Design and Development of a Controlled Environment Chamber

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Abstract

This project aims to build a versatile chamber that is capable of allowing experimental trials for many components required in an advanced life support system while maintaining a much lower cost compared to similar commercial products. We plan to use the chamber for conducting experiments on plant and microbial life in a stable environment. These experiments will further research toward a bio-regenerative life support system capable of allowing humans to explore beyond Earth. Our system is designed to control temperature, atmospheric composition, air flow, ambient pressure, water distribution, and light intensity. With these factors, the experiments can more closely mimic the environment of Mars, test the ability of an aeroponics growth system for plants, and even use a previously built-in-house clinostat to achieve hypogravity testing. The chamber walls have gone through structural evaluation and the analysis has driven further design constraints. Additionally, other subsystems are being tested separately before their integration.

Structural Improvements

- More exaggerated curves at internal edges.
- Interlocking cuts when building the Coosa board walls.
- Increasing to 1” thick Coosa board for safety.
- Using plastic layers for more uniform resin spreading.
- Switching to contact cement for small surface area attachments.

Electronic Capabilities

- Sensors will be used for: Temperature, Light Intensity, UV Intensity, Humidity, Oxygen, and Pressure.
- Data is sent from sensors to an Arduino Mega, packaged and relayed to a Raspberry Pi 3B+, then stored on a server to be accessed from a computer.

Heat Management System

Key features:
- Peltier units for cooling internal chamber and water tank temperature.
- Water pump used for create a flow rate through the exchange
-Fans needed for air flow and increased cooling.
- Cooling blocks will be placed on LED panels to remove excess heat generated.
- Silicone heat pad will add heat into the system if required.
- Temperature sensors will provide input to Arduino and systems will be automatically turned on or off as necessary.

Future Work

Once the model is fully designed in Inventor, this configuration will be exported to FEMAP with Nastran to obtain any failures that could arise with the structural design of the chamber. Following the construction of the walls, hardware will be integrated with systems capable of conducting hydroponic and/or aeroponic research. Beyond this integration, the chamber will be outfitted with a custom sensor suite, a vacuum pump, and additional materials to ensure desired environmental conditions. Experiments will consist of plant growth in altered environments, cyanobacteria growth, and efficiency testing for power. Behind our own testing, other researchers in academia could potentially use this device for numerous variations of experiments.

Structural Findings

Using a Tinius Olsen 3-point flexure bending machine, we were able to achieve baseline testing for the three configurations of wall layering we decided were viable. We tested the following types:
- 1/2” Coosa board by itself
- Double layer Coosa board joined by Polyester Resin
- Single layer of Coosa board with woven/chopped mat fiberglass sheets joined by the Polyester Resin.

We obtained stress and strain from the bending stress that was applied to the test samples. We can obtain the necessary material property values to be simulated in FEMAP w/ Nastran to evaluate the structural integrity of the chamber. In accordance to the results we obtained, we decided that it would be beneficial to acquire 1” Coosa board to construct the best rendition of the chamber. The double-layer Coosa test samples were substantial in our findings except for the shear failure found between the sheets due to the inability of the resin to bond the two together completely.

Acknowledgments

Dr. Jeff Brown — College of Engineering
Dr. Hugo Castillo — College of Arts and Science
Dr. Pedro Llanos — College of Aviation
Americraft Enterprises Inc.
Orlando Salgado — AE Undergraduate Student