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SAE Formula Team Carbon Fiber Seat

Sean Turner
sat83@uakron.edu

Jacob Jaksic
jjj54@uakron.edu

SAE FORMULA TEAM CARBON FIBER SEAT

By

Dovydas Sodys

Jacob Jaksic

Mike White

Sean Turner

Sevin Johnson

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Faculty Advisor: Daniel Deckler

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Abstract

Our group was tasked with creating a new Carbon Fiber model for the Zips Racing team for their annual competition. The purpose of this change in material is to lower the weight of the car and to make a more inexpensive model, all while keeping the geometrical integrity of the car's cabin in mind for the seat to rest in. Throughout the duration of this project, our main findings had to do with the design and production processes that are implemented when making a device like our carbon fiber seat. It exposed all of us to industry project teamwork, as well as taught us how to communicate with engineering companies to meet our needs as it pertains to the buying and machining of our seat and seat mold. Overall due to many factors. Our group was not able to finish this project to completion but we were able to gain some experience in a mechanical engineering industry project.

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1. Introduction

This project exposed our group to an industry-like project within the mechanical engineering design field as our group was tasked with creating a carbon-fiber seat for The University of Akron's formula car team. The main problems that this project was tasked to address was lowering the overall weight of the formula car with the use of lighter material, as well as making a cheaper alternative to past years' formula car seats. The purpose of our project was to create an interchangeable seat for the formula team that maintained the dimensional integrity of the vehicle as well as offering a comfortable seat for the formula team's drivers to sit in. The seat needed to be able to be removed temporarily for vehicle maintenance during the races as well as fit snug into the car while allowing a comfortable ride for the different sized drivers. Although we were unable to finish the project to completion, we were able to compile a final design for the seat as well as order the material needed to make the mold of the seat to be machined. The next steps to our project would be to glue the materials together to be machined and to send them to a company that can machine to our final design's specifications. Once that would be complete we would be left to wrap our seat in the carbon fiber material for the completion of the design project.

2 Design

2.1 Design Procedure

In the early stages of the design process, we researched the available resources at our disposal, the constraints we had to work with, along with any possible engineering standards this project may be involved with. By gaining a full understanding of these parameters, we were able to confidently begin the design procedure of this project.

2.1.1 Cabin Contraints

The design for the new seat had to follow certain geometrical constraints of the cabin of the vehicle. The design had to properly fit within the walls of the cabin, shown in Figure 1.0. The T-brackets shown are used to mount the seat. Thus, the location of the brackets in relation to the seat was critical. A vertical constraint was considered as well, as the head rest was not allowed to exceed a certain height to account for other components within the cabin. Following the cabin constraints allow the seat to be installed without worry of interference.

