# Osprey Design Experience Weekly Memo

**TEAM NAME**: Green Ellipsis

**DATE**: 10/13/23

**ATTACHMENTS:** 1) Work Breakdown Whiteboard pic for CDR, 2) Prob statement V3

**WORK COMPLETED**:

- Version 3.0 of the problem statement has been created further refining what is required and added more visual depictions of the process.
- Worked on completing critical design review report
- Refined and detailed splicing processes to pursue

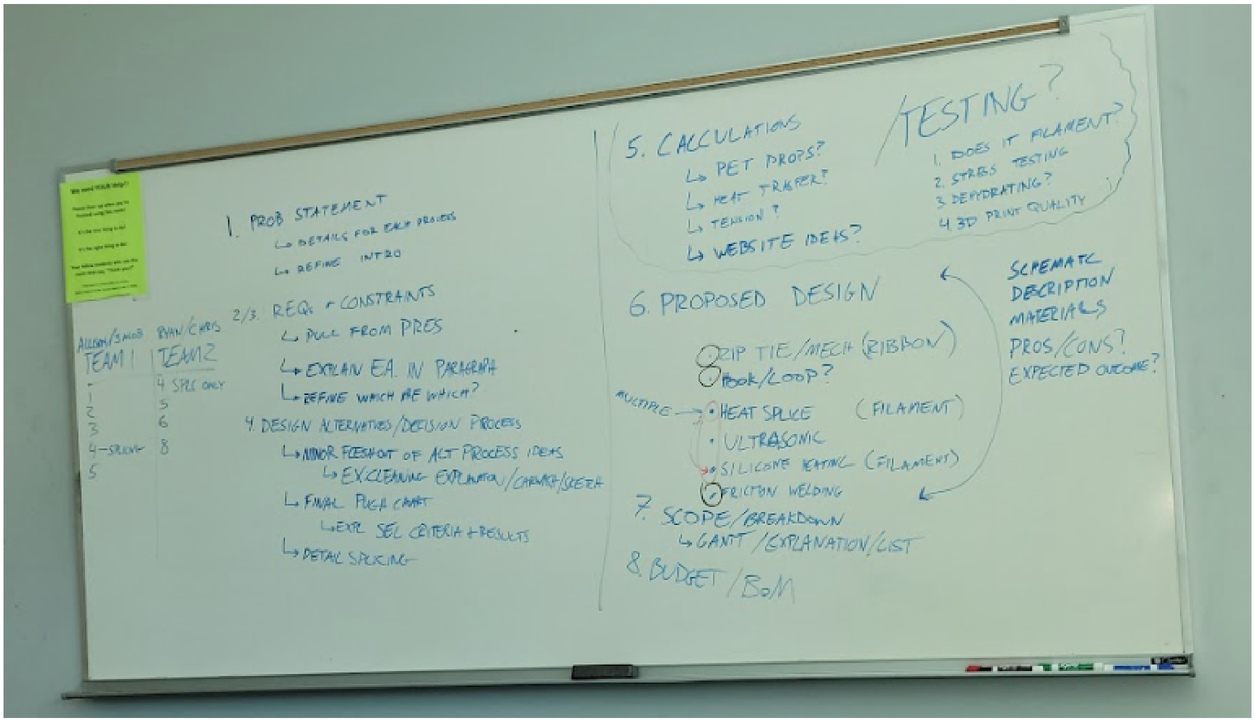
**WORK TO BE COMPLETED NEXT WEEK**:

- Finish CDR report
- Finalize splicing process designs
- Finalize filament testing experiments

**TEAM HOURS**:

| Name | Hours |
| --- | --- |
| Ryan Hunter | 6 hours |
| Christopher Zervos | 5 hour |
| Jacob Davis | 3 hours |
| Allison Wolfson | 8 hours |
| Total | 22 hours |

Author: Ryan Hunter



1. PROB STATEMENT
2/3. REQ + CONSTRAINTS
PULL FROM PRES
4. DESIGN ALTERNATIVES/DECISION PROCESS
FINAL PUGH CHART
TEAM 1
TEAM 2
5. CALCULATIONS
PET PROPS?
TENSION ?
WEBSITE IDEAS?
TESTING?
1. DOES IT FILAMENT?
2. STRESS TESTING
3. DEHYDRATING?
4. 3D PRINT QUALITY
6. PROPOSED DESIGN
ZIP TIE/MECH (RIBBON)
HOOK/LOOP?
HEAT SPLICE (FILAMENT)
ULTRASONIC
SILICONE HEATING (FILAMENT)
FRICTION WELDING
SCHEMATIC
DESCRIPTION
MATERIALS
PROS/CONS?
EXPECTED OUTCOME?
7. SCOPE/BREAKDOWN
GANTT/EXPLANATION/LIST
8. BUDGET/BoM

