AquaTow: Swimmer Towing Device

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EXECUTIVE SUMMARY

The goal of this project is to design and manufacture a device that tows a competitive swimmer across a 25 yard pool at a given pace so that the athlete can work on repeatable technique at a race speed without experiencing fatigue. Currently there is no method for assisted training that pulls the swimmer at a known or constant pace therefore our customers (swimmers and coaches) require that this device be able to pull the athlete at a set pace specified by the user (up to 3.1 yards/sec) from 5 yards to 20 yards where it is then shut off to allow the swimmer to glide into the wall safely. They must be able to reset/unwind the cord in less than 30 seconds with less than 10 pounds of resistance to ensure repeatability with little fatigue of the athlete. The device must be less than a 3 foot sided cube to allow for adequate space on the pool deck and must also be splash proof and electronically safe around water. The system must be able to be set up in 5 minutes and be mounted securely beside the pool to withstand a maximum 100 lb force.

Horizontal and lateral competitive products were researched to help inspire and generate several different concepts. All new concepts were then eliminated or combined into five unique final concepts. The five remaining concepts were then compared using a Pugh Chart based on the engineering specifications to select the final concept. The concept of the power winch system scored the highest; therefore it was selected as the final design and named the AquaTow.

After continued development and sketching of the final design concept, a complete CAD model and bill of materials was put together. The user attaches with a harness connected to a wire which is guided through a roller fairlead and around a drum that is in the front compartment of the system. The dry section of the AquaTow contains the motor, batteries, microcontroller, motor driver, and cooling fan. The final compartment is the belt guard which houses the belt, gears, encoder, LED screen and the user functional buttons. There are two on/off switches which power the motor driver and microcontroller separately. Two buttons are used to increase or decrease the set lap time and when both buttons are pressed the “slow tow” function is activated to wind in extra slack in the line. A third button is used to initiate the tow and the final button is located behind the roller fairlead to stop the tow when compressed. Two 90 degree PVC pipes are used to create airflow through the compartment for cooling purposes.

The AquaTow was designed to be built with the equipment and tooling available in the ME Student Shop. Most of the manufacturing time was spent on machining and welding the aluminum stock into the frame. PVC panels were cut to length on the band-saw and corresponding holes were drilled for mounting. The lathe was used to machine the drum center and flanges as well as the encoder pulley. All components were assembled using screws and press fits for the bearings, axle and timing belt pulleys. After completing the wiring and programming the Arduino MEGA microcontroller, we inserted the electrical system into the device. Silicone Caulk was applied to protect the electrical compartment from splashes.

The first test of towing a weighted skateboard validated the mechanical and electrical systems. The AquaTow achieved the engineering specifications of top speed of 3.1 yards/second from 5 to 20 yards and shutoff with 5 yards remaining both with and without resistance applied from the rider. The force required to unwind the cable averaged 2.9 lbs, well under the maximum 10 lbs. All materials used for the manufacturing of the device are corrosion resistant therefore satisfying the material requirement, the total dimensions of the AquaTow measure 2.25 ft by 1.75 ft by 0.75 ft, and a splash test ensured no water enters the electronics compartment. The second test validated the ability to tow age group swimmers up to professional swimmers with the device at varying speeds although a limitation of the device was not being able to tow the swimmer at a pace more than one second better than their fastest time. This is due to the motor and motor driver capabilities but even with this limitation all swimmers will be able to use the device to train technique at a faster speed than they are capable of achieving which is the overall goal of the AquaTow. Recommendations for improvements moving forward include an injection molded housing, higher resolution encoder for greater accuracy of speed, and more advanced PID control algorithm.

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