Pyrolysis of LDPE to Yield Fuel

Daniel Rotta, David Street, Carson Wallace
Dr. Scott Grayburn
Department of Biological Sciences
College of Engineering and Engineering Technology

NORTHERN ILLINOIS UNIVERSITY
College of Engineering and Engineering Technology

Abstract

With global plastic production growing at an unprecedented rate, plastic waste pollution is continuously growing, causing threats to wildlife and increasing greenhouse gas emissions. The development of an electric-powered pyrolysis system that converts plastic waste to liquid fuel presents a promising solution to this problem, and an incentive to collect plastic waste that is so abundant in the environment. Low-density polyethylene (LDPE) is the most used packaging material globally and is resistant to biodegrading, making it an appropriate plastic to study due to its significant negative environmental impact. The proposed system is modular, benchtop scaled, and able to be powered by renewable energy sources. Furthermore, it creates an economic incentive to collect plastic waste in the environment, as it provides an efficient and reliable way to convert it into usable fuel.

Introduction

Pyrolysis is the thermal decomposition of a material at high temperatures in the absence of oxygen. By pyrolyzing low-density polyethylene $(C_2H_4)_n$, energy can be extracted from the plastic in the form of shorter length hydrocarbons. Hydrocarbons from LDPE can be condensed and used in a similar fashion to hydrocarbons produced in a standard oil refining process. Hydrocarbons come in a vast assortment of lengths, with only chains of lengths 14-20 carbons corresponding to diesel. Vapor from the pyrolyzed LDPE is sorted through zone heating such that only hydrocarbons that are diesel length are recovered. Once passed through these zones, the diesel-like hydrocarbons are cooled in a condenser, converting the vapor into liquid fuel. Plastic-to-fuel technology such as this system is proven to reduce greenhouse gas emissions and fossil fuel use.

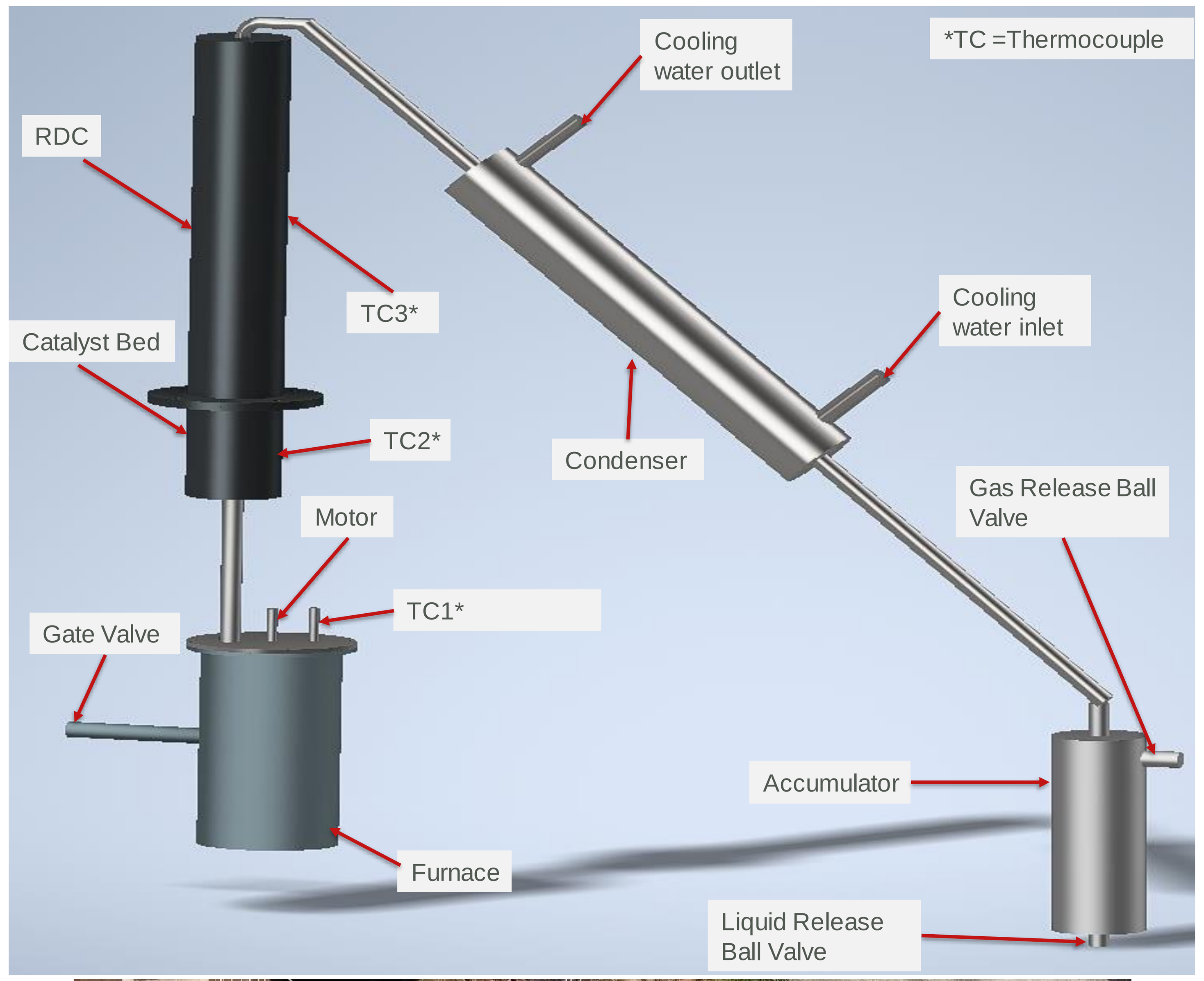
Components

This system consists of four components: a furnace to pyrolyze waste plastic, a reactive distillation column (RDC) to house a catalyst and aid in the isolation of diesel-like hydrocarbon chains, a condenser to convert input vapor fuel into a liquid output, and an accumulator to collect the liquid fuel output of the condenser and dispose of any syngas produced during the process through use of valves. The catalyst bed housed in the RDC serves to lower pyrolysis temperature of the LDPE and to increase the similarity of the output fuel to commercial diesel in terms of chemical composition, observed using gas chromatography. All components were made from carbon steel and were fabricated in the NIU machine shop primarily using the OMAX Waterjet and welding.

Results

The system can pyrolyze LDPE. System temperatures were found to easily reach pyrolysis temperatures, with the furnace reaching between 400 ºC-450ºC after 50-75 minutes of heating. Heating rate of the furnace was relatively constant at 8-15ºC/min. The zone temperatures of the RDC were 220ºC-300ºC at the bottom near the catalyst bed, and 180ºC-220ºC at the top. Cooling water was pumped through the condenser to cool the vapor, with little change in cooling water temperature over time. Temperature readings were recorded using Type K thermocouples inserted throughout the system. After passing through the condenser, fuel was collected in the accumulator, where recovered liquid was stored. Recovery rates are dependent somewhat on thermal behavior set by the user, fugitive emissions, and feedstock. Recovery rate was defined as the ratio of output yield volume to input volume. All components of the system requiring electricity were powered using 120V wall outlet.

System



Acknowledgements

Without the constant advising and guidance of Dr. John Shelton and Dr. Scott Grayburn, this project would not be possible. Additionally, Mike Reynolds, Jeremy Peters and Greg Kleinprinz were exceptional in their instruction and aid in fabrication. Lastly, Dr. Douglas Klumpp of the Chemistry Department aided in gas chromatography analysis of yielded fuel.