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Research Article

Minimum Bump Steer Approach Method for Design of Double Wishbone Suspension System for an ATV

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Abstract

The main objective of the paper is to design and analyze the entire Double Wishbone Suspension (SLA) system By minimum bump steer approach method for an All Terrain Vehicle. There has been tremendous development in the suspension system. The topic is focused on designing the above mentioned suspension systems considering the dynamics of vehicle. The suspension system of an All Terrain Vehicle needs to be durable, light weight, efficient and less expensive. The vehicle must be able to withstand the harsh environment of off-road terrain. The Bump Steer i.e. toe angle change with suspension travel is a very troublesome condition for the driver, especially in ATV. Hence the design consideration in suspension kinematics includes about in the design, hence given a prominent importance in this project.

Keywords: *Double Wishbone Suspension, SLA, Bump Steer, Toe Angle.*

1. Introduction

The study of a vehicle suspension system can be broken into two measure categories Suspension kinetics and Suspension Kinematics. In this paper Methodology for 'Minimum Bump Steer Approach for design of Suspension Link' for Double Wishbone (SLA) is explained briefly for an ATV which comes under the Suspension Kinematics. This system is the mechanism that physically separates the vehicle body from the wheels of the vehicle. The motion of tires is highly dependent on the type of suspension. 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. Also, this is Independent type of Suspension which allows Left and Right wheel moves independently providing better resistance for Steering Vibrations, High suspension Roll Stiffness, Suspension and Steering geometry is easily controlled, High Wheel Travel which is highly required in an ATV (William F. Milliken,*et al*,1995).

1.1Objective

Minimum bump steer
Optimum roll Centre height
Minimum 12 inches ground clearance

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2. Toe Angle

The toe angle is defined as the angle between the longitudinal axis of the vehicle and a line passing through the center of the tire when viewed from the top.(William bombardier, *et al*,2007)

2. Bump Steer

It is important to recognize that the suspension and steering systems are coupled. As the suspension goes through its travel, so does the tie rod and it is important that the tire does not toe with suspension travel. The inside point of the tie rod is fixed (the point at the steering rack) so that if the length of the tie rod is not at the correct length and the tie rod does not have the same instant center as the suspension system then as the suspension travels and thus the tie rod travels (but not at the appropriate path) it will force the tire to rotate about the steering axis. Bump steer by definition is toe angle change with suspension travel. If one tire goes over a bump and experiences a toe angle change the vehicle will steer. This condition is very troublesome for the driver because the driver will consistently have to correct the vehicle as the vehicle travels over changes in road conditions. Roll steer occurs when a vehicle rolls and there is weight transfer and thus the suspension on the inside compresses and the suspension on the outside goes into rebound. The net effect is that one side of the vehicle will toe in and one side of the vehicle will toe out, thus forcing the vehicle to steer as it rolls. The steering geometry can be chosen such that the more the vehicle rolls the more it will steer or the less it will steer. Therefore, the oversteer/understeer characteristics can be controlled by the roll steer effect. However, most of the time the suspension geometry and tie rod position and length are chosen to minimize toe angle change with suspension travel, and thus minimizing the effects of roll steer and bump steer.

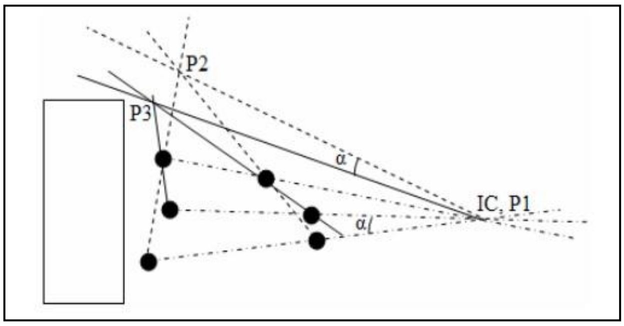

Fig.3. Steps to find Length of Links to minimize bump steer (William bombardier,*et al*,2007)

