

MIGHTi: A Sustainable Mushroom Pasteurization System for Remote and Off-Grid
Communities

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Overview

The Mission to Improve Global Health Through Innovation (MIGHTi) bought land in Zambia to create a community farm where they educate and share resources with the women of the community. In many Zambian families, men typically focus on income-generating work, while women manage household responsibilities such as cooking, cleaning, and caring for children. MIGHTi's goal is to provide additional education for the women of this community for their greater success. Other projects they have are literacy programs, providing menstrual products, and teaching agricultural techniques. A new project they are working on is growing mushrooms for the community to have access to mushrooms all year round. Mushrooms and insects are a big part of the cuisine in Zambia. However, they are only available in a short season, which has been a long-standing challenge. The majority of the time, communities there live off the same types of foods like corn and beans, limiting their diet diversity and nutritional benefits. There is a great demand within the community to find other produce to eat that is not the same thing they consistently eat.

On the MIGHTi farm, these mushrooms will be growing on different material substrates depending on what is readily available to them. Substrate materials consisting of mango tree leaves, cotton stover, cottonseed hulls, and many more materials. As part of the growing process, they live in two different environments while they are growing. In the beginning, they start in a cold, dark environment until they reach a certain size. Later, they will need a warm environment to grow larger. In between the two environments, the substrate has to be pasteurized so there are no surviving competitors or contaminants that grow with the mushrooms. This is the hesitation to mushroom farming because of the large resources and materials necessary for pasteurization. For example, typical pasteurization autoclaves can be very expensive or use a lot of power that

would likely need to be generated with grid power. The MIGHTi organization needs a reliable, energy-efficient mushroom substrate pasteurization apparatus to grow mushrooms for a community in Zambia to help with food security and diet diversity.

This project demonstrates how a traditionally resource-intensive agricultural system can be adapted for use in limited-resource communities. Individuals living off-grid or in remote regions can apply this approach to develop a solution that minimizes water consumption and operates independently of grid-based power. Furthermore, it highlights how the mushroom industry can be made accessible to a wider population.

Final Design

Our main goal was to create a system for pasteurization of mushroom substrate that can be used outdoors, powered by off-grid energy, and is easy for individuals to operate. The goal behind pasteurization is to eliminate organisms and bacteria that could compete with mushroom growth, while still maintaining non-competitive, beneficial organisms. In contrast, sterilization kills all microorganisms, which leaves the substrate vulnerable to contamination from airborne bacteria or other organisms.

There are many ways to pasteurize substrate, including hot air, hot water, and hydrated lime methods [5]. The hydrated lime method involves soaking the substrate in water and adding calcium hydroxide until the water reaches a specific pH, allowing the substrate to sit for a designated period of time. The hot air method is similar to an oven, where the substrate is heated to reach an internal temperature for a certain duration. The hot water method involves soaking the substrate in water that is held at a specific temperature for a set amount of time.

We selected a hybrid approach that combines aspects of the hot air and hot water methods, while also incorporating elements commonly found in sterilization or autoclave systems. In this design, water is heated to the point of boiling or vaporization, allowing the internal environment of the tank and the substrate to reach the required temperature for the necessary duration. This approach reduces the amount of water required compared to the traditional hot water method while remaining suitable for off-grid applications and aligning with protocols currently used by the MIGHTi farm in Zambia.

Our pasteurization system requires the substrate to reach a temperature of 60–70°C, with the duration depending on the type of substrate. Research indicates that this process can take anywhere from 30 minutes to 2 hours [5, 6].

The main components of the system include the tank, baskets, and user interface box. The stainless steel tank is housed within a plastic drum that is cut to match the height of the steel tank, allowing users to easily load and remove baskets filled with substrate. A drain is located on the outside of the tank to allow water to be removed efficiently and to maintain cleanliness. The user interface box houses the microcontroller and all primary electronic components and connections. A thermocouple is placed at the top of the system, where the user inserts it into the substrate in the top basket to ensure that the substrate reaches and maintains the desired temperature.

