Pyrolysis: a Solution to the Plastic Problem

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Introduction

Plastic is made from fossil fuels that are refined and chemically altered. Once plastic , it will not decompose for thousands of years. 300 million tons of plastic were produced in 2013, and that number increases by 4 percent each year. As seen in figure 1, prevention, minimization, and reuse of plastic wastes are the most effective ways to reduce plastic production.

Only 10 percent of the world's plastic waste is recycled. On islands, which often lack the infrastructure for a large recycling center, recycling is less sustainable than energy recovery, the conversion of waste into fuel. Transporting recyclables to the closest recycling center is expensive and releases abundant carbon emissions, whereas energy recovery requires no transportation and utilizes the potential value of plastic waste. At The Island School's Center for Sustainable Development, the plastic pyrolysis research team aims to use energy recovery through pyrolysis in attempt to become a zero-waste campus and fight the global plastic crisis.

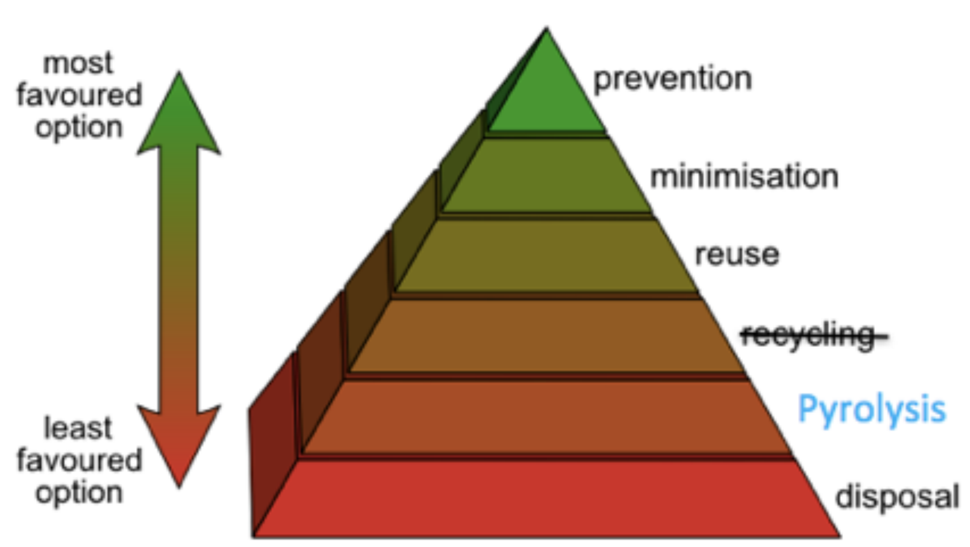

Figure 1: Waste management hierarchy

Pyrolysis & Uses of Synthetic Oil

Pyrolysis is thermal decomposition in a hot and anoxic environment. The Island School is using pyrolysis of plastic to revert plastic waste back to its fossil fuel form as a synthetic fuel similar in structure to diesel fuel. When pyrolyzed, the longer hydrocarbon chains that make up plastics are cracked into smaller chains that make up gases and liquids. There are three products of pyrolysis: 5 wt% char, 10 wt% non-condensable gases such as methane, and the remaining yield is synthetic fuel.

Synthetic fuel at The Island School would mainly be used in the small machines and vans around campus. The campus generates about 5,000 pounds of plastic waste every year, which is stockpiled in a large resource area on campus. While the fuel produced through pyrolysis offsets some of the diesel fuel already being produced at The Island School, the goal of pyrolysis is to make use of the plastic waste on campus rather than to find a fuel alternative to the currently running biodiesel facility.

