Waste Plastic to Fuel Using Pyrolysis

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Introduction

Plastic is everywhere. Humans have produced over nine billion tons of plastic throughout history, which is equivalent to more than one ton of plastic for every human being. This issue is specifically detrimental to The Bahamas, because plastic cannot be put in a landfill or in a plot of land far from civilization. Instead, people must live with their waste or have it shipped to larger countries with more land mass. This process wastes fossil fuels as well as money, time and resources. If the plastic is not shipped off island, it is incinerated, and thousands of harmful toxins are released into the atmosphere.

Background

The extensive production and continuous demand of plastic across the globe has led to major accumulation of plastic in landfills. Although there have been many attempts to solve this rapidly growing problem (incineration, recycling, energy recovery methods), they require too much time, money and resources to be a feasible solution. A potential solution is the conversion of waste to energy, in this case, waste plastic to fuel (pyrolysis). Pyrolysis is thermal decomposition in a low oxygen, high heat environment. The combination of heat and lack of oxygen thermally degrades long chain polymers into smaller molecules resulting in oil, gas, and char. The high volatile matter and low ash content in plastic gives it a high potential liquid oil yield, making plastic a viable option for pyrolysis.

Picture 1: The Island School's landfill or "Boneyard".

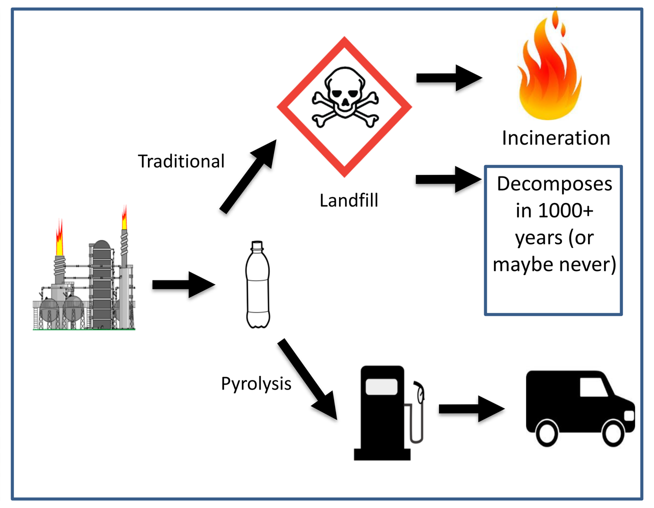


Figure 1: Life cycle of plastic with and without pyrolysis.

How it Works

Approximately 650 grams of plastic are shredded and put into the airtight reaction vessel. The reaction vessel is then placed into an insulatory drum where it is heated using propane to between 470 and 530 degrees Celsius. The gases released from the decomposing plastic flow into a condenser, where a fraction of it cools into liquid oil. The oil is then collected in a chamber while the non-condensable gasses flow into a chamber filled with water called the bubbler. The non-condensable gasses are then flared off. These non-condensable gasses are 10,000 times safer than the gasses that would be released through incineration.

