<table>
<thead>
<tr>
<th><strong>Project Title</strong></th>
<th>Upcycled plastic bottle chip melter</th>
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<tbody>
<tr>
<td><strong>Project Number</strong></td>
<td>P19433</td>
</tr>
<tr>
<td><strong>Primary Customer</strong></td>
<td>Kellan Morgan <a href="mailto:kellanpmorgan@gmail.com">kellanpmorgan@gmail.com</a>, 585-752-0227; Enlace Project, <a href="https://www.enlaceproject.org/">https://www.enlaceproject.org/</a>, <a href="https://www.facebook.com/enlaceproject/">https://www.facebook.com/enlaceproject/</a>; Bonnie Yannie, <a href="mailto:bonniyannie@gmail.com">bonniyannie@gmail.com</a>; Sally Kuehl, <a href="mailto:bksk74@frontiernet.net">bksk74@frontiernet.net</a>; Robert Boxer, <a href="mailto:rboxer78@gmail.com">rboxer78@gmail.com</a></td>
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<tr>
<td><strong>Sponsor</strong></td>
<td>MSD</td>
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<tr>
<td><strong>Faculty Champion</strong></td>
<td>Sarah Brownell</td>
</tr>
<tr>
<td><strong>Other Support</strong></td>
<td>Bob Bectold, HARBEC Plastics</td>
</tr>
<tr>
<td><strong>Project Guide</strong></td>
<td>[Assigned by MSD]</td>
</tr>
<tr>
<td><strong>IP Considerations</strong></td>
<td>[Finalized by MSD]</td>
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Various stakeholders in the town of El Sauce, Nicaragua are interested in promoting solid waste separation and recycling to clean up the town, reduce mosquito breeding sites, and to stimulate the local economy through both recycling revenues and increased tourism. Two organizations with connections to Rochester have worked in the community for many years and will help facilitate this project: 4 Walls builds houses for families with inadequate shelter and the Enlace Project has helped support local small business and cooperative development. Based on information collected during a study abroad trip in March 2017, the goal of this project is to develop a way to melt plastic chips and form them into a 12” x 12” sheet that can be vacuum formed into useful products. This project may provide the opportunity for student travel to Nicaragua during fall or spring break, but this will depend on the political situation in Nicaragua, which has been unstable. Fluent Spanish is a plus on this project!

MSD Team P17433 conducted research on the bottle recycling systems in place in the town of El Sauce during a spring break study abroad trip (extensive notes available) and sketched out the relationships of the stakeholders in a Mess Map (Figure 1).

Figure 1: Stakeholder Mess Map for Bottle Upcycling in El Sauce

They met with Gravita, a bottle processing company in Managua that is currently collecting bottles from collectors at the dump in El Sauce for 4 Cordoba per kg. Gravitas representatives expressed interest in paying a higher price (10% higher plus lower transportation fees) for bottles with additional processing (shredded or compacted), but stressed the importance of ensuring quality and purity of the plastic. Small amounts of PVC can ruin an entire load of PET.
P17433 was tasked with designing a product to be made from shredded bottles. They developed an initial concept for a building block (figure 2). The block is intended to be used as a non-structural component in house construction for room dividers, decoration above doors, and to fill in the “culata” – the empty triangular space between the walls of a house and the peak of the roof. The block form is designed to increase ventilation and make a home feel cooler through a venturi effect. Based on interviews in El Sauce with residents of homes constructed by 4 Walls, in addition to the aesthetic value of decorative blocks, the homeowners were interested in using the blocks to provide added security, i.e. to keep people from breaking into the home through the culata. They also liked the idea of using the blocks to allow light and airflow into the home while keeping out rain and pests.

**Figure 2: Recycled plastic to building block concept**

Teams P17433 and P18433 designed and built two of the tools required in the system to create upcycled items such as the block: a shredder to turn the bottles into chips and a melter to melt the chips into a flat sheet that can be used in a vacuum former. The shredder has unfortunately since been lost or stolen. The melter is available for your team’s use. Chips can be obtained from local recyclers.

**Figure 3: The bottle shredder and melter.**

Melting and forming plastic proved to be difficult and last year’s melter is in need of further revision, including support from electrical engineering expertise which was not represented on the previous team. In this iteration of the project, your team’s job is to:

1) **create a method and tools for turning bottle chips into a 12” x 12” flat sheet**
2) **continue to develop and refine product ideas that can be made from the chips**
3) **create a method and tooling for vacuum forming the sheet into a useful product.**
The first bullet above is the top priority. Your team may use last year’s melter for experimentation and may keep or discard its subsystems as you see fit. The team left an extensive list of recommendations on their customer hand off page under “Recommendations”. Some of the issues include:

- The compression system uses a jack that was not designed to operate in tension (i.e., it has difficulty holding the heavy plate open)—**BE CAREFUL WHEN OPERATING THE PROTOTYPE AS THE PLATE MAY FALL.**
- The electrical control system that allows a temperature to be set and maintained is not working.
- More heat is needed to melt the chips.
- Heat needs to be more evenly distributed to the chips.
- Mold surface quality could be improved by buying better starting material.
- The mold alignment system needs work.
- It is uncertain whether or not a melted sheet can be removed from the current mold. An ejection system may be needed.
- A cooling system is needed to speed up the process in order to make it economically viable.