As shown in Figure 1, the full assembly of the system includes the tank, baskets, and user interface components working together.



Figure 1: Assembly of System

Figure 2 illustrates the bottom portion of the tank, where the drain valve is located and where the water reservoir is contained. A heating element is submerged in this water to increase the temperature until the desired condition is reached. Additionally, a thermocouple is located at the bottom of the system for safety purposes. This thermocouple monitors the temperature of the water and helps detect whether the water level has dropped below the heating element. This is important because if the heating element is not fully submerged, it can overheat and create unsafe operating conditions. The thermocouple detects a rapid increase in temperature when exposed to dry heating conditions and will automatically shut the system down.

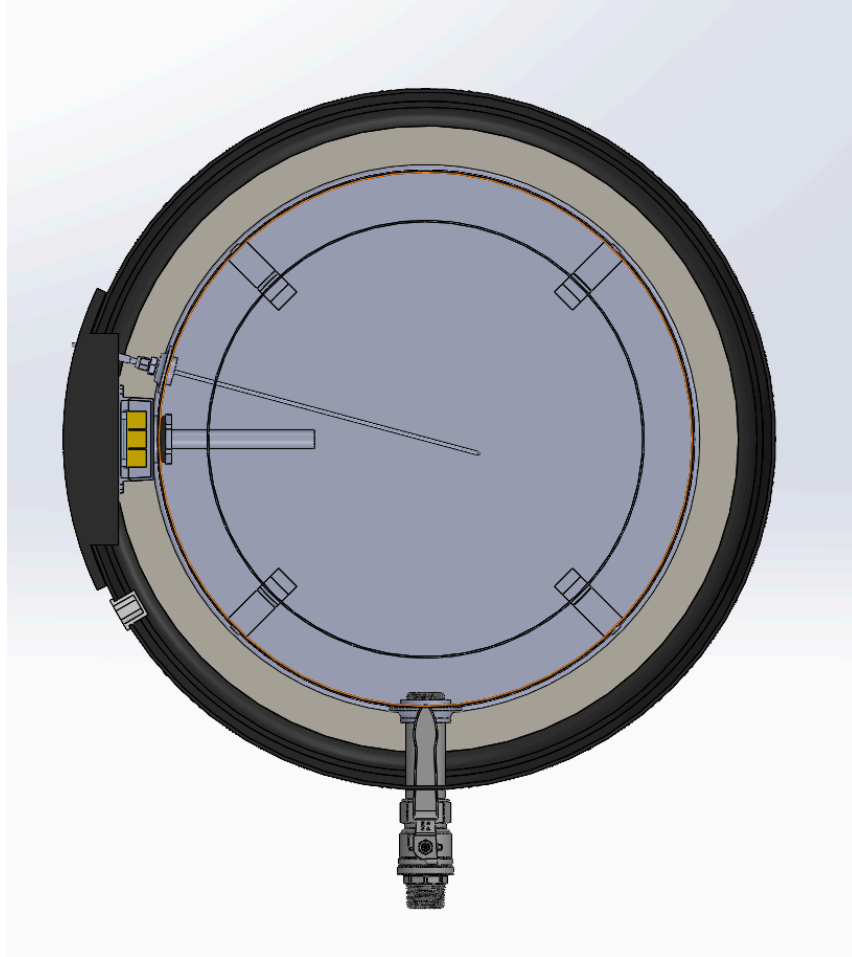


Figure 2: View of the Water Compartment

Once the system is loaded with water in the bottom reservoir, and the substrate-filled baskets are stacked within the tank, the system can begin operation. When the system is plugged in, the electronics boot up and run the program on the touchscreen display. The display allows the user to input the desired temperature and time for pasteurization. It also shows the status of the heating element, such as whether it is on or off, and indicates if the system is undergoing an emergency shutdown. The user is able to start and stop the system at any time through the interface.

