Design of Suspension and Steering system for an All-Terrain Vehicle and their Interdependence

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ABSTRACT

Off-roading and all terrain capabilities are the areas which not only test the endurance limit of properly designed vehicle but also test the driver's endurance to get the thrilling experience on road. With an increasing demand of off-roading day by day and the criticality of the terrain the vehicle is subjected to it is a very challenging task to design systems for off-roading vehicles.
Aim of this project is to develop a new approach and method to properly design the Suspension and Steering Systems of an All-Terrain Vehicle without compromising the wheel alignments and achieve desired set of combinations in a predefined proper manner not in iterative way.

KEYWORD: *Suspension, Steering, Wheel geometry, off-roading*

1.INTRODUCTION

1.1 Problem Statement

Design of suspension and steering system are an interrelated process, it is very difficult to maintain the desired optimized requirement in individual departments and many a times compromise is needed to be made to meet the requirements. This both departments are connected by wheel geometries. So optimisation of wheel geometries has been the main goal of this research.

1.2 Methodology

The project approach is based upon providing the driver with maximum level of comfort. First the wheel geometry parameters were decided to optimise and design the steering and suspension geometries for weight reduction as well as maximum strength and fatigue life.

2. WHEEL GEOMETRY [1]

Wheel geometry consists of these parameters: 1) Wheel Track, 2) Wheel Base, 3) Camber, 4)Caster, 5) King Pin Inclination, 6) Toe Change over the travel.

2.1 Wheel Track

It is the centre to centre distance between tyres as viewed from front view. The front wheel track is set to 52 inches and rear wheel track is set to 48 inches.

2.2 Wheel Base

It is the centre to centre distance of tyres as seen from side view of vehicle. It is set to 56 inches.

2.3 Camber

It is the angle between vertical lines and tire centreline in front view of vehicle. According to the graphs available on practical data manipulation, it is observer that the vehicle road gripping ability increases with negative camber on the wheels.

2.4 Caster

Castor angle has been provided to counterbalance the effect of positive camber gain on outer wheels due to KPI angle. It is the angle between axis made by knuckle pivot points to the vertical axis in the side view. Caster is set to 6 degrees.

2.5 King Pin Inclination

It is the angle between axis by knuckle pivots with vertical axis in the front view of vehicle. KPI is set to 7 degrees.

2.6 Toe change over the travel

Toe is the angle made by tyres to the longitudinal axis of vehicle as seen from top view. This angle has to be minimum to avoid excessive wear of wheels and to increase efficiency. Static toe angle is set to zero.

3. SUSPENSION[2]

3.1 Assumptions

To begin with our design approach we have chosen to design the systems for the All- Terrain Vehicle used for participation in international level competition known as BAJA SAE. This helps us define some of the starting constraints which depend upon the track and topography of the application terrain.

3.2 Classification of Suspension Systems[1]

- **Independent Suspension**

Wheels move independently with respect to each other on bumps and droops i.e. if one wheel is subjected to bump/droops then it will not affect the motion and position of other wheel.

- **Dependent Suspension**

Wheels move dependently with respect to each other i.e. if one wheel is subjected to bump/droops then it will also affect the motion and position of other wheel.

Depending upon our requirement we have chosen to use independent suspensions for our design as this ensures maximum comfort and safety.

3.3 Front Suspension[2]

Considering all the advantages and disadvantages of various independent suspension types, we have selected **Double Wishbone Suspension Mechanism** in front.

3.4 Rear Suspension[2]

We have selected **H-arm and Camber link Mechanism** in rear. This provides best torsional rigidity required for rear suspension.

