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Design & Analysis of Wheel Assembly for FSAE F3 Vehicle

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ABSTRACT

Generally, in automotive industry, weight reduction, cost of engineering design and reduction in vehicle development cycle time are becoming increasingly focused on. In order to tackle this, Computer Aided Engineering (CAE) is popularly being used to lead design process.

The aim of our project is to design, optimize and manufacture the wheel assembly to compete in SAE-SUPRA competition. In this project we are going to design the wheel assembly for proper mounting of accessories, for fast response on track, better stability and reduction in the vibration. We are focusing on each and every point of wheel assembly to improve the performance of vehicle without failure of vehicle. The major challenge is to rigidly manufacture a light weight wheel assembly at minimal expense without compromising the driver safety. We are going to validate our design by using Solid works 3D cad Software.

KEYWORDS: *Formula SAE, Ansys, Hubs, Uprights*

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INTRODUCTION

In automotive suspension, a steering knuckle is that part which contains the wheel hub or spindle and attaches to the suspension and steering components. It is variously called a steering knuckle, spindle, upright or hub, as well. The wheel and tire assembly attach to the hub or spindle of the knuckle where the tire/wheel rotates while being held in a stable plane of motion by the knuckle/suspension assembly in the attached photograph of a double-wishbone suspension, the knuckle is shown attached to the upper control arm at the top and the lower control arm at the bottom. The wheel assembly is shown attached to the knuckle at its centre point. Note the arm of the knuckle that sticks out, to which the steering mechanism attaches to turn the knuckle and wheel assembly. Steering knuckle is that component of a vehicle which connects the suspension system, braking system and the steering system to the chassis of the vehicle. A steering knuckle should have high precision, durability and low weight. The purpose of this study is to design a knuckle which is low in weight and has better performance with considerable factor of safety. The study is divided into two steps. The first step involves the designing of a steering knuckle with the help of designing software and by estimating the loads which are acting on the component. The second part is carrying out FEA on the component to find out the stresses induced and the deformation. This will help in optimizing the knuckle. After the analysis is done, the knuckle can be optimized by removal of materials where the induced stress is low.

Project Objectives

The objectives for the design and optimization of the SAE Vehicle Upright Assemblies are listed as followed:

- Less Weight: Compare to 2018 design.
- Maintains Stiffness: Achieve the same level of stiffness when compared to the 2016 design.
- Maintain Serviceability/Reliability: Achieving the same serviceability and reliability exhibited with the 2018 design.

These goals can be verified through FEA, physical testing, and actual on track performance of the vehicle. Though for the purpose of the report and due to the importance of the finished product, no actual destructive testing will be performed on the finished assemblies.

Principle components

1. Front hubs

The front hubs provides mounting holes for both wheel rim and brake rotor. The rim fits with 4 holes PCD 100mm and 12mm bolt diameter. A central shaft connecting these mounting points is designed with groves cut for inserting the roller bearings at the two ends of the hub. Front Hub modelled in CATIA V5 R20, After modelling of the hub in Solid Works, the model was meshed in ANSYS WB. For the impact analysis, the central axial shaft was given a roller support and Force of 3g was applied on the mounting holes of the wheel rim in upward direction.

An upright is one of the key components in vehicle dynamics which connects all suspension components between the wheel and the car. The uprights provide a link between the upper and lower ball joints. The upright connects components for example, the control arms, steering arms, springs, shock absorbers, brakes, tires and at the rear it connects the axles. Since it is a key component it must withstand all forces that the suspension will encounter. The uprights must be strong enough to withstand those forces, sum may occur simultaneously for example during braking into a corner. As for this design, the goal is to design a light, yet sufficiently strong uprights that can withstand the forces that the new FS car will encounter.

Figure: Front hub Model

Figure 4.1.1: Front upright Model

Upright

Ansys Report

Table: 5.6.1 Loads on Rear Hub

Direction	Magnitude	Situation
Brake moment	1700Nm	Braking
x	6278 N	Acc/braking
y	6278 N	Bump
Z	9418 N	Engine torque
Torque	37Nm	