The internal configuration and layout of the system are shown in Figure 3, which provides a side profile view of how the components interact during operation.

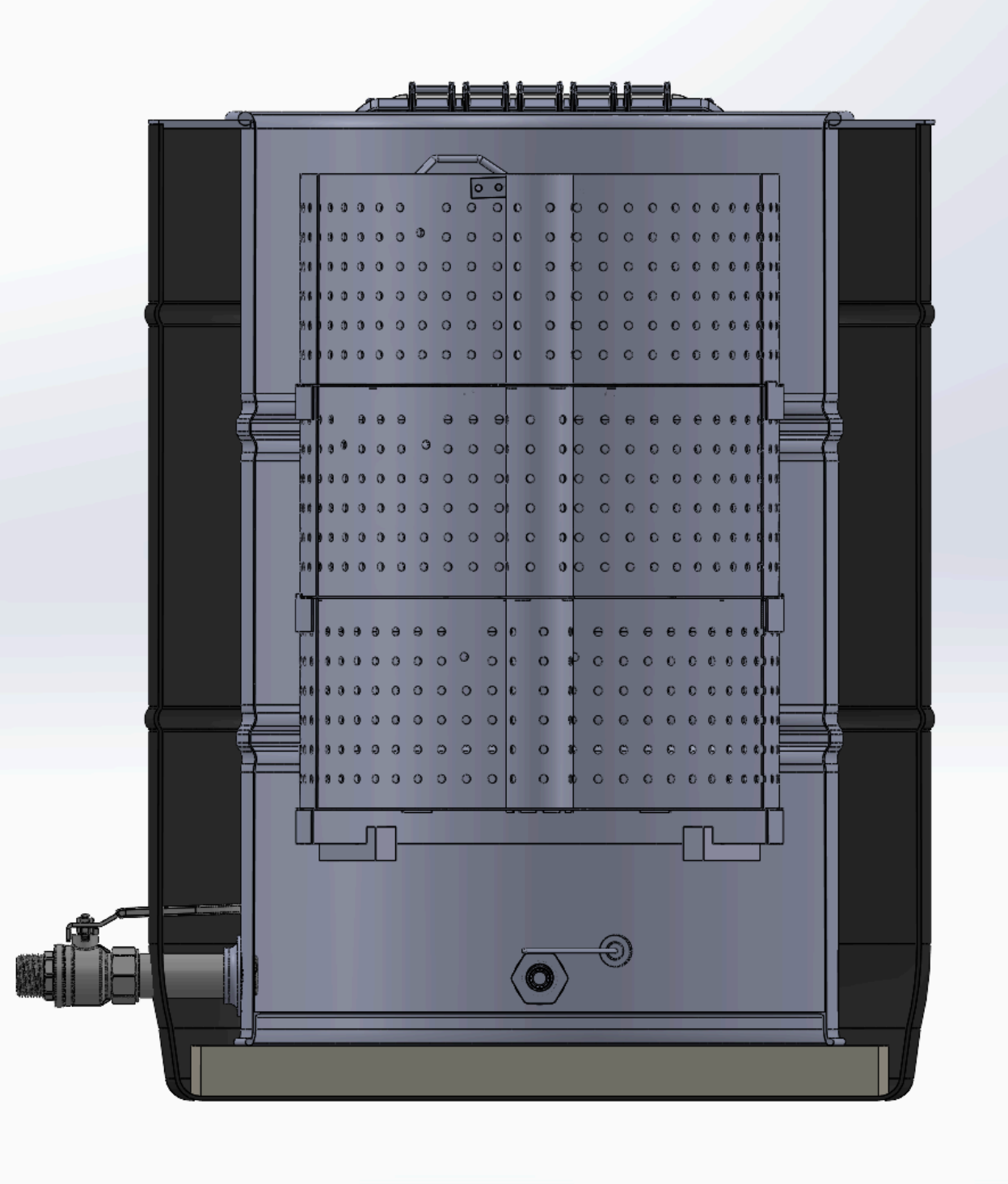


Figure 3: Side Profile of the Inside of the System

A main goal of this project was to reduce the energy and resources required for operation. The MIGHTi organization is developing a solar system on their farm to support both this system and general electricity needs. Under the environmental conditions in Zambia, this approach is practical due to the high availability of sunlight. The farm operates in a rural, off-grid environment, making solar energy an appropriate solution [1].

