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Design and Analysis of Electric VehicleSuspension

Saurav Rebhankar[1], Ritesh Raj[2], Akash Sambare[3], Prof. Sagar Shinde[4]

Department of Mechanical Engineering, SKNCOE Pune

***Abstract*— Suspension system is one of the most important parts of an automotive. This system is to reduces shocks and vibrations in vehicle, balancing loading thus helping in stability of motion and providing comfort to drivers. The presented work discusses design and analysis of Double wishbone suspension system used for an Electric Vehicle. Design of Spring and Shock absorber was considered. Further modelling was done by CATIA. Models of suspension spring was further analysed using ANSYS 22 based finite element software. Stress concentration was within the allowable limits; hence the design was safe from structural failure. Compiled in this reportare the specifications of the components that will be integrated into our suspension system.**

***Keywords*— Suspension, CATIA, Ansys, Double Wishbone,**

I. INTRODUCTION

Suspension is the system that connects the vehicle body (chassis) to its wheels and allows relative motion between the two and hence isolating the vehicle from road shocks. The suspension system consists of springs, dampers (shock absorbers), linkages, tiers and air which are filled in those tires which absorbs shocks and provides better road holding/handling and ride quality to occupants during driving, cornering, and braking. There are different types of suspension systems are available.

There are 3 types of Suspension system in automobiles – Dependent Suspension, Independent Suspension and Semi-Independent Suspension.

1) *Dependent Suspension -*

In Dependent Suspension there is a rigid linkage between the two wheels of the same axle. A force acting on one wheel will affect the opposite wheel. For each motion of the wheel caused by road, irregularities affect the coupled wheel as well. It is mostly employed in heavy vehicles. It can bear shocks with a great capacity than independent suspension. Example of this systemis Leaf Spring suspension, Solid Axel suspension, Coil Spring suspension, Torsion bar.

2) *Independent Suspension -*

This system means that the suspension is set-up in such a way that allows the wheel on the left and right side of the vehicle to move vertically independent up and down while driving on an uneven surface. A force acting on the single wheel does not affect the other as there is no mechanical linkage present between the two hubs of the same vehicle. In most of the vehicle, it is employed in front wheels. This type of suspension usually offers better ride quality and handling due to less unsprung weight. The main advantage of independent suspension is that they require less space, they provide easier steerability, low weight etc. Example of this system is Double wishbone suspension, MacPherson strut, trailing arm suspension, Pushrod and pull rod.

3) *Semi Independent Suspension -*

This type of system has both the characteristics of a dependent as well as independent suspension. In semi-independent suspension, the wheel moves relative to one another as in independent suspension but the position of one wheel has some effect on the other wheel. This is done with the help of twisting suspension parts. Example of semi-independent is Twist Beam Suspension.

Double Wishbone Suspension:

It is an independent suspension system design using two wishbone-shaped arms (called A-ARM WISHBONE) to locate the wheel. Each wishbone or arm has two mounting points to the chassis and one joint at the knuckle. The angle movements of the compressing and rebounding wheels can be managed by using arms of unequal length. The main advantage of the double- wishbone suspensions is that they allow easy adjustments of camber, toe and other properties. This type of suspension also provides increasing negative camber gain all the way to full jounce travel. On the other hand, it takes more space and is slightly more complex than the other system like Macpherson strut. It also offers lss design choice.

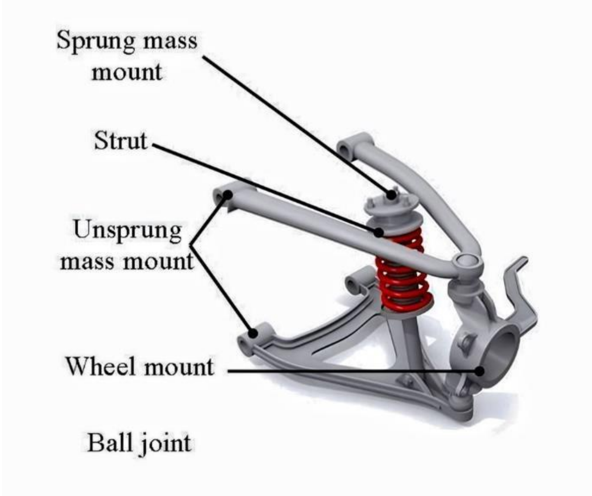


Fig. 1 Double Wishbone Suspension

Typically, this suspension system is found in higher-end luxury cars. A number of vehicles also use this setup in off-roaders because the travel of the suspension setup is long, and it can take care of larger bumps and potholes with ease. If comfort and handling is your priority, Double Wishbone setup is one of the best suspension systems out there at the moment.