Front

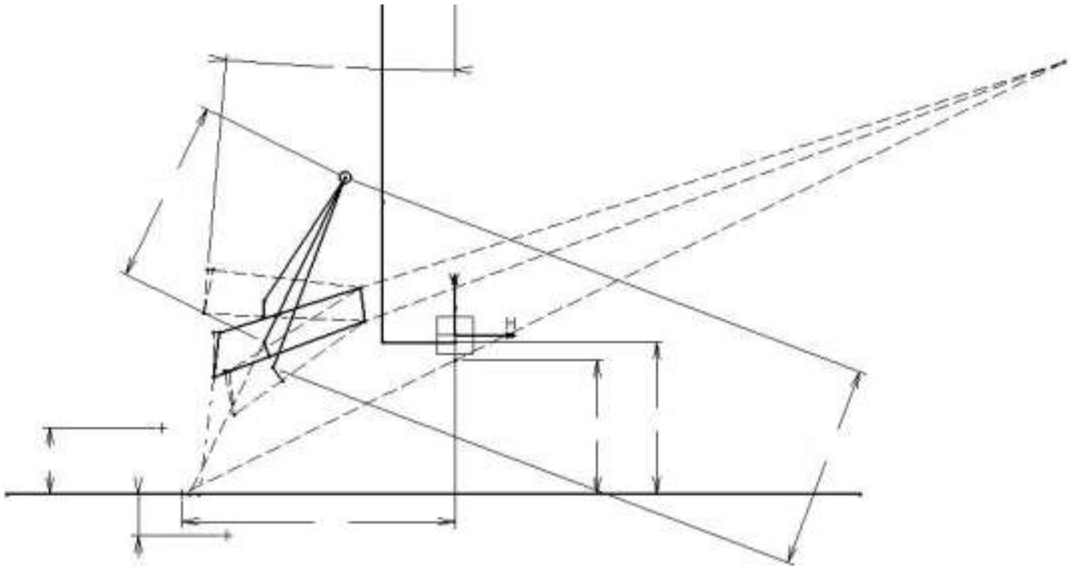

Figure 1 Front Suspension Geometry

Rear

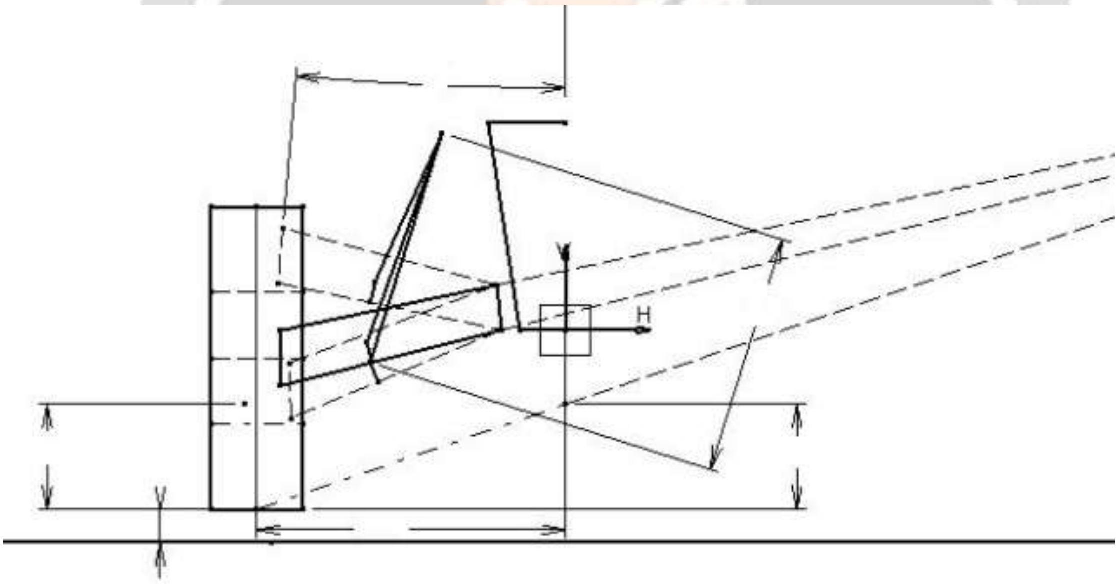

Figure 2 Rear Suspension Geometry

4.STEERING SYSTEM

4.1 Introduction

Steering is of the system that connects driver to the vehicle. What if we have a vehicle but there is no mechanism to give direction to it, in such a case our vehicle will wander aimlessly and it is certainly going to hit something.

Good steering system has following features:

- Provides directional stability

- Less steering effort
- Good response from road to driver[3]

4.2 Objective:

To design and manufacture steering system of single seated All Terrain Vehicle by considering the constraints provided in rulebook of BAJA SAE India 2018.[4]

4.3 Selection of steering system:

After going through various steering systems we decided to have rack and pinion in our vehicle. Reasons behind selection of rack and pinion steering:

- It is Simple, light and responsive system
- Occupies very small place
- Use of less number of linkage components

Because of above mentioned features rack and pinion is best suitable for our vehicle and also fulfils requirements of good steering and therefore it is beneficial for us.

4.4 Working:

- The rotary motion of steering wheel is transmitted to pinion of steering gear through steering column.
- The circular motion of pinion is transferred into rack movement which is further relayed through ball joints and tie rods to the stub axles for the wheels to be steered.
- The tooth profiles of both pinion as well as rack are involute form so that side profile of pinion teeth is curved. However, side profile of rack teeth is straight line as its pitch circle being straight line.

5. VALIDATION OF INTERDEPENDENCE AND ANALYSIS

Both the steering and suspension geometries were analysed in Lotus Shark Suspension Simulation software. This software provides results for camber, caster and toe change over wheel travel. This also provides many other results but they are out of context of this research.

