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STATIC ANALYSIS OF DOUBLE WISHBONE SYSTEM IN ATV

HARSHAL JAMBHURE[1], MOHAN AWARI[2], GAURAV DHADOD[3], SAURABH SHINDE[4]

[1]*Student, Mechanical Engineering, J.D.I.E.T. Yavatmal Maharashtra, India,* ***harshalytl@gmail.com***
[2]*Student, Mechanical Engineering, J.D.I.E.T. Yavatmal Maharashtra, India,* ***mohanawari12@gmail.com***
[3]*Student, Mechanical Engineering, J.D.I.E.T. Yavatmal Maharashtra, India,* ***gdhadod07@gmail.com***
[4]*Student, Mechanical Engineering, J.D.I.E.T. Yavatmal Maharashtra, India,* ***saurabh.shinde0504@gmail.com***

Abstract

The Independent motion of wheels, capable of navigating on uneven and bumpy road is important characteristic of suspension system for vehicles. The system connects to the wheels and chassis by means of an assembly, and provides stiffness necessary to withstand uneven surface of road from roads. The Suspension system allows resistance to roll moment, over steer or under steer characteristics and other factors of vehicle. In this way, it is directly responsible for handling of vehicle and safety. The suspension design must be stiffer in order to bear sudden shocks due to potholes, steep drops, etc. The suspension characteristic of vehicle is helpful in manueverablity and to drive vehicle comfortably. Therefore, correct design of system isn't only the matter of driver safety, but also a key factor in result of racing. The paper discusses various types of suspension systems suitable for vehicles, So the design methodology and results achieved by simulation and analysing it on various parameters. This report is specifically based on the analysis of double wishbone system of ATV (All terrain vehicle).

Index Terms: *Independent Suspension, Double Wishbones, spring and Damper System, Roll Moment, ICR Diagram, Simulation, Air Spring.*

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1. INTRODUCTION

All Terrain Vehicle is a vehicle that travels on low pressure tires driven using handlebar or steering wheel for steering control. Although, ATVs were first designed only one seated but now-a-days many companies have developed ATVs with two or more seats. In many countries around the globe, these vehicles are banned on streets. All Terrain Vehicles is a package of different systems that are designed to improve the performance and to provide comfort to the driver. Different systems include design, steering system, suspension system, braking system and drive train. Failure of a single system or a part may lead to the death of the driver. ATVs are also popular for their good aesthetics and sporty looks. Suspension system of All Terrain Vehicle is one of the most critical system that needs to be designed for better stability and comfort for the driver. Suspension system is generally designed in accordance with the steering system.

2. SUSPENSION SYSTEM

Suspension system includes the spring, shock absorber and linkages that connect the vehicle to the wheels and allows relative motion between the wheels and the vehicle body. Suspension system also keeps the driver or operator isolated from uneven surfaces. Also, the most important role played by the suspension system is to maintain contact between wheels and road surface. Good suspension system and better handling is the characteristic of a good ATV. One of the functions of suspension system is to maintain the wheels in proper steer and camber to the road surface. It should engaged to the various forces that act in dynamic condition. These forces include longitudinal (acceleration and braking) forces, lateral forces (cornering forces) and braking and driving torques. It should hinder the roll of chassis. It should keep contact of the wheels and any uneven road by isolating the chassis from the roughness of the road. All the dynamic parameters are to be considered while designing the suspension system, specially the behaviour of the suspension for various loading conditions. Besides the dynamic parameters, other factors considered in design process are cost, weight, manufacturability, assembly, etc.

3. TYPES OF SUSPENSION SYSTEM

The suspension system is classified into two main types :-
1) Dependent Suspension System
2) Independent Suspension System.

3.1 Dependent Suspension System

This type of suspension system acts as a rigid beam such that any movement of one wheel is transferred to the other wheel. Also, the force is transferred from one wheel to the other. It is mainly used in rear of cars and in the front of heavy vehicles. Different types of dependent suspension system are

- Leaf Spring Suspension
- watts linkage
- panhard rod

3.2 Independent Suspension System

This type of suspension allows any wheel to move independently. These suspensions are mainly used in cars and light trucks as they provide more space for engine and they also have better resistance to steering vibrations and improve steering stability. Different types of independent suspension system are

- Swing Axle Suspension
- Macpherson Strut Suspension
- Double Wishbone Suspension
- semi- Trailing Arm Suspension
- trailing Arm Suspension
- Transverse Leaf Spring Suspension

Among all the above mentioned independent suspension systems, Double Wishbone Suspension System is the most common type of suspension system used in the cars and most of the All Terrain Vehicles.

