Prototype Iteration

Team Wheelders

Rice Robotics Club | University Rover Challenge

Prototyping Overview

During our prototyping process, we ended up having six key iterations of our design. At the beginning of our prototyping journey, we identified a minimum of three key features: the wheel's axle attachment structure, non-pneumatic tires, and spikes/treads for increased traction.

Iteration 1 & 2: PLA Low Fidelity Prototypes

For our first two iterations, we created a low-fidelity prototype that was both representative and a proof-of-concept. This included making two wheels that were the same in terms of their structure and dimensions but differed in the wheel exterior, either having treads or spikes. We pursued both of these exterior designs in this iteration due to the CAD process for designing these wheels to 3D print being almost a copy-and-paste of each other.

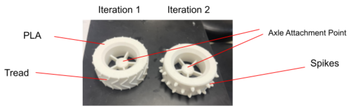

Figure 1: PLA Low Fidelity Prototypes (Iteration 1 & 2)

We incorporated all of the features we identified in this low-quality 3D printed model. The axle attachment structure was created in the center of the wheel after we discovered the type of motor that Rice Robotics was considering using in the Rover. The spikes and treads were made with similar dimensions to what we planned to use in our final design. The purpose of this prototype was to translate our idea into a 3D space and see how our wheel design compared to the pre-existing low-fidelity wheels that Rice Robotics had made for their low-fidelity prototype of their Rover. From this prototype, we discovered that PLA did not give a satisfactory amount of traction or wheel compression. We also found that we needed to ensure that the spikes were securely attached and wouldn't take excessive damage or fall off, as they were a weak point of this iteration. As a result of these findings, we decided to move on and 3D print in TPU, which is known for having a better grip and a higher compression factor than stiff PLA.

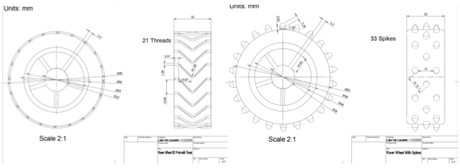

Figure 2: CAD Technical Drawing (Iteration 1 & 2)

Iteration 3: TPU Medium Fidelity Prototype

In our third iteration, the main goal was to explore the possibility of printing our final design with a TPU exterior and a PLA core structure. To do this, we cut the center structure out of the CAD models from our first iteration and printed just the outside of the wheels. However, we faced challenges in the printing process of this wheel and struggled to get a print that came out with decent quality. Finding the right balance of extruding speed, extruder temperature, and keeping overall print time down proved a difficult task. From this prototype, we saw that the time put into making just this single low-quality wheel was not feasible to scale up and repeat four times in our final design. As a result of this iteration and the first one, we decided to move on to purchasing a pre-existing wheel and modifying it to gain the desired attributes we wanted in our final design.

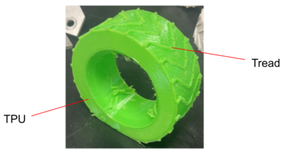

Figure 3: TPU Medium Fidelity Prototype (Iteration 3)

Iteration 4: Medium-High Fidelity Prototype

In our fourth iteration, we purchased and modified a wheel that met our needed scale and was non-pneumatic. This wheel allowed us to test manufacturing methods on it for our final design, and we also used this wheel to perform our first durability and traction tests since it was at the needed size and just slightly over our goal weight. We modified the existing wheel by drilling holes into the exterior and then fitting the screws of rugby cleat spikes into the holes with adhesive. We tried to excavate some of the rubber from the exterior to make treads, but this proved very difficult given the wheel's hardness. We made a make-shift axle and attached it to the wheel for testing purposes and to check the ease of use of the axle attachment structure. We also began exploring spike layout designs in this prototype, trying to find what would offer us the greatest traction result. Ultimately, this iteration gave us a lot of information, and we realized that we would achieve the most successful final design by using this purchased wheel as a base for further modifications. This showed us that using the spike exterior design would be best moving forward, and we stopped pursuing the idea of treading our wheels. The spikes did have a tendency to fall out, so improving the connection method was needed for higher durability. In the testing of this prototype and meetings with Dr. Holmes and Dr. McGlamery, we saw that these spikes were too large and didn't allow us to maximize surface area with the ground, resulting in less traction. As a result, we purchased more of these wheels and continued modifying them, but with different spikes, and we manipulated the spike layout.

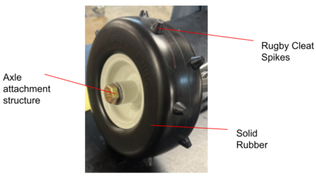

Figure 4: Medium-High Fidelity Prototype (Iteration 4)

Iteration 5 & 6: High Fidelity Prototypes

In our fifth and sixth iterations, we used the same wheel from iteration 4, but used track spikes instead of rugby cleats, and we varied the spike layout. In attaching the spikes, we precisely measured out the distances between each spike and used precise drilling and adhesive to ensure a high-quality and strong attachment for each spike. We used a fresh set of wheels as well to ensure that the tread excavation on the wheel from iteration 4 wouldn't lower the quality of these iterations. In our testing, we saw that these wheels performed the same in terms of traction, but iteration 6 performed better in durability and replicability.

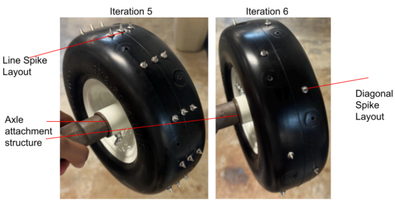

Figure 5: High Fidelity Prototypes (Iteration 5 & 6)

Final Prototype Selection

Due to the experimentation and iteration above, we selected iteration 6 as our final prototype. This model has our three key features: wheel axle attachment structure, non-pneumatic tires, and spikes/treads for increased traction. It performed best in most of our tests and met all of our clients' requirements. We made sure to make this iteration with sourcing the highest quality parts, and we took time to accurately place and secure all of the spikes. Ultimately, at the end of this process, we have created a prototype that incorporates all the elements we sought at the beginning, and performs above our target goal in our most important criterion, traction. All the features and the high performance of this recent iteration were made possible as a result of the systematic iterative process.