VORTEX

An automated modular system for preparing and maintaining the quality of water for fresh and saltwater aquariums.

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CONCEPT

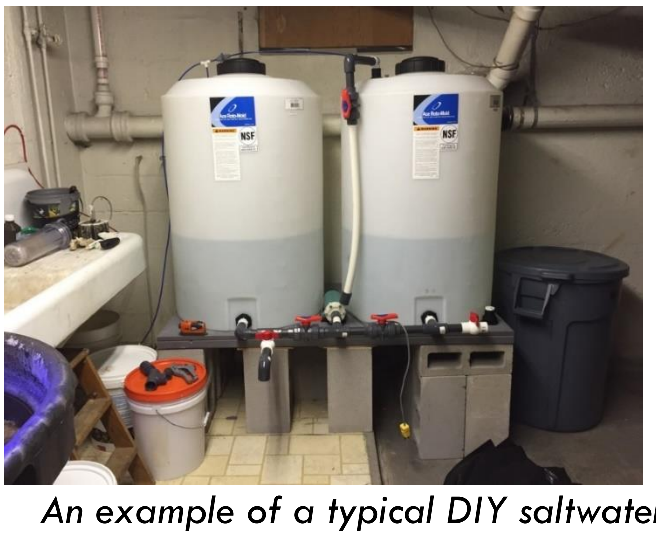
Maintaining an aquarium is an incredibly challenging, technical, and time-consuming task. One of the most important components of any aquarium is the water. Most water cannot be directly used in an aquarium and must first be processed. Unprocessed or incorrectly processed water may prove to be fatal to any pets in the tank.

There are many factors to consider regarding aquarium water, and it differs from tank to tank depending on the animals/plants being kept in it. Some of the chief variables to consider are pH chlorine/chloramine, ammonia, nitrite/nitrate, salinity. [1]

My family owns several aquariums, and I have noticed the immense amount of time and effort (and hundreds of dollars of equipment and a large chest of chemicals) that is required to maintaining them. This is something that I have wanted to investigate and look for avenues of automation and making the process generally easier.

MARKET RESEARCH

Some designs do exist as saltwater mixing stations. However, they are all incredibly large, expensive, technically involved, and difficult to use.



An example of a typical DIY saltwater mixing station.[2]

Most are DIY systems built by hobbyists with much experience and are quite expensive (typically >$1200) and large (typically >50 gallons).[2]

There are commercial designs available, but they are intended for commercial tanks (typically >500 gallons). They are usually custom ordered as well and far out of the price range of a hobbyist.[3]

There are no commercially available systems that satisfy the needs of hobbyists or amateur aquarium enthusiasts.

[1] https://www.petsmart.com/learning-center/fish-care/healthy-aquarium-water/A0083.html
[2] https://www.reef2reef.com/threads/if-you-own-a-saltwater-mixing-station-please-share-your-pictures-ideas.281744/
[3] https://www.marineland.com/Commercial/Products/Aquatic-Retailer-Systems/Saltwater-Mixer-Dispenser.aspx

OBJECTIVES

➠ Create a modular/customizable easy-to-use system that would aid a beginner/intermediate level aquarium owner in creating consistent batches of water with properly chemical levels for use in a small to medium size (5~25 gal) tank.

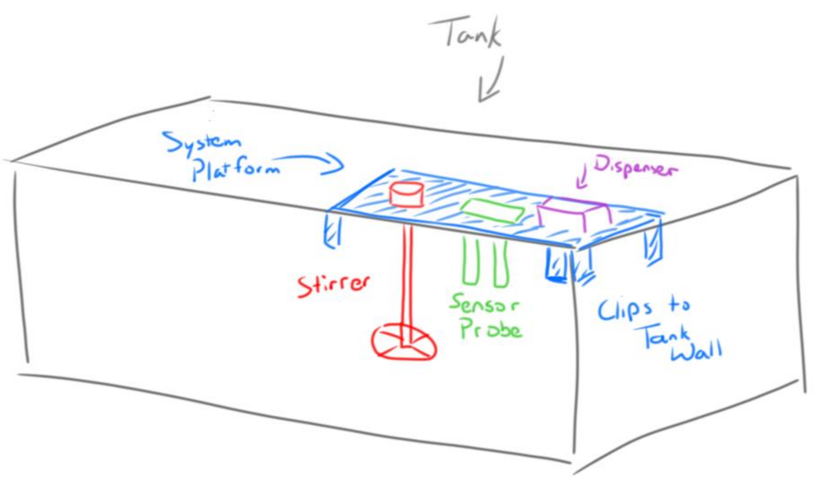
DESIGN OBJECTIVES

- Sensor suite, capable of measuring:
  - pH
  - Chlorine
  - Salinity
- Chemical dispensing capability.
  - Capable of adding certain amounts of designated chemicals to correct for the factors listed above.
- Water mixing/stirring capability.

