Compostable Polymer Mixing Study
OSU Chemical Engineering

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Plastic Cutlery

Every year an estimated 40,000,000 plastic utensils are used in the United States.[1] This is due to:

- Low cost
- Ease of use
- Robust design

The majority of plastic utensils end up in landfills after a single use. This waste can be reduced through use of compostable cutlery. According to ASTM standards, single polymer compostable plastics must degrade by 60% in 24 weeks.[2]

EcNow Cutlery

Project Overview

The project objective is to formulate, extrude and mold a plant-based polymer system into inexpensive, robust, compostable utensils. Working with EcNow Tech, a local start-up company currently producing compostable cutlery, fillers were chosen to improve the following properties:

Product Specifications:

- Flex Modulus: 3500 - 5500 MPa
- Heat Deflection Temperature: > 70 °C
- Impact Resistance: > 3.4 x 10^{-2} J/m
- Pellet Cost: < $ 4.5 /kg

The project process flow is outlined below:

- Fillers are blended with plant-based polylactic acid (PLA) in an extruder
- Extrudate is ground and injection molded into utensils
- Product specifications are tested and compared with the current formula

This research will result in final utensil formulations containing one or more of the tested fillers.

Prep → Extrude → Mold → Test

Fillers

Fillers were obtained emphasizing the following criteria:

- Local plant-based fillers are emphasized
- Local fillers promote sustainability and help local businesses
- Before extrusion, fillers are dried in a convection oven and ground using a Wiley Mill if needed

Fillers used in this project:

- Nanocor I.34TCN
- Nanocor I.44P
- Rice hulls
- Berry pomace
- Bamboo poles
- Wood flour
- Flax shive fiber

Convection Oven

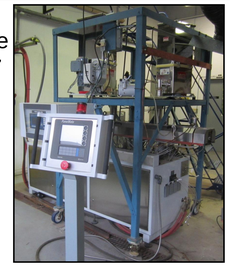
Wiley Mill

Extrusion Background

Extruders are used to mix and form materials for the metals, ceramics, plastics, and food industries.[3] Extrudate trials in this project were run on a twin-screw ENTEK E-27 extruder donated to OSU in 2005.

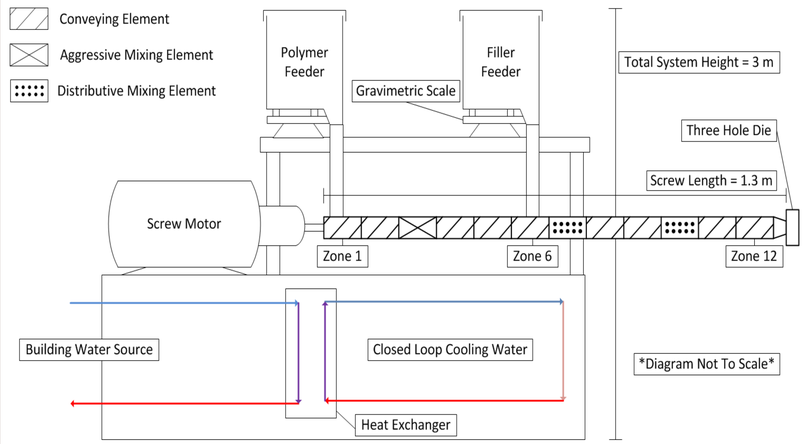
The E-27 contains:

- 12 independent temperature controlled barrel zones
- Conveying and mixing elements on the screw
- Two feed hoppers
- HMI to operate extruder controls



ENTEK E-27 Extruder

Extruder Diagram

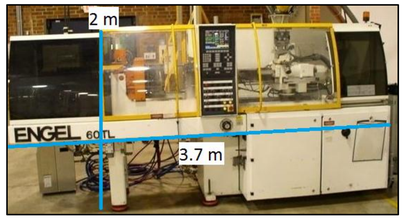


Injection Molding Background

Injection molders mold polymer based materials into shapes such as packaging, bottles, and utensils. Extrudate trials in this project were molded on an ENGEL ES200/60.

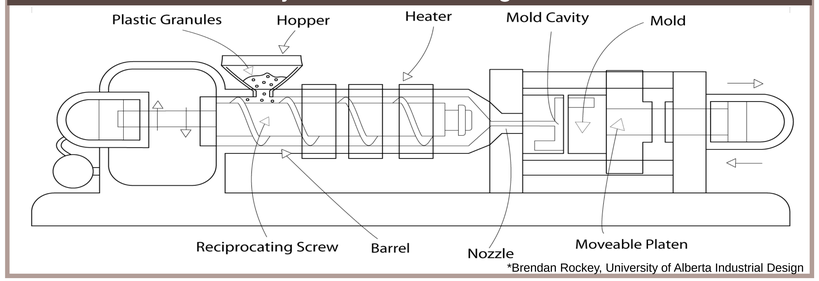
The ENGEL injection molder contains:

- A feed hopper
- An extrusion screw with heating elements
- A mold cavity
- A mold plate with cooling water
- HMI to operate ENGEL controls



ENGEL ES200/60 Injection Molder

Injection Molder Diagram



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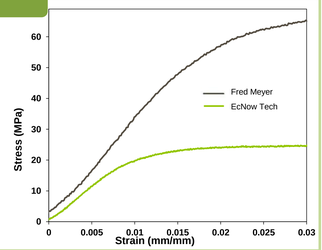
Mechanical Testing

Mechanical testing quantifies performance differences due to various filler types and loadings. These tests simulate customer use.

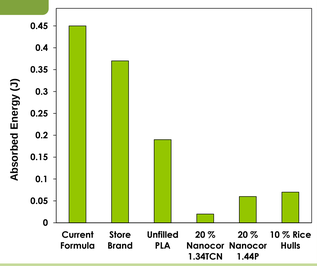
Flexural Modulus

- A material's ability to resist deformation under load
- Quantifies flexural rigidity
- Assessed using a three point bend test.
- Reported in MPa



Impact Resistance

- A material's ability to resist impact
- Quantifies toughness
- Assessed using a weight drop test.
- Reported in energy lost per specimen thickness (ft·lb/in)



Heat Deflection

- A material's ability to resist deformation at high temperatures
- A specimen is heated and then deformed
- The max temperature recorded before deformation is reported

References

1. "Disposable Lunch Facts - Items Carried in Work and School Lunches." *Reuseit.com*. WorldCentric, 2012. Web. 10 May 2012. <http://www.reuseit.com/learn-more/top-facts/disposable-lunches>.
2. ASTM D6400-04: *Standard Specification of Compostable Plastic*s. ASTM International, 2004.
3. Rauwendaal, Chris. *Polymer Extrusion*. 4th ed. Cincinatti, Ohio: Hanser Gardner Publications, 2001. Print.

Acknowledgements

- Paul Nash & Chris Vitello (EcNow Tech) – Sponsor
- Linda Campbell & Dean Elliott (ENTEK) – Extruder Technical Support
- Scott Nason – Extruder Mechanical Support
- Dr. Philip Harding & Dr. John Simonsen – Faculty Advisors