The Jungle: An Aeroponic System For Individual Urban Agricultural Needs

Gonzalo Forero, William Mayorga, AS-CE, and Dylan Neary
Vaughn College of Aeronautics and Technology, United States of America, Gonzaloforero1@live.com Dylan.neary@vaughn.edu
William.mayorga@vaughn.edu

Abstract– A plant incubator is a system that introduces an artificial environment in which plants can grow. Typically, the environment has automatic controls for light, moisture, and temperature to promote efficient production, reducing the growth time while increasing the quality and output of the plants. This increase in efficiency in growing methods will allow a greater opportunity for local markets and individuals to produce their food. The purpose of plant incubators is to combine energy efficiency, space efficiency, and quality output.

The purpose of the project is designing a plant incubator using 3D CAD for a scaled design, to drive the production of a full-scale prototype; also to retrieve an FEA on the design with the max stresses on the parts utilized. To accomplish the design task of the project, it will be necessary to combine a few technologies together; these include LED's for lighting, atomizer nozzles for water and nutrient delivery, a motor system for rotation, it may expand in scope to make it a smart system through programming. The final goal is to have a working prototype that can keep a plant healthy. Further studies include measuring the growth of the plants and developing a comparative analysis study against growth rates in other incubator types.
Keywords – Aeroponic, food, growth, lighting, plants.

I. INTRODUCTION

As populations spread out, some communities get left out of quick, inexpensive access to fresh crops. These are called "Food Deserts." On a macroeconomic scale, the distance and the logistics of moving food and produce from farm to table inherently drives up the prices in markets. These food deserts are areas typically in urban settings, like cities, where people have to travel a distance to purchase groceries or fresh produce. The incubator hopes to address the problem of food deserts through the introduction of a cost practical solution to urban farming [2]. A plant incubator could serve communities where land is scarce, or soil conditions are unfavorable for agriculture. Using aeroponic methods a marked decrease in growing times and increase in yield may be observed making it more viable in these communities [3].

A. Objective

The project was to design a plant incubator that can comply with four design objectives. The design must have a central support around which the plants will rotate. The purpose of the rotation is to provide easy access to the plants held within the incubator. It must be an aeroponic system to keep water usage down and utilize the benefits of this system. It should use sensors to control the different mechanics of the incubator. The final goal is for this to provide increased yield while minimizing the space requirements

II. ENGINEERING REQUIREMENTS

1. The cost should be no more than $600USD for all parts. This would allow it to remain in an affordable range for many consumers while still maintaining the full range of functionality.
2. The diameter of the device will have at least a one-foot radius to accommodate the plants and the growth of both the roots and stems.
3. The device must rotate to make the access to plants held on other sides of the door possible. It would also allow even distribution of the water from the nozzles to the roots.
4. For the final design, the stand must be able to support the weight of four full grown plants on each level with two different levels. The reasoning for this is that with this we will be able to maintain easy access to the plants and water to the roots without overcrowding the surface.
5. The water needed will be approximately one cubic foot over the course of four days making this the time that it could remain active without refilling barring an increase in the size of the holding tank.

.

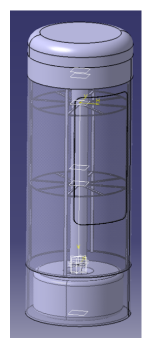

Fig. 1 Initial Design- including all structural components

III. ENGINEERING DESIGN

The shape of the Jungle (Fig. 2) was chosen to be an octagon. While the original design called for a tube-shaped enclosure, this proved difficult to implement with the materials available. The height was decreased to three feet approximately to accommodate the growth of the plants. Lighting was chosen that would fit within the new enclosure shape. Motor, pump, and tank placement were all placed at the bottom of the incubator to maintain stability. An Arduino microcontroller was chosen due to the ease of programming and versatility. The Jungle is in progress to become a "Smart Plant Incubator," sensors like the humidity sensor, temperature sensor, a relay, Bluetooth, and a wireless Ethernet port are all in mind applications.

