Design, Modelling and Analysis of Front Wheel Assembly of Baja SAE Vehicle

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ABSTRACT: The purpose of the Society of Automotive Engineers (SAE) Baja Major Qualifying Project (MQP) was to analyze the pre-existing Baja SAE (BSAE) vehicles to determine flaws and design a new chassis that improved upon the previous designs. This MQP identified particular problems with the size of the engine compartment, the overall suspension alignment and attachment points, as well as the visibly crooked nature of the vehicle. After consideration of possible solutions, the MQP created various preliminary designs utilizing the Baja SAE Rules as a guide for design decisions. In this study we have perform the numerical solutions for different subsystems of Baja SAE vehicle to design the front wheel assembly. The modelling of front wheel done in auto desk fusion 360 software and assembly operations performed.

Key words: Design, Modelling, Fusion 360, SAE, MQP

I. INTRODUCTION

The purpose of this paper is to optimize the design of front wheel assembly of ATV for the better performance of the vehicle by reducing the weight of the components of front wheel assembly and also by changing the material properties of components of front wheel assembly. Therefore, the design should meet the following criteria, Lightweight to maintain good performance to weight ratio of the ATV. Optimum stiffness to ensure low system compliance and maintaining designed geometries. Ease of maintenance for enhancing serviceability and setup repeatability. As the name suggest, Front Wheel assembly consists of various component, as shown in figure 1, that are Assemble together to get a single complete unit. The complete wheel assembly is attached to the rim of the wheel, with the four mounting points on the one side and from the knuckle side; it is attached to the suspension control arms and the tie rod including both, with the three points. The front wheel assembly is used to allow the vehicle to move. Front wheel assembly connects the steering arm, which allows the driver to steer the vehicle, and the caliper is the component, which allows the driver to stop the vehicle with the help of Brake pads which mounts on the rotating disc.

The major problem of this assembly is that its weight includes in the unsprung weight of the vehicle which is totally undesirable. The unsprung mass of the vehicle has an impact on the various performance parameters of the vehicle while it is moving in dynamic conditions like problems in acceleration, braking, steering effort etc.

The objective of the research work is to design the front wheel assembly for ATV vehicle and further optimizing it by reducing its weight. The sub objective of the paper includes:

1. Study of static and dynamic parameters of the wheel assembly.
2. Study of suspension, steering, braking systems and parameters affecting its performance.
3. Workout the parameters by analysis, design, and optimization of the system.

II. METHODOLOGY

The design and optimization of the front wheel assembly has a very wide scope. The designers modify and optimize the front wheel assembly especially the hub and knuckle in order to reduce the unsprung weight of the vehicle which in turn improves the overall performance of the vehicle. This is very vastly seen in the student integrated competitions at college level. The front wheel assembly is excessively integrated in the automotive industry as well. This results in overall weight reduction of vehicle, fuel efficiency which is an important matter of concern these days.

In this report, firstly calculations are done on steering, braking, and suspension subsystems. For the design of steering and suspension system this report uses special type of ICR (instantaneous center of rotation) diagram and for calculating various parameters related to the front wheel assembly a extensive survey is done. For obtaining the vehicle behavior in various conditions special software is used called as LOTUS. The formulae derived are validated using design books and research papers. The points required to design the front wheel assembly were obtained.

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Then exact number of forces which are executed on the front wheel assembly are calculated.

The material of various parts in front wheel assembly are decided on the various properties and the forces acting on each component of the front wheel assembly. The points which are considered while selecting the material were density, bending strength, shear strength, strength per unit weight of the material, elasticity, availability, cost, machinability etc. Low cost, high strength, easily available and light in weight material is selected.

The design was accomplished on designing software named CATIA (ACADEMIC SOFTWARE) provided by Dassault systems Pvt. Ltd. The software was chosen due to its simplicity in designing moreover most of the leading automobile companies prefer CATIA. Then the front wheel assembly was analyzed using a FEA software called as ANSYS (ACADEMIC SOFTWARE) provided by ANSYS INC. Experimental validation is done on the universal tensile machine. The front wheel assembly is used on the off-road track. Various tests were performed on the vehicle with thirteen laps of endurance.

Further the design of the front wheel is optimized repeating then above procedure to give extreme performance on extreme terrains. The major goal is to reduce the weight by fifty percent without disturbing and compromising on the stress handling capacity of the assembly.

