Senior Design BS Project
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Lightweight Wheel for HERC

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Abstract

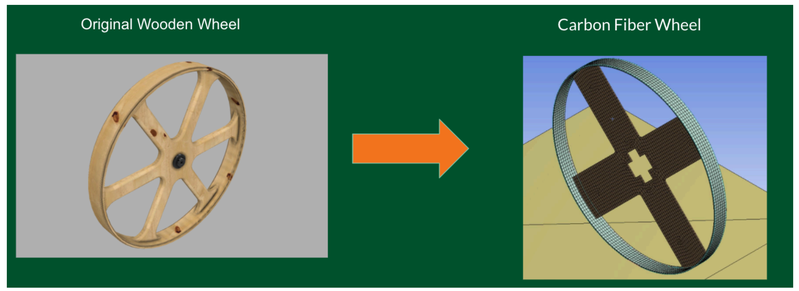
The two main objectives of this project were to design a lightweight wheel made of carbon fiber and to build 4 of these wheels for the HERC competition. We succeeded in creating an accurate model in ANSYS workbench, where we found that the spokes of the wheel had to be 2.5 mm thick and the rim 4.5 mm thick. The wheels in the previous year's design were made from pinewood, with dimensions of 3.5 feet in diameter, a 4-inch rim, and spokes that were 2.5 inches wide and 1.5 inches thick. The next step of our process would have been to make the mold and start fabricating wheels using the vacuum bagging technique.

Introduction

The Nasa Human Exploration Rover Challenge (HERC) is an annual engineering design challenge that engages students around the world in designing a vehicle that mimics a rover, suitable to traverse various terrains on other planets.[1] . We successfully made a sturdy vehicle, but as it was our first time competing, our design was wrought with issues. The subsystem that had an apparent design flaw were the wheels, due to their weight and lack of maneuverability After conducting more research, our team determined that carbon fiber possessed the ideal lightweight and high strength properties for this project. One downside to carbon fiber, however, is its high cost.[9] Its price point is higher than other comparable materials, which is why it is not readily used as a lightweight replacement.[10,11] Nevertheless, we decided that the reduction of the weight was worth the increased cost. In using this material to design and manufacture our wheels, we hope to achieve our objective of creating lightweight, sturdy wheels for our rover in the HERC.

Methods | Design | Analysis

- We designed a wheel based on the original design changing dimensions to accommodate for our objectives.
- We then chose our cross-ply carbon fiber and did tensile testing to determine properties.
- Using these properties we conducted analysis to obtain our optimized wheel dimensions



Results

Set	Average Thickness (in.)	Nominal Thickness (in.)	Average Width (in.)	Max Force (lbf)	Modulus of Elasticity Low (Msi)	Modulus of Elasticity Medium (Msi)	Modulus of Elasticity High (Msi)
1	0.071	0.070	0.888	5267	7.70	7.49	7.08
2	0.064	0.070	0.962	4917	7.02	7.35	6.94

- The testing of the cross-ply carbon fiber was done on an MTS-22 kip. A tensile test was done on 2 sets of specimens, shown above.
- This data was used to determine the final properties of the cross-ply carbon fiber, which proved to be similar to the properties of the woven carbon fiber already in ANSYS Workbench.

Conclusion

- Two main objectives:
  - design a lightweight wheel made of carbon fiber
  - build 4 of these wheels for the HERC competition.
- We succeeded in creating an accurate model in ANSYS workbench
  - took into account the different properties of composites in different directions
  - accurately represented the carbon fiber we were going to use
  - If the wheels were to fail, we would have determined the volume fraction and adjusted the vacuum bagging process in the next attempt.

Acknowledgments

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