Bladder Well: A World-Wide Solution to the Water Shortage Challenge

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Abstract- The growing scarcity of water around the world, especially in lesser developed countries (LDCs) with arid climates, has led to challenges in obtaining clean water for drinking and sanitation purposes. In these areas, many use cumbersome means to collect water which often take long periods of time. Additionally, proper sanitation is often not an option, thus leading to disease and illness. With a proper enclosure, the portable bladder well serves as a self-sufficient system for collecting and storing water underground until desired for distribution while also implementing a filtration system to ensure its cleanliness. Not only is water collection increased and automated, but concerns of illness and disease are reduced. Commercial implementation of such a device would revolutionize water storage and sanitization, along with solving a critical issue worldwide.

I. Introduction

Clean water and proper sanitation are essential for the survival and development of human beings. As of 2019, 780 million people do not have access to a reliable, consistent water source and 2.5 billion people lack access to improved sanitation [1]. The limitations of current water collection and sanitation technologies create a clear and definite issue worldwide, especially in LDCs with arid climates that have extremely restricted access to these technologies.

Capturing and storing water in LDCs is still a primarily manual labor task, while sanitation is often not ever considered. The water is stored in above ground tanks that are prone to collecting bugs and bacteria, which lead to disease and illness. The greater amount of water collected and properly sanitized, the greater these areas can thrive in health, which is linked to economic growth due to the averted healthcare costs and time saved [2].

To address these concerns, a system is designed that incorporates a collection system, water bladder for storage and accompanying filtration system. The water bladder, pictured in Figure 1, allows water to be easily stored and collected, while also being extremely portable. The bladder is made of elastomeric polyethylene, ensuring both flexibility and durability. As water enters the bladder, it expands until it reaches full capacity, and contracts as it exits without any concerns of stress. Additionally, the bladder consists of one inlet and one outlet for easy collection and distribution of water.

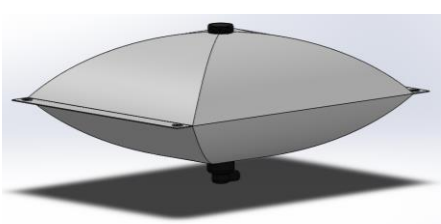

Figure 1: 3D modeling of water bladder

II. Materials and Methods

The water bladder itself was a component that was sourced from an existing product. The main structural designs for this project involved designing an appropriate casing to store the water bladder and all other system components underground, as well as a funnel to collect water. The casing consists of corrugated steel sheets that are secured to an assembled 6061 T-slotted aluminum framing. The funnel is attached to the top of the framing and is made of galvanized steel sheet metal. These serve to protect all system components from external factors such as animals and insects. The assembly was modeled using SolidWorks as shown in Figure 2.

Figure 3: 3D modeling of Bladder Well system

In addition to the structural components, a system was designed to provide filtration and distribution of the stored water. Components of this system were connected using Schedule 40 PVC piping. A section separated from the funnel and bladder by sheet metal serves as housing for the electrical components, which sanitize and move water throughout the system.

The control for the sanitizing system is comprised of single pole relays and single pole time delay relays. These timers continuously call the sanitizing cycle, purifying the water in the bladder with an Ultra-Violet light filter, which loops back into the bladder by powering a normally closed valve; this prevents bacteria growth. Level sensors use water in the bladder to close the circuit and check water levels. Ladder logic was created on a PLC programming software, CLICK, and checked for errors. The control panel system is build-to-test, to allow the panel to be wired in functional segments for test during build. **The control panel is pictured in Figure 3.**

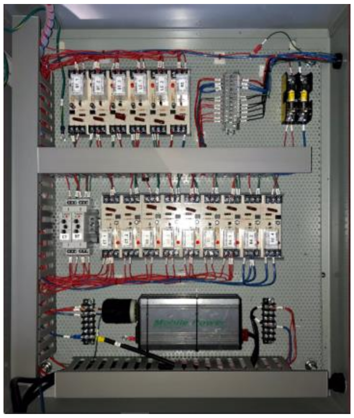

Figure 3: Control panel

A solar panel is used to power the system and charge the battery. This allows the system to be powered off grid and implemented in a large range of geographic locations. The voltage from this panel is in the form of DC and an adapter is used to invert this to AC for the pump and UV-filter. This set up is shown in Figure 4

