Design for Gas Exhaust and Recycling in a Food Preservation System

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Clean Crop Technologies:

Clean Crop Technologies (CCT) is a Holyoke, MA based startup with the goal of decontaminating food from dangerous fungal toxins. They use a cold plasma system and a proprietary gas mix to do this. Their current prototype has no means of recycling exhaust gases. Recycling the exhaust would reduce operating expenses and carbon emissions of the system.

Project Goals:

Design of proof of concept system for gas separation for CCT’s prototype	Prototype and test the separation of CO_2 from a gas mix	Provide insights for how to integrate and scale up prototype

Design Process Overview:

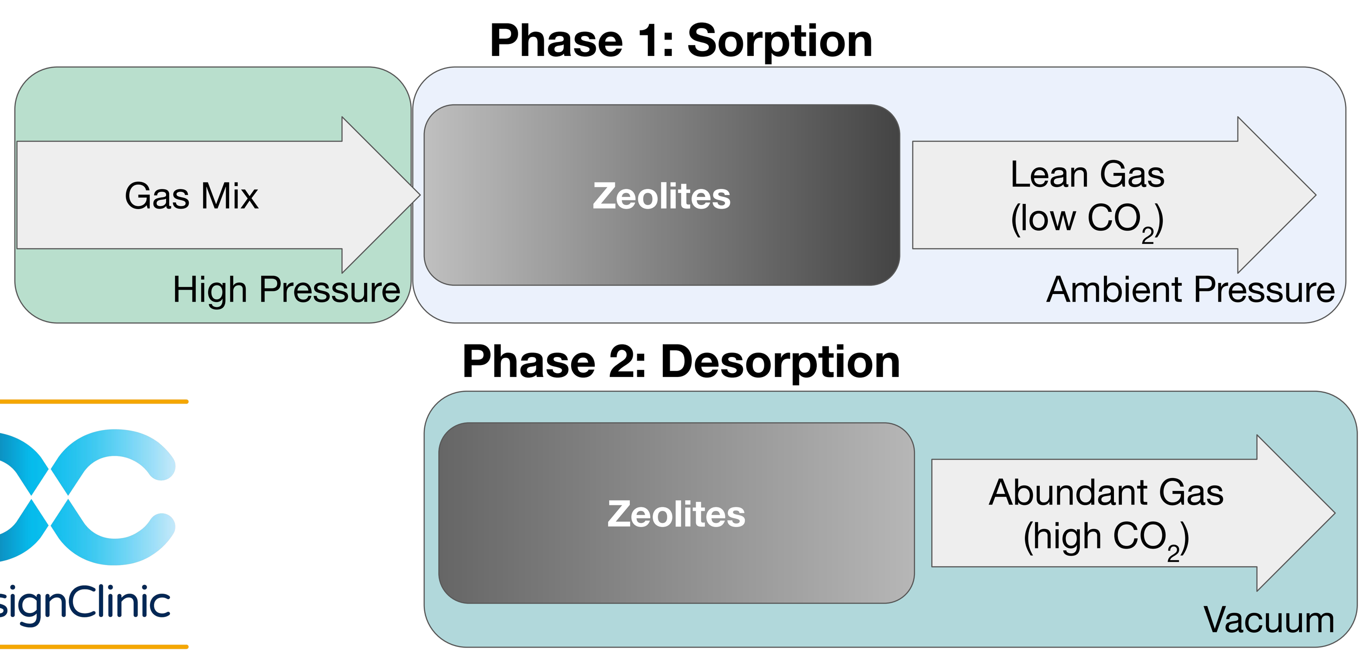
1. Preliminary Research
2. Current Methods Research
3. Conceptual Design
4. Simulation
5. Prototype
6. Final Recommendation

Prototype Design Requirements:

- ✓ Modular design
- ✓ Separates 70% of CO_2 from mix
- ✓ No gas leaks in prototype
- ✓ Functions at CCT’s flow rate
- ✓ Separated CO_2 is 80% pure
- ✓ Doesn’t affect ambient air temperature
- ✓ Doesn’t affect gas mix temperature

Gas Separation and Sorption:

After in-depth research into many types of gas separation, sorption was chosen as the most viable option for this project based on availability, effectiveness, and cost. Sorption is a process by which certain types of gas, in this case, CO_2, stick to a specific material, in this case zeolite 13X. Certain environmental changes, such as a shift in pressure, triggers desorption and causes the zeolites to release the CO_2 and the gas can be isolated and recycled.



