Pyrolysis Reactor Burning Plastic Feedstock

Cadet: David Foster

Advisor: CPT Robert L. McMasters

Throughout the world, there is over 380 million tons of plastic produced each year, and of that 380 million, only 9% is recycled. In the Pacific Ocean, there is a trash island that covers more square miles than the entire country of France. Clearly, there is an issue of plastic waste accumulation that future generations will have to solve. Pyrolysis reactors can be an efficient method of disposing plastic waste and recycling that waste into usable energy through hydrothermal generators. These generators can operate with an efficiency between 10-15%; however, research suggest that those numbers can increase with better materials and more development. This project was performed as a step that can validate the thermal gain of these reactors and there overall worth towards combating waste and producing energy.

The first step in my design process was to design a functioning reactor. A picture of the final design, and a schematic of the reactor can be seen in Figures 1 and 2, respectively. Once the reactor was built, temperatures at key points were taken within the system; these points were the reactor exit, the combustion chamber, and the exit exhaust. Using a differential pressure gauge, I was able to measure the flowrate of compressed air entering the system. This would prove critical in my ability to calculate molar flowrates to determine the heat gain of the system.

Figure 1. Final Design of Reactor

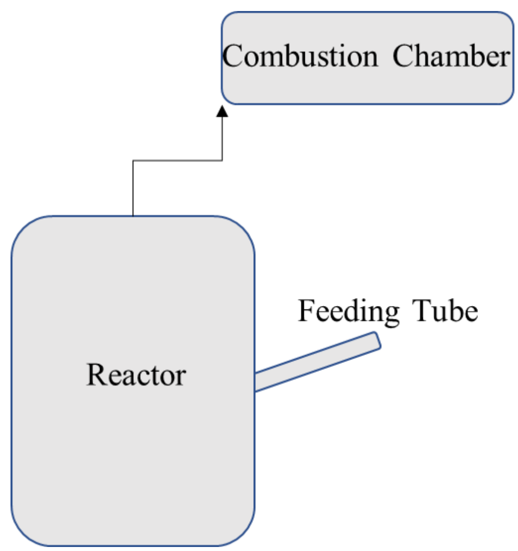

Figure 2. Schematic of Reactor.

Once the reactor was modeled and I collected my data. The next step was to calculate the molar flowrates for the products leaving my reactor. Table 1 shows these flowrates. The temperatures at the key points within my system can be found in Figure 3.

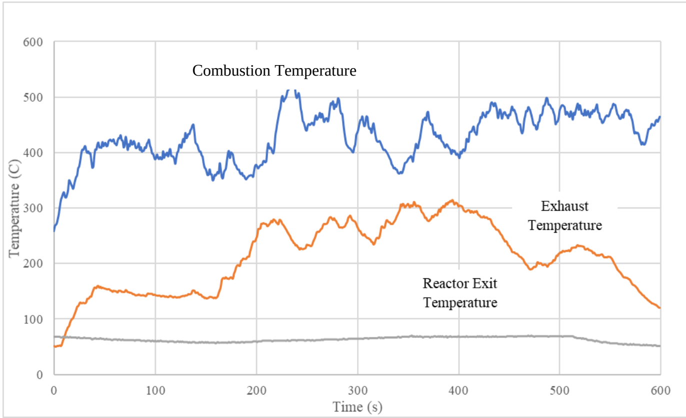

Figure 3. Collected Data for Reactor.

Table 1. Molar Flowrates for Products.

Compound	Molar Flowrate (kmol/sec)
Nitrogen	0.000013270
Methane	0.000001180
Carbon Dioxide	0.000001180
Oxygen	0.000003529

Scaling the products of the reactor by the molar flowrate of oxygen, the total energy produced by the products was 268,000 $\frac{kJ}{kmole}$, and the reactor was effectively producing 0.949 kW of power. Comparing that to the input power of the reactor, 0.967 kW, the heat gain was 0.98. While I expected to have a positive heat gain, when taking into consideration the heat loss of the reactor, the true heat gain would have been 3.39. Using the adiabatic flame temperature, found using online references and a Magnus Excel file, the max theoretical gain was 4.30. These results can be seen in Table 2. Follow up work will be needed to determine how many watts of electricity can be produced from a thermoelectric generator. This could then be used to power a small engine or other small appliances to further validate the use of pyrolysis reactors that turn plastic waste into useable energy.

Table 2. Actual, commercial, and max theoretical gain of the reactor.

Measured Gain	0.98
Measured Gain + Heat Loss	3.39
Max Theoritical Gain	4.30