4. DOUBLE WISHBONE SUSPENSION SYSTEM

Double Wishbone Suspension System includes two lateral control arms (lower arm and upper arm) of unequal length along with a coil over spring and shock absorber. It is popular for front suspension mostly used in rear wheel drive vehicles. For designing the geometry of double wishbone suspension system along with design of spring plays a very important role in maintaining the stability of the vehicle. This type of suspension system gives increased negative camber gain. They also allows easy adjustment of wheel parameter such as camber and caster.

5. DESIGN OF WISHBONES

Design of wishbones is the introductory step to design the suspension system. Firstly, the material is selected using Pugh's Concept of Optimization. By considering the properties of the selected material, the allowable stress is calculated using sheer stress theory of failure. The roll-centre is calculated in order to find the tie-rod length. Wishbones are modelled using software and then analysed using Ansys analysis software for finding out the maximum stress and maximum deflection in the wishbone.

5.1 Material Selection of Wishbone

Material consideration for the wishbone becomes the most primary need for design and manufacture. Strength of the material should be well enough to withstand all the loads acting on it in dynamic conditions. The material selection also depends upon the number of factors such as carbon content, material properties, availability and the most important parameter is the cost. Initially, three types of materials are considered based on their availability in the market- AISI 1018, AISI 1040 and AISI 4130. By using the Pugh's concept of optimization, we have chosen AISI 1040 for the wishbones. The main criteria were to have better material strength and lower weight along with optimum cost of the material.

5.1.1Pugh's Concept

This is a method for the concept selection using an scoring matrix called the Pugh Matrix. It is implemented by an evaluation team, and setting up a matrix of evaluation criteria versus alternative embodiments. This is the scoring matrix which is the form of prioritization matrix. Usually, the options are scored relative to the criteria using a symbolic approach (one symbol for better than, another for neutral, and another for worse than baseline). These get converted into scores and combined in the matrix to yield scores for each option.

5.1.2Comparison of Materials

The properties of the above mentioned materials which is considered for wishbones are as follows,

Table 1: Properties of Materials

Properties	AISI 1018	AISI 1040	AISI 4130
Carbon Content (%)	0.18	0.40	0.30
Tensile Strength (MPa)	440	620	560
Yield Strength (MPa)	370	415	460
Hardness(BHN)	126	201	217
Cost (Rs./metre)	325	425	725

Table 2: Pugh's concept selection chart

Description Criteria	AISI 1018	AISI 1040	AISI 4130
Total Weight	-2	0	+1
Yield Strength	-1	0	+1
Tensile Strength	-2	+2	0
Cost	+1	0	-2
Elongation at break	-2	+1	0
Net Score	**-6**	**+3**	**0**

Hence, AISI 1040 is selected for the wishbones because net score is highest for AISI 1040.

5.2 Stress Calculation

For ductile materials, allowable stress is obtained by the following relationship

$$\sigma = \frac{S_{yt}}{fs} \quad (1)$$

(1 Assume factor of safety, fs = 1.2 (as AISI 1040 is a ductile material)

$$\sigma = \frac{415}{1.2}$$

$$\sigma = 345.83\ MPa \quad (2)$$

This is the value of allowable stress value in wishbones. The designed wishbone is safe when the induced stress is lesser allowable stress value. The allowable stress is determined by using Ansys analysis software.

