

DESIGN AND ANALYSIS OF SAE BAJA VEHICLE WHEEL ASSEMBLY

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ABSTRACT

This paper is based on how to decide, design, simulate and then analyze wheel assembly correctly for SAE BAJA vehicles and also for ATV. Taking ATV as a reference, the design and analysis results in this paper are plotted. All-Terrain Vehicle is designed according to the BAJA SAE rulebook. In order to achieve stability and compactness one should know how to design an optimum car wheel assembly. Steering and suspension geometry are of major importance of a wheel assembly. The deep understanding is established between logics and limits of vehicle. The design parameters are defined either from judgments or from worst condition of track and the simulation of parameters are conducted.

KEYWORDS: - ANSYS, BAJA SAE, LOTUS, SOLIDWORKS2017, TYRE PARAMETERS

INTRODUCTION

Baja SAE India is an intercollegiate design competition organized by the Society of Automotive Engineers (SAE). The dynamic events include endurance race, hill climbs, maneuverability events, and suspension & traction events. The goal is to design, build, test and race a single seat off-road car following SAE guidelines. A perfectly manufactured vehicle encompasses of correctly designed suspension assembly, steering assembly, roll cage and transmission along with breaks. SAE, in addition to these sub-assemblies also emphasizes on the safety features for the safety of driver and vehicle. The importance of wheel assembly relies on how the suspension and steering geometry is decided which includes parameters like camber, caster, king pin inclination, toe, wheel track, wheel base, location of center of gravity, sprung mass, unsprung mass, spring parameters, damper parameters, tyre geometry, design of knuckle, selection of wheel hub.

1.Tyre Parameters

Selection of rim and tyre according to proposed design conditions must be done. Manufacturer's catalogues for tyre properties must be referred. These properties are then fed into lotus tyre property window as shown in fig. 1.1.



Fig. 1.1

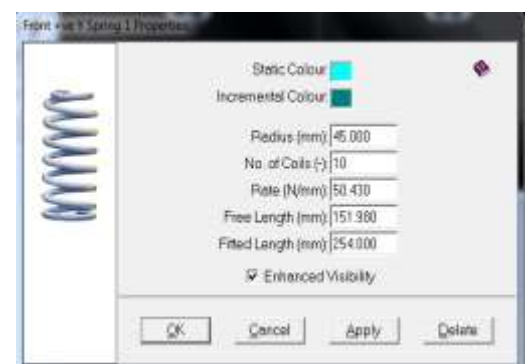


Fig. 2.1

2 Front Wheel Geometry

To make Suspension geometry in lotus, parameters like spring radius, number of coils, spring rate, free length are to be calculated and feeded as shown in fig 2.1. Similarly, damper parameters are to be defined.

The core objective of the front suspension is to provide the maximum wheel travel in bump as well as in sag. Moreover, it should provide better grip when it comes to cornering. Design also has to be compatible with nose design. Front suspension is combined with steering and both are inter-reliant. Here we have used Double Wishbone, damper to lower wishbone suspension- pick type. It means we have to design A-arms and do FEA. Deciding the ground clearance effects the position of lower wishbone pivot points.

We have to fix the turning radius, wheelbase and find out the required track width because these are the only independent variables. For better stability, suspension is combined with steering. Now there are two ways to get correct wheel geometry. The first way is to make A-arms of unequal length in order to satisfy correct wheel geometry. The another convenient way is to design stub axle which includes all the angle like camber, caster, kingpin and knuckle arm angle as shown in fig 2.2. This leads to equal length of both upper and lower wishbones. This procedure eliminates the error in manufacturing upper and lower wishbones. Even after adopting this procedure if you find incorrect steering angles then they can be corrected by screwing and unscrewing of upper and lower ball joints.

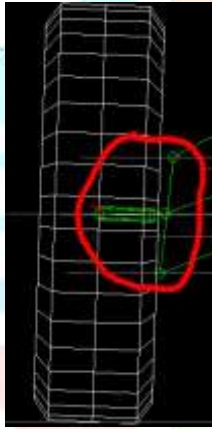


Fig2.2

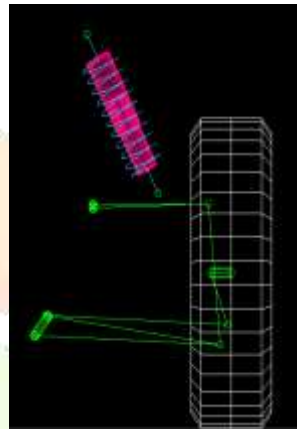


Fig. 4.1

3. Steering Geometry

The linkage which is responsible for directional stability and turning the tyre in order to execute the turn at the will of driver is called steering geometry. Using of rack and pinion steering gear according to Ackermann's geometry is quiet common. The gear ratio of rack and pinion should be taken 13.7:1. Parameters like rack travel, tie rod length, inclination of steering column, radius of steering wheel should be known. On lotus software these parameters need to be defined and then adjusted so as to satisfy correct arrangement according to lotus. After completing front suspension analysis and steering analysis on lotus the nose design of vehicle is set to be done.