SECONDARY OBJECTIVES

- Water pumps to ease the transferring of water from mixing bucket to tank.
- Compatible with multiple batch (bucket) sizes.
  - Minimum compatibility with a standard 5-gallon bucket.
- Modular design for easy expansion and accommodation for specific batch size, aquarium goals, etc.

INITIAL DRAFTS



The first design draft was an in-tank design. This draft had all the key components: monitoring sensors, a stirrer, and a chemical dispenser.

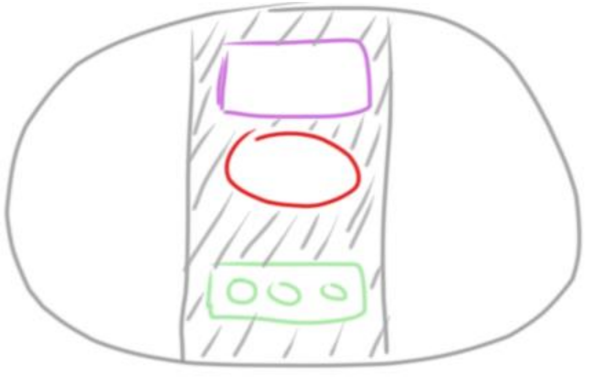
However, the relatively heavy system could not be securely clipped onto the tank.

Additionally, this design would not work for regular maintenance (water changes) in existing tanks that had fish and objects in it.

The second draft uses a standard 5-gallon bucket as the mixing container, and the components would be attached to the cover.

The bucket had several advantages; the components were securely mounted, and the stirrer was significantly more effective in a cylindrical container.

On the other hand, attaching the components to the bucket cover made it difficult to add/remove water.



The third draft most closely resembles the final design. It is largely based on the second iteration and improves on the second draft by using 'clips' and rods that act as rails to attach the components to the bucket.

This solves the previous access issue. Water can be added to the bucket without the need for removing the whole system, and it can be easily pumped out as well.

DESIGN

MODULAR SETUP

- **The base of the system is built on two ¼" steel rods. This allows multiple different 'modules' to be added, removed, and rearranged easily.**

The rods are attached to two 'clips' that attach to the bucket. The bucket does not require any modifications and can still be used normally. It also makes it quite effortless to detach the system from the bucket.

This setup also allows easy access to the interior of the bucket which makes it easy to add and remove water. Additionally, the modular design enables opportunity for future expansion.

SENSOR SUITE

- **The sensor suite provides an active feedback loop for the system to help determine what factors in the water needs adjusting.**

The sensor suite consists of 3 sensors[4]:

- pH (measures pH)
- ORP (measures chlorine/disinfectant)
- Electrical Conductivity (EC) (measures salinity and total dissolved solids (TDS))

These digital sensors are significantly more accurate than testing strips and much more user-friendly, and significantly helps beginners obtain high quality aquarium water. It can also be detached from rails and the system and put into the aquarium itself for active monitoring of these vital measurements.

[4] https://atlas-scientific.com/probes/

MIXER

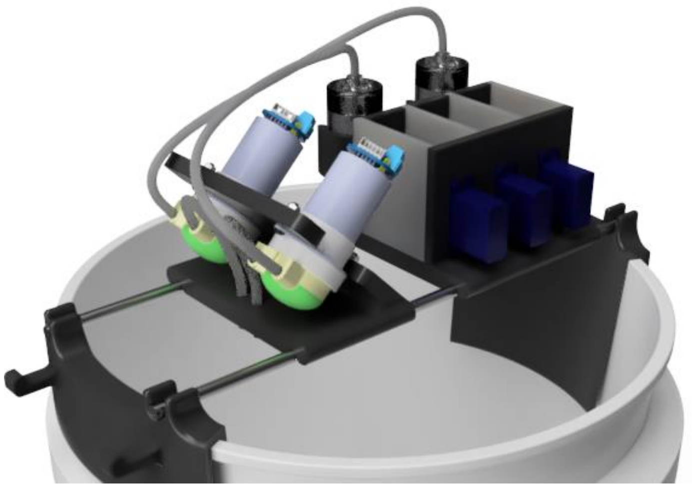
➤ **The mixer is used to stir the water and chemicals to ensure a homogenous mixture and accurate readings.**

This helical mixer blade was chosen because it can mix large volumes of water at lower speeds, and it also adds less air to the water compared to other designs. The blade is attached by a steel shaft coupler, so it can be changed out if necessary.