5.3 Determination of Roll Centre

Roll Centre of the vehicle is the point about which the vehicle rolls while cornering. There are two types of the roll centres the geometric roll centre and force based roll centre. The roll centre is the notional point on which the cornering forces in the suspension are reacted to the vehicle body. The location of geometric roll centre is solely dictated by the suspension geometry, and can be found using principles of the instant centre of rotation. Determination of the roll centre plays very important role in deciding the wishbone lengths, tie rod length and the geometry of wishbones. Roll centre and ICR is determined because it is expected that all three elements- upper wishbone, lower wishbone and tie rods should follow the same arc of rotation during suspension travel. This also means that three elements should be displaced about the same centre point called the ICR. Initially, wishbone lengths are determined based on the track width and chassis mounting. These two factors- track width and chassis mounting points are the limiting factors for wishbone lengths. Later, the position of the tire and the end points of the upper arm and lower arm are located. The vehicle centre line is drawn. The end points of wishbones are joined together to visualize the actual position of the wishbones in a steady condition. When the lines of upper and lower wishbones are extended, they intersect at an certain point known as Instantaneous Centre (ICR). A line is extended from ICR to a point at which tire is in contact with the ground. The point on which this line intersect the vehicle centre line is called the Roll Centre. Now, stretch a line from ICR point to the steering arm. This gives the exact tie rod length in order to avoid pulling and pushing of the wheels when in suspension.

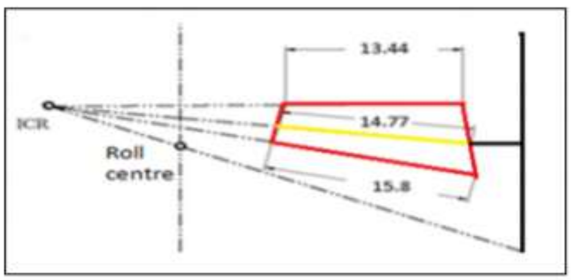

Figure 1 Determination of Roll Centre

6. ANALYSIS OF WISHBONES

Analysis of the wishbone in Ansys Analysis Software is necessary in order to determine the induced maximum stress and maximum deflection in wishbones. For the analysis, wishbones are first needed to be modelled in software.

6.1 Modelling of wishbone

solidworks is modelling software which allows 3D- modelling and 2-D drafting of elements. In order to perform the analysis of wishbone in Ansys, it is necessary to model the wishbones in any of the modelling software such as Pro-Engineers, Catia , etc. We have selected to use solidworks modelling software because of its availability.

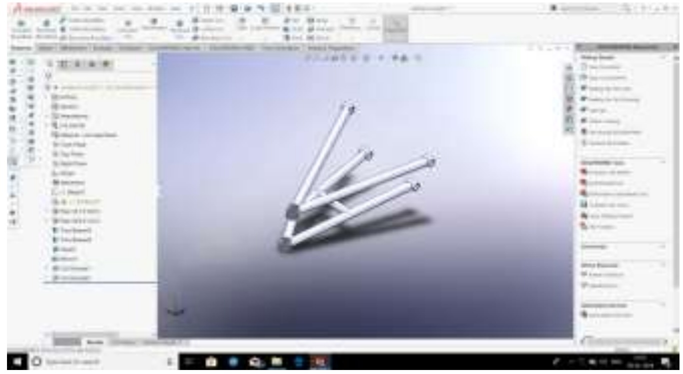

Figure no.2

6.2 Analysis in Ansys :-

Ansys is engineering simulation software (computer-aided engineering). Various types of analysis like structural analysis, nodal analysis,thermal analysis, etc. are possible using Ansys analysis software. In the structural analysis in Ansys, boundary conditions has to be defined in order to determine the stress and deflection. After modelling the wishbones in the Pro-E modelling software, these models were imported into Ansys Analysis Software for analysing it on various parameters. Various boundary conditions and load cases is applied to determining the maximum stress and maximum deflection of wishbone. Input parameters are as follows,

