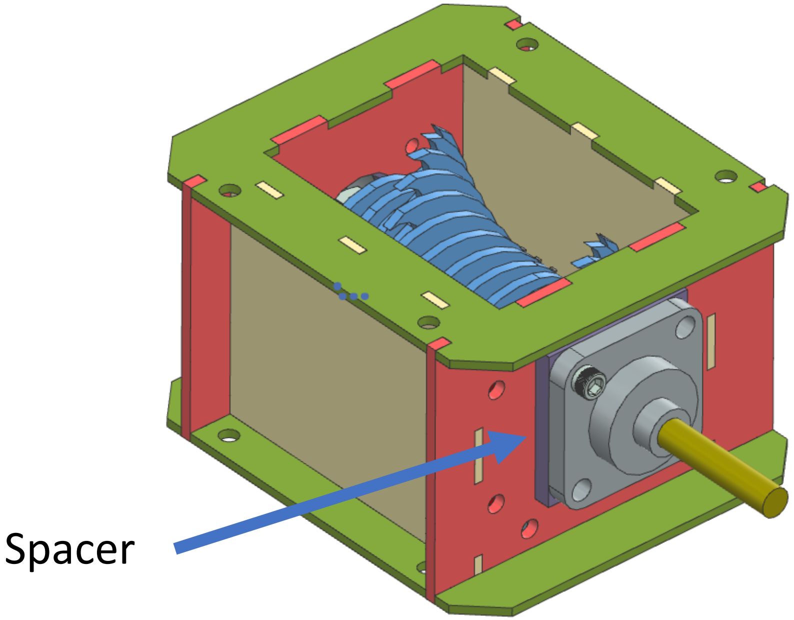
Design continued:

- Additionally, we tailored the design to be manufacturable.
    - We opted for a keyed shaft rather than a hex shaft as the plasma cutter did not cut sufficiently accurate hex in the blades
    - We adjusted thicknesses from metric values to imperial ¼” and 3/16”
- We encountered a challenge in designing the axel and locknut for a wall thickness of 1/2” and then changing the wall to 1/4” . Spacers were added between the bearing and the wall.
- The grate assembly was adapted from SHR 3.3 and simplified to be bolted into the bearing plates



- Throughout the design process we compared CAD measurements to actual measurements, to ensure parts would fit together.

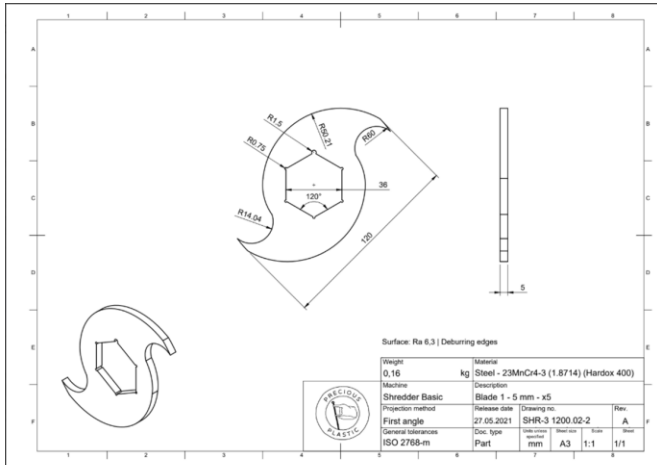


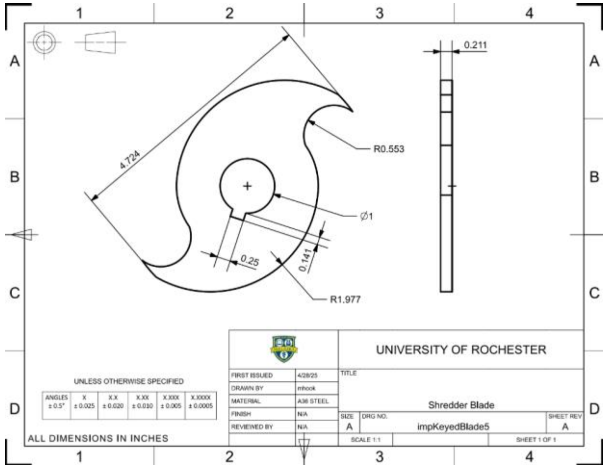


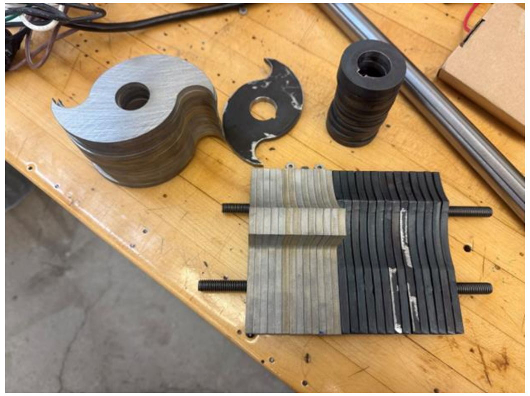
Current Project Status

Manufacturing Challenges:

- Inaccuracy of the plasma cutter meant hex shaft design was changed to a keyed shaft design.
- Because the plasma cutting process caused hardening, the spacers and blades needed to be annealed before additional drilling
- Rather than have three blade types ono a hex shaft, a key slot was broached at a different angle on each blade.
    - To achieve this a jig was 3d-printed to calculate angles needed
- The initial motor that was selected to power the shredder generated an insufficient amount of torque.
    - Constant jamming and poor shredding consistency
    - Motor was swapped for a more powerful alternative







Current Project Status

Current progress:

- Shredder is semi-functioning
    - Jams frequently
    - Able to shred thin pieces of plastic including Starbucks cups
- Produces injection sized pieces of plastic
- Produced pieces can be used in injection molder

Next steps:

- Finish surrounding guarding
    - Acrylic shielding over all belt mechanisms
- Add second reducing stage to increase torque and lower rotational speed
- Manufacture dice mold to fabricate final products with shredded plastic

Conclusions

- Shredder works well with a ½ horsepower motor; it is able to shred the Starbucks cups as designed.
- The mold injection process is tested and fully operational.
- Our group meets the majority of the project requirements and specifications from our sponsor.

Future Work

- We will increase the manufacturing accuracy of the parts to prevent defects.
- Using a more powerful motor and a gearbox with an even larger reduction ratio to provide better performance of the shredder.
- As a result, our shredder could handle different kinds of plastic recycling, including thicker pieces of plastic.

Acknowledgement

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- Christopher Muir