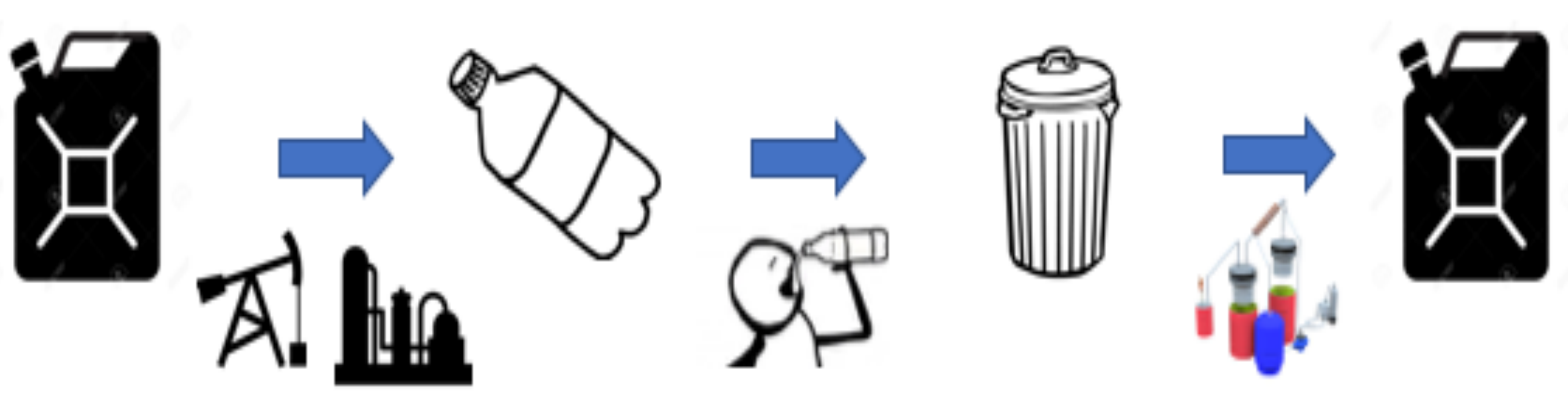

Figure 2: Lifespan of plastics at The Island School

Design

The system was created from scratch without instructions. Construction of the pyrolyzer included metal-working such as angle grinding, drilling, welding, and pipe threading. There was an abundance of troubleshooting during the creation of the system, particularly over the framework and insulation of the reaction vessel. Instead of purchasing an expensive gasket, a copper gasket was created from repurposed waste. The plastic pyrolysis research team hopes to pyrolyze The Island School's weekly plastic waste, generate replicable data, and extract synthetic fuel from each experiment. Last term created a small lab-scale system that successfully pyrolyzed approximately 100 grams of waste plastic, yielding about 60-80 milliliters of synthetic fuel per batch. With 60 pounds of shredded waste plastic from the recycling center at The Island School, it is hypothesized that the system could yield approximately 5.7 gallons of synthetic fuel per batch.