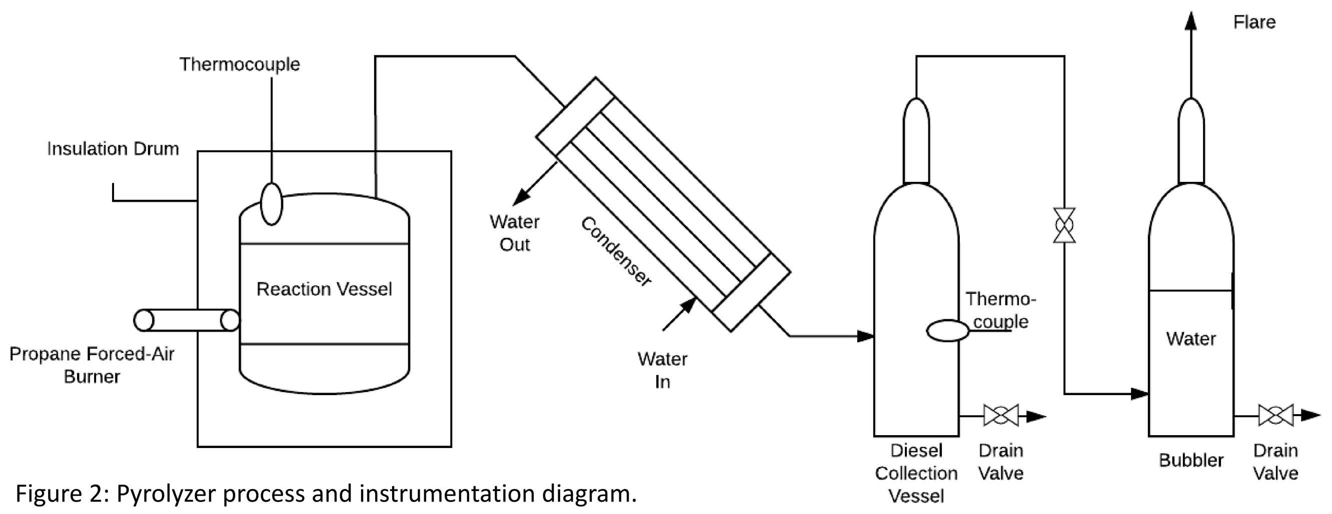


Figure 2: Pyrolyzer process and instrumentation diagram.

Picture 2: Pyrolysis system at The Island School.

Goals & Methods

Two of the major goals that the pyrolysis research team aims to achieve are to create a zero-waste campus at The Island School, as well as creating a working model for rural communities. This semester specifically, one goal is to increase the plastic to fuel yield conversion, allowing the team to maximize the amount of fuel that is being produced per the amount of plastic that is put in. The pyrolysis team also aims to increase the thermal efficiency of the system. To improve the thermal efficiency of the system, numerous upgrades to the insulating drum were made allowing more heat to be contained. The method of feedstock preparation time was sped up by attaching a motor to a plastic shredder, which has been able to successfully shred polystyrene into consistent strips.

Results

There has been a notable decrease in the feedstock preparation time for the system which is greatly beneficial, as it was one of the largest time consumptions. The previous pyrolysis group had to cut plastic for their reactions by hand which caused the pieces to be inconsistent in size. Since this provided an uncontrolled variable in the experiment, their results were more likely to be inconsistent in terms of fuel yield.

The old insulating drum was causing a lot of heat loss. It only had one inch of ceramic fiber lining the inside of the drum and the underside of the lid, and was held in place by chicken wire. This caused the insulation to degrade quickly and lose its ability to trap heat, as it was constantly being exposed to the high temperatures required to run the experiments. The new drum has two inches of ceramic fiber, a more tight-fitting lid, and steel wall lining the inside to protect the ceramic fiber.

The new insulation drum is 71.5% more efficient in heating up the reaction chamber. The insulation drum is also 23.4% more efficient in containing the heat. In spring 2017 the fuel yield conversion was less that 10% and the system is currently at 63% (Cook, 2017). In spring 2017 the energy efficiency was less than 2% and the cost efficiency less that 1% (Cook, 2017). The system is now above 32% energy efficiency and 21% cost efficiency.

Picture 3: New Insulating Drum.

