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DESIGN AND ANALYSIS OF SUSPENSION SYSTEM IN QUAD BIKE USING LOTUS SHARK SIMULATION SOFTWARE

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ABSTRACT

The main objective of this paper is to design and analyze the entire double wishbone suspension system for an All-Terrain Vehicle like quad bike for improving the stability and handling of the vehicle. The real gratification of driving for an off-road enthusiast can be described as the thrill of the terrain coupled with a proficient machine to handle the terrain. However, this gratification can be derived only when the well-being level of the driver is maintained. Thus, it is concluded that the suspension system (which is responsible for providing a comfortable ride quality to the driver) is one of the most important sub-systems to be designed. The topic is focused on designing the suspension systems considering the dynamics of the vehicle along with minimizing the unsprung mass. The vehicle must be able to withstand the craggy environment of off-road terrain.

Adjusting height of roll center is the major problem in most off road vehicles. If the height of roll center is not properly adjusted their will be more roll angle and leads to topple of the vehicle. By confining the height of roll center in between ground and C.G. so the vehicle will roll less. During the entire design process, user interest through innovative, inexpensive, and effective methods was always the primary goal. By adjusting small track width and wheel base, obtained the reduced (small) turning radius.

Keywords: Double wishbone suspension, Roll centre, Motion ratio, Sprung mass.

INTRODUCTION

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. Suspension systems be of assistance a dual purpose contributing to the car's road holding handling and braking for good active safety and driving pleasure, and keeping vehicle occupants well-being and reasonably well isolated from road noise, bumps, and vibrations, etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is essential for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a vehicle is different.

The main components of a suspension system are:

- springs
- shock absorbers
- struts
- tires

When an additional load is placed on the springs or the vehicle meets a bump in the road, the springs will absorb the load by compressing. The springs are very important components of the suspension system that provides ride comfort. Shocks and struts help control how fast the springs and suspension are allowed to move, which is important in keeping tires in firm contact with the road.

TYPES OF SUSPENSION SYSTEM

Suspension systems can be broadly classified into two subgroups: dependent and independent. These terms refer to the ability of opposite wheels to move independently of each other. The different types of suspension systems are as follows

1. **Non-Independent Suspension** has both right and left wheel attached to the same solid axle. When one wheel hits a bump in the road, its upward movement causes a slight tilt of the other wheel.

2. **Independent Suspension** allows one wheel to move up and down with minimal effect to the other.

TERMS RELATED TO SUSPENSION SYSTEM

1. SPRUNG MASS

Sprung mass (or sprung weight) is the portion of the vehicle's total mass that is supported above the suspension, including in most applications approximately half of the weight of the suspension itself. The sprung weight typically includes the body, frame, the internal components, passengers, and cargo, but does not include the mass of the components suspended below the suspension components (including the wheels, wheel bearings, brake rotors, calipers, which are part of the vehicle's unsprung weight).

2. UNSPRUNG MASS

The unsprung mass is the mass of the suspension, wheels or tracks , and other components directly connected to them, rather than supported by the suspension. Unsprung mass includes the mass of components such as the wheel axles, wheel bearings, wheel hubs, tires, and a portion of the weight of driveshafts, springs, shock absorbers, and suspension links. If the

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vehicle's brakes are mounted outboard (i.e., within the wheel), their mass (weight) is also considered part of the unsprung mass.

3. MOTION RATIO

Motion ratio in suspension of a vehicle describes the amount of shock travel for a given amount of wheel travel. Mathematically it is the ratio of shock travel and wheel travel. The amount of force transmitted to the vehicle chassis reduces with increase in motion ratio. A motion ratio close to one is desired in vehicle for better ride and comfort.

4. INSTANT CENTRE OF ROTATION

The instant centre of rotation, also called instantaneous velocity center, or also instantaneous centre or instant centre, is the point fixed to a body undergoing planar movement that has zero velocity at a particular instant of time. At this instant, the velocity vectors of the trajectories of other points in the body generate a circular field around this point which is identical to what is generated by a pure rotation.

5. ROLL CENTER

Roll Centre in the vehicle is the point about which the vehicle rolls while cornering. The roll centre is the notional point at which the cornering forces in the suspension are reacted to the vehicle body. . Determination of roll centre plays a very important role in deciding the wishbone lengths, tie rod length and the geometry of wishbones.

DOUBLE WISHBONE SUSPENSION SYSTEM

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. It is popular as front suspension mostly used in rear wheel drive vehicles. Design of 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 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

The double-wishbone suspension, also known as an A-arm suspension, is another common type of front independent suspension. While there are different possible configurations, this design typically uses two wishbone-shaped arms to locate the wheel. Each wishbone, which has two mounting positions to the frame and one at the wheel, bears a shock absorber and a coil spring to absorb vibrations

DESIGN OF WISHBONES

Design of wishbones is the preliminary step to design the suspension system. The length of Wishbones is derived from Track width. The roll-centre is determined in order to find the tie-rod length. The designed wishbones are modeled using software and then analyzed using ANSYS to find the maximum stress.