3.1 Steps for methodology of minimum Bump Steer and Designing of Geometry of links of suspension

1. Draw a line extending through upper ball joint and lower ball joint.
2. Draw a line extending the tie rod (which is fixed and already designed).
3. Assume angle of lower wishbone of the line passing through the lower wishbone points and draw it.
4. Measure the 'angle α' between the tie rod line and the line drawn in step 3.
5. The intersection of the two lines in step 4 will give Instantaneous Centre (ICP_1).
6. Draw a line which is assumed and passes through P_1 and line drawn in step 1.
7. Draw another line which also passes through P_1 and which is at 'angle α' with the line drawn in step 6.
8. Draw a line passing through the outer ball joint of rack and ball joint of upper wishbone. The point obtained at the intersection of the line is drawn in step 7 and name it as point P4.
9. Draw a line from Point P4 to the inner ball joint of rack the intersection of this line with the upper wishbone line will be the inner point of upper wishbone and the length of that point to the upper wishbone ball joint will give the length of upper wishbone.
10. Draw a line passing through inner point of upper wishbone and the intersection point of lines drawn in step 6 and step 1. The intersection point of this line with the lower wishbone line will give the inner point of lower wishbone.
11. In this way the upper and lower wishbone lengths are determined and the angle of them with the horizontal XY plane are also obtained and we get the Suspension Geometry which satisfies the minimum bump steer criteria which is the governing factor in designing the suspension system.

4. Roll Centre

The point in Transverse plane where the lateral forces may be applied to the sprung mass without any suspension roll.

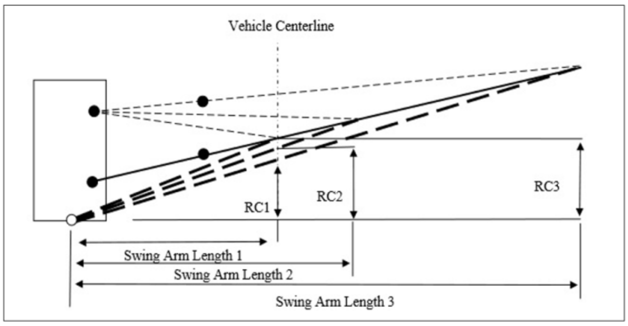

Fig.4 Roll Centre (William bombardier,*et al*,2007)

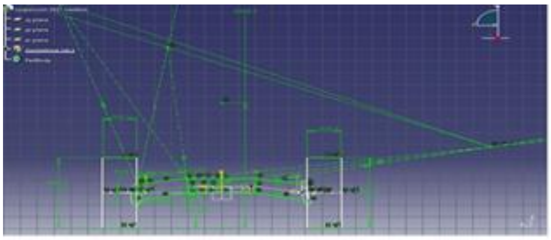

Fig.5 Final Iteration

6. Geometry Obtained

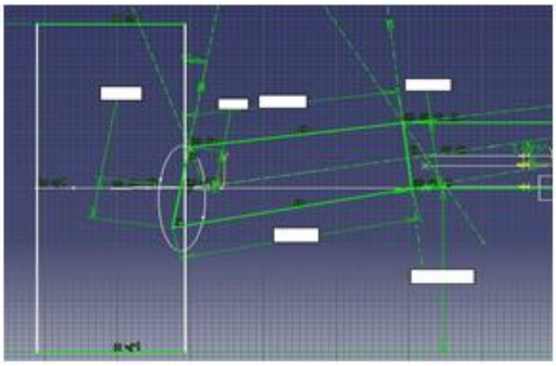

Fig. 6 Geometry obtained

5. Iterations done in CATIA of Bump Steer Approach

The below figure shows the CATIA iterations done with assumed King Pin Length, Tire Dimensions , King pin offset , King pin inclination .Also Various values of lower wishbone angle with the rack and assumed lines were taken and the following geometry was finally obtained after 6 Iterations.

7. Results Obtained are Measured from the Geometry which are as follows

1. Roll Centre height for corresponding geometry.
2. Ground Clearance.
3. Moment arm.
4. Camber gain for full jounce.

8. Iterations

The above mentioned results are compared with the standard and desired values which are the objectives defined earlier

1. Roll Centre height should be optimum if RC
2. (Roll Centre) height is more, then Jacking forces increases compromising with handling performance and luxury.
3. Ground Clearance should be minimum 12 inches In order to negotiate with the road profile for an ATV
4. Camber gain at full jounce should be optimum.
   If the results are not satisfying as mentioned above then the 'angle α' and lower wishbone angle and the other assumption are Iterated and the procedure is repeated to obtain the desired Results

Conclusions

The bump steer is the most important factor of concern which mainly governs the joining of suspension geometry and if Bump steer is present more than +2 or -2 Degrees than the entire suspension system and steering system will fail resulting in complete breakdown of vehicle.
Hence to avoid this troublesome situation our 90 % concern in the design consideration should be bump steer only and anyhow it shouldn't be compromised.

By using this bump steer methods we can avoid this situation compromising the other factors and parameters a little like roll centre height, ground clearance etc. The geometry of links will satisfy the desirable range of camber gain, roll centre propagation is the biggest advantage of this method which along with this will give Close to ZERO degrees of bump steer, increasing the stability of vehicle.

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