WATER TREATMENT USING ULTRAVIOLET TECHNOLOGY

Team Members

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Customers

Clean Water for the World
B9 Plastics, Inc.

P11412

FOR ADDITIONAL INFORMATION VISIT OUR TEAM WEBSITE ONLINE AT https://edge.rit.edu/content/P11412/public/Home

MISSION STATEMENT:
The ultimate goal of our senior design team is to provide a cost efficient water treatment system using Ultra Violet (UV) disinfection technologies to supply drinking water to rural communities that do not have access to clean drinking water. We are aiming to improve upon current system designs to increase maintainability, efficiency, and longevity with sensitivity to overall system cost. Our efforts are to help those in Haiti and Africa who are currently using both Clean Water for the World and B-9 Better Water Maker units.

MOTIVATION:
“1.8 million people die every year from diarrheal diseases including cholera and E coli. 4,900 people die each day. 90% of those are children under age five, mostly in developing countries.” - Clean Water for the World

“More than 1 billion people draw their water from unsafe sources, exposing them to diseases such as diarrhea, dysentery, cholera, typhoid, and many others. Over 80 percent of these people live in rural areas where water and sanitation infrastructure is nonexistent.” - B-9 Plastics

CLEAN WATER FOR THE WORLD

- Introduction
  - The original enclosure for the Clean Water for the World unit is made out of painted plywood. Environmental effects have played a major role in reducing the useful life of the device as the current enclosure disintegrates and insects enter the device interfering with both mechanical and electrical components. Original system did not account for Ultraviolet lamp failure. Incentive for operation and maintenance was voluntary. See Figure 1.
  - Primary Needs of Focus
    - Cost of the redesigned enclosure shall not exceed the cost of the original enclosure
    - Weight of the redesigned enclosure shall not exceed the weight of the original
    - Redesigned enclosure needs to be weather and insect resistant
    - Redesigned enclosure shall serve the purpose of a shipping container
- Concept Selection: Material of Enclosure
  - Treated Wood Enclosure
  - Canvas with Metal Frame
  - Blow Molded Plastic
- Selected Concept
  - A prefabricated plastic enclosure with sturdy hinges, latches and handles was selected. This type of enclosure, PZ9, weighs 9lbs (4.08kg) less than the original design, functions as a shippable enclosure, and most importantly; is sealed from the outside environment.

Figure 1: Original Design

- Final Design (see Figure 2)
  - Mechanical Safety Features
    - When system is shut off, no untreated water can escape the system due to flow direction
    - Outlet nozzle is located higher than the inlet nozzle
    - Inlet and outlets of water to the enclosure are on opposite sides of the system to prevent inadvertent contamination
  - Electrical Safety Features
    - Timing circuit ensures 15 second delay before the solenoid opens to treat water left in the UV chamber
  - Operator Incentive
    - Cell-phone charging capability was added to the system. Power consumption is not permitted until the solenoid is opened, ensuring ethical use of the unit.
  - Ease of maintenance
    - LED indicators notify consumer of operability of the system
    - UV chamber is not recessed within the enclosure, ensuring that when the enclosure is open, the UV bulb can be replaced without having to remove the entire UV chamber from the enclosure
    - Filter housing is located so that removal of the filter is also permitted without any disassembly of the system
- Test Procedure
  - All electrical systems were tested with 12VDC source and proper functionality was confirmed
  - Mechanical system and Electrical system were integrated, and overall system performed as expected: no leakage, proper flow, and solenoid timing operation was appropriate.