The lengths of Wishbones can be calculated from Racing Aspirations Software. Racing Aspirations is an calculator for whatever your motorsport related math problem may be racing aspirations aims to provide a solution. It gives the accurate measurements of lengths

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and angles of wishbones assembled to a vehicle which is not possible by simple math. It also shows the deflection of roll center on varying angles of wishbones.

DESIGN SPECIFICATIONS:

Track width = 40"

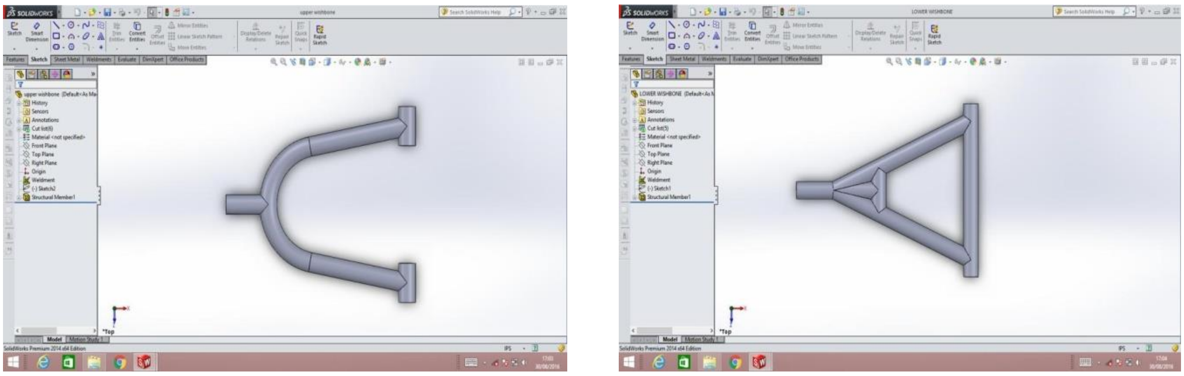
Length of lower wishbone = 11.68"

Length of upper wishbone = 10.68"

Inclination of upper wishbone = 4.2 deg

Inclination of lower wishbone = 6.2 deg

Ride height = 10"



Design of upper and lower wishbones in Solid Works

MATERIAL SELECTION FOR WISHBONES

The strength of the material should be well enough to withstand all the loads acting on it in dynamic conditions. The material selection also depends on number of factors such as carbon content, material properties, availability and the most important parameter is the cost. Initially, three materials are considered based on their availability in the market are AIS1018, AISI1040, AISI4130. Based on the properties of the selected material, the allowable stress is calculated using sheer stress theory of failure.

COMPARISON OF PROPERTIES OF MATERIALS

The properties of the above mentioned materials which were considered for wishbones

PROPERTIES	AISI 1040	AISI 1018	AISI 4130
Carbon content (%)	0.40	0.18	0.30
Tensile strength (MPa)	620	440	560
Yield strength(MPa)	415	370	460
Hardness(BHN)	201	126	217

Table 1- Properties of Materials for Wishbones

As the above properties were selected AISI 4130 based on hardness, tensile and yield strength.

ANALYSIS OF WISHBONES

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

Material	AISI 4130
Vertical load	9600 N
Spring force	1500 N

Table 2- Wishbone Analysis Input Parameters

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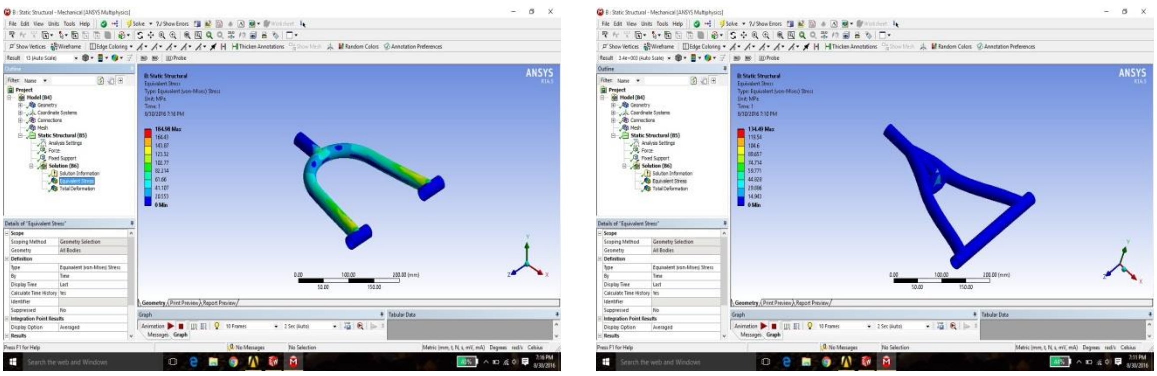

Analysis of Wishbones in ANSYS

DESCRIPTION	OBTAINED RESULT
Maximum Stress	52.84Mpa
Deformation	1.29mm

Table 3- Result of Analysis of Wishbones

SIMULATION OF DOUBLE WISHBONE SUSPENSION SYSTEM IN LOTUS SHARK SOFTWARE

Lotus Engineering Software has been developed by automotive engineers, using them on many power train and vehicle projects at Lotus over the past 15 years. The entire suspension geometry can designed and analyzed in Lotus Shark simulation software. The results of the dynamics of suspension geometry can also be viewed.

