International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 859- 862 www.ijaem.net ISSN: 2395-5252

Double Whishbone Suspension: a review

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Date of Submission: 14-06-2023 Date of Acceptance: 24-06-2023

ABSTRACT: Progressions in science and innovation, powerful plans and recently progressed methods of manufacturing for the need to satisfy the client expectations and to give them better products has let to these developments. With the create and help of various mechatronic systems there is innovative progressions in different automobile areas and hence gave better performance output. A suspension system has responsibility of safety of both the vehicle and occupants by providing stability and comfort ride during vehicle running. Without the help of any suspension system, it would have made extremely hard for a driver to control a vehicle since all the shocks and vibrations would have been directly transmitted to steering without any damping. A double wishbone suspension allow for more control over the camper angle of the wheel, which describes the degree to which the wheels tilt in and out. They also help to minimize body roll and provide for more consistent steering feel.

KEYWORDS: dependent suspension, independent suspension, double whishbone

I. INTRODUCTION

Suspension system in an automobile is a system mediating the interface between the vehicle and the road, and their functions are related to a wide range of drivability such as stability, comfort and so forth. The suspension of modern vehicles need to satisfy a number of requirements whose aims partly conflict because of different operating conditions such as loaded/ unloaded, acceleration/ braking, constant/ variable terrain road, straight running/ cornering. For the purpose of ensuring the optimum handling characteristics of the vehicle in a steady state as well as in a transient state, the wheels must be in a definedposition with respect to the road surface for the purpose of generating the necessary lateral forces. When a tire hits an obstruction, there is a reaction force and the suspension system tries to reduce this force.

The suspension consists of spring, dampers and links that connect the tires to the springs anddampers. When the tire hits a bump or an obstacle on road, it would be subjected to some forces,which would get transferred to the chassis if they are not damped. These forces would cause chassisa permanent damage resulting in the breakage of the metal. The loads transferred strictly dependon the sprung and unsprung mass of the vehicle. The larger the ratio of sprung mass to that of theunsprung mass, the more stable the vehicle would be.

The main functions of the suspension system are as follows:

1. It helps to keep the tires in contact with the road.
2. Prevents damage to the chassis if any sudden forces are encountered.
3. Provides comfort to the driver
4. Supports the weight of the vehicle.

II. TYPES OF SUSPENSION SYSTEM

Generally, the suspension system is classified into two main types- Dependent Suspension System and Independent Suspension System.

2.1Dependent suspension system

This type of suspension system acts as a rigid beam such that any movement of one wheel is transmitted to the other wheel. Also, the force is transmittedfrom one wheel to the other. It is mainly used in rear of many cars and in the front of heavy trucks.

2.2. Independent suspension system

This type of suspension allows any wheel to move vertical without affecting the other wheel. Thesesuspensions are mainly used in passenger cars and light trucks as they provide more space for engineand they also have better resistance to steering vibrations

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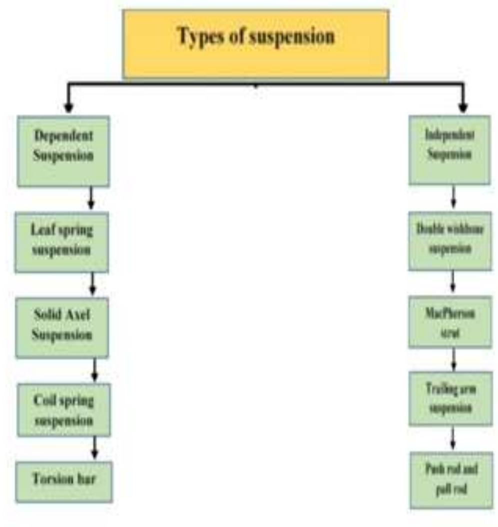

Fig.1 types of suspensions

III. DESIGN OF DOUBLE WHISHBONE SYSTEM

Double whishbone suspension is one of the independent suspensions. It is popular as front suspension mostly used in rear wheel drive vehicles. Design of the geometry of double wishbonesuspension system along with design of spring plays a very important role in maintaining the stability of the vehicle.

