Humidified Shaking Incubator

Team 50

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***Abstract*— The following paper covers the development and construction of a Humidified Shaking Incubator. To be specific, the functionality of this device is to provide physical agitation to chemicals in test tubes in a temperature and humidity-controlled environment. Controlling the variables of temperature, humidity, and speed of agitation allow the user to more precisely replicate the real-world application of their research. This in turn increases the quality of their research improving the development of everything from medicine to fertilizer. Although there are incubators on the market that provide humidity-controlled incubation, they are prohibitively expensive to many entities. The goal of this project was to create a low cost, market competitive, solution. Much of the physical and most of the electrical/coding work has been completed, however because of the pandemic completion was impossible. Although proof of concept testing was successful.**

I. Introduction

When preforming research in the biomedical field it is critical that as many variables as possible within the environment are controlled. In the past, devices for achieving a controllable orbital motion, humidity and heating have been built, however the cost of said devices is high and they may not provide the level of control needed by a researcher. This creates a need in the world for a cost effective, easy to control incubator. This project of creating a shaking incubator is a second-generation project, this allows for the reuse of parts from the old prototype which will bring the cost of the new design down significantly.

The purpose of this project was to create a humidified incubator with a shaking platform for preforming experiments. The incubator must maintain 100% humidity and be able to maintain constant temperature ranging from room temperature to 100 degrees centigrade. The motivation behind the development of the project came from the fact that Northern Illinois University's professors lack such a machine due to budget constraints. In fact, when looking at competitive devices and patents, very few offer the ability to control humidity. Our new design will also have a modern graphical user-interface (GUI) to control all operations, something not seen on other market solutions.

With the exception of the fiberglass insulation our incubator is made of entirely recyclable materials. This is important as large amounts of otherwise reusable materials ends up landfills every year.

II. Components

The following is a brief overview of each of the components of the incubator.

A. Housing

The housing itself is made up of two compartments: the incubation chamber and the electronics/control compartment. The incubation chamber is 18" long by 18" wide by 14" high. It includes a door for unloading and loading, an input for the motor shaft, and intakes for heat and humidity. There are two sub housings for the chamber itself: an aluminum interior and a stainless-steel exterior. In between these two layers is a layer of fiberglass insulation. This layer of insulation will prevent the outside housing from becoming hot enough to burn the user or people who may touch it. The insulation also improves the energy efficiency of the unit. Holding together the chamber sides are rivets and bolts. The chamber is mounted on top of the electronics compartment. Four stubs protrude from bottom of the electronics compartment to support the incubator. All electronic components are mounted to the bottom of the compartment to avoid excess heat from the incubation chamber. The compartment is made of 1/8in stainless steel and has inlets for power. The front of the compartment is also slanted and holds the LCD displays and the power switch. A water tank is connected to the side to feed the humidifier.

B. Porthole

A major addition we made to our generation of the incubator was a porthole for visual monitoring of incubation. The porthole is made from two 1/4" panes of tempered glass separated by a purpose made Viton spacer. A one-way valve was inserted into the spacer to so that air can be removed creating a vacuum insulation effect. A porthole cover was also designed but not built, it is needed as some chemical reaction are photosensitive. Lastly, high temperature resistant lights were acquired and were planned to be installed in the chamber to improve viewing.

C. Electrical Components

The electrical system consists of temperature/humidity sensors, fans, high temperature lights, an ultrasonic humidifier, and a motor all connected to a relay bank. The relay bank is connected through an AC/DC converter to wall power and voltage is stepped down at each relay per the voltage requirements of the components. A pair of heating elements is connected directly to wall power. Controlling all of these components is an Arduino. Connected directly to the Arduino are a pair of LCD screens for taking user inputs and displaying internal conditions. The Arduino controls most of the components by turning on and off the relay that they are attached to. A notable exception being the heating elements which are connected to the Arduino through a shield. The control method used for the design is PID. In basic terms what happens is that when the temperature and humidity are set by the user, the Arduino turns on the heating elements and humidifier. Once conditions hit the top of a narrow range around the input, the Arduino shuts off the components. As conditions fall the bottom of the range the components are turned back on, see figure 3.

III. Results and Conclusion

Before spring break, we were ahead of schedule, however because of current events we were not able to complete the project. We were however able to conduct proof of concept testing. The code was used to control the different electrical components which responded as desired in a cardboard box meant to simulate the incubation chamber.

After completing the virtual build, it is our belief that should the stay at home order be lifted, the physical reconstruction of the incubator could be completed in as little as a week. Basically, what needs to be done is to fashion a porthole cover, replace some rivets with bolts, install the internal lights, and bring everything together. Once everything is together, its basically fine tuning until it works as desired. Budget wise, we were well below budget spending about a third.

IV. Figures

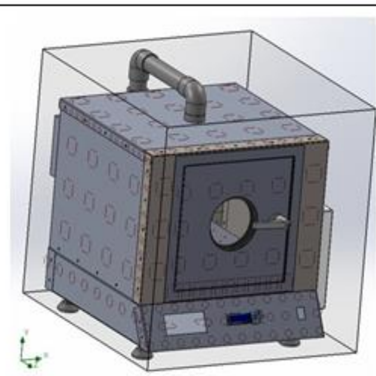

Figure 1. SolidWorks Model.

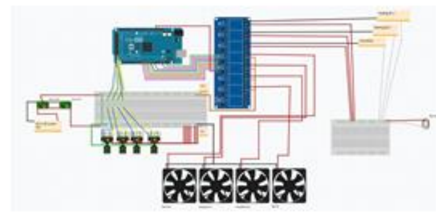

Figure 2. Wiring Diagram

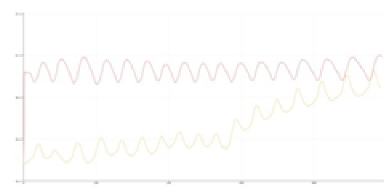

Figure 3. Control Ranges.

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[2] Muller, N. , Girard, P. , Hacker, D. L., Jordan, M. and Wurm, F. M. (2005), Orbital shaker technology for the cultivation of mammalia