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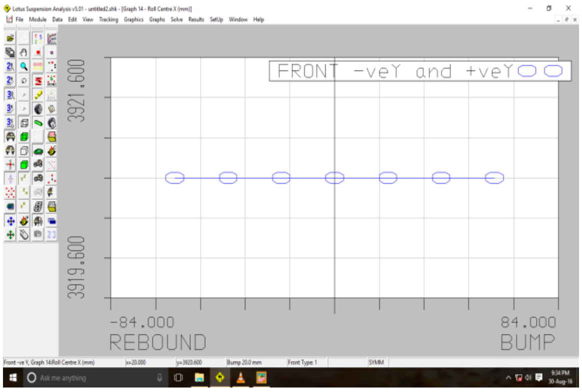
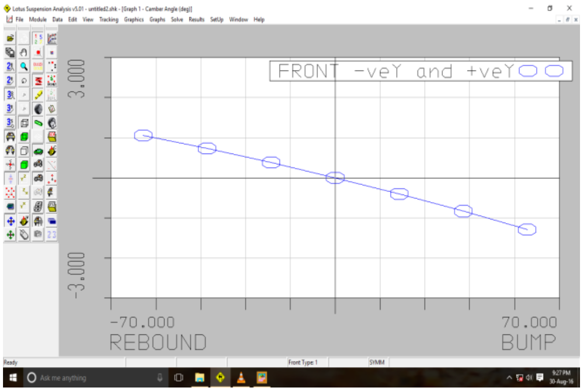
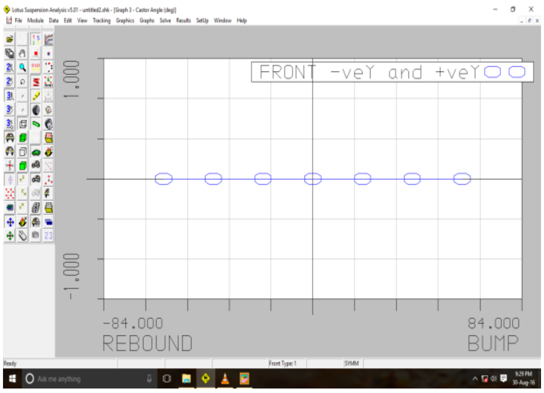
The graphs of roll center, camber angle change, castor angle change, spring travel change in lotus coordinates are shown in Figures below.



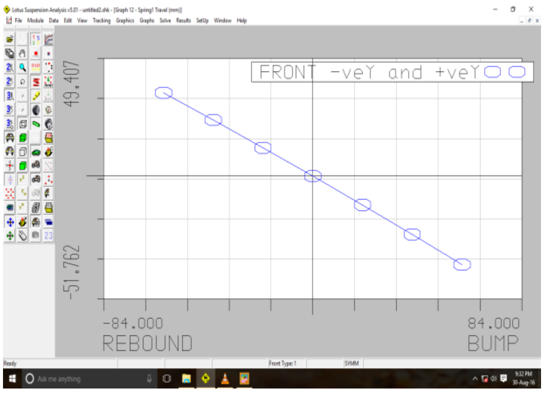
Roll Center Change In X Direction



Camber Angle Change



Castor Angle Change



Spring Travel Change

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SPECIFICATIONS OF SHOCKS:

Diameter of coil = 12.74 mm

Mean diameter of coil = *88.93 mm*

No. of turns = *15*

The material used for spring is hardened steel spring.

Stiffness of the spring (K) = $G\ x\ d4\ /\ 8\ D3\ n$,

Where G = Modulus of rigidity = 70 Gpa

Stiffness of front spring K=70,000 x 12.74 / 8 x 88.93 x 15 = 21.59 N/mm

Weight of vehicle= 270 kg

According to the mass distribution of 60: 40 (Rear: Front)

Mass per wheel (Front) = 54 kg

Mass per wheel (Rear) = 81 kg

Sprung mass= 140 kg

Un-sprung mass= 60 kg

CONCLUSION

The double wishbone suspension system was designed and then simulated it in the LOTUS software. This was followed by analysis of the system in the ANSYS. The stipulated objectives namely providing greater suspension travel, reducing the un-sprung 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 is modified for decreasing the weight and cost.

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