MECE 538 Final Project Report: Driveshaft Analysis of a Formula SAE RaceCar

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***Abstract*— Formula one is one of the most watched motorsports in the world, one of them being me. It is a sport where the driver of the vehicle completely relies on the car and the ability of the car to respond to the drivers' skill. The driveshaft plays an important role in this extremely dangerous endeavor. A broken driveshaft means that the car wheels don't turn the way the driver intends for them to turn and that means tragedies can occur. This paper analyzes the driveshaft of a student competition based formula racing vehicle. While the Formula SAE isn't comparable to the Formula 1 vehicles, the Formula SAE must contain all the components of the F1 cars, so it will be a good starting point. The driveshaft was digitally designed and analyzed using Solidworks.**

I. Introduction

Formula One has slowly but surely started to garner a large number of people's support in the last few years. It is a top motorsport and it boasts a viewership of 1.54 billion viewers in 2022. Formula One is a sport that consists of impressive machinery and equally impressive divers driving the vehicle to push them to their limits.

Formula SAE is a student competition that emulates Formula One. It is an international competition, where engineers come together to build a formula style race car. It is highly competitive and focuses on the design, safety, and performance of the vehicle, much like formula one. One of the critical components in a formula-style race car is the drive shaft, which transfers power from the engine to the wheels.

The driveshaft is an important part of every vehicle, but its importance definitely grows exponentially when it comes to high speed motor racing. A broken driveshaft means that the car wheels don't turn the way the driver intends for them to turn and that means tragedies can occur. The drive shaft is what acts like a bridge between the differential and the rear wheel hubs. If a driveshaft is not designed properly it can affect the performance of the vehicle in many different ways. It can be a source of intense vibration, which can be a huge problem when a vehicle is being driven at speeds upwards of 300 kmph. A high performing drive shaft is the difference between the wheel turning at a 5 degree angle which will help the F1 driver win the race or a 6 degree angle which will cause the drive to crash out. This project models this driveshaft using Formula SAE vehicles as a benchmark to determine what strength material one must use to have a high-functioning Formula SAE car.

II. Literature Review

When it comes to the designing of a Formula SAE car, the material that is chosen for the driveshaft is extremely important. The material needs to be one that is strong and durable, but not something that is overly heavy as that will weigh the car down and compromise the speed that the car achieves. Common driveshaft materials used in racing are carbon fiber, titanium and aluminum because they are strong, durable and lightweight. Another important consideration is the length and diameter of the drive shaft. The length and diameter must be optimized for the specific application to ensure maximum power transfer and minimize weight. The drive shaft must also be designed to fit within the limited space available in the race car. The driveshaft regardless of the material must adhere to all the rules set by the SAE organizers for it to be fair.

There are many different types of driveshafts that one can choose from depending on the needs that the designer of the vehicle wants to prioritize. But all of the various types of drive shafts must be able to withstand the forces that are applied onto it. One of the forces that a drive shaft is likely to experience are torque or rotational force. This force is usually transmitted from the engine to the driveshaft and then to the wheels. Due to torque the drive shaft often feels torsion. Due to formula style driving involving accelerating, braking or cornering the driveshaft also experiences bending and axial force.

III. Methodology

First, the Formula SAE car that is now used for research purposes at Rochester Institute of Technology used as the baseline for this paper. Each car is different and the driveshaft will be designed on the basis of the needs of the designers and what they wish to extract from the vehicle.

The original method of research was to measure the drive shaft of the FSAE car that is at RIT. Then those measurements were going to be used to create a Kisssoft rendering of the driveshaft. Once the Kisssoft rendering was generated, torsional force and stress would be applied to see how the material reacted. Whether or not the results differ on the basis of the material chosen- AISI 1025 Carbon Steel or Carbon Steel. If the results differed dramatically, then a determination would be made as to which material suits the needs of the FSAE car the best on the basis of what needs to be prioritized for the vehicle.

But because the computer that was used to do all the analysis and the held all the data, got corrupted and due to a deadline that needs to be adhered to. The paper will be taking a look at the data that a fellow colleague in this field has generated in the same way that this paper intended on doing, and will be analyzing that data.

IV. Results

Since we are considering only torsion and stress acting on the results were pretty straight forward. The results were measured from the left shaft perspective and the right shaft perspective for a 23mm shaft. The images below show the FEA on the shafts.