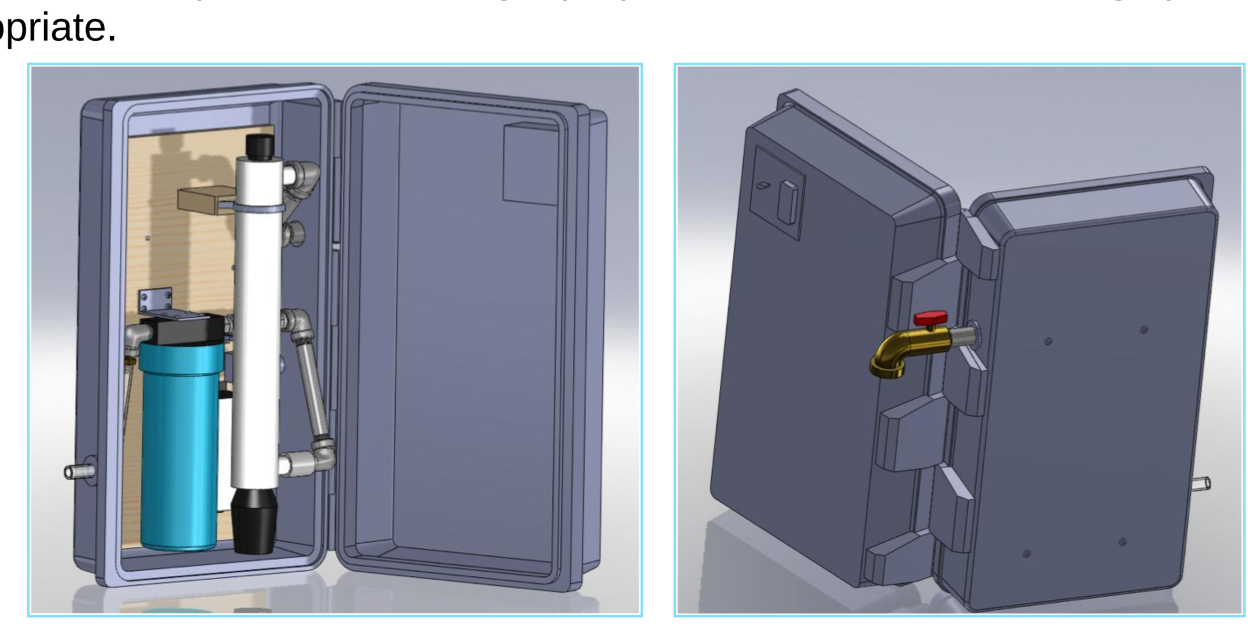


Figure 2: Final Design

- Results and Conclusion
  - Cost-benefit analysis with consideration of shipping costs due to reduced weight of the overall system was performed and revealed a net savings of $31.77/unit. The significant increase in enclosure life should also be considered. The original enclosure has a lifetime of about 1.5 years before needing to be replaced, whereas the redesigned enclosure is anticipated to have a much longer lifetime due its resistance to the environment.

B-9 BETTER WATER MAKER

- Introduction
  - Currently, a water treatment system including a pump and Ultraviolet (UV) disinfection chamber is manually powered by use of the hand crank shown in figure 1. The system notifies the operator of proper use through activation of green LED.
  - The hand crank, however, requires extraneous muscle use, such that the consumer remains at an anaerobic activity level throughout the duration of operation. Anaerobic activity is not sustainable.
- Concept Selection: Manual Power Generation System
  - See-Saw
  - Spring Floor
  - Addition of Flywheel to Drive Shaft
- Selected Concept
  - To enhance the current system, we have decided to add a flywheel to the driveshaft as shown in Figure 2. The additional moment of inertia supplied by the flywheel acts as a source of rotational energy storage. The flywheel should serve two purposes in this application: “smooth” out torque input to avoid rectified sine input and increase inertia of the system to decrease negative angular acceleration. These two improvements should allow the consumer to more efficiently treat their water for potable and consumption purposes.

Figure 1: Original Design

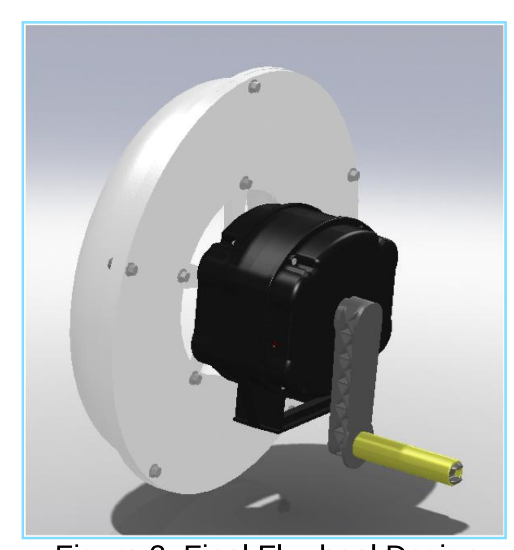


Figure 2: Final Flywheel Design
$I_{flywheel}$ = 900 lb in^2

- Engineering Model
  - Simulated inertia of the flywheel with use of rectangular steel tubing and 2 10 lb. gym weights, as shown in Figure 3. This is the model that was used for all testing.
- $V0_2$ Study
  - A VO2 test is used to see how much oxygen is required to do a certain task. This data could then be extrapolated to find the users respiratory exchange ratio (RER), calorie usage, and overall ability to make water with the device.
- Test Procedure
  - Test requires being hooked up to a breathing tube that captures all of your oxygen and CO_2 production. The user’s nose is plugged, and heart rate data is collected. See Figure 4.
  - User operates the hand crank system and continues until exhaustion occurs. Data is collected over operation time.