An underwater motor[5] was used because the motor required to be below the surface of the water to have a low center of mass. It is attached to the rails by an adapter which can also be swapped to accommodate a different bucket.

DISPENSER

➤ **The dispenser adds precise amount of chemicals (such as water conditioners, pH buffers, salts, etc.) to reach the desired water quality.**

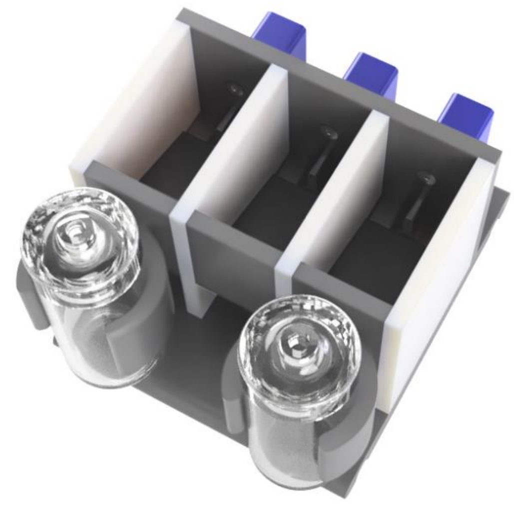


The dispenser is split into two section: liquid and solid (some chemicals are liquid while others are flakes).

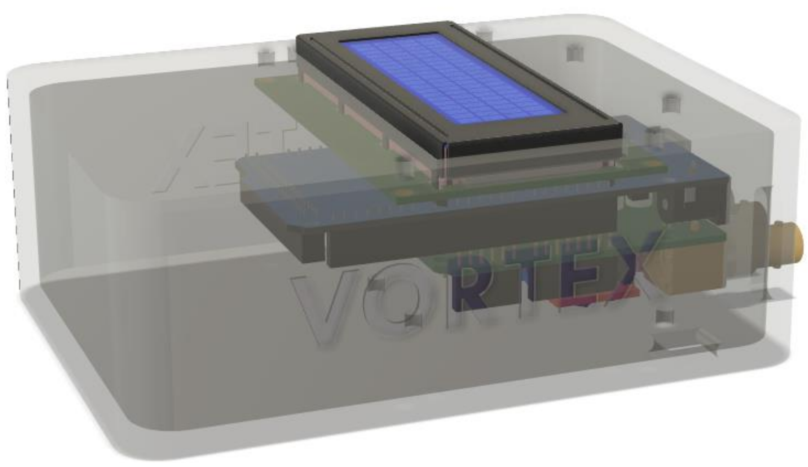
The liquid dispenser section houses two peristaltic pumps[6] which are linked to reservoirs on the solid dispenser section. Peristaltic pumps were chosen for their precision dispensing capability and because the chemicals are isolated from the pump motors.

[5] https://bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-asm-rotor-r3-rp/
[6] https://atlas-scientific.com/peristaltic/ezo-pmp/

The solid dispenser section contains three water resistant servos.[7] On the end of the servos are rubber ‘dosing wheels’ that can add small, precise amounts of the required chemical.



ELECTRONICS



- **Vortex runs on an Arduino Mega which handles all the sensor processing, motor/ servo control, etc.**

The system would be Wi-Fi enabled and largely be controlled via a mobile app.

The electronics for the system are housed in a water-resistant casing that clips onto one of the bucket clips.

CONSTRUCTION

- **The main structural components are intended to be:**
  - **Strong, rigid, saltwater/chemical resistant plastics (such a polypropylene).**
  - **Fasteners and the rods are to be stainless steel (for saltwater resistance).**