II. Objectives

1) To Design and create CAD model of a Double A Arm Wishbone Suspension.
2) To select suitable material.
3) To conduct Analysis of the model using suitable material for e.g., Mild stone, Aluminum, EN-19, etc.
4) To check the performance of the suspension for the given material.
5) To calculate various load factors like Total Deformation, Stress, Factor of Safety using Ansys.
6) To fabricate the components of suspension.

III. Methodology

From the literature it is learned that how 3D CAD model is to be prepared and the calculations which are to be solved. The conditions required for applying various loads on suspension system is briefed in the research papers referred. The primary objective of this project is to improve the efficiency of vehicle suspension, which is a critical system that connects the vehicle body (chassis) to its wheels and allows relative motion between the two, thus isolating the vehicle from road shocks. To achieve this objective, we needed to study the various types of suspension systems used in vehicles, including their components, design, material, analysis, and manufacturing.

For this project, we focused on the double A-arm wishbone suspension system and designed it using 3D software such as CATIA V5. After creating the CAD model, we performed meshing using finite element analysis to determine the strength of the material used in the suspension system. The geometry was then validated using Lotus software to ensure that it met the required specifications and performance criteria. To ensure that the suspension system is efficient, we calculated the forces acting on the system and selected appropriate materials that fulfilled the required criteria of lightweight and durability. We then analysed the wishbones in detail, considering various factors such as static structural load, total deformation, equivalent stress, and safety factor.

Finally, we fabricated a physical model of the suspension system based on the design and analysis results. This allowed us to evaluate the performance and efficiency of the suspension system in real-world conditions and identify any areas for further improvement.

Overall, this project demonstrates the complex and multi-disciplinary nature of suspension system design and analysis, requiring expertise in materials science, mechanical engineering, and software analysis. By focusing on key design considerations and using advanced tools and techniques, we were able to improve the efficiency and performance of the vehicle suspension system, contributing to the development of more efficient and sustainable transportation solutions.

1) *Design* - Modeling for this project was prepared by designing in CATIA V5R21. Following are the CAD models of components of the Double Wishbone Suspension.

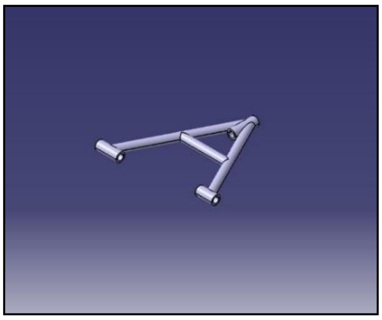


Fig. 2 Front Lower Control Arm

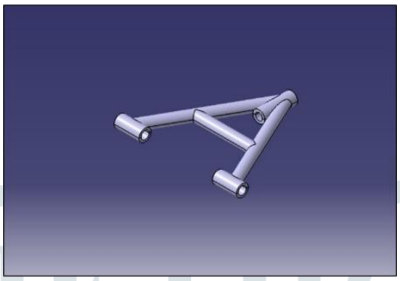


Fig. 3 Rear Upper Control Arm

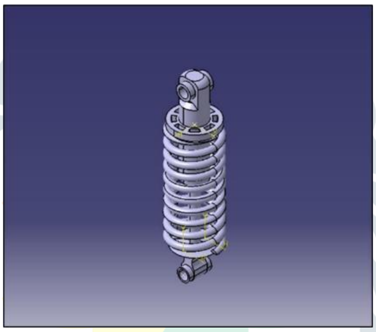


Fig. 4 Shock Absorber

2) *Analysis* – An Analysis of all the components was done in order to compare the various load factor like Stress, Totaldeformation, Factor of Safety for different materials in analysis software Ansys R1 2022.