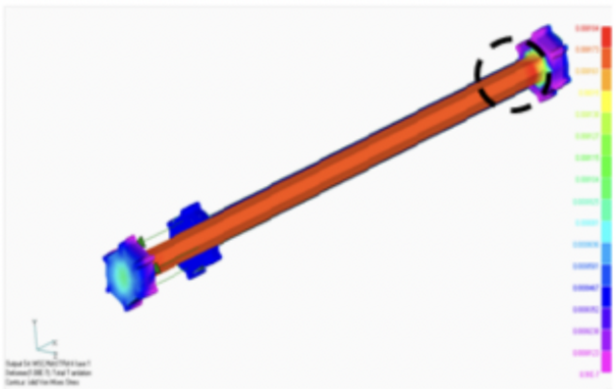

Figure 1.1- Horizontal Stress on an AISI 1025 Carbon Steel Left Hand Side Shaft [9]

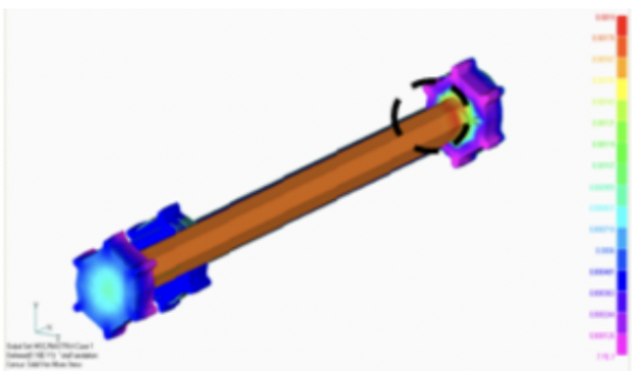

Figure 1.2- Horizontal Stress on a Carbon Steel Left Hand Side Shaft [9]

Material	Right Shaft	Left Shaft
Carbon Steel	1.69 E-11 mm	1.16 E-11 mm
AISI 1025	1.49 E-07 mm	1.08 E-7 mm

Table 1- Horizontal Stress on Left and Right Hand Side Shaft [9]

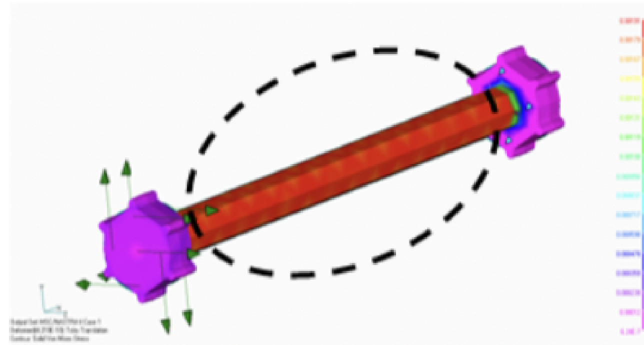

Figure 2.1- Rotational Torsion on a Carbon Steel Left Hand Side Shaft [9]

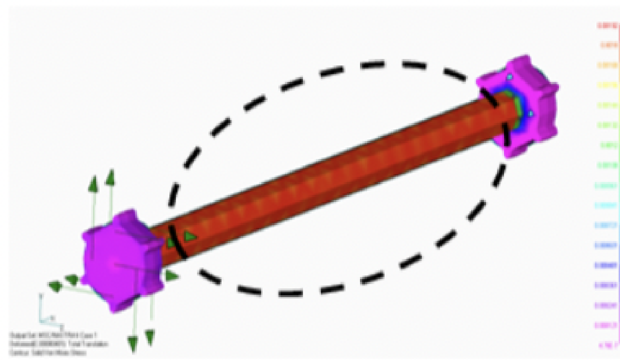

Figure 2.2- Rotational Torsion on an AISI 1025 Carbon Steel Left Hand Side Shaft [9]

Material	Right Shaft	Left Shaft
Carbon Steel	6.25 E-10 mm	4.22 E-10 mm
AISI 1025	5.55 E-07 mm	4.01 E-07 mm

Table 2- Rotational Torsion on Left and Right Hand Side Shaft [9]

V. Analysis and Recommendations

Since the characteristics that we have deemed important when choosing a material for the driveshaft of a FSAE car are durability, strength and lightweightedness. Since the two metals are similar in terms of lightweightedness, the only other two factors that are left are durability and strength. These factors were put to the test under the FEA that was conducted.

It is clear by looking at the numbers on the table that Carbon Steel is the obvious choice for a couple of reasons. The effect of rotational torsion and horizontal stress on carbon steel is far lower than the effect on AISI 1025 Carbon Steel. The value is also fairly even whether it is being applied on the right shaft or the left shaft. This is especially important as we want the drive shaft to be pretty balanced so the car is not biased towards one side. The difference between the right side and the left side is pretty negligible for carbon steel and not as negligible for AISI 1025 Carbon Steel. While this difference might not be noticeable at lower speeds, it will definitely be noticeable at higher speeds which is what F1 cars, and FSAE cars drive at.

VI. Potential Improvements

Since the numbers are not my own and are from a model that was created by someone else, it is hard to suggest any potential improvements. But one big thing would be to conduct my own analysis and mathematical model to have better control. Another thing would be to check how the weight of the material that I have picked affects the way it reacts to these forces. Consider changing up the design for the driveshaft to see if that helps in reduction of deformation.

VII. Acknowledgments

I would like to thank Professor Salman Pervaiz because without his motivation, support and teachings, I would not be in position to complete this paper. The fact that he gave me the freedom to pursue a topic in my passion really means a lot and I am glad that as a result of his class I am a better engineer. I would also like to thank my parents and my brother for supporting me while I was writing this paper. All the little gestures that you did for me did not go unnoticed, even if might have felt like it. I would not be the engineer that I am today without my family's support.

VIII. References

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1