4. Rear Suspension and wheel Assembly

In rear suspension, there are mainly two types of arrangement widely used namely semi-trailing arm. and Double Wishbone damper to upper wishbone as shown in fig 4.1. The semi-trailing arms are used where independent suspension arrangement is required this arm is roughly parallel to the ground, with the angle changing based on road irregularities. These are used where there is flatter floor or cargo room.

Double Wishbone damper to upper wishbone is used because of the fact that alignment of rear wheel is far difficult in trailing arms as compared to Double Wishbone damper to upper wishbone.

5. Equation to be used

5.1 To find out outer lock angle according to decided wheel track(b), wheel base(l), inner lock angle (ϕ),

$$\frac{1}{\tan \theta} - \frac{1}{\tan \phi} = \frac{b}{l} \text{-----1}$$

Where θ is outer lock angle.

5.2 To find out turning radius,

$$r = \frac{b}{\tan \phi} + \frac{l}{2} \text{-----2}$$

$$R = \sqrt{r^2 + b^2} \text{-----3}$$

R= turning radius

5.3 Wheel track should be less than 70% of wheel base i.e. $b \leq 70\%$ of l .

6. Our Analysis

TABLE 6.1

PARAMETERS	DATA
BUMP TRAVEL	40.00mm
REBOUND TRAVEL	-40.00mm
ROLL ANGLE	5.0 deg
STEER TRAVEL	35.22mm
WHEELBASE	1600.2mm
C of G HEIGHT	457.20mm
TOTAL SPRUNG WEIGHT	250KG

Tyre, spring, damper parameters are shown in fig 1.1 and 2.1 respectively.

7. Results



FIG7.1

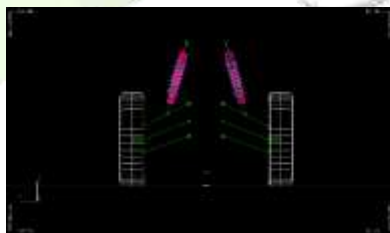


FIG7.2

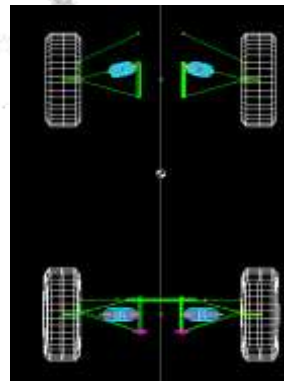


FIG7.3

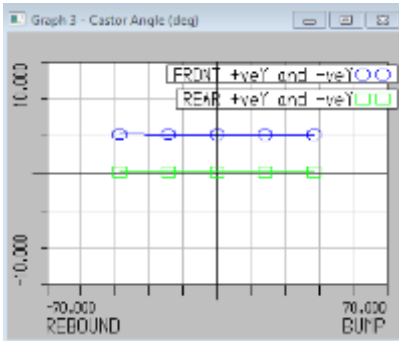


FIG7.4

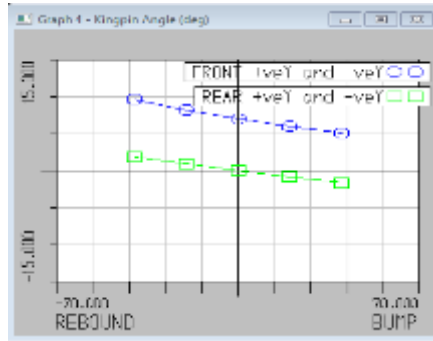


FIG7.5



FIG7.6

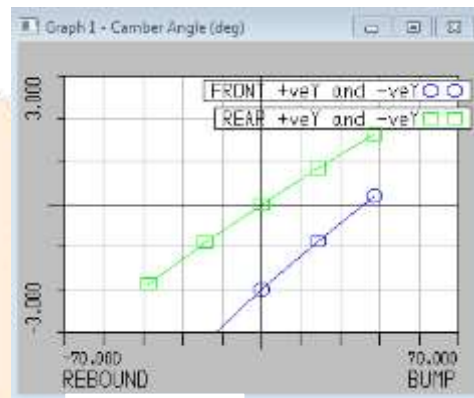


FIG7.7

8. Conclusion

The use of Lotus shark in the modeling was expected and helped a lot to restate and obtain satisfactory results. User friendly user interface make it much easier to carry out various analysis and visualize the geometry. Analysis of wishbones with the help of ANSYS helped to structurally strengthen them without using excess material. The designed suspension was found to give satisfactory wheel travel in the front. The steering system was responding very well and turning radius is 3m. Hub, stub axle, rim, were optimized by using solidworks2017.

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FIG.7.4	CASTOR ANGLE
FIG.7.5	KINGPIN ANGLE
FIG.7.6	TOE ANGLE
FIG.7.7	CAMBER ANGLE

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