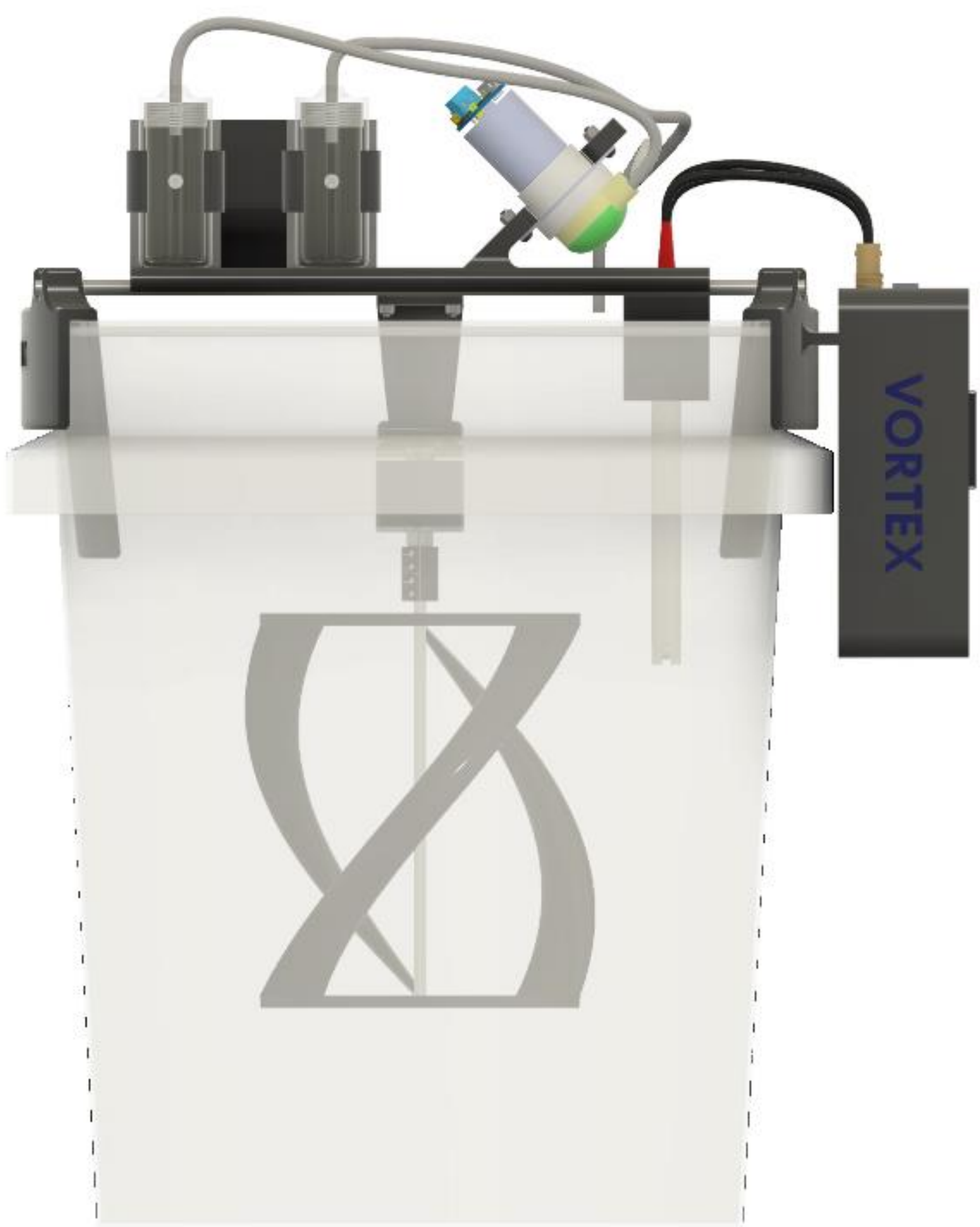
The electrical components (motors, probes, etc.) were specifically chosen for their ability to operate underwater (and for extended duration) and resistance to saltwater.