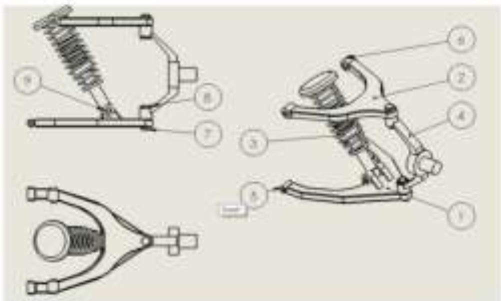

Fig.2 Assembly of double whishbone suspension

1. Bottom Wishbone
2. Upper Wishbone
3. Spring Damper
4. Partial Knuckle Hub Assembly
5. Bottom Wishbone pivot
6. Upper Wishbone Pivot
7. Bolt
8. Nut
9. suspension nut and bolt

Double Wishbone Suspension System consists of two lateral control arms (upper arm and lower arm) usually of unequal length along with a coil over spring and shock absorber. This type of suspension system provides increasing negative camber gain all the way to full jounce travel unlike Macpherson Strut. They also enable easy adjustment of wheel parameter such as camber. Double wishbone suspension system has got superior dynamic characteristics as well as load-handling capabilities.

Since the upper arm is usually shorter which induces a negative camber as the suspension rises, and this arrangement is often known as Short Long Arms suspension. When the vehicle is taking a turn, body roll results in positive camber gain on the lightly loaded innerwheel, while the heavily loaded outer wheel

The Four bar link mechanism formed by the unequal arm lengths causes a change in the camber of the vehicle as it rolls, which helps to keep the contact patch square on the ground, increasing the ultimate cornering capacity of the vehicle. It also reduces the wear of the outer edge of the tire.

IV. MATERIAL SELECTION

The most important part in designing and manufacturing of any component is the selection of the material. Few factors that are to be considered in the selection of material are like Availability, Cost of the material, Density of the material, Yield strength of the material, Weight of the material, etc.There are several materials that can be used for the manufacturing of the double wishbone suspension. For parts that required structural stability and light weight, Aluminium alloy (Al 7075-T6) was used whereas for the nuts and bolts, grey cast iron was used. The material for damper is chosen to be Neoprene (Rubber) and the spring was designed using Chromium Vanadium Steel (AISI 6150).

Table 1 gives the material properties of various components.

Material	Density (kg/m^3)	Young's Modulus (MPa)	Poisson's Ratio	Yield Stress (MPa)	Ultimate Tensile Strength (MPa)
Grey Cast Iron	7200	1.1E+05	0.28	190	300
Chromium Vanadium Steel (AISI 6150)	7850	1.9E+05	0.27	415	670
Aluminum Alloy (Al 7075-T6)	2810	0.717E+05	0.33	503	572

Table.1 materials and properties

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V. ANALYSIS OF SUSPENSION

Loading Conditions:

The system was subjected to the self-weight of the vehicle. The sprung mass was 13880.N. For a quarter car model, one fourth of the total load of the vehicle was carried by then suspension and the value is 3345N.

The static analysis of the front suspension was performed using ANSYS Workbench and from the results obtained, it can be observed that the majority of the deformation occurred in the spring damper system. The maximum deformation was recorded at 41.595mm. Fig. 4 gives the variation of Von Mises stresses. From the stress distribution it is observed that the external load was directly transferred onto the suspension system via the damper and spring system which caused it to compress due to the nature of a coiled spring. Hence this part experienced maximum stress. Static analysis also gives us information about the structural integrity of the system. It was observed that the double wishbone arms experienced minimum stress (due to the presence of the spring-damper system), and hence can withstand even heavy loads without undergoing any deformity. Since the wishbones are made of strong Aluminum alloy where the pivots are acted upon by a nominal load of 83.75N, the contact points at the pivot of the wishbones are subjected to negligible deflection or stress as evident from Fig. 3 and 4, the analysis proves the safety of the design for static conditions. This is because the maximum stress induced in the coiled spring does not exceed the yield stress value of the material from which it is made.

