

# INL - Man-Deployable Municipal Solid Waste Preprocessing System

## Project Description

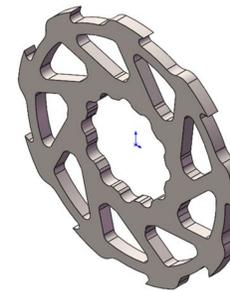
The goal of the man-deployable municipal solid waste preprocessing system is to enhance the current shredder system by enabling more uniform and efficient sizing of plastic waste generated within military operations. There is significant interest in developing methods and processes to convert municipal solid waste, which would otherwise be considered useless, into food or fuel resources.

In active war zones, statistics show that one soldier is killed in every ten supply trips. By decreasing the frequency of supply trips, it is possible to reduce the number of American soldiers' lives lost. Therefore, this project has a dual objective: first, to reduce the weight of the shredder to facilitate easier transportation and operation; and second, to enhance the efficiency of the shredders in their daily function of processing plastic waste, predominantly from MREs (Meals Ready-to-Eat) and plastic bottles to help alleviate the need for supply runs..

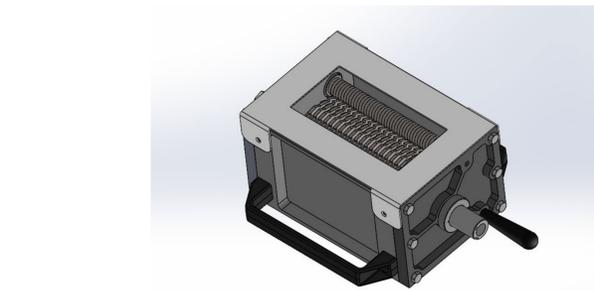
Requirement	Threshold	Target
<b>Blade Weight Reduction</b>	-15%	-20%
<b>Reduced blade count</b>	-10 blades	-20 blades
<b>Cutterhead weight reduction</b>	-20%	-30%
<b>Bottle Throughput</b>	Maintain current speed	Increase 10%

## Design Description

New Blade Design

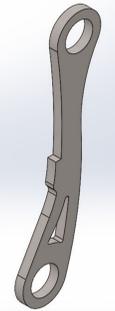


Initial prototype



Single Blade array to reduced weight

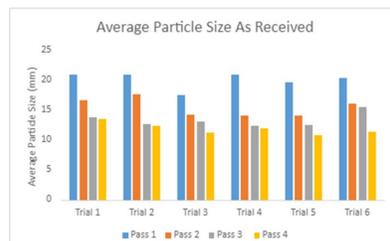
Stationary cutting fence



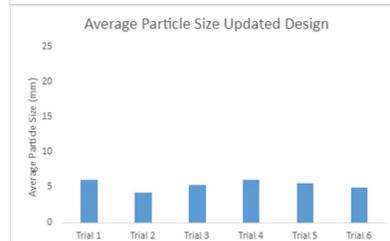
Final cutting assembly with both shredder and perforator

## Performance Review

- We tested the strength of the new blades and the effectiveness of the shredder

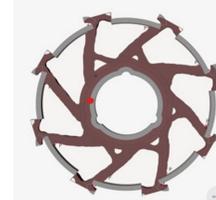


This figure (left) shows our evaluation of the performance of the shredder as-received. "Passes" indicate that the shredded material was re-fed into the shredder to try to get the pieces smaller. The goal was 5mm strips, which we were unable to achieve with the original design.

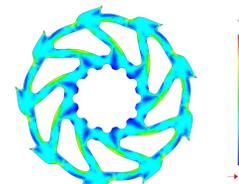


This figure (left) shows our evaluation of the performance of our redesigned shredder. Our design sized particles to 5mm in only one pass, making re-feeding the materials unnecessary.

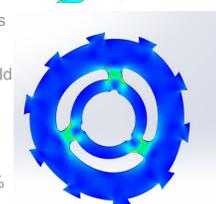
This figure (right) shows the results of a static stress analysis on the blades that we received. Our analysis shows that the blade would yield when subjected to the same loading conditions as the one that we designed, even when made of the same material. This demonstrates that our design is superior not only because it is 35% lighter, but because it is also significantly stronger.



This figure (left) shows the results of generative design. We put a solid model of a blade into a computer program that then removed material in the optimal locations for the testing that we were performing. The shape shown shows the results of the computer program for the lightest, strongest blade design.



This figure (left) shows the results of a static stress analysis on the blade that we designed. The software applies forces in specified locations to help visualize what will happen to the blade when it cuts plastic. This figure shows how the blade deforms when it cuts and also shows that our blade will not yield during normal operations.



This figure (right) shows the results of a static stress analysis on the blade that we designed. The software applies forces in specified locations to help visualize what will happen to the blade when it cuts plastic. This figure shows how the blade deforms when it cuts and also shows that our blade will not yield during normal operations.

## Conclusion

During our testing and prototyping, we realized that we would be unable to measure bottle throughput. We also decided to keep the same number of blades as the original design, but with all the blades on a single shaft. We also staggered the sizes of the blades to reduce weight and facilitate bottle feed-through. We were able to reduce the blade weight by more than 30%, exceeding our target by a significant margin. We were also able to reduce the cutterhead weight by 31%, meeting our target. As a secondary objective, we were able to reduce the number of passes that it takes to shred materials to the correct size from more than four passes to one.

### Lessons Learned

- Generative Design Enhances Solutions:**
  - Lesson:** Learning about generative design was valuable.
  - Insight:** Leveraging generative design techniques helped optimize our blade designs. Going forward, we feel that generative design will take an important role in all aspects of mechanical design and engineering. Becoming familiar with this technology will be critical in staying ahead of technological trends.
- Prototyping Reveals Flaws and Improvements:**
  - Lesson:** Rapid prototyping is essential for identifying issues.
  - Insight:** We learned that testing a new design every week allowed us to quickly identify where our designs needed to be improved and where we were succeeding. A rapid, agile approach allows a more streamlined solution to be found quicker.

### Recommendations for future work

- Mounting the Motor to the Frame:**
  - Objective:** Improve ease of maintenance and safety.
  - Recommendation:** Attach the motor directly to the frame. This way, the cutting head assemblies can be removed without having to take off the motor. It will also reduce forces on the cutting assemblies during bottle jams, making them less likely to jam.
  - Note:** Avoid using plumber's tape for mounting; instead, utilize the bolt holes on top of gear box.
- Replace the Perforator with a Single Shaft and Ramp Design:**
  - Objective:** Streamline the system.
  - Recommendation:** Explore replacing the perforator with a single shaft and a ramp design. This could eliminate the need for the other gear box as well (Figure 15 and Figure 16). This could eliminate the need for the gear box on the perforator side as well, drastically reducing the weight requirement.
- Blade Cover Design:**
  - Objective:** Enhance blade safety and convenience.
  - Recommendation:** Design blade covers with snap fittings. These covers should sit securely on top of the blade boxes, ensuring easy removal and replacement.