Figure 3: Engineering Model

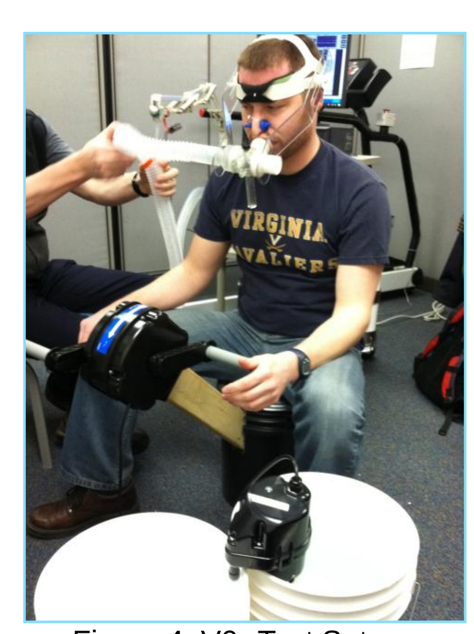
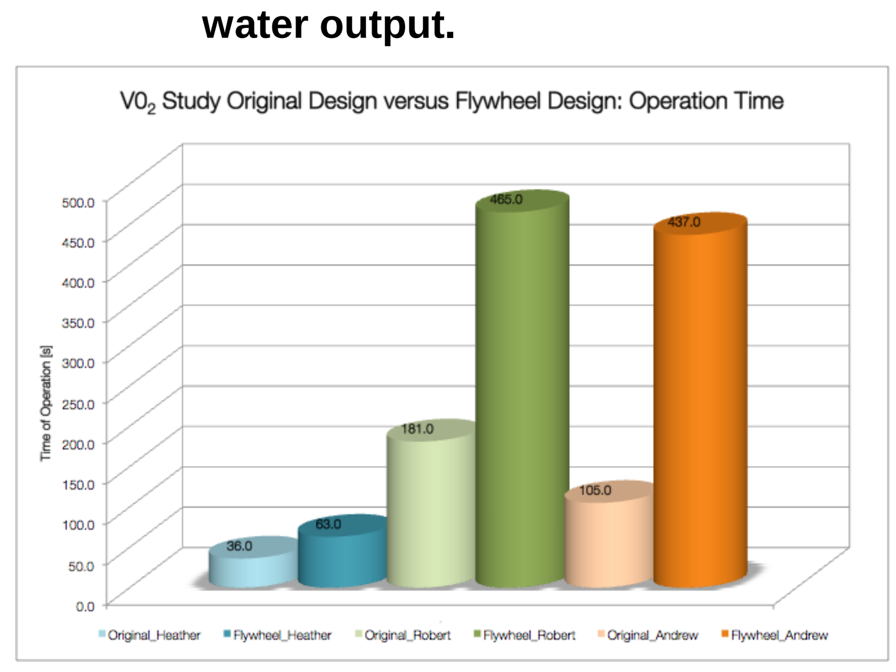
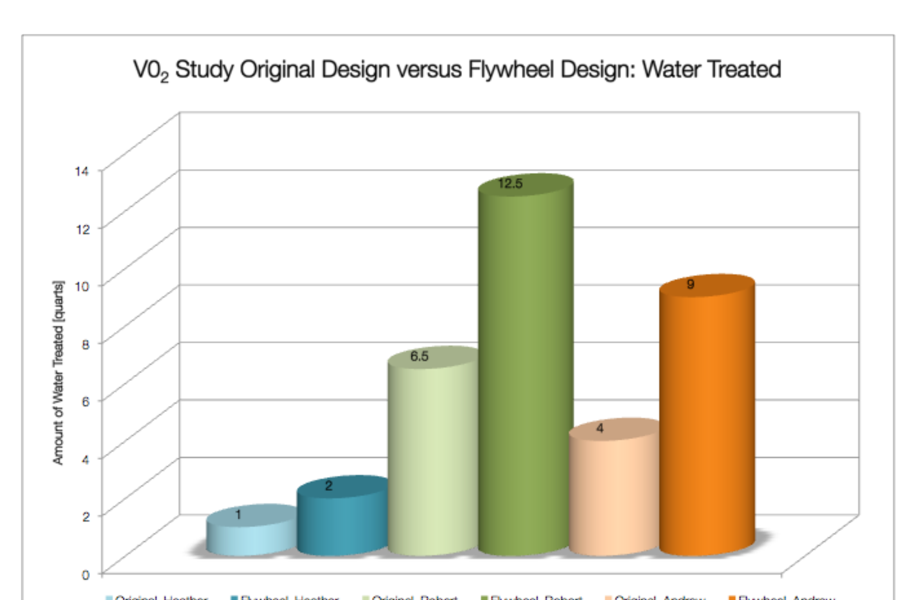


Figure 4: $V0_2$ Test Set-up

- Results and Conclusion
  - Water Treated over Time of Operation was collected for three team members for both the original and flywheel system. Data is shown below in Graph 1 and Graph 2.
  - **Approximately 100% system improvement for both time of operation and treated water output.**





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