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Design and Analysis of the Suspension Upright Structure of a Formula SAE CCar

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Abstract

The suspension system is one of the most important parts of a vehicle. It plays an important role in the absorptions of shocks and impacts. It also determines the safety and rigidity of the rear and front arm connection of vehicle. The objective of this study was to design a new suspension system for a Formula SAE Competition. The scope and parameters are identified with the selection of a racing car wheel and tires and availability of current resources from previous research projects such as car chassis and lower and upper double A-arm. The upright structure was designed in certain steps to reduce weight by minimizing the surface area at the same time by considering the strength of the material. Results showed that the geometry with the lowest stress is at 8.037 MPa with a length of 220 mm and width of 120 mm. The simulation provided a concrete data of how the structure behave with different dimensions but also the most critical point is attaining the equivalent stress of the designed structure. For future studies, improvements can be done by changing the parameters and conduct experimental method to see any deviations from the theoretical/simulation results.

Keywords

Blended learning, Challenge, Higher learning Education.

Introduction

In the automotive engineering field there are various types of vehicles such as conventional use vehicle and competition types of vehicles (Mitra et al., 2018). The Formula racing car is one of the most popular car racing competition in the world (Browne et al., 2014;). There are many classes of the formula racing competitions. One of the competitions that is created solely for university

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students is called the Formula SAE which is organized by the Society of Automotive Engineers SAE international (Azmeer 2017). The competition consists of two events which are the static and dynamic events. The statics event is the presentation of the car along with the cost and design analysis. Whilst, the dynamic conditions include tests such as: acceleration, skid pad, auto cross, and endurance and fuel economy (Mihailidis. 2009). All of the criteria and requirements are followed by the FSAE rules (Fsaeonline.com, 2018). There are many components and a number of systems that need to be taken into consideration in successfully building a FSAE car; for instances, the suspension system, chassis or frame, engine, braking system, wheels and tires etc. The suspension system is attached to all four wheels of the car from the chassis. Whereas the chassis is the whole back bone or body of the car. The upright structure is one of the component of the suspension system that is used to provide a physical mounting and links the suspension arms to the hub and wheel assembly (Ning et al., 2011).

All suspension components such as control arms, steering arms, springs, shock absorbers, brakes, tires and axels are all connected to the upright (Garg, 2017). All of the interactions will go through the upright system, thus, it need to be critically designed. This is because due to the complexity of the design and chosen material it can determine the whole stability of the car. Any error or incorrect analysis might lead to failure of the whole chassis in accordance to the FSAE rule and regulations. Henceforth, the FSAE rule stated that the upright design will be followed by the specifications of the wheel which should 203.2mm or more in diameter.

The objective of this study was to design a new suspension system for a Formula SAE Competition. The design of the upright structure will be based on the dimension of the rims as well. In between the distance of the rims the upright will be placed there and the upright will be designed not to collide with the rim.

Methodology

Parameters have been identified following a filtering of the dimensions available from the upper and lower arm. The steering tie rod and the design process of the upright structure is designed with references to previously available sources. Figure 1 shows the design of the upright structure.

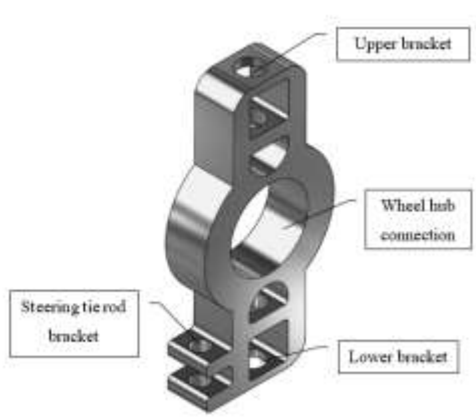

Figure 1. Design of the upright structure

The design of experiment analysis was used in the selection of the upright structure that has the lowest percentage of bending stress that can withstand various loadings from the forces. In order to select the strongest structure, a Finite Element Analysis was used to simulate the structure accordingly. The applied forces are on the upper arm and lower arm position and the fix point is at the wheel hub of the upright structure.

Results and Discussion

Table 1 shows results from the analysis of a 35 mm thickness structure. The geometry such as length are from 200 to 250 mm and the width are from 100 to 120. It is based on the parameters and limitation of this project and also the design as well considering the weight of the structure and also the size of the whole upright structure. In order to select the structure with the lowest stress, the results are needed to be chosen. The data can be generated into a graph which is shown in Figure 3. The y-axis represents the equivalent Von-Mises stress of the structure where the x-axis represents the length of the structure. The different coloured lines represent the different width of the structure. As mentioned above, the best structure theoretically need to have the lowest stress possible which states that it has the less deformation. There is some variation in the resulting stress from the table due to the changes in length and width.