STEERING SYSTEM

Steering is the collection of components, linkages, etc. which allows any vehicle (car, motorcycle, bicycle) to follow the desired course. Steering system is used to control directional characteristics and the stability of the vehicle. Typical target for a designer is to try and achieve the least turning radius so that the given feature aids while maneuvering in narrow tracks, also important for such a vehicle for driver's effort is minimum. The next factor to take into consideration deals with the response from the road. The response from the road must be optimum such that the driver gets a suitable feel of the road but at the same time the handling is not affected due to bumps. Lastly the effect of steering system parameters on other system like the suspension system should not be adverse.[4]

Research and comparison were made between multiple steering systems. A steering system that is easy to maintain, provide easy operation, excellent feedback, cost efficient and compatible to driver's ergonomics is needed. Thus 4 bar linkage centralized point steering system was selected. The front track width is increased than rear track width to improve the lateral stability according to off road conditions. Rear track width is kept slightly less than front track width to create a slight over steer in tight cornering situation which allows easier maneuverability at high speed. [11]

Significance of Steering in Front Wheel Assembly

The function of steering system is to steer front wheels in response to driver's command inputs in order to provide overall directional control of vehicle. This is directly related to the front wheel assembly as it transfers motion to the tires. Tie rod is connected to steering arm of the knuckle, the linear motion of the tie rod is converted into angular motion of the knuckle which in turn results in angular motion of the tire. The basic objective to study the steering system is to calculate the length of the steering arm required, length of the total wheel assembly and force exerted on the knuckle by tie rod. [11]

III. RESULTS OBTAINED

CAD MODELS OF WHEEL ASSEMBLY

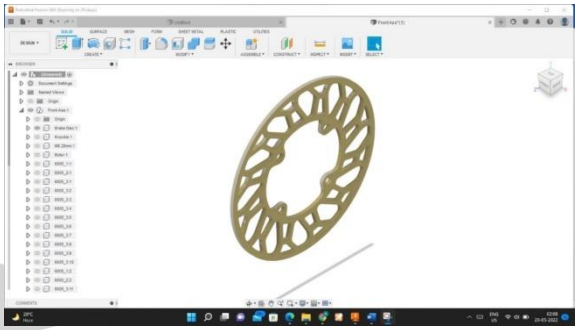

Figure 1 Designing of Disc Brake

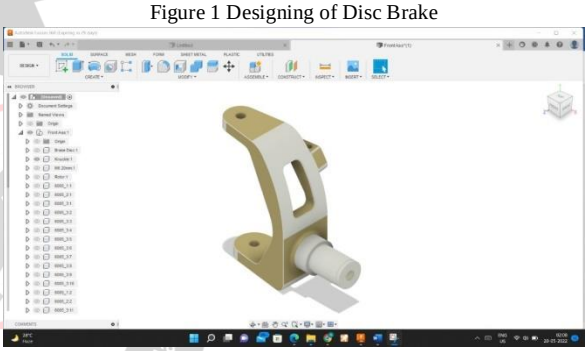

Figure 2 Knuckle with Stub Axle

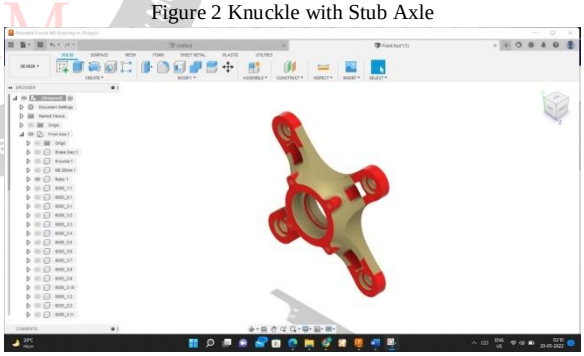

Figure 3 Wheel Hub

IV. CAD MODEL OF COMPLETE ASSEMBLY

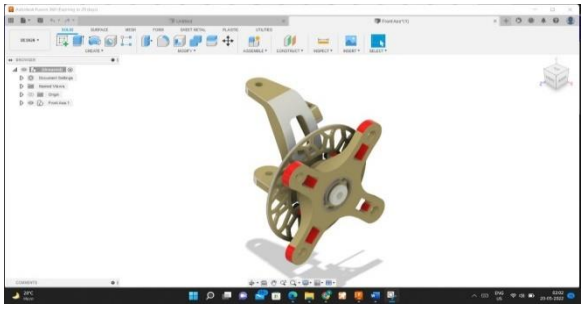

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Figure 4 Isometric View of Front Wheel Assembly