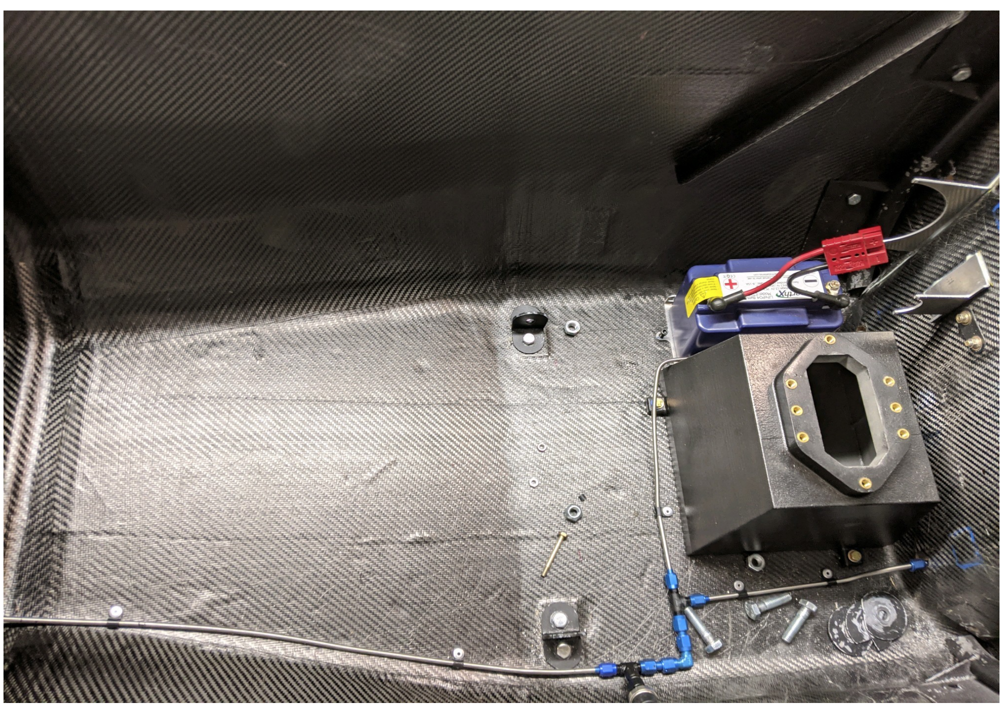

Figure 1.0 - Interior Cabin of Vehicle

2.1.2 Engineering Standards

In a production environment, our project would need to satisfy ASME (American Society of Mechanical Engineers) standards. Namely, "**Engineering Drawing Practices (Y14.100)**", "**Model Organization Practices (Y14.47)**", "**Guide for Verification and Validation in Computational Solid Mechanics (V V 10)**", and "**An Illustration of the Concepts of Validation in Computational Solid Mechanics (V V 10.1)**" would apply to our system. These standards include recommended practices for preparations of computer generated drawings, requirements and guidelines for computer-aided-design (CAD) users developing three-dimensional models, and general guidance and illustrations for an overall approach to verification and validation of computational modeling.

In addition, we had multiple constraints for the seat design, along with prototype requirements. Throughout the duration of this project, we had to balance cost, performance, and production restrictions:

- Prototype Design Requirements
  - Low weight
  - Low cost
  - Efficiency (stress resistance and stiffness)
  - Geometrical restrictions of vehicle
  - Mounting options

2.1.3 Design Brainstorming Solution

After assessing the requirements dictated by the Formula Racing Team, along with the constraints and standards listed above, our team decided to pursue a new material of carbon fiber for the seat redesign. This material provides numerous benefits such as being low cost, lightweight, and flexible.

2.2 Initial Design (Revision 1)

The goal of the first design was to provide a baseline model that accounted for the dimensions of the driver, along with satisfying the constraints of the project.

Figure 2.0 - Initial Seat Model

2.2.1 Design Analysis

A preliminary Finite Element Analysis (FEA) was conducted on the initial model to determine how the design would react to the stresses experienced during racing. Two key forces that the seat experiences are as follows:

Defined Force	Force Experienced (lbf)
Lateral (turning)	405
Acceleration (braking)	225

Note: The applied force shown in the table was calculated with an assumed driver weight of 150 lbf, along with raw data provided by the racing team.

The software ANSYS was used to run the FEA, with a static structural analysis being performed. By fixing the bottom of the model to simulate the mounting brackets described above, the larger lateral force was simulated across the seat surface. The intent of this analysis was to gain an understanding of how the seat could potentially deform due to the above stresses. The values of deformation were not critical at this junction. Thus, the visible reaction was all that was needed. Below shows the deformation of the seat model due to the applied lateral force:

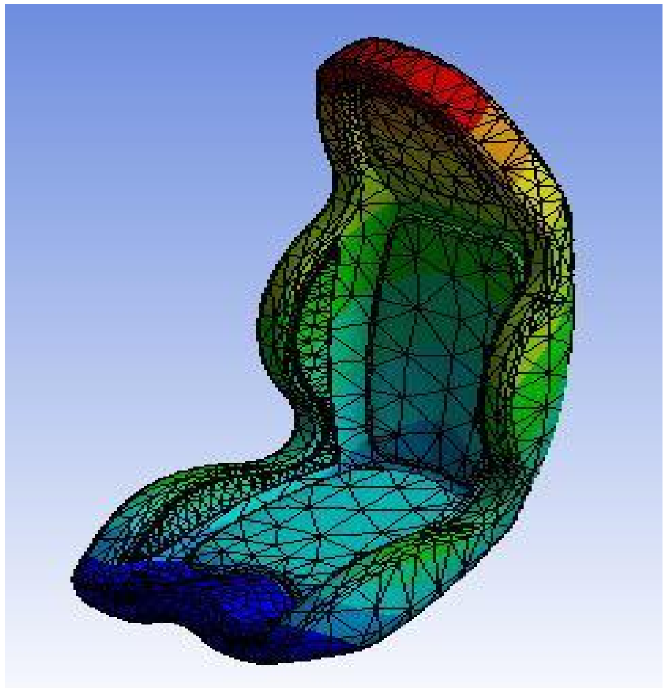

Figure 2.1 - FEA Simulation of Initial Model

As shown in Figure 2.1, the maximum deformation is experienced at the head rest, while the minimum lies at the bottom of the model.

2.2.2 Design Review

This design had some failures, in that it was much too heavy and the weight needed to be reduced. There was also an issue with the forces acting on the headrest, as it seemed to be too much for the driver during use of the vehicle.

2.3 Updated Design

The goal of the updated design was to improve upon the previous design by retaining the comfort and stability, while updating the material to carbon fiber to become a more streamlined and lighter design. The new design also needed to account for the dimensions of the driver, along with satisfying the constraints of the project. It had to be less complex, while also complying with SAE standards. Improvements were then made to the overall thickness, while the team adjusted to form around the mold created by the racing team.

2.3.1 Design Analysis

Additional FEA test not conducted due to time constraints. The benefit if we were able to run this test include knowing if the desired requirements were met. We would be able to adapt the design again if needed.

2.3.2 Design Review

The design of our updated model of the 2021 carbon fiber racing seat improved upon the flaws previously mentioned about the previous version of the seat. One of the main goals of the new design was to decrease the weight of the seat, thus reducing the weight of the car as a whole. While attempting to decrease the weight of the race car, it is essential to make sure that any level of structure or safety is not sacrificed or compromised. If so, both the car and the driver could be hurt. In the case of a crash or fire, it must be certain that the material and design of the car will be able to endure the harsh elements or impacts that it may be exposed to. To meet all of these requirements, carbon fiber was the group's material of choice. Weight-for-weight, carbon fiber has 2-5 times more rigidity than aluminum or steel. Additionally, the component made from carbon fiber of the same dimensions will be 42% lighter than an aluminium one and more than 5 times lighter than a steel one ("Carbon Fiber vs. Aluminum," 2015).

One drawback of using carbon fiber over another material, such as aluminum, is its cost. Thankfully, we were able to find a company that offered an academic discount, which we were able to pay for using the University of Akron's funding available for senior projects.

Additional information regarding all of the above requirements and their verification processes can be found in Appendix A at the end of this report.

3. Design Verification

The design for the carbon fiber seat had to follow certain geometrical constraints to fit inside the cabin of the vehicle. The design had to properly fit within the walls of the cabin, as well as within a certain height. All of these constraints were easily fulfilled by our latest design.

In addition, throughout the duration of this project, we had to balance cost, performance, and production restrictions:

All of these constraints were fulfilled, despite our project not being fully completed.