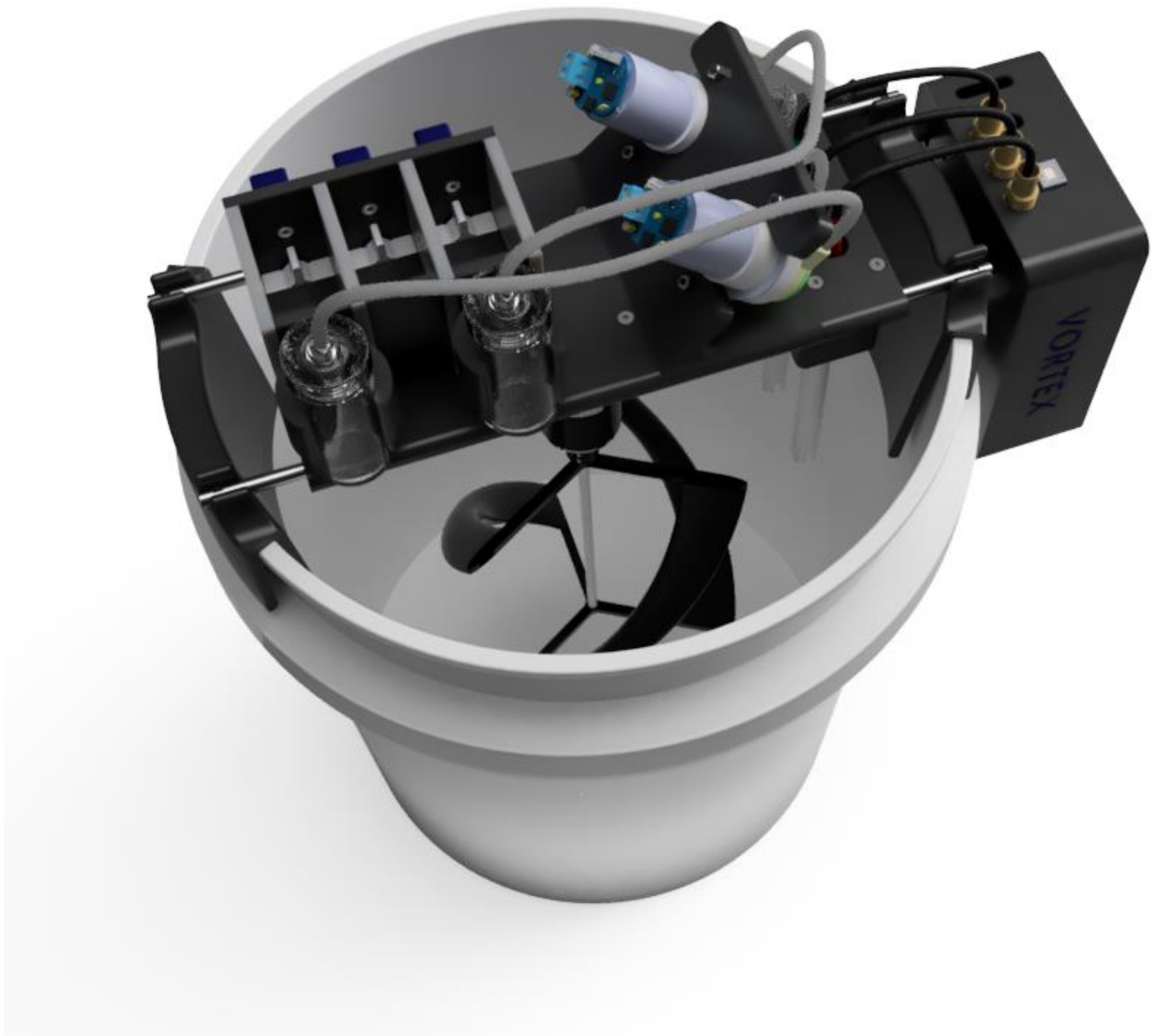
[7] https://www.savoxusa.com/collections/waterproof-servos/products/savsw0250mg-waterproof-digital-micro-servo#technical-details

FINAL DESIGN

➤ **Vortex is an easy-to-use modular system for aquarium beginners and enthusiasts to prepare and maintain high quality water through a precise and semi-automated process. Vortex would be an incredibly helpful tool especially for beginners and ensuring their first aquariums are a success.**

The final cost is around $425, and this can be drastically lowered by mass-manufacturing and sourcing other servos, pumps, probes, as well as using a custom-printed controller. Vortex is still significantly more affordable than any existing commercial option.

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ACKNOWLEDGMENTS

This project contains 3D models from commercial-off-the-self suppliers and from individual creators. Models not created by me are attributed here:

- LCD Display
  - https://grabcad.com/library/lcd-display-module-20x04-chars-2004a-1
- Arduino Mega
  - https://grabcad.com/library/arduino-mega-2560-rev3-microcontroller-board-1#
- Whitebox T2 Mini MkII (Arduino stack for probes)
  - https://www.whiteboxes.ch/docs/tentacle/t2-mkII/#/
- pH, ORP, EC probes
  - https://atlas-scientific.com/probes/
- Peristaltic pumps
  - https://atlas-scientific.com/peristaltic/ezo-pmp/
- M200 Motor
  - https://bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-asm-rotor-r3-rp/
- Miscellaneous hardware
  - https://www.mcmaster.com/