PLASTIC TO FUEL:
Kiln-Based Pyrolysis Reactor for Use in Underserved Remote Communities

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BACKGROUND

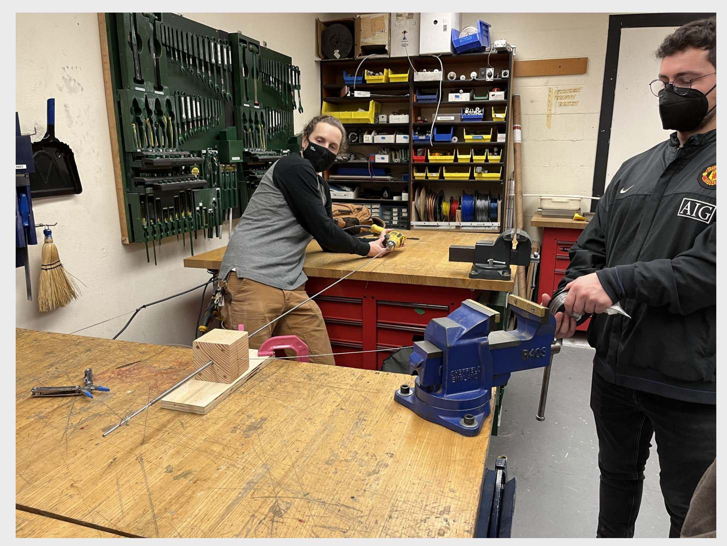
- Eight million tons of plastic end up in oceans and waterways every year [1]
- Degradation to ocean plastics caused by exposure to the elements can make mechanical recycling difficult or impossible
- Pyrolysis, the act of heating material to the point of degradation, can be used as a chemical recycling process for plastics at any level of degradation
- Dr. Skip Rochefort has been conducting research with a 1 kg pyrolysis reactor for the last five years that now needs upgrading

OBJECTIVE

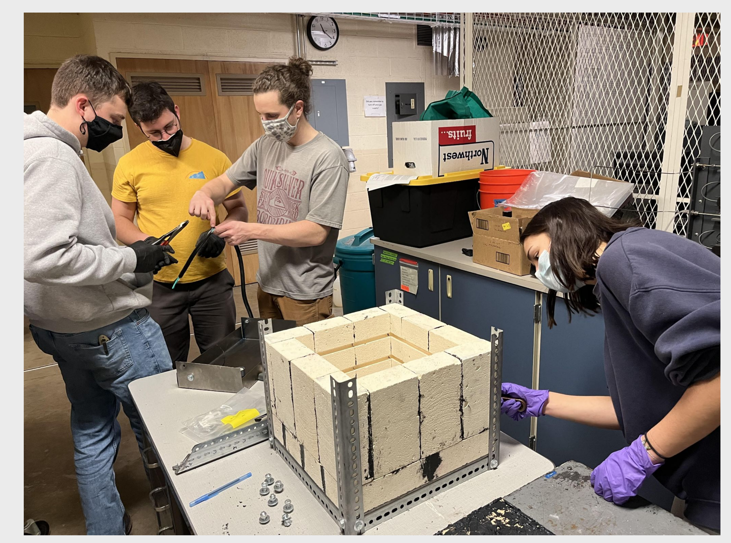
The goal of this project was to redesign a pyrolysis plastic to fuel reactor for Dr. Rochefort's lab with intended future use in underserved communities. The original reactor needed updates to materials, heating, and insulation to increase efficiency and safety.

