Recycling 3D Print PLA: Sheet Production for Laser Cutting

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Angy Lara[1], Ishtiaque Mahdi[2], Molly Ritmiller[3], Victoria Bill[4]

[1]Angy Lara; Dept. of Electrical Eng, NYU; e-mail: anl393@nyu.edu

[2]Ishtiaque Mahdi; Dept. of Mechanical Eng., NYU; e-mail: im1293@nyu.edu

[3]Molly Ritmiller; New York University; e-mail: mer497@nyu.edu

[4]Victoria Bill; New York University Tandon School of Engineering; e-mail: victoria.bill@nyu.edu

Introduction and Background

The NYU MakerSpace is a 10,000 sq ft prototyping space located within the engineering school at a private university - NYU Tandon - located in Downtown Brooklyn. The MakerSpace serves students across disciplines and provides them access to fabrication tools and trainings as well as workshops and educational programming through the DesignLab.

As part of the sustainability initiative at NYU MakerSpace [1], circular design skills and concepts are promoted through a series of projects and workshops. This creates platforms for students to apply their skills to real-world projects related to sustainability while also creating real impact in NYU by promoting community engagement. One of these projects is to recycle Polylactic acid (PLA) 3-D print waste and excess into laser-cuttable PLA sheets [2].

PLA is a monomer made from fermented plant starch making it a renewable bioplastic that is industrially compostable [3]. While this is a great solution to discard PLA waste, the sustainability team at the MakerSpace seeks to find in-house solutions to reuse the PLA waste and create a closed loop system. Inspired by the Precious Plastic PLA Sheetpress process [4], this project has developed a process for creating usable PLA sheets using a convection oven.

Purpose

The PLA Sheets Project goal is to recycle and reuse PLA waste in the space as efficiently as possible at the NYU MakerSpace. By reducing plastic waste in the space, the NYU community can prototype while being environmentally conscious and promoting a circular economy. Thus developing a circular economy within the space, as shown in ***Fig 1***.

Overview

The MakerSpace has 13 desktop 3D printers which are almost continuously used by the NYU community to print their prototypes and projects. The majority of these printers use PLA filament. At times the prints will fail or the user no longer needs the print resulting in the prints being discarded. Per semester, 6.98 kg of PLA prints are discarded and sorted by color to be shredded into pellets. These pellets are then melted in an oven to create laser-cuttable PLA sheets.

A. *Procedure*

Using the in-house plastic shredder [5], thrown away PLA is broken down into 2.5 mm - 8 mm in sized pellets. Roughly 450 g of these pellets are spread onto a 350 by 660 mm tray, ***Fig 4***, and heated in a convection oven for 2 hours at 176 °C, ***Fig 5***. The tray is cooled for 10 minutes, then the partially formed PLA sheet is flipped on the tray. The tray is then reheated in the oven for one hour at 176 °C. The tray is cooled again for 10 minutes, then the PLA sheet is completed and removed from the tray, ***Fig 6***. It should be noted that the color of the PLA doesn't affect the procedure so different designs can be created for every sheet. In addition, the ends of the sheet can be trimmed with a saw as they are often curved or sharp.

Laser cutting testing was then done on the PLA sheets, ***Fig 7***. The Epilog laser cutter (a carbon dioxide laser cutter) was used on a 3.175 mm thick sheet of PLA. For engraving on PLA, the most effective method to see visible engraving is by engraving outlines. Vector cutting settings at a lower speed and power percentage are used to achieve deep and visible engravings. The speed is set to 20%, power to 60%, and frequency to 5000 Hz. These settings are particular for our laser cutters and individual testing should be done for each machine as settings can vary widely.

For vector cutting PLA, the Speed is set to 10%, Power to 60%, and Frequency to 5000 Hz. Similar to the engraving settings, individual testing needs to be done on your own machine to cut the sheets properly. The cut must run two times and the cut pieces must be removed before the PLA cools or else they may melt back together.

To determine the correct settings for specific laser cutters, create a sample grid of varying speed and power settings.

B. *Outcomes*

The result is a 350 by 660 mm sheet of PLA with thicknesses ranging from 3 mm to 5mm that can be laser cut.