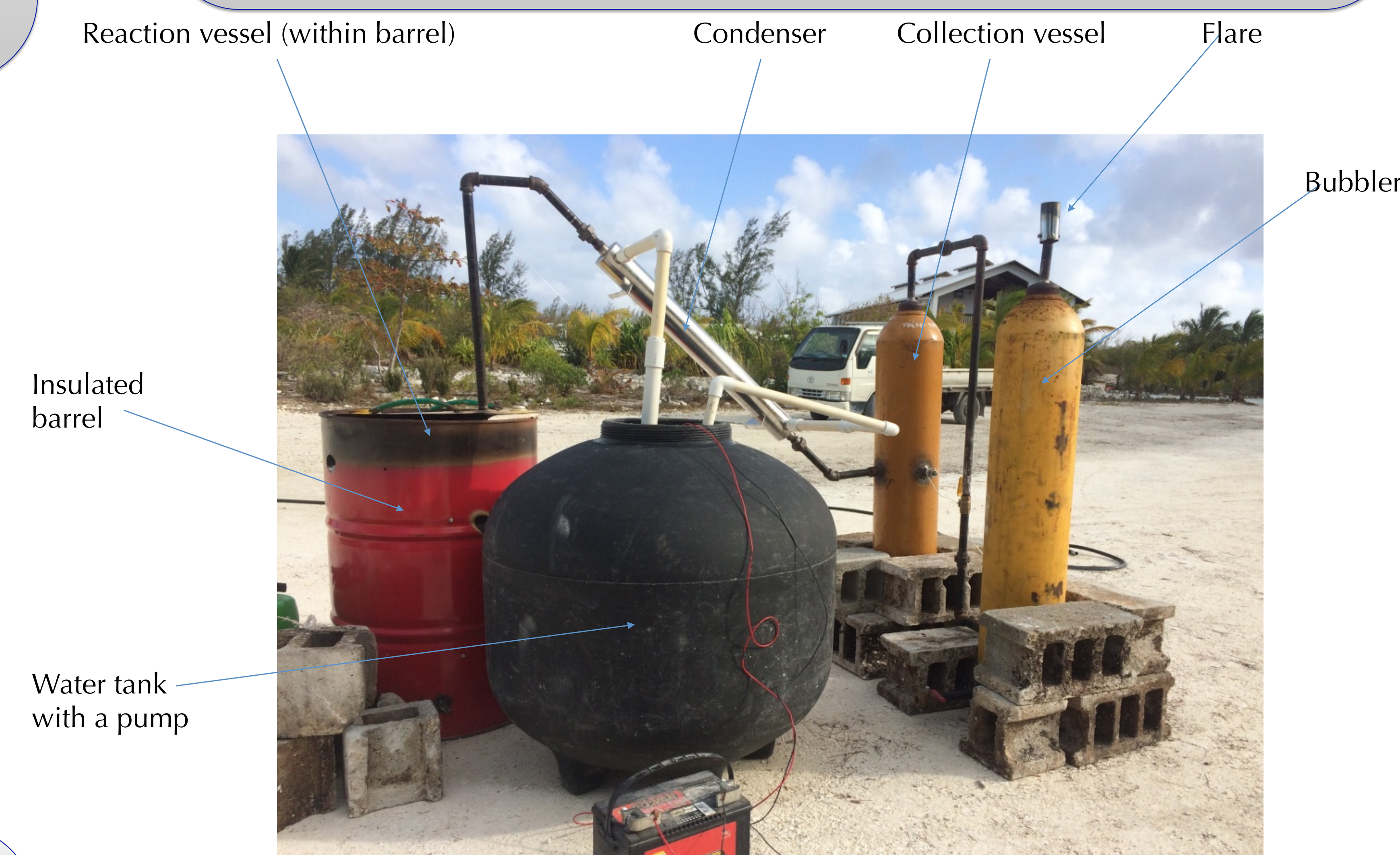

Figure 3: System components

The System

Waste plastic is put into the reaction vessel and is sealed shut to minimize oxygen in the reaction. The reaction vessel rests within an insulated barrel, and the reaction vessel is heated using a propane heat source. The plastic within the vessel vaporizes up the pipe into the condenser. Within the condenser, water, from the tank, surrounds the pipe, condensing the plastic gas into an oil that gets collected in the collection vessel. There are some gases that do not properly condense. The bubbler is a vessel that is filled with water and has a flare at the top. This flare burns off the non-condensable gases from the reaction. Burning off a small amount of CO_2 from the system is far better than the gases that plastic would emit in a landfill, such as methane (27 times worse than CO_2) or dioxins (10,000 times worse than CO_2).

Figure 4: Testing the system

Figure 5: Tarpum bay landfill

Analysis

One of the things that must be kept in mind during analysis are the calorific values of the process. The energy and money ratios on each end must be measured to ensure that more value is being gained from pyrolysis than is being used to run the reaction. There is a theoretic 4000% energy conversion rate, which means that with one unit of energy inputted, 40 units of energy can be yielded. Part of this research process includes evaluating how close the efficiency can get to that 4000% conversion rate. For The Island School, running the pyrolyzer twice a week will deal with the weekly waste stream, and the pyrolyzer will pay itself off in two years. With the amount of waste The Island School produces annually, one half of one Island School van can run off the amount of syn-fuel that can be yielded from that plastic waste.

Figure 6: Pipe threading

Figure 7: Angle grinding

Figure 8: Syn-fuel yield

Future Research

The pyrolyzer was designed to run tests on temperature, rate, and plastic type. Future research includes automating the process, using non-condensable gases as a heat source, toxicology studies on char, and sending fuel out for laboratory analysis. The Island School's long-term goal is to become a zero-waste campus, and to find a way to utilize all byproducts of pyrolysis. A lab fuel analysis could provide more information on what the diesel-range syn-fuel contains. Viscosity, flammability, and density can be tested on The Island School campus, a lab analysis could give deeper insight into the quality of the oil product yielded from pyrolysis.

Once pyrolysis is fully functioning at The Island School, one of the broader goals is to spread it to the greater community and remote locations globally.

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