3) *Material Selection* – It is one of the most important factor in designing of suspension. For suspension of electric vehicle, it must be light weight, more stress absorber, with greater factor of safety and also cost efficient. Some of thematerials considered for comparison were EN-19, Mild Steel, AL 7075 T6, AL 6061.

IV. CALCULATIONS

Force Calculations for Front axle -
Total weight of the vehicle: - 200 kg
Force exerted by the vehicle (W) = 200x 9.81 = 1962 N

Load on front axle (Fa) = W x (Dist. of CG from front Axle/ track base)
= 1962 x (685.476/1054.1 = 1275.87 N

Load on each wishbone (f) = Fa/2 = 1275.87/2 = 637.935 N
This force is in static conditions but in actual practice, more force will act on the wishbones. At the bump, the maximum loadwill act on the wishbones.

Let us assume 3G force at the time of bump. Therefore, max. Force F = 3 x f = 3 x 637.935 = 1913.805 N

Since this FOS is greater than 1 the working stress is well under the allowable stress and the design is thus

safe.Force Calculations for Rear axle –

Total weight of the vehicle: - 200 kg

Force exerted by the vehicle (W) = 200 x 9.81 = 1962 N

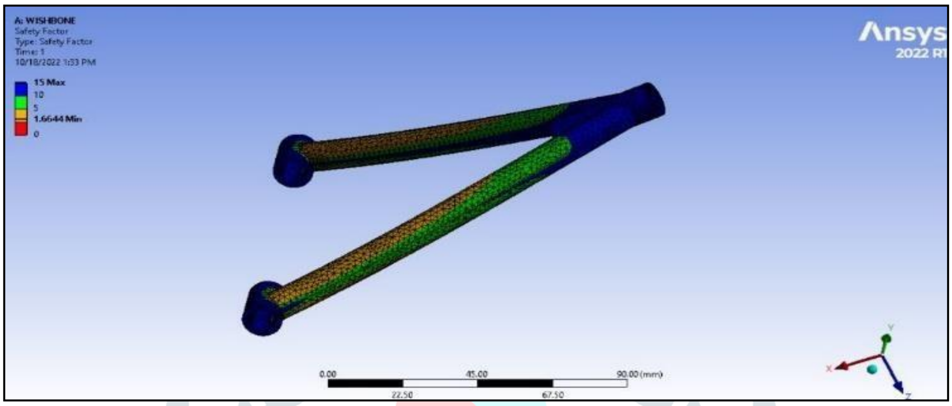
Load on Rear axle (Ra) = W x (Dist. of CG from Rear Axle/ track base)
= 1962 x (413.88/1054.1) = 770.35 N

Load on each wishbone (R) = Ra/2 = 770.35/2 = 385.17 N

This force is in static conditions but in actual practice, more force will act on the wishbones. At the bump, the maximum loadwill act on the wishbones.

Let us assume 3G force at the time of
bump.Therefore, max. Force F = 3 x f
= 3 x 385.17 = 1155.51 N

Since this FOS is greater than 1 the working stress is well under the allowable stress and the design is thus safe.



V. Conclusions

The successful design and analysis of electric vehicle suspension involved several critical steps, including the creation of a 3D CAD model done in CATIA V5, the selection of appropriate lightweight materials, and careful analysis of various loads acting on the suspension components. Through the use of advanced analysis techniques like Ansys 2022, we were able to calculate the safety factors, total deformation, and equivalent stress in various parts of the suspension, including the damper, front and rear upper wishbones, front lower wishbone, and stud. Additionally, we estimated the cost of materials for each component, ensuringthat the design remained cost-efficient while meeting the criteria for lightweight and efficient materials.

For Damper, when various material were compared, it was found that Mild Steel having Density 7.89g/m^3 with reference taken from V. B. Bhandari, Yield Strength was found to be 370MPa which was not too maximum or minimum and the Factor of Safetywas greater i.e. 1.2. Thus Mild Steel was preferred.

Overall, this project demonstrated the importance of rigorous analysis and testing in the design of electric vehicle suspension, which is essential to ensure that these systems are safe, efficient, and reliable in the challenging conditions of modern transportation.

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