Hence, from the findings, it can be seen from Table 1 and Figure 2 that the geometry with the lowest stress is at 8.037 MPa with a length of 220 mm and width of 120 mm. Not only that this method provides a concrete data of how the structure behave with different dimensions but also the most critical point is attaining the equivalent stress of the designed structure. This structure with the following dimension will be selected for the design and also the complete and full model for this project. Figure 3 shows the stresses on the upright structure.

Table 1. Result of design of experiment method

Thickness 35mm	**Width/Base (mm)**				
Length/Height (mm)	100	105	110	115	120
200	9.838	9.639	8.719	9.299	8.296
205	10.081	9.169	9.199	9.095	8.801
210	9.753	9.504	9.461	9.072	8.776
215	9.969	9.958	8.565	8.427	8.431
220	8.806	9.231	9.354	8.906	8.037
225	9.929	9.616	8.557	8.705	8.502
230	9.724	9.751	8.944	8.375	9.653
235	9.208	9.714	8.918	8.798	8.192
240	9.859	9.661	9.157	8.874	8.165

245	9.525	9.803	8.699	8.949	8.733
250	9.453	9.562	9.016	8.481	8.721

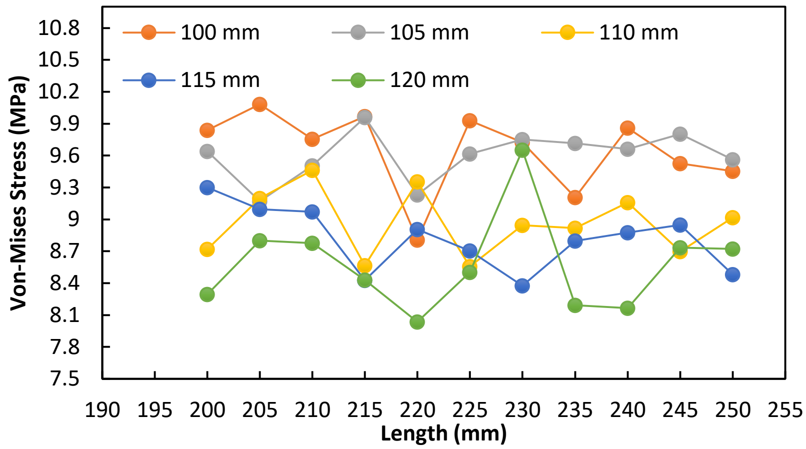

Figure 2. Von-Mises stress versus length

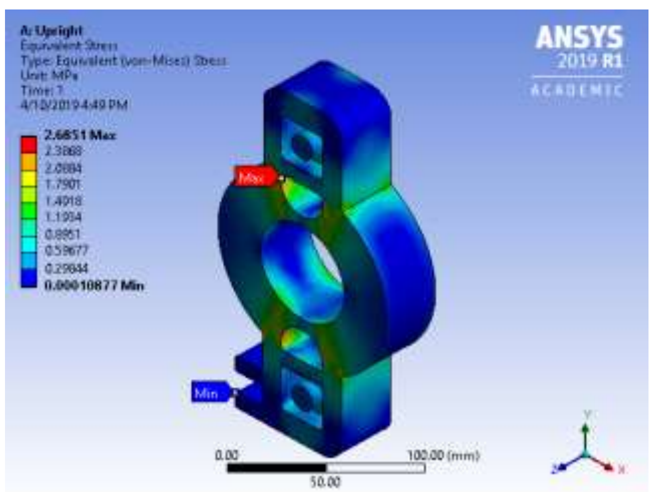

Figure 3. Finite element analysis of the structure

Conclusions

This paper presents the design and analysis of the suspension upright structures of a formula SAE car. It can be seen from the methodology of this project that the parameters in designing the upright has been identified. Upon investigating the parameters, the design process also undergoes a thorough check in order to ensure the best design is selected out of the parameters. The results have successfully shown that the geometry with the lowest stress is at 8.037 MPa with a length of 220 mm and width of 120 mm. This project has been done with one specific wheel size.

Improvements can be done by changing the parameters and conduct experimental method to see any deviations from the theoretical/simulation results. One of the points would be by increasing or decreasing the parameters which are all dependent on the wheel and tire size.

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