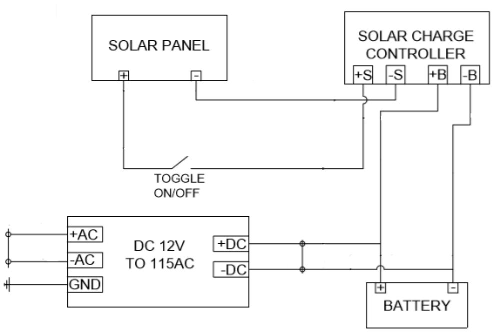

Figure 4: Power supply

III. Results and Discussion

In order to verify the structural design, finite element analyses were conducted … The amount of pressure applied to the framing and funnel is due to the weight of the gravel, solar panel, and electrical panel. Both minimal deformation and equivalent stress are experienced on the device, with the pressure respectively applied to where it acts. See Figure 4 below for deformation results.

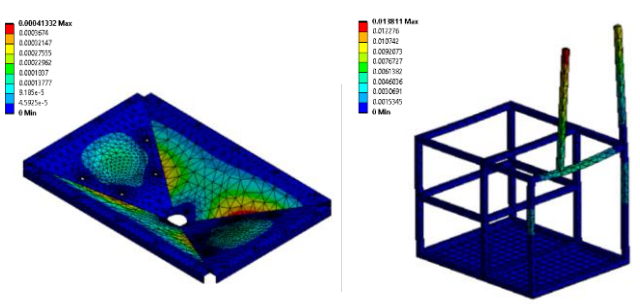

Figure 5: Deformation contour plots of funnel (left) and framing (right)

To evaluate the system design, an experiment was conducted to move water through the system with all currently ordered parts. The experimental set up involves a 12V battery charged by a solar panel, a bladder with water, and tubing that connects the 3.3 GPM pump, an Ultra-Violet filter, a normally closed valve, and a picket spout. The system was powered to observe the cycle state and bacteria cycle state. It was tested to ensure the filter would only turn on with water flow and that it would cycle continuously as long as water is present.

During the build to test, many checks were added. One was to ensure the pump and UV-filter would engage only if there was water in the tank, otherwise the UV-filter could burn. It was prevalent to add indicator power lights on the door to show DC and AC power working correctly. Because water does not conduct electricity when pure, 12VDC is sent to the bladder but only 7 VDC returns to the panel. This is not enough voltage to close the 12VDC relays. To charge the water, sodium was added, thus closing these relays during experimentation. Lower voltage relays can be added, or a higher voltage can be sent to the tank to resolve this.

IV. Conclusion

Water collection and sanitization desperately needs new, efficient, adaptive technology for not only LDCs, but also globally. Portable water bladders stored underground offers an economic, healthy, and automated solution to existing sorting techniques. Structural devices, backed by sensors, filters, and prototyping experimentation allows for large-scale water collection and sanitization to occur. A bladder well device capable of collecting, storing, sanitizing, and distributing water has been designed and analyzed with partial construction and experimentation evaluated out of relatively similar materials. This lays the foundation for future adaptation of portable underground water storage systems through the curation of the project by proceeding teams or commercial implementation. A commercialized design would utilize a larger-scale device so that the amount of water collected and sanitized can serve an entire community.

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[1] World Health Organization. Drinking Water. (n.d.). https://www.who.int/news-room/fact-sheets/detail/drinking-water

[2] SIWI. "Making Water a Part of Economic Development: The Economic Benefits of Improved Water Management and Services." *Stockholm International Water Institute*, https://www.siwi.org/publications/making-water-a-part-of-economic-development-the-economic-benefits-of-improved-water-management-and-services/