C. *Lessons Learned*

- The sheet must be flipped to melt on both sides for a smooth sheet.
- The sheet must be cooled for 10 minutes or when no longer malleable before moving it to avoid any curvature. Without doing so, the PLA sheet became warped and was more difficult to laser cut.

- **To vector cut, cut the material in subsections.** The purpose is to be able to remove the cut pieces before the PLA cools completely. If not the PLA will harded and the cut pieces will bind again to the PLA sheet.
- **Ensure the PLA batch is pure and contains no contaminants.** There were instances of ABS being dropped off in the PLA waste bins causing the batch to be unusable.
- Clean the laser lens after each use so that the lens isn't covered by the smoke residue.

D. *Next Steps*

In this project, the sustainability team has successfully recycled PLA waste in house by creating PLA sheets. Laser cutting machine settings were determined for the PLA sheets through multiple tests. For future work, the PLA sheet making process will be standardized in a guide for all of MakerSpace Staff to make the sheets. The PLA sheets will be available to the NYU Community for their prototyping purposes. The laser cut settings will be standardized for the users who would like to laser cut the sheets. Testing will be done on the macromolecular structure of the PLA sheets at its glass-transition temperature and melting point temperature. Stress tests and X-ray scans of the PLA will be done to observe the structure changes.

E. *Figures*

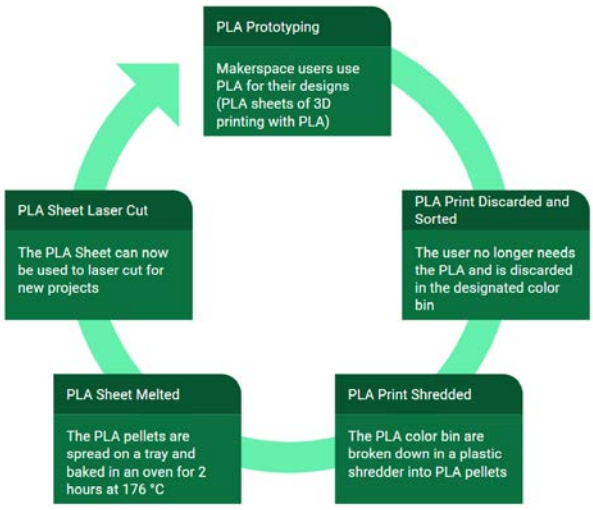

Fig.1 PLA Life Cycle at NYU MakerSpace

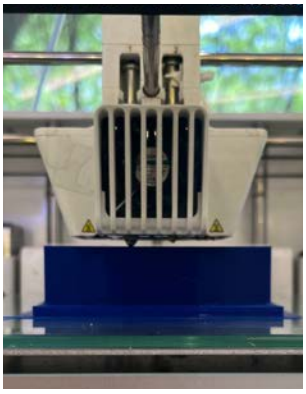

Fig.2 PLA Prototype Printing

Fig.3 PLA Waste Sorted

Fig.4 PLA Pellets on Tray

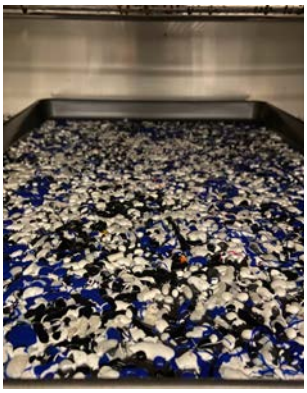

Fig.5 PLA Pellets Melting

Fig.6 PLA Sheet Completed

Fig.7 PLA Sheet Laser Cut

Fig.8 PLA Laser Cut Projects

Fig.9 PLA Laser Cut Project

References

[1] NYU MakerSpace, "Sustainability at the MakerSpace", Cited July 2022 from https://makerspace.engineering.nyu.edu/sustainability/

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[4] Precious Plastic, "SheetPress Starter Kit" Cited July 2022 from, https://preciousplastic.com/starterkits/showcase/sheetpress.html

[5] NYU Tandon, "An NYU Green Grant helps the MakerSpace shred PLA", Cited July 2022 from, https://engineering.nyu.edu/news/nyu-green-grant-helps-makerspace-shred-waste

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