Dr. Rochefort's original pyrolysis reactor

Oregon State University



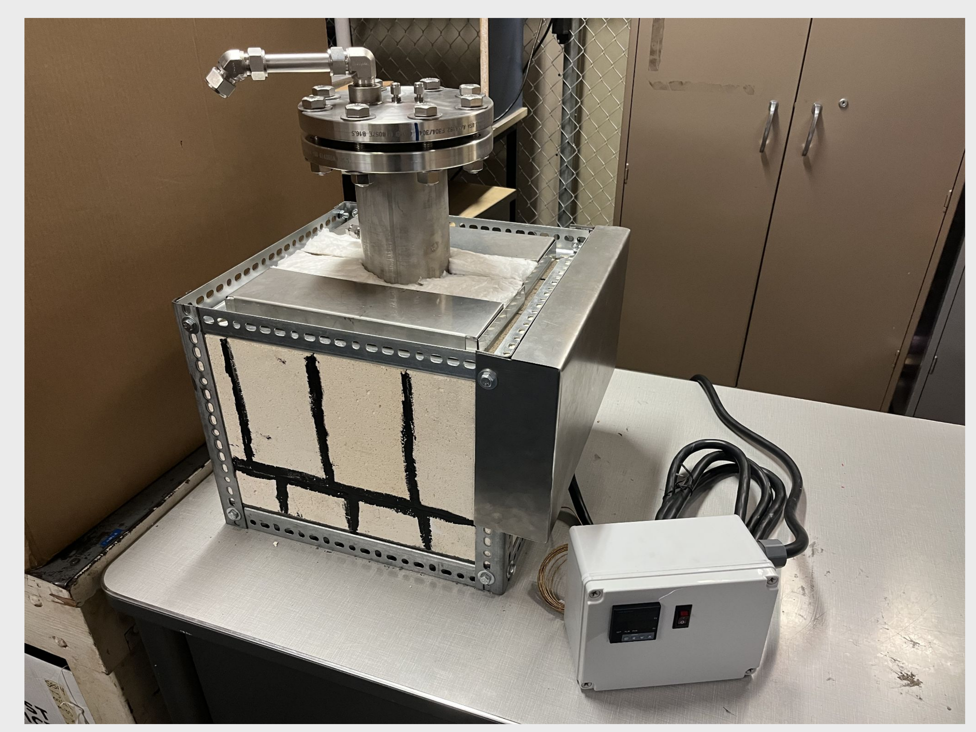
Making the heating coil with custom jig



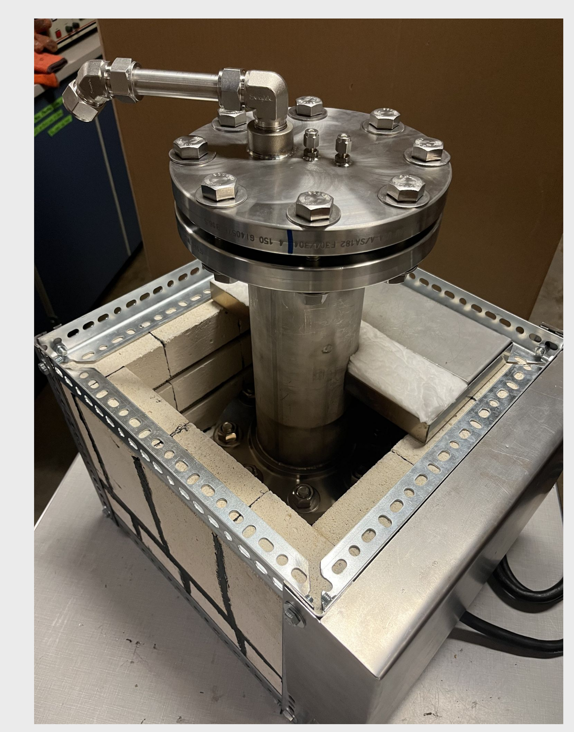
Mortaring kiln bricks together and wiring control system

Pinning heating coil into routed channels

Channels in kiln brick for heating coil made on router table



Final system including reactor, kiln, and control system



Final system looking inside kiln

DESIGN

The reactor setup consists of three main subsystems: reactor, kiln, and control system. The reactor is loaded with plastic and placed into the kiln, which heats and insulates the reaction. The control system connects a PID controller to the heating coil embedded in the kiln. Temperature is regulated from a thermocouple fed into the plastic from the top of the reactor.

REACTOR

- Stainless steel pipe with removable end caps for loading and cleaning
- Two compartments separated by internal washer:
  - 1 kg capacity main compartment
  - Packed bed that increases residence time and improves product quality
- Nitrogen port added to create inert environment within the reactor

KILN

- K23 soft insulating fire bricks cut to size and held together by high-temperature mortar
- Half-inch square routed channels hold heating coil
- Slotted steel angle frame provides structure
- Interior and exterior steel base plates protect the brick
- Stainless steel and ceramic fiber insulated lid fits around the reactor in two parts