Table 3: Wishbone Analysis Input Parameters

Material	AISI 1040
Vertical Load	9600 N
Spring Force	1500 N

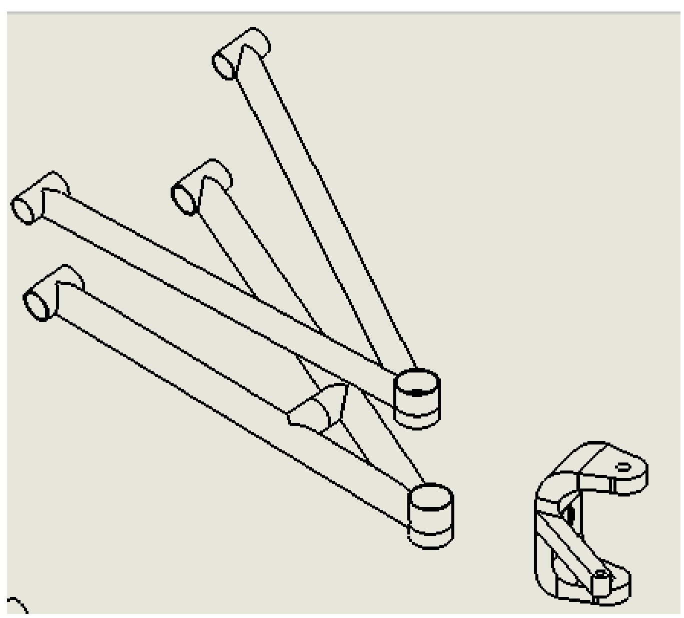

Figure no.3

6.3 Results of Analysis of Wishbones:-

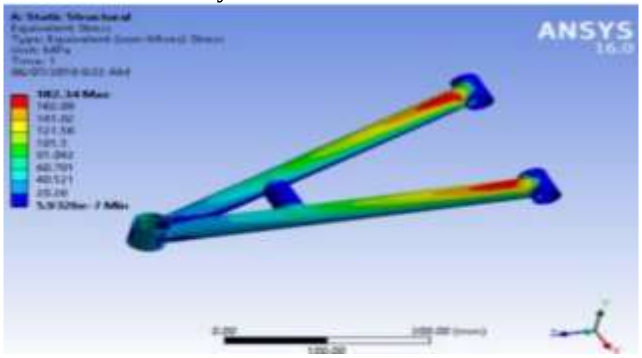

Figure no.4

Comp.	Equivalent stress (Mpa)	Max. deformation	F.O.S.
Front-wishbone	182.34	3.43 mm	3.31
H – arm	327.09	7.16 mm	1.8

Table no. 4

Since the maximum stress induced in wishbone is less compared to allowable stress, hence the wishbone is safe.

7. Camber Change in Bump

Camber change in bump is simulated using Lotus simulation software. The camber changes in the bump looks like as shown:

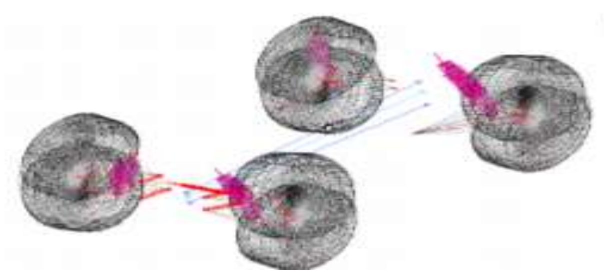

Figure no.5

7.1. 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 -2 0 to +20 with roll angle.

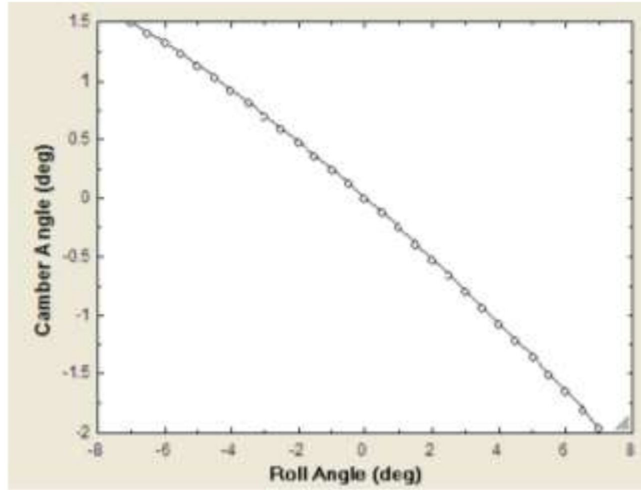

Figure no.6

9. CONCLUSION AND FUTURE WORK

We have designed a double wishbone suspension system and then simulated it in the LOTUS software. This was proceed for analysis of the system in the ANSYS. The stipulated objectives namely providing greater suspension travel, reducing the unsprung mass of the vehicle, maximizing the performance of suspension system in the vehicle and better handling of vehicle while cornering; have been achieved. The suspension system can be further modify for decreasing the weight and cost of vehicle. The transverse leaf spring can be use to decrease the weight of suspension system. Pneumatic suspensions can be used in the future for better performance.

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