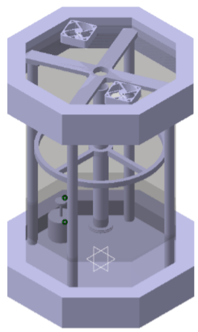

Fig. 2 Final Design- including all structural components and placement of motors and fans

IV. CURRENT AND SOLVED ISSUES

1. The cost of the project increased past the expected amount but was able to be kept in line with other expectations by changing construction materials while keeping the mechanical components required. The proposed structural components were modified from plastic and aluminum to PVC and wood to maintain the structure and lower costs.
2. The control mechanism was more problematic to implement than expected, requiring many modifications before reaching the current stage of completion. It is now at a more functional state than under the initial planning.
3. Water space requirements were met but for this smaller sized prototype water must be kept external to the structure but would be able to fit internally on a full sized model.

V. ANALYSIS

1. The shape was edited to an octagonal design. This was done to reduce the overall complexity in developing a tubular enclosure with a limited budget.

2. The gear sizes and required motor torques were found using MATLAB scripts written by the team for this purpose. The gear sizes found were 3 inches and 1.3 inches, modifying the plans and requiring the gears to be 3D printed to achieve the correct size.

3. Finite element analysis.

   Steel, PVC, and aluminum were all tested for the support ring holding the plants. This was done using CATIA and SolidWorks software. It was only done for this part as it was the one that would be exposed to stresses due to the weight of the plants. It was found that PVC would be the most cost effective in these circumstances (Fig 3, 4) as both did not deform greatly not passing elastic deformation. As the load would be a constant one this was deemed acceptable.

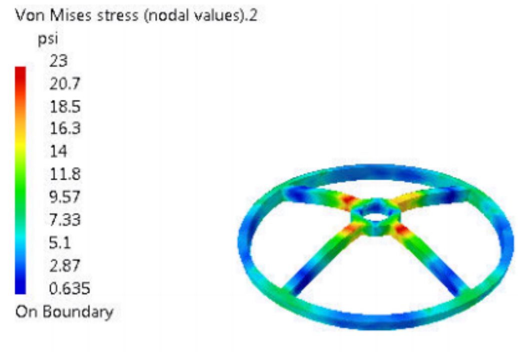

Fig. 3 Ring Support-Aluminum

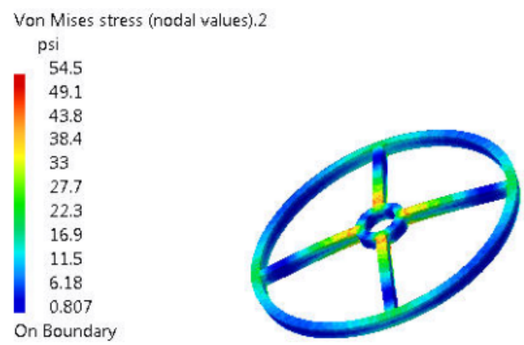

Fig. 4 Ring Support-PVC

V. PROGRAMMING AND ASSEMBLY

Assembly is progressing on track to the final design as all components have been acquired. Programming of the Arduino circuit is ongoing and nearing completion as is the circuit which will operate the system.

REFERENCES

[1] "Aeroponics." Aeroponic Hydroponic Systems | Mist or Fog. N.p., n.d. Web. 08 Mar. 2017. <http://www.flairform.com/hints/aeroponics.htm>. M. King, B. Zhu, and S. Tang, "Optimal path planning," *Mobile Robots*, vol. 8, no. 2, pp. 520-531, March 2001.

[2] Gallagher, Mari. "USDA Defines Food Deserts." American Nutrition Association. N.p., 2011 .Web. 07 Mar. 2017. http://americannutritionassociation.org/newsletter/usda-defines-food-deserts

[3] Urban farms bring fresh food closer to city tables." Delta Farm Press, 26 Mar. 2013. Agriculture Collection, go.galegroup.com/ps/i.do?p=PPAG&sw=w&u=nysl_me_coae&v=2.1&id=GALE%7CA327867067&it=r&asid=ccba08ef11bf4e363328b078902ea81a.