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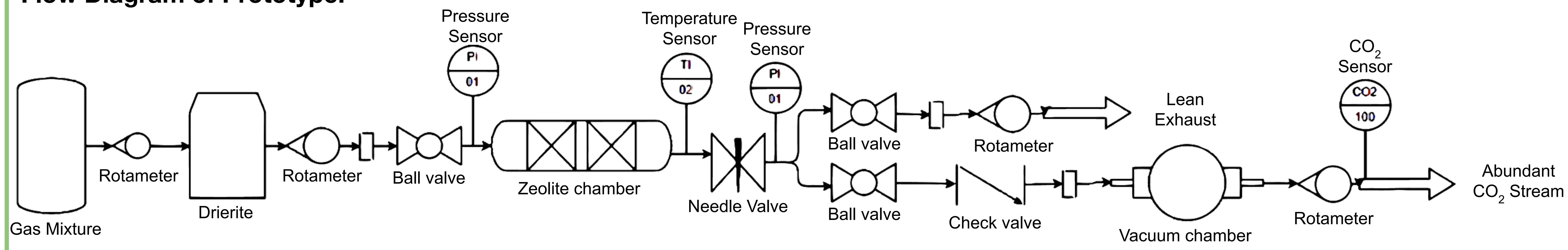
Flow Diagram of Prototype:



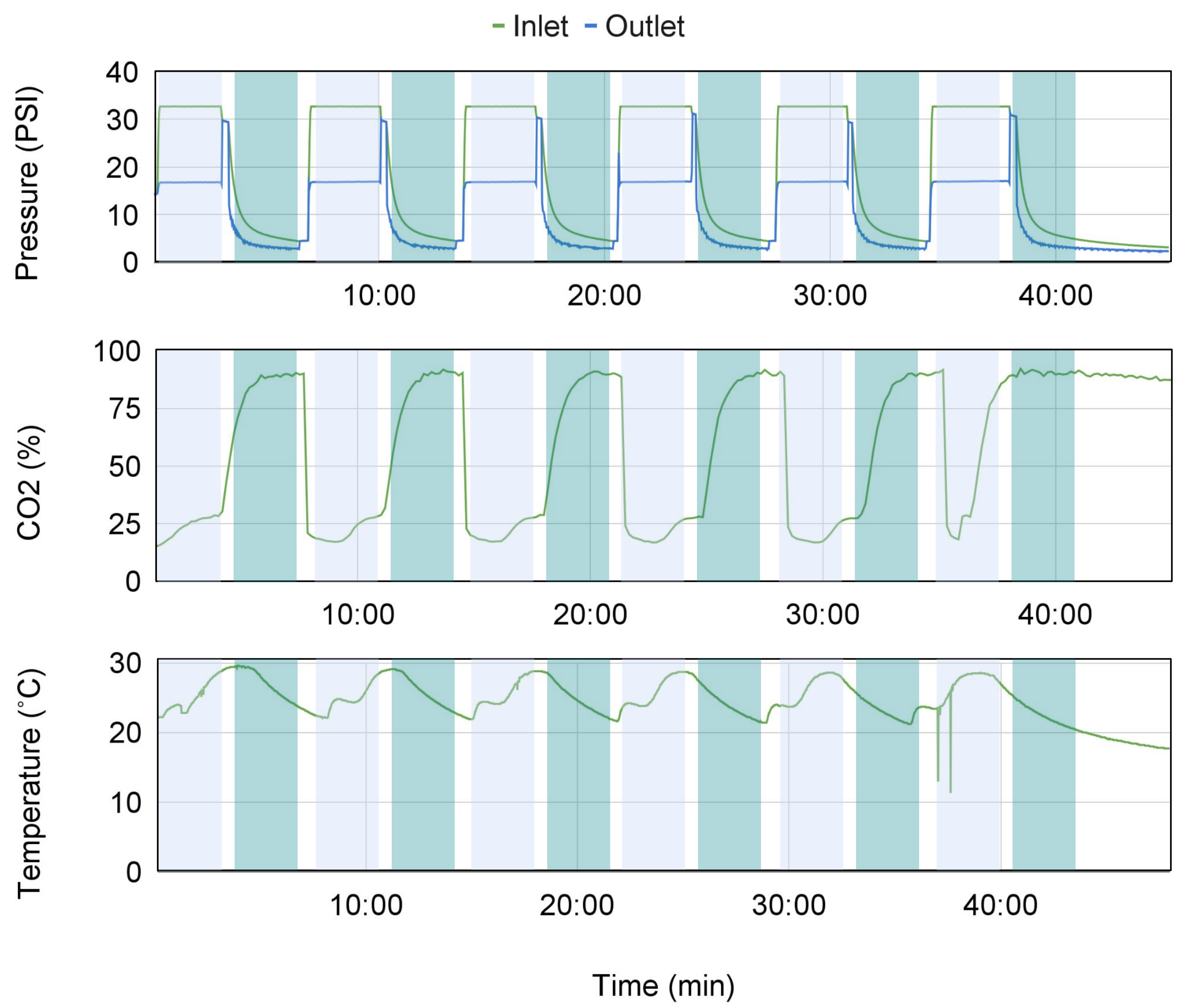
Prototyping Design:

Components of the sorption system include a chamber to hold the zeolites, drierite to dry the gas mix, valves to switch the direction of gas flow, a vacuum to trigger pressure swing desorption, and sensors to collect data on temperature, pressure, CO_2 concentration, and flow rate.

Testing Set Up:

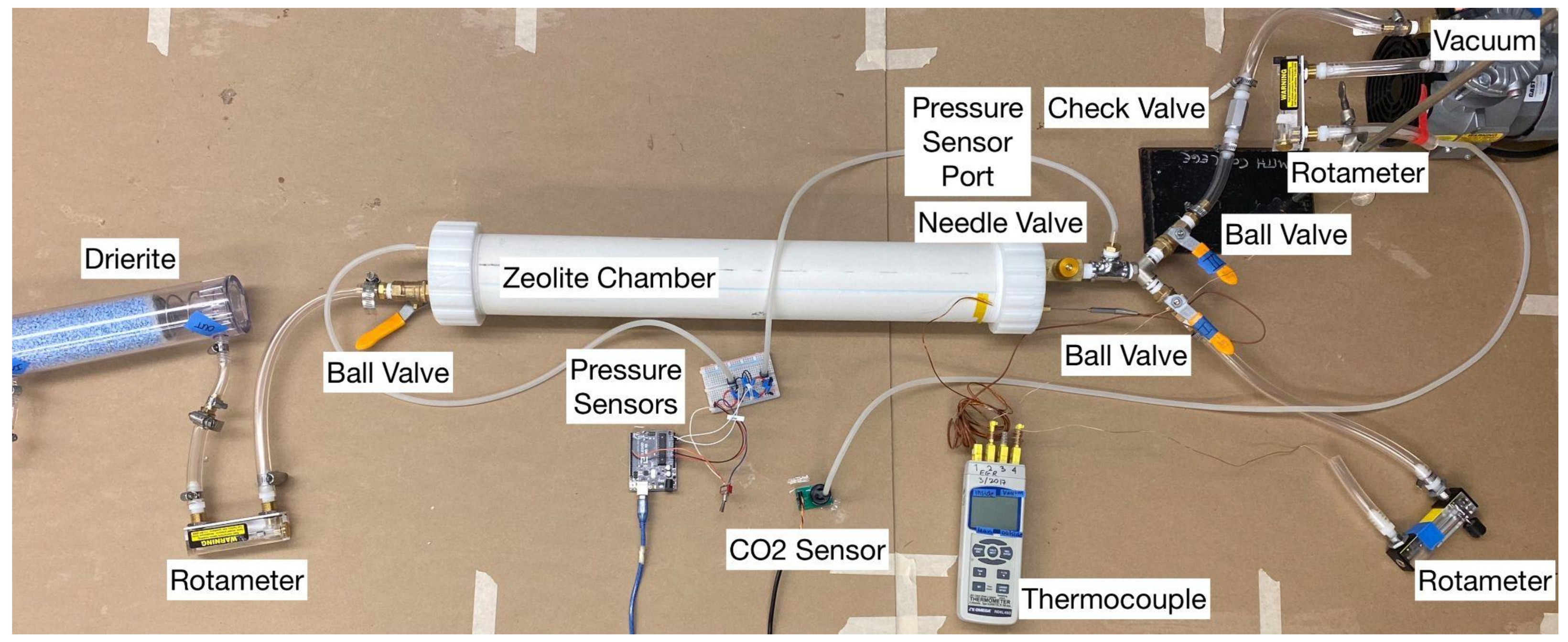
Testing was done with zeolite chambers to test adsorption and desorption.. There were three phases of testing, one to test sorption, one to test desorption, and one to test sorb-desorb cycles of varying lengths.