![Diagram of the compression system, mold, insulation, heaters, and electrical system.]

**Resources:**
- MSD Team P18433 Nicaragua Bottle Upcycling Product Design and Manufacturing’s website is available here: [http://edge.rit.edu/edge/P18433/public/Home](http://edge.rit.edu/edge/P18433/public/Home)
- MSD Team P17433’s website is available here: [http://edge.rit.edu/edge/P17433/public/Home](http://edge.rit.edu/edge/P17433/public/Home)
- A Design Project Leadership course team explored the idea of upcycling plastic bottles during spring 2016. Their work can be found here: [http://edge/edge/R16401/public/Home](http://edge/edge/R16401/public/Home)
- Article on sorting plastics: [http://www.slate.com/articles/health_and_science/the_green_lantern/2008/05/thou_shalt_sort_thy_plastics.html](http://www.slate.com/articles/health_and_science/the_green_lantern/2008/05/thou_shalt_sort_thy_plastics.html)
- 4 Walls, [http://www.4wallsproject.org/](http://www.4wallsproject.org/)
Preliminary Customer Requirements (CR)

Manufacturing Process
Melts primarily PET but also HDPE chips to form sheets for vacuum forming in the Construct (check required sizes)
Scaled for operation as a home or small business
Uses human or grid power (110V or 220V AC)
Safe
Must not tip over when bumped into by an average person
Protect user from to sharps, hot surfaces and pinch points
Ergonomic operation
Machine SHOULD NOT work when disconnect device is engaged
Viable business: product price offsets labor, overhead, and marketing costs.
Low start up costs for business
Does not emit toxic fumes at levels dangerous to people

Product
Made from recycled bottles
Manufactured in El Sauce

Preliminary Engineering Requirements (ER)

Melting temperature range, 240-260 °C
Adjustable thermostat to hold temperatures between 100 and 260°C
Max Temperature differential over the plate, tbd (15°C?)
Products per hour >0.5
Machine footprint < 1m²
Sheet size approx. 12” x 12” (check with Construct for exact measurements for vacuum former)
Sheet thickness < ¼”
Number of workers needed to operate <=3
Pressure to form plastic, tbd
Temperature of contact surfaces <50°C
Chip sizes accommodated, tbd (up to 1cm²?)
Efficiency, better than current
Force to tip >500N
Max weight of each removable component <22kg
Max voltage <250VAC
Skilled operations, ideally 0
Pinch points, ideally 0
Sharps, ideally 0
Electrocution hazards, ideally 0
Components powered when disconnect engaged, 0
Revenue – Costs >0
Total Machine cost <$1250
 Constraints

Uses chips from recycled PET bottles
Run as a small business
Low start up costs
Project budget of $500

 Project Deliverables

 Minimum requirements:
- All design documents (e.g., concepts, analysis, detailed drawings/schematics, BOM, test results)
- Working prototype
- Technical paper
- Poster
- All teams finishing during the spring term are expected to participate in ImagineRIT

 Additional required deliverables:
- List here, if applicable

 Budget Information

$500 MSD. Team may submit a proposal for additional funds in MSDI if required.

 Intellectual Property

No

 U.S. Citizenship

No
Project Resources

Anticipated Student Staffing by Discipline

Please provide a brief explanation of the expected activities for each required discipline. “Other” includes students from any department on campus besides those explicitly listed. For example, we have done projects with students from Industrial Design, Business, Software Engineering, Civil Engineering Technology, and Information Technology.

<table>
<thead>
<tr>
<th>Department</th>
<th>Expected Activities</th>
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<tbody>
<tr>
<td>Biomedical Engineering</td>
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<tr>
<td>Computer Engineering</td>
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<tr>
<td>Electrical Engineering</td>
<td>Power system for heaters and cooling, temperature sensor and controls, cooling system controls, high voltage, circuit design, controllers</td>
</tr>
<tr>
<td>Industrial &amp; Systems Engineering</td>
<td>Safety, ergonomics, manufacturing systems, project management, engineering economy</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>Heat transfer, fluids (cooling, plastic properties), mechanic design of compression system and extraction pins, GD&amp;T</td>
</tr>
<tr>
<td>Other</td>
<td>Possible ID for developing products</td>
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Required Resources

Describe the resources necessary for successful project completion. When the resource is secured, the responsible person should initial and date to acknowledge that they have agreed to provide this support. We assume that all teams with ME/ISE students will have access to the ME Machine Shop and all teams with EE students will have access to the EE Senior Design Lab, so it is not necessary to list these. Limit this list to specialized expertise, space, equipment, and materials.

<table>
<thead>
<tr>
<th>Faculty</th>
<th>? Could use a plastic expert. EE faculty, FMS for high voltage work.</th>
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<tbody>
<tr>
<td>Environment</td>
<td>Fume hood. High voltage. Fire safety. Last year’s team used the paint room downstairs in the shop.</td>
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<tr>
<td>Equipment</td>
<td>Possible need to monitor air quality</td>
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<tr>
<td>Materials</td>
<td>Plastic chips, mold release</td>
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<tr>
<td>Other</td>
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