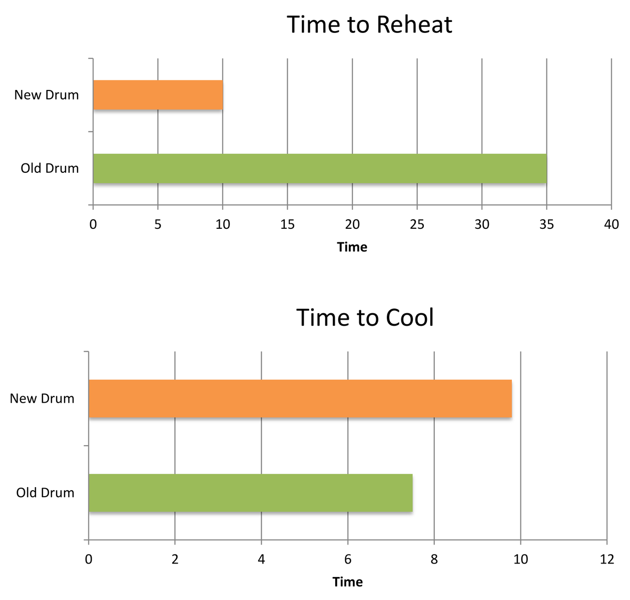
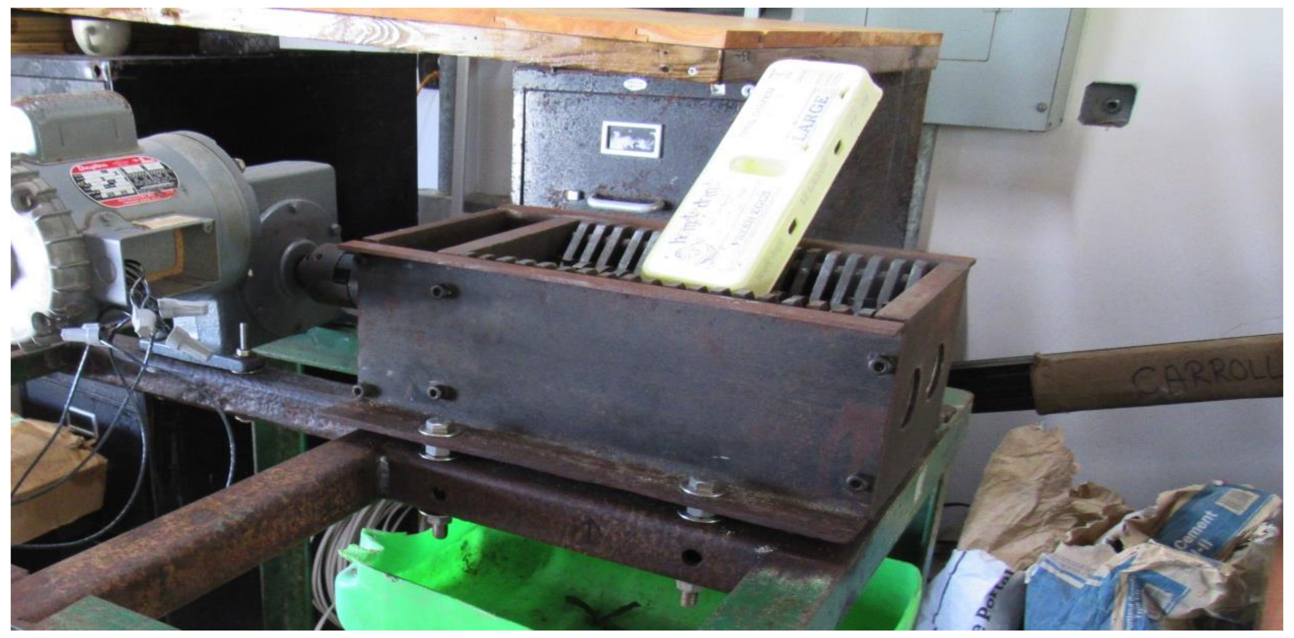


Figure 3: Insulating Drum Efficiency.



Picture 4: Motorized Shredder.

Analysis Type	Spring 2017	Fall 2017
Cost Efficiency %	Less than 1%	21%
Energy Efficiency %	Less than 2%	32%
Fuel Yield Conversion %	Less than 10%	63%

Table 1: Pyrolysis efficiency comparison with previous Island School research.

Future Research

In the future, The Island School pyrolysis team hopes to increase the energy conversion to over 100% which will increase the cost-benefit outcome. This means that the amount of money generated from the fuel produced in comparison to the cost of energy put into the system is greater. The Island School is collaborating with a senior design team from the Thayer School of Engineering at Dartmouth College to use mass spectrometry to determine the specific composition within the fuel. As of now, researchers at The Island School are only able to test the flammability and density of the fuel in order to compare it to traditional fuels. Mass spectrometry allows for greater certainty that the fuel produced is safe to use in engines.

Discussion

The Island School has been able to reduce the volume of plastic on campus and create usable fuel. Pyrolysis could potentially offset imported fossil fuels, which would make the nation more energy secure. Pyrolysis is a system that could be utilized all around the world. Every community has plastic that is categorized as end of life plastic that will remain in a landfill permanently, and pyrolysis can bring new life to this plastic by creating usable fuel.

Literature Cited & Acknowledgments

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