CONTROL SYSTEM

- PID controller used to regulate internal kiln and reactor temperatures
- Combination of mechanical rocker switch and solid-state relay (electrical switch) to provide power to the kiln
- Type-K thermocouples used to measure temperature inside the kiln wall, reactor main chamber, and reactor packed bed

MAJOR DESIGN CHANGES

- New reactor is constructed from 304 stainless steel instead of low-carbon steel
- Reactor pipe is shorter with a larger diameter and thinner walls to reduce height but retain original volume
- Kiln provides both heating and insulation instead of heater bands and insulation jacket
- More compact control box with individual power cords for ease of transport
- Mechanical rocker switch to turn kiln power on and off

ACKNOWLEDGEMENTS

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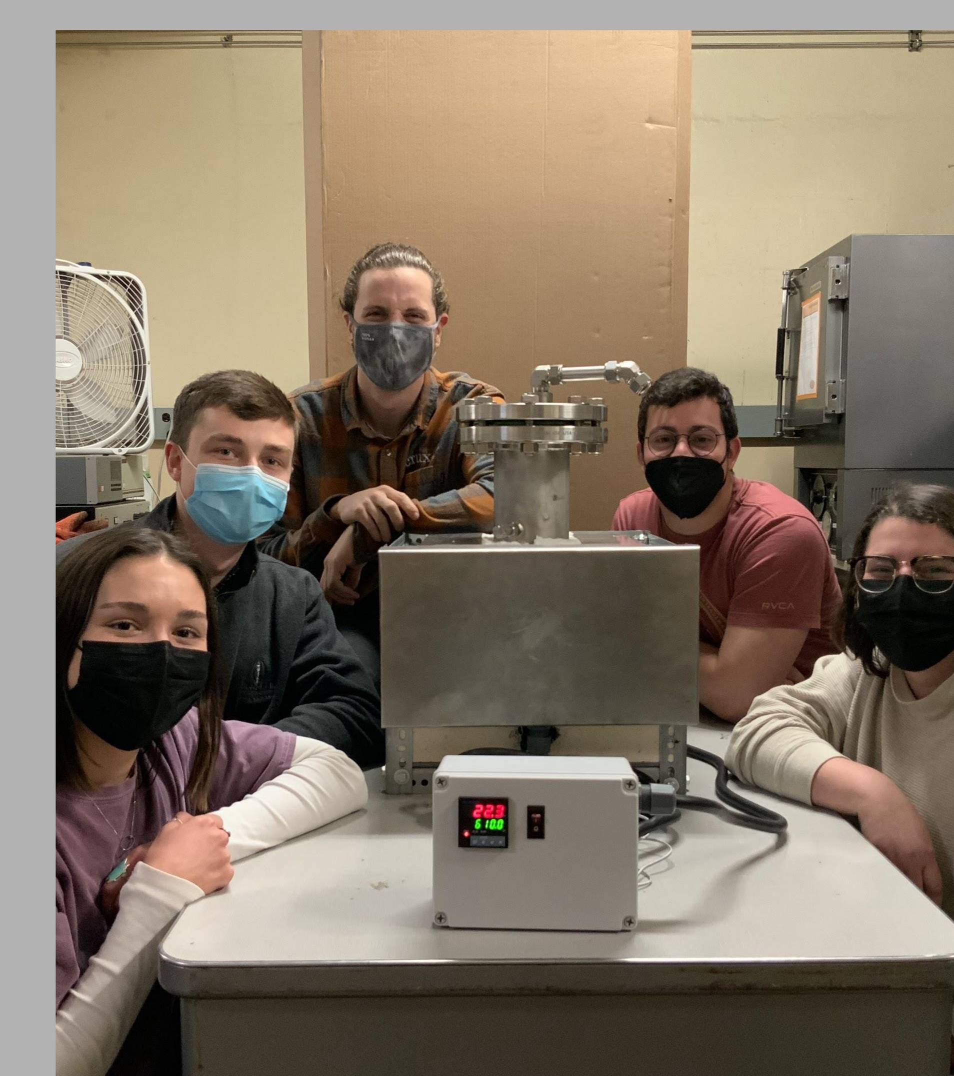

PTF Capstone team with redesigned reactor. Clockwise from left: Avrie Van Tilburg, Andrew Eyre, Kiernan Kilkenny, Adam Osovsky, Emma Lingle

SOURCES

[1] International Union for Conservation of Nature, 2018, "Marine Plastics"