Design of an Custom Limited Slip Differential

Colin Schell | c.schell10@gmail.com
Science, Discovery, and the Universe | Mechanical Engineering

Research Context

Limited Slip Differentials (LSD's) are incredibly beneficial to the performance of an off-road vehicle such as the Baja vehicle but due to the engine we run (only produces 10 horsepower), aftermarket LSD's that would work with our car do not exist. Until this year, we have run a very outdated LSD that just broke and is no longer manufactured. Can a viable in-house LSD be designed in order to replace the previous differential? Are there ways to design this differential so that it is more optimized to our current car?

In order to understand the purpose of this project, it is important to understand the desirable characteristics of the LSD. Because our car only weighs about 300 pounds, it is crucial to cut weight at every component. The new differential must be lighter than the previous model in order to justify the complications of machining it. In addition to this, the differential must have the smallest diameter possible in order to minimize gear size. This problem may be able to be avoided by using a worm gear drive or a planetary gear system but for now, it is important to create a system that works with our current drive.

Methodology

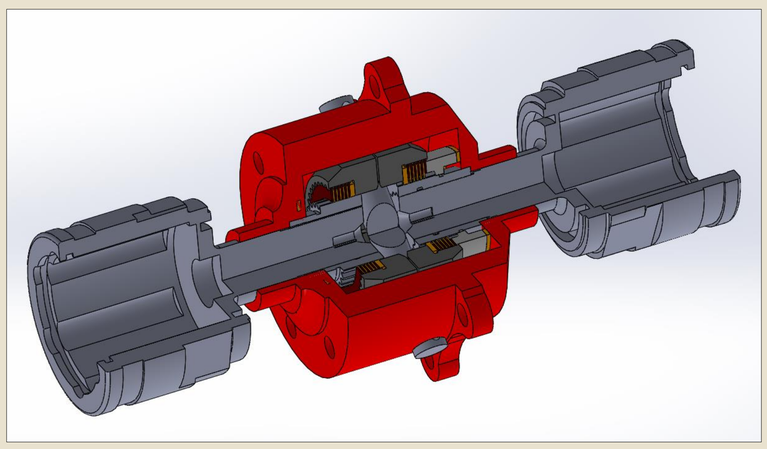
The first step to this project was first to repair the previous differential so that it can serve as a benchmark in order to test the new differential against. Next was to use the old differential to determine where to make the changes to the new differential. Finally, the CAD model for the new differential must be created. Although creating the CAD was trivial design was not.

Limitations

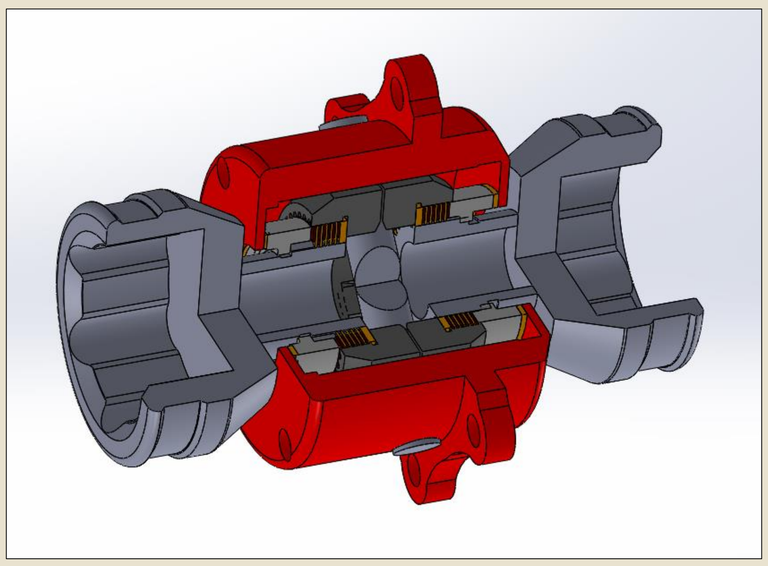
Because of the timing of the competitions for Terps Racing, there was no time to do testing for anything that wasn't for getting ready for competition. Since this project is for next year's car, I was not able to obtain any data to measure the performance of the differential. Therefore, the only ways to measure change were the mass of the differential, the ease of servicing (the current differential is very difficult to disassemble), and the size of the differential.

Data

2017-2018 Differential
Mass: **9.76 lbs.**
Diameter: **3.43 inches**



2018-2019 Differential
Mass: **5.96 lbs.**
Diameter: **3.14 inches**



Analysis

Overall, the redesign of our limited slip differential was a very enlightening process. The main success was the massive amount of weight that was removed from the component. 3.8 lbs. may not seem like a lot but when the car only weighs around 300 lbs., every bit counts. The other significant design change was the decrease in length of the differential. The smaller differential means that the angle that our CV joints operate at will be smaller. Smaller articulation angles lead to higher efficiencies for CV joints. The diameter reduction however was disappointing. The difference of .29 inches will not allow for any meaningful change in the size of the gears. I don't believe that these changes are enough to incentivize this sizable machining project.

Future Research

I believe that the best decision moving forward is to explore other options that allow for more optimization. The trunkel pin has proven to be easily broken and the light weighting of the component makes it more susceptible to fracture. I believe that best options are to optimize a spool differential setup for the car or to use an open differential with cutting brakes and one-way clutch packs. Regardless, I believe that this option, while very cool, does not hold the potential reliability and performance aspects of other options.

Acknowledgements

I'd like to thank Scott Schmidt for advising me throughout this project and making sure that I never lost sight of the main goal as well as the Terps Racing team for providing me the resources required for this project.