Results for Six Consecutive Sorb-Desorb Cycles:



The three graphs above show pressure, CO_2 concentration, and temperature data collected during a trial of 6 consecutive adsorb-desorb cycles (3 minutes adsorb, 3 minutes desorb). Adsorption cycles are marked by the lighter blue regions and desorption cycles are marked by the teal regions.These graphs show similar behavior of the gas and zeolites over multiple cycles.

Prototype:

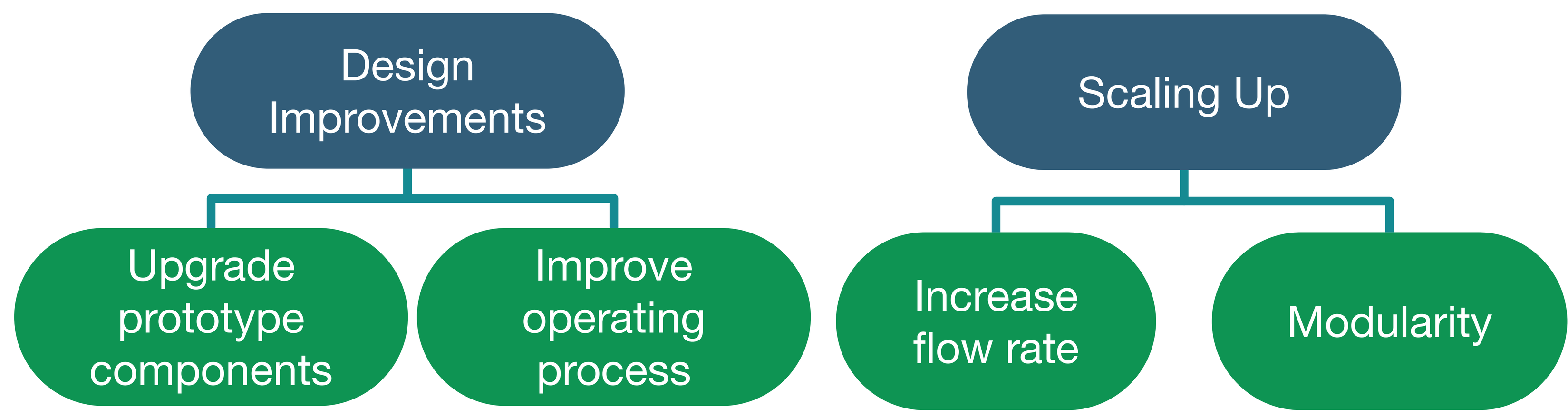


Conclusions:

Cycle	% Mass Desorbed
1	71
2	67
3	65
4	106
5	90
6	96
Average	83

- Zeolites are able to capture CO_2 from the gas mix
- The longer chamber is more effective than short chamber
- The vacuum is able to desorb some of the CO_2 from the zeolites
- Desorbed CO_2 is about 90% pure
- Temperature and pressure change throughout the cycle, but similar trends are seen each cycle

Implementations and Next Steps:



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