The system requires a battery and charge controller to store energy collected from the photovoltaic (PV) system, as well as an inverter to convert DC power to AC power [2], which is the most recommended approach for rural applications. The design assumes the use of a 120V AC inverter, as this is the required operating voltage for the system and is commonly available for solar applications.

To ensure efficient energy use, it is important to consider cooling methods for the solar panels, as high temperatures in Zambia can reduce their efficiency [3]. Additionally, maintaining clean panels is critical, as dust and debris can impact performance. One potential sustainable solution is the use of a hydraulic RAM pump system to circulate water over the panels for both cooling and cleaning purposes [4].

Reflection

This project has shown me what it means to be an effective engineer and has become an important chapter in my educational journey. Much of the work completed as a student is designed to help us learn material and understand the fundamentals of engineering principles,

etiquette, and procedures. However, this project taught my group and me how to create a product and present it to stakeholders in a professional and technical manner.

Through this experience, I learned many practical skills that are not typically taught in the classroom—skills that are gained through hands-on work, problem-solving, and collaboration. It also helped me realize that I enjoy creating and developing something with a larger purpose. Knowing that this system will be used by a community and contribute to a real application has been one of my biggest sources of motivation.

This project has shaped how I see my future as an engineer. It has shown me that I want to pursue work that has a tangible impact and serves a clear need. I am especially interested in continuing to design systems that are accessible, sustainable, and applicable to real-world challenges. The experience of working with experts and conducting independent research has also reinforced the importance of continuously learning and seeking out knowledge beyond what is taught in the classroom.

Overall, this Honors Thesis represents a transition from learning about engineering to actively practicing it. It has helped define the type of engineer I want to become—someone who creates meaningful, practical solutions that can positively impact others.

References

[1] Chauhan S, Singh B. Control of solar PV-integrated battery energy storage system for rural area application. *IET Renewable Power Generation*. 2021; 15: 1030–1045.

<https://doi.org/10.1049/rpg2.12086>

- [2] D. Debnath and K. Chatterjee, "Two-Stage Solar Photovoltaic-Based Stand-Alone Scheme Having Battery as Energy Storage Element for Rural Deployment," in *IEEE Transactions on Industrial Electronics*, vol. 62, no. 7, pp. 4148-4157, July 2015, doi: 10.1109/TIE.2014.2379584.
- [3] Parthiba, R. and Ponnambalam, P., (2022). An Enhancement of the Solar Panel Efficiency: A Comprehensive Review. <https://doi.org/10.3389/fenrg.2022.937155>
- [4] W. J. C. Melis, S. K. Mallick and P. Relf, "Increasing solar panel efficiency in a sustainable manner," 2014 IEEE International Energy Conference (ENERGYCON), Cavtat, Croatia, 2014, pp. 912-915, doi: 10.1109/ENERGYCON.2014.6850534.
- [5] Grimm, D., Sonntag, E., & Rahmann, G. (2024). EVALUATION OF DIFFERENT PASTEURIZATION AND STERILIZATION METHODS FOR OYSTER MUSHROOM SUBSTRATES. *Journal of Microbiology, Biotechnology and Food Sciences*, 13(5), e10428. <https://doi.org/10.55251/jmbfs.10428>
- [6] Kurtzman, Jr, R. (2011). Pasteurization of mushroom substrate and other solids. *African Journal of Environmental Science and Technology*, 4(13), 936–941. <https://doi.org/10.4314/ajest.v4i13.71411>