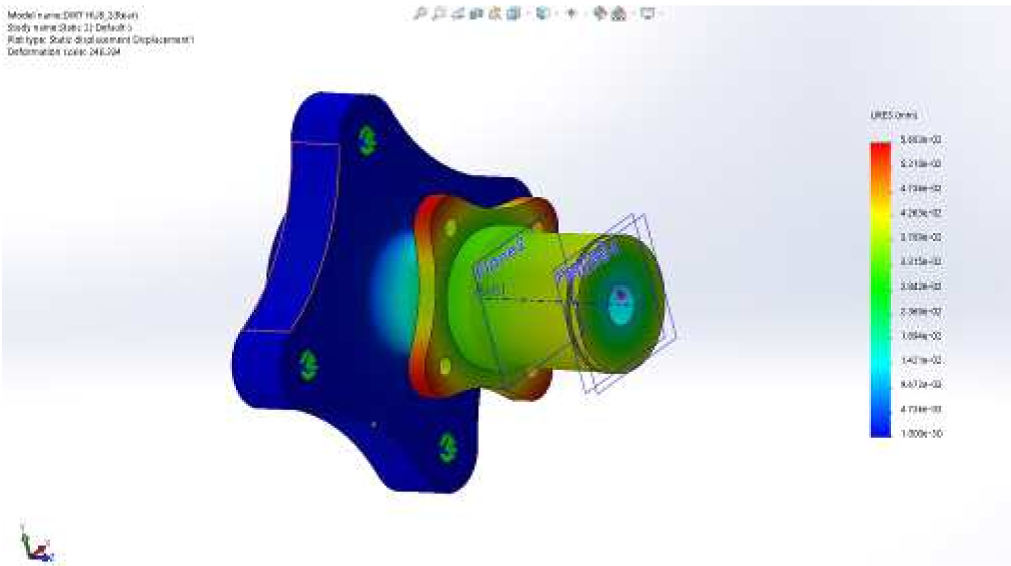

Figure.5.6.1 Rear Hub Forces Analysis

Direction	Magnitude	Situation
Brake moment	1700Nm	Braking
X	6278 N	Acc/braking
Y	6278 N	Corner
Z	9418 N	Bump

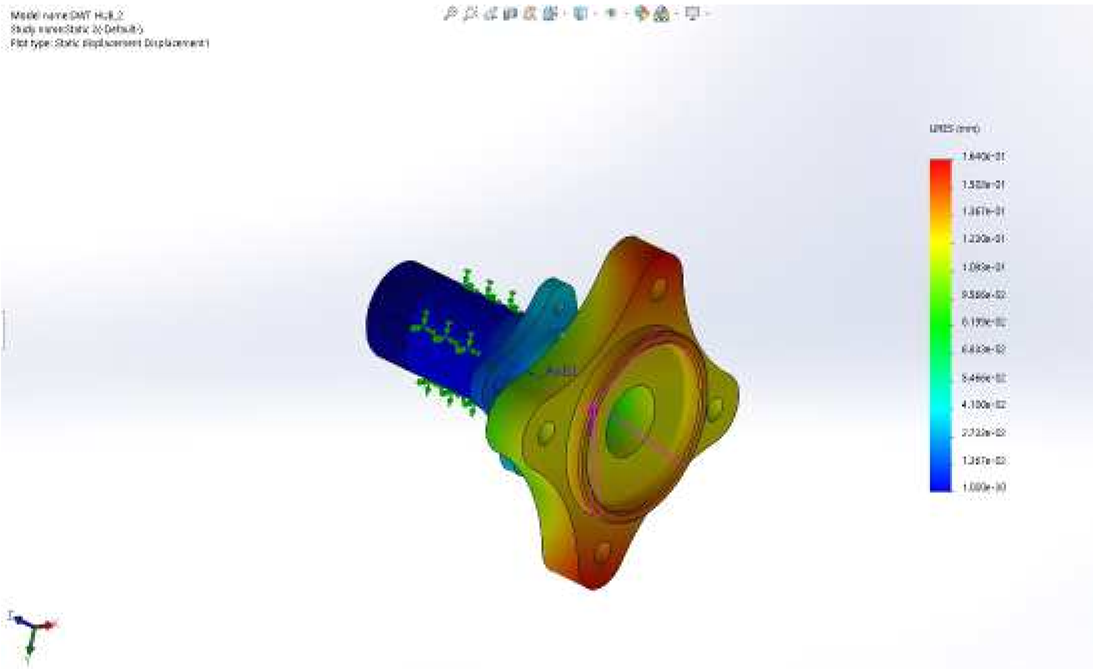

Figure.5.4 1 Forces on Front Hub Analysis

Table.5.2.l load on front upright

Direction	Magnitude	Situation
Steering rack	1000 N	Steering effort
Brake moment	1700 Nm	Braking
X	6278 N	Acc/braking
Y	9418 N	Bump
Z	6278 N	Corner

Constrain points:

Loads are applied on the A arm mounting points from all three directions and bearing seat is kept constrain or fixed.

Solutions:

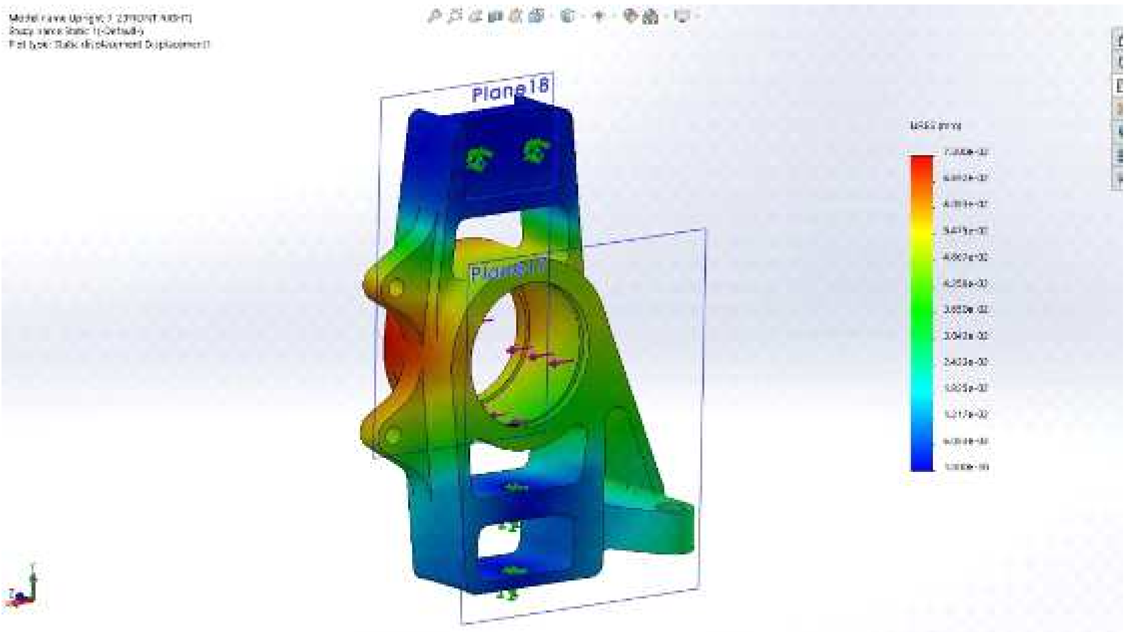

Figure: 5.2.1 Forces on Front Upright

Table: 5.3.l loads on rear upright

Direction	Magnitude	Situation
Brake moment	1700Nm	Braking
X	6278 N	Acc/braking
Y	6278 N	Corner
Z	9418 N	Bump

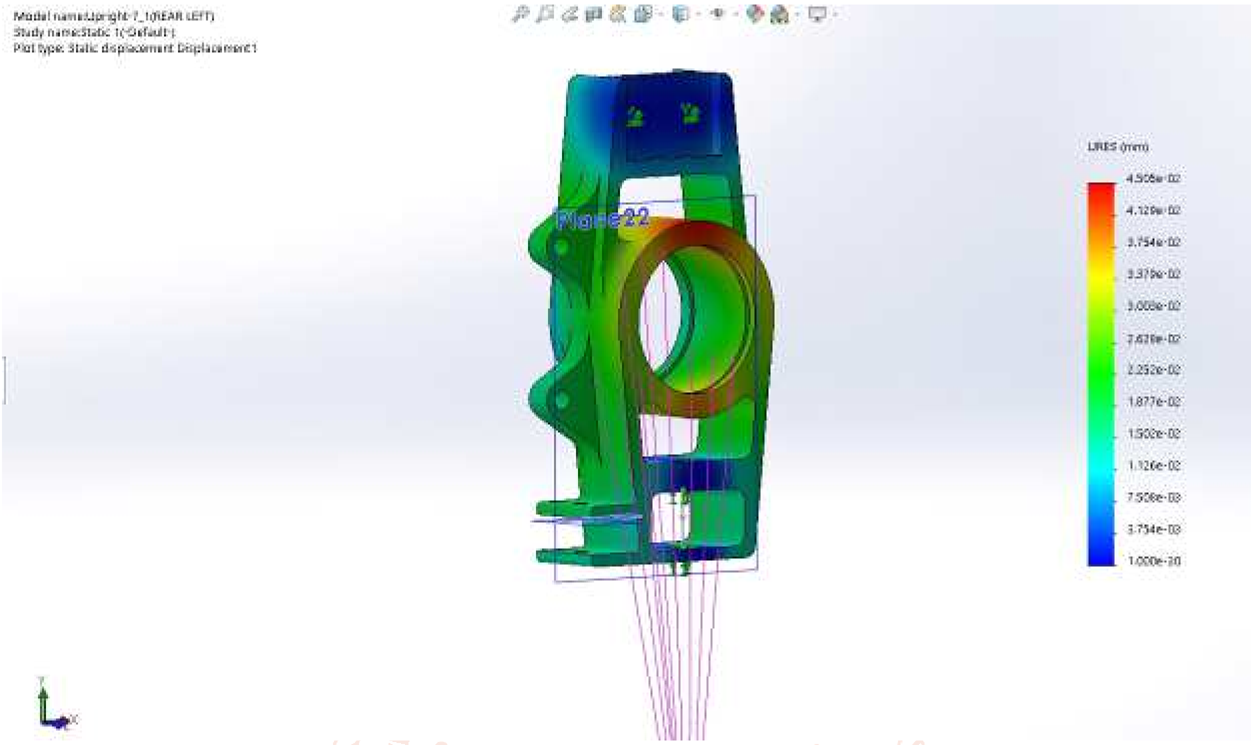

Figure: 5.3.1 Forces on Rear Upright

CONCLUSION

The deflection of the upright assembly will be on the basis of the optimization process. With stiffness being the performance standard and weight being the concern. the design goals are defined to be reduction in weight over the 2018 design with comparable stiffness. To optimize for weight, sheet metal thickness for different races of the upright are changed respectively based on the previous runs stress distribution and deflection value. the material thickness was reduced in the areas where stresses are in the limiting factor being stress cannot exceed the material limit. With allowable thickness value based on available stock material, a number of combinations were analysed and the optimum front and rear upright and hub designs were selected as the final designs.

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