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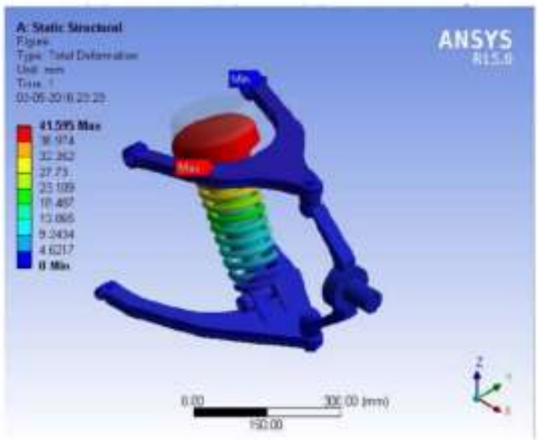

Fig. 3. Vriation of deformation

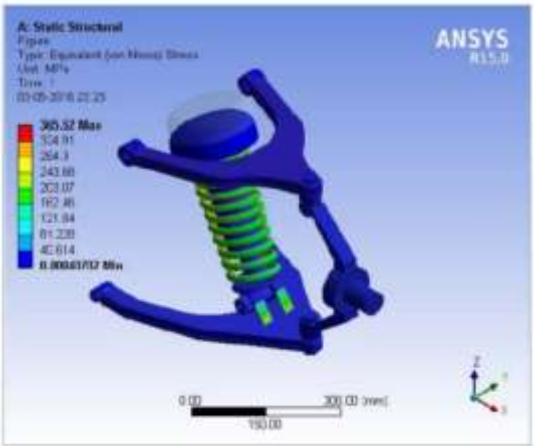

Fig. 4. Variation of Von Mises stress

VI. SIMULATION OF SUSPENSION SYSTEM

Lotus Engineering Software has been developed by automotive engineers, using them on many powertrain and vehicle projects at Lotus over the past 15 years. It offers simulation tools which enable the user to generate models very quickly, using a mixture of embedded design criteria and well-structured interface functionality.

6.1. Suspension Geometry in Lotus

Lotus simulation software has been used to simulate the suspension geometry of double wishbone suspension system. Various co-ordinates of the entire system are given as input and the virtual model is built. It looks like as shown:

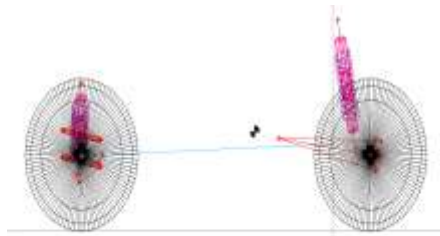

Fig. 5. Suspension geometry in Lotus

6.2 camber change in bump

Camber change in bump has been simulated using Lotus simulation software. The camber change in bump looks like as shown:

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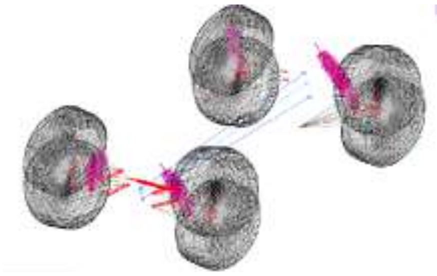

Fig. 6. Camber change in bump

6.3 Plot of camber angle Vs roll angle

From the below graph of Camber Angle vs. Roll Angle, it is clear that, as the camber of the tire varies in bump and droop then roll angle also varies. The camber angle varies from -20 to +20 with roll angle.

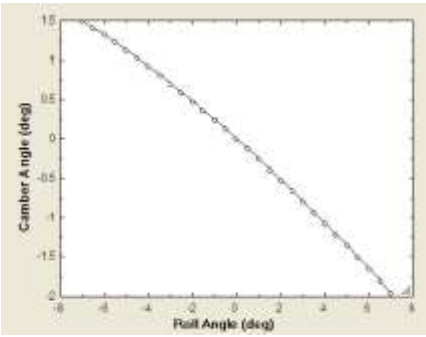

Fig. 7. Camber angle Vs Roll angle

VII. CONCLUSION

The static analysis of the model indicates that it is structurally stable to sustain the weight of a passenger car. It was observed that the maximum deformation and maximum stress is generated along the spring which absorbs the most of the force while ensuring that the rest of the framework is subjected to minimal stress and deformation. The damper works appropriately in undergoing large deformation to reduce vibrations in the system. The stress values were well within the material limitations in terms of their yield and ultimate tensile stresses. Then the system simulated In Lotus software. The stipulated objectives namely providing greater suspension travel, reducing the unsprung mass of the vehicle, maximizing the performance of the suspension system of the vehicle and better handling of vehicle while cornering; have been achieved. The suspension system can be further modified for decreasing the weight and cost.

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