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Baja Rack and Pinion

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Senior Design/Honors Project
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1. Abstract

Our senior design team chose to team up with The University of Akron's SAE Zips Baja Team. The Zips Baja Team races off-road vehicles that they build every year. The team is trying to optimize and improve several sub categories for the 2019 car such as steering, drivetrain and suspension. Our design team met with a couple of the captains on the Zips Baja Team and were given a few choices of what sub category we could focus on for our project. We decided to take on the task of improving the vehicle steering rack and pinion gear system. The rack and pinion is a critical component of the steering system that transfers driver steering input to wheel turning on the vehicle.

The main goal of our project was to maintain the team's factor of safety while reducing the total weight of the rack and pinion system by 10%. The reason for this goal was to work with the Baja Team's overall goal of reducing total vehicle weight to improve the Baja vehicles acceleration score. If we could exceed our goal of a 10% weight reduction in our sub-category that can act as a buffer for another sub-category that couldn't achieve a 10% weight reduction. The current weight of ZB18 (the 2018 car) is 337 lb.The weight of the car four years ago was 400 lb. That's an average reduction of 15.75 lb per year. That is roughly a four percent weight reduction per year on average, thus a goal of a ten percent weight reduction for the 2019 car is more than double what has been achieved the last four years.
The second goal of our project was to reduce the cost of the overall rack and pinion system. This was in conjunction with the team's overall goal to reduce the car cost by 20%. The cost of ZB18 was $8976.65 which factors in material cost, labor and machining for the car. To quantify the cost of the rack and pinion system, we took into account the same factors.

The motivation for this project was to obtain a better understanding of material properties and gain knowledge and experience in different types of material testing. This project provided real world experience of the different types of material testing that we have learned about in the classroom, but had not yet performed. This project also provided a great opportunity to redesign and improve an already existing design. Receiving experience in mechanical testing and in redesigning a mechanical system was of great benefit to our team. Helping the Zips Baja Team's racing performance by improving a system on one of the cars was also an additional incentive. Our work on this project will be able to improve the performance on one of The University of Akron's best design teams. Go Zips!

2. Executive Summary

2.1 Introduction

To begin the project we needed to know where we were starting in terms of weight, cost, and material selection for the system. We also needed to analyze, using FEA software, the rack gear in the system to help us understand the stress the rack gear experiences to help determine the direction of material selection for the rack. We created a morphological chart and created comparison tables to brainstorm ideas which gave us a direction for the project in terms of weight, cost, and materials for each component.

Our next phase of the project was to research materials and make any design changes to the system where we saw fit. We finalized our design changes and purchased materials to prepare for the manufacturing of the components in our final design.

Our final phase of the project was the manufacturing, testing, and analysis phase. We researched and contacted various sources to manufacture components for our system and chose the most cost effective method. We utilized outside sources, resources available to us with The University of Akron, and our own team's skills to manufacture and assemble the components of the rack and pinion system. We succeeded to meet and exceed our weight and cost goal of the rack and pinion. The final weight reduction achieved was 15.3% and the material cost reduction was 25.7%. The final rack and pinion design was installed on car ZB18 and was put through the team's normal vehicle test procedure. Our rack was confirmed to be structurally sound with our design changes and weight reduction.