**Green Ellipsis**


Ryan Hunter

Allison Wolfson

Jacob Davis

Christopher Zervos


Problem Statement Version 3

10/13/23

## Project Problem Statement and Description

Green Ellipsis, the sponsor of the project, processes 2-liter plastic bottles and upcycles them into usable filament for 3-D printing. The company currently has a mostly manual process that creates a viable end product but is not economically feasible due to the labor-intensive nature of the operation and the minimal amount of filament that is produced with each bottle. The goal that Green Ellipsis has for the future of this endeavor is to reduce the cost of producing the filament (primarily labor) so that the filament can be sold for a profit or at least cover the cost of producing it as much as possible. Once the process has been optimized, the plan is to either sell kits that include the necessary components for individuals to repeat the process or provide plans for free to achieve the same goal. The hope is that the process developed will be used by community level groups that have interest in environmental work, 3-D printing, or both. Because the raw material (2-liter bottles) will generally be acquired at no cost through donation and recycling collection, the only cost to these groups would be buying/building the process and whatever running costs it takes to make the filament.

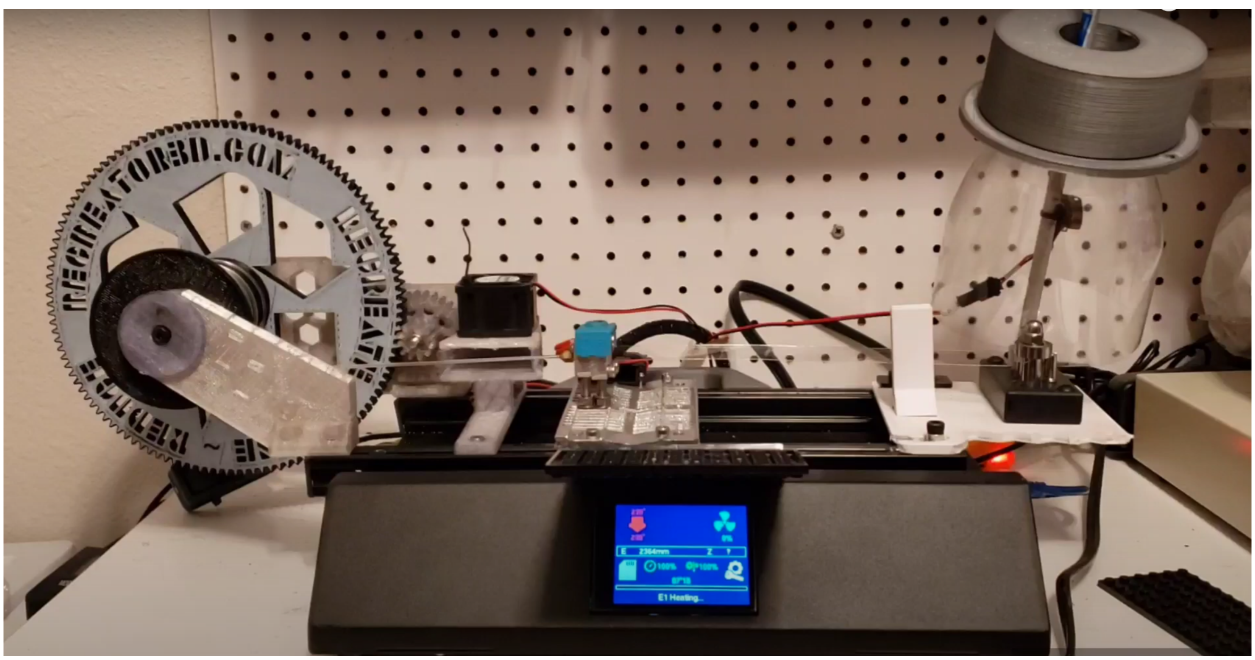


Figure 1: full machine set up [1]

Going from 2-liter bottles to usable filament requires multiple sub processes:

1. Bottle preparation: Before the bottles can be used, they must first be prepared in a number of ways. The labels need to be removed, the label adhesive needs to be removed, the plastic needs to be cleaned, and the bottles must be dried.
2. Cutting: After the bottles have been prepared, they are cut into 8mm strips. A previous UNF senior design team automated this process.
3. Threading/Pultrusion: After being cut into thin strips, the end needs to be fished through an extruder nozzle. Currently this is done by hand. Once fished through, the strip is heated to reform into the desired shape of a 1.75 mm strand. This strand is pulled through the hot nozzle in a process called pultrusion. The strand is attached to a spool and continues to be pulled until the entire strip obtained from the bottle is formed into the desired filament.
4. Winding/Packaging: The filament is unwound from the spool and packaged in a way that it can be stored before use/sale. This is currently done by hand and must be done for each individual bottle which can bottleneck the process.