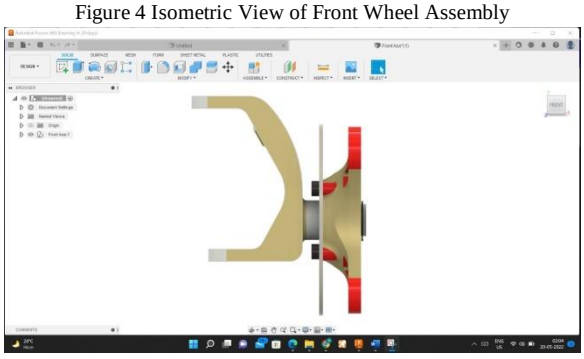

Figure 5 Front View of Front Wheel Assembly

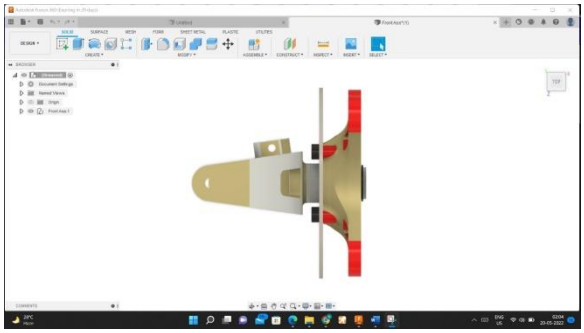

Figure 6 Top View of Front Wheel Assembly

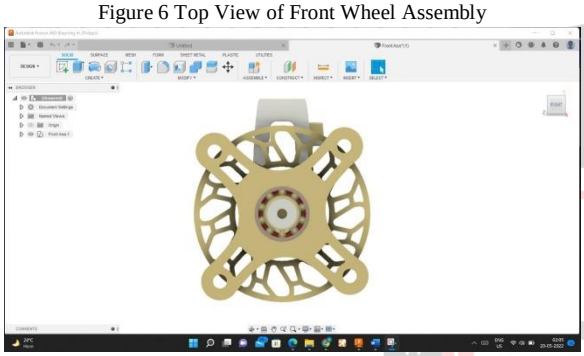

Figure 7 Left Side View of Front Wheel Assembly

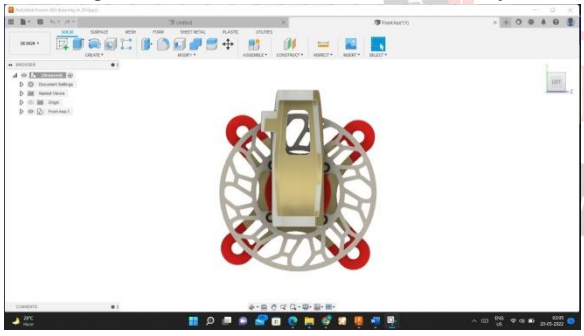

Figure 8 right side views of front wheel assembly

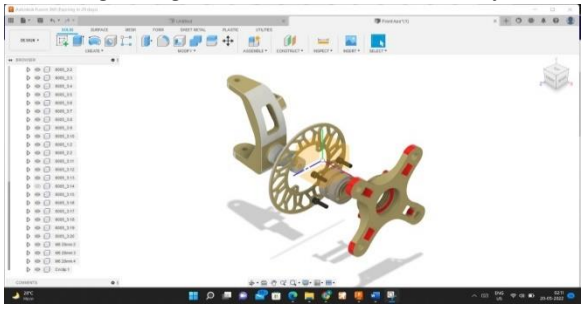

Figure 9 exploded view of front wheel assembly

V. CONCLUSIONS

1. All parameters affecting the front wheel assembly are studied thoroughly in this report.
2. Each and every force acting on the wheel assembly is calculated using standard formulas.
3. All the components of the front wheel assembly are designed
4. CAD Model of the front wheel assembly is made with the help of calculated dimensions.

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