4-24-2020

Investigating Recycled 3D Printing Filament Infrastructure: A Cost-Benefit Analysis

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Abstract

3D printing capabilities have expanded and grown at Boise State University with developments such as the MakerSpace in the Library as well as the Engineering Innovation Studio. PLA (polylactic acid) plastic is a widely used material for 3D printing. Currently the Engineering Innovation Studio alone spends about $3,000 each year on 3D printing filament, which is about 120 spools of filament. Our project is investigating a way to use recycled PLA to create 3D printer filament, while helping the Engineering Innovation Studio save money and reduce waste. Sources for recycled PLA include bad or wasted 3D prints, and other resources such as recycled water cups on campus. Over the course of the semester, we have identified specifications for an extruder system and shredder in order to begin recycling PLA. We will have created a cost-benefit analysis recommending an extruder set and shredder for the College of Engineering to purchase for the Engineering Innovation Studio.

Investigating Recycled 3D Printing Filament Infrastructure

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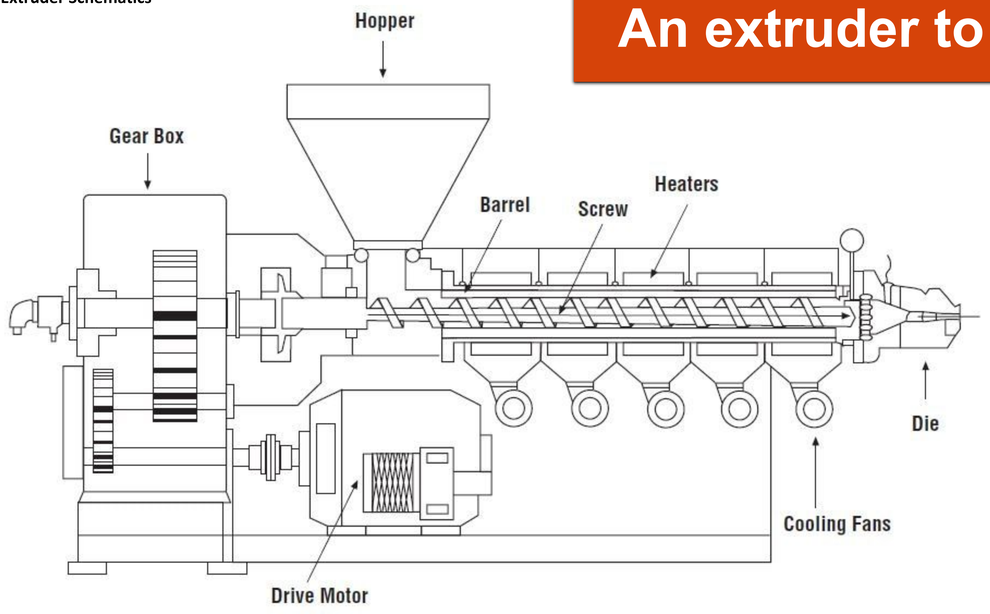
Engineering Plus

Figure 1. Extruder Schematics



An extruder to convert waste PET and PLA into 3D printer filament

INTRODUCTION

Single use plastics, and in general plastic waste, are increasingly problematic worldwide. The larger scale systems for recycling and reuse are unable to keep up with the waste generated. At the same time that plastic waste is growing, the "Maker" movement and use of 3D printers is growing. On the Boise State campus, Albertson's library and the College of Engineering's Innovation Studio house more than a dozen 3D printers. Is it possible to use plastic waste generated on the Boise State campus to fabricate 3D printer filament and hence have a local closed loop recycling process? The key to creating this recycling system is an equipment set that can convert plastic waste into useable 3D printer filament.

BACKGROUND DATA

- Plastic waste is a problem worldwide
- Plastic was previously sent to China for recycling, but China has limited the amount of waste it imports.
- PET and PLA are the focus.
- PLA is Polylactic acid [3]
  - an organic based plastic made with corn starch and sugar cane.
  - melting point is between 150 - 160 °C
  - easy to process including extrusion
  - a common material for 3D printing
- PET is Polyethylene terephthalate [3]
  - clear, strong and lightweight
  - typically used for single use bottles
  - materials properties including a higher melting point make it more difficult to extrude.

TECHNICAL APPROACH and RESULTS

Extruders were characterized by:

- Cost of the extruder
  - Alone and as a set (cooling system and spool winder included)
- The plastics that can be extruded
- The diameter of the filament it can create
- The maximum temperature
- The extrusion rate

Two possible extruders were identified that fit the majority of the design criteria.

The Filabot EX2 Extruder [2]

- Pros:
  - Has an option to purchase an extruding set
  - Large range of plastic types
  - Less expensive than other models
- Cons:
  - Cannot extrude PET

NozTek Pro HT Extruder [1]

- Pros:
  - Significantly higher price
  - Large range of plastic types- including PET
  - Options to purchase a cooling system and spool winder
- Cons:
  - The extruding set is more expensive than other models

OBJECTIVES

- Demonstrate a local solution to recycling plastic waste.
- Reduce the amount of plastic waste generated at Boise State that ends up in landfill.
- Create 3D printer filament from plastic waste
- Determine the equipment to be purchased to:
  - Shred waste PLA and PET
  - Extrude waste PLA and PET into 3D printer filament.
- Pursue a funding source for the purchase and installation of the extruder.

Figure 2. NozTek Pro HT Extruder

[1.] "Noztek Pro HT Desktop Extruder," *Noztek Extrusion Systems.* [Online]. Available: https://www.noztek.com/product/noztek-pro-high-temperature-extruder/. [Accessed: 03-Feb-2020].
[2.] "Filabot EX2 Extruder Setup," *Filabot.* [Online]. Available: https://www.filabot.com/collections/ex2-extruder/products/ex2-bundle. [Accessed: 03-Feb-2020].
[3.] J. Steiha. Polymer Processing Expert.

Figure 1.: Giles, Harold. "Azom." *Azom*, 2017. www.google.com/url?sa=i&url=https%3A%2F%2Fwww.azom.com%2Farticle.aspx%3FArticleID%3D13566&psig=AOvVaw1HlUUGqoxa454qY2PtJ3Bn&ust=1585008139027000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCID508Klr-gCFQAAAAAdAAAAABAI. [accessed 22-Mar-2020]

Figure 2.: "Noztek Pro HT Desktop Extruder," *Noztek Extrusion Systems.* [Online]. Available: https://www.noztek.com/product/noztek-pro-high-temperature-extruder/. [Accessed: 07-Feb-2020].