The problem that Green Ellipsis has is the current cost of producing the filament compared to what it can sell for is too high. It is expected of this group to find solutions to improve the cost ratio to make the process worth doing. Currently, the filament is produced one bottle at a time which produces discrete 10 meter strands, and then 20g of filament as seen in figure 2. Generally, it is desirable to have one long strand of filament for ease of use while 3-D printing. Due to the short length of the filament produced, the sale value of the product is low. Green Ellipsis has indicated that the best way to increase the value would be splicing multiple strands of filament together into 1kg spools. There is currently no known process for reliably splicing the strands together in a way that maintains the desired mechanical properties of the filament. Creating such a process would increase the value of the filament and increase the viability of selling the product. PET plastic has a glass transition temperature of 70° C and a melting point of 245° C [2]. The plastic of the bottles is amorphous which has very ideal, soft, and pliable properties. If during the splicing process the material is not quenched quickly enough, about two seconds, the amorphous material will begin to crystallize[3]. The semi-crystalline PET is much less pliable than the amorphous form. If the plastic of the joint is allowed to crystalize too much, it will be brittle and not survive the spooling and printing process. The main hurdle that must be overcome when splicing PET filament is avoiding this brittleness. The filament also needs to stay a consistent size so as not to cause any inconsistencies when running through the 3D printer. Attempts by others to find methods to splice this filament have had mixed results. Some solutions have been found but have been unreliable and difficult to repeat with any level of accuracy. Approaching this issue from an engineering standpoint will hopefully yield a more reliable approach. The goal is to experiment and find an easy, repeatable method of joining the plastic from one bottle to the next in order to create a continuous spool of filament that can be used successfully by a 3D printer. Chemical, thermal, and mechanical experimentation will be done to try and find a solution.

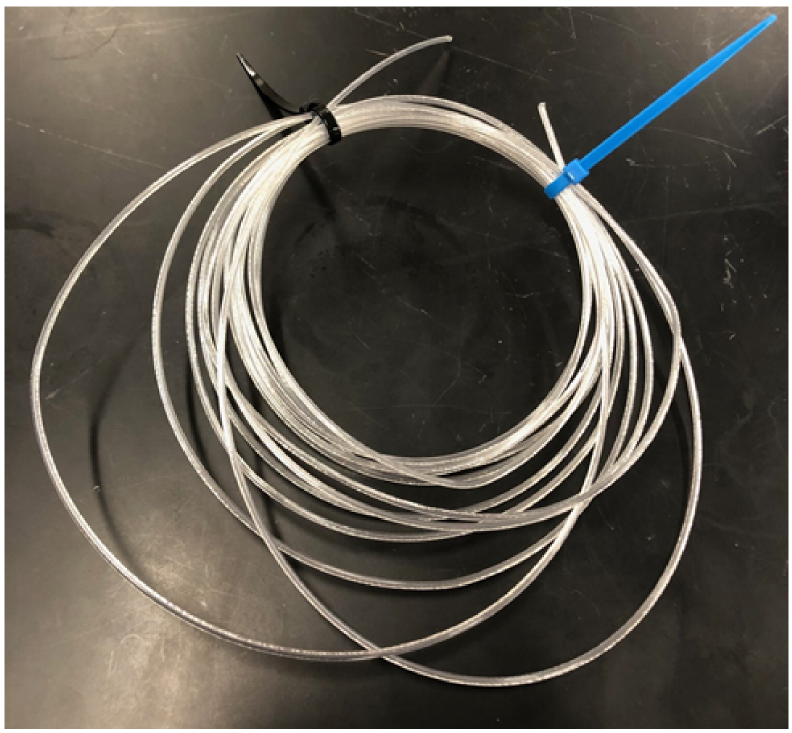


Figure 2: current end product spool of filament.

**Requirements**

- Process uses all portions of the plastic bottle with minimal waste or byproducts
- The filament must be cheaper to produce than the cost it can sell for, the current cost to produce is $109.
- The filament must be continuous up to 1kg spools
- Filament splice joints must withstand stress of spooling and 3D printing. Bending stress is the greatest risk. Must withstand 45° bend with radius of 5 mm

- The filament should not consistently clog or outgas the 3D printer. Should at least get through 5 prints without clogging or outgassing.
- All design components must use the metric system of measurements
- Budget of <$1000
- The process must be low cost to build so the average consumer can afford to repeat it, <$100.

**Constraints**

- The raw materials are sourced from used plastic bottles
- The process must be environmentally friendly with a net positive impact
- The process must be safe and usable by an average person
- The filament must be of desirable properties to use on any standard 3-D printer: 1.75mm +/- .1mm
- The filament cannot break or become jammed during the pultrusion process.
- Any power requirements must be available from a standard outlet: 120V

References:
[1] "Tension rod-less Recreator3D with runout detection", YouTube, Jul 12, 2022. Available: https://www.youtube.com/watch?v=w-EAWBNNP8s

[2] Y. Celik, M. Shamsuyeva, and H. J. Endres, “Thermal and Mechanical Properties of the Recycled and Virgin PET—Part I,” Polymers, vol. 14, no. 7, p. 1326, Mar. 2022, doi: 10.3390/polym14071326.

[3] B. Demirel, A. Yaraş and H. Elcicek, "Crystallization behavior of PET materials," 2011.