4. Costs

4.1 Parts

Parts Costs

Part	Manufacturer	Retail Cost ($)	Bulk Purchase Cost ($)	Actual Cost ($)
Renshape 460 .625’x20’x60’ boards	Freeman Manufacturing	$23/piece for 40 pieces	$920	$979.80
Total				**$979.80**

Table 1 - Cost Breakdown

Note: Our group was relieved from expenses for glue for the boards, and carbon fiber material as both were provided and paid for by the Racing team. We have not gotten an estimate from a company to see how expensive it will be to machine the mold to our specifications. Our group would recommend Freeman manufacturing for a future group’s needs as they responded to our inquiry in a timely fashion and offered reasonable prices for materials for school design projects.

4.2 Labor

For the production of our seat there is labor needed for the production of the seat mold. After receiving our boards in bulk, our group needed to cut the boards to match the needed dimensions for the seat pre-treatment. Once cut to the specific dimensions that are needed for each mold, these boards need to be glued together tightly so they conform to a cube-like shape so the mold will be ready for machining. The mold will then need to be sent off to a company to be machined to meet the dimensions of the seat mold. Once the seat mold has been machined and treated, the next task is to add the carbon fiber material to the seat mold. This can be done by simply wrapping the seat with this carbon fiber material until it is completely wrapped and meets the approval of the racing team. Once this process is complete, the seat will need to be installed in the formula car for final useage.

5. Conclusion

5.1 Accomplishments

Although our group was unable to complete the project as a whole there were still some positive takeaways to our project. First off, we were able to gain experience in teamwork as it comes to mechanical engineering projects that can be related to real world industries. We were also able to gain experience in communicating with professional companies to coordinate and purchase materials that were needed in order for us to craft the mold for our carbon fiber seat. We were able to see how important it is to set deadlines and meet them throughout the duration of an industrial project and learn how to effectively communicate with our group throughout the duration of our project.

5.2 Uncertainties

Our biggest uncertainty throughout this project was the effects of COVID-19 and how they would affect things such as budget and production of our carbon fiber seat. About halfway through our project we were told that we may not have money for our seat this year as the Zips racing team was preparing to save up for next years' model car. This really narrowed down our options on where we could find materials to use for our mold and most importantly how much we were able to spend on these materials. Another impact that the pandemic had on our project was the effect that Covid has had on many of our potential sponsoring companies for our seat. Understanding that the pandemic would have an effect on things such as price and shipping for our projects, such as potential shipping delays, would've helped our group out substantially if we would've sped up the project timeline for this carbon fiber seat.

5.3 Future work

As mentioned before our team was unable to complete the entire project in the timeframe that was given to us. We were able to successfully order the materials for the seat that were needed and handled transporting those materials to where they needed to be. Next, cutting the boards to be glued to our mold's dimensions is what we have to do in order for the mold to be ready to send off for machining. Once a company is found for machining we are then tasked to ship the mold to that company to get machines and cured. Once the final mold is sent back, with the assistance and materials from the formula racing team, our group needs to wrap our final seat mold in carbon fiber material in order for the seat to meet this project's goal of reducing the weight of the formula car. The seat will then need to be installed in the car to be ready for the racing competition.

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Appendix A- Requirement and Verification Table

Table 2 System Requirements and Verifications

Requirement	Verification	Verification status (Y or N)
1. Ensure Seat Structurally Sound	1. Verification a. FEA Analysis was conducted. b. Test seat with driver We were not able to verify this requirement due to not completing our final model in time due to COVID and other time constraints.	N

2. Find material and funding necessary for the project	2. Verification a. After receiving multiple estimates from companies, Freeman Manufacturing was chosen as the supplier. b. Funding was secured via the University of Akron.	Y
3. Reduce weight of car without compromising structure or safety.	3. Verification a. The chosen material would have had successfully reduced the overall weight of the vehicle while maintaining both its structure and safety requirements.	Y
4. Expose team to engineering field projects seen in workforce	4. Verification a. Communicated together as a team b. Establish time frames c. Work with outside companies professionally	Y
5. Install Carbon Fiber Seat in 2021 Zips Racing car	5. Verification a. Obtain design mold after tooling board comes back from company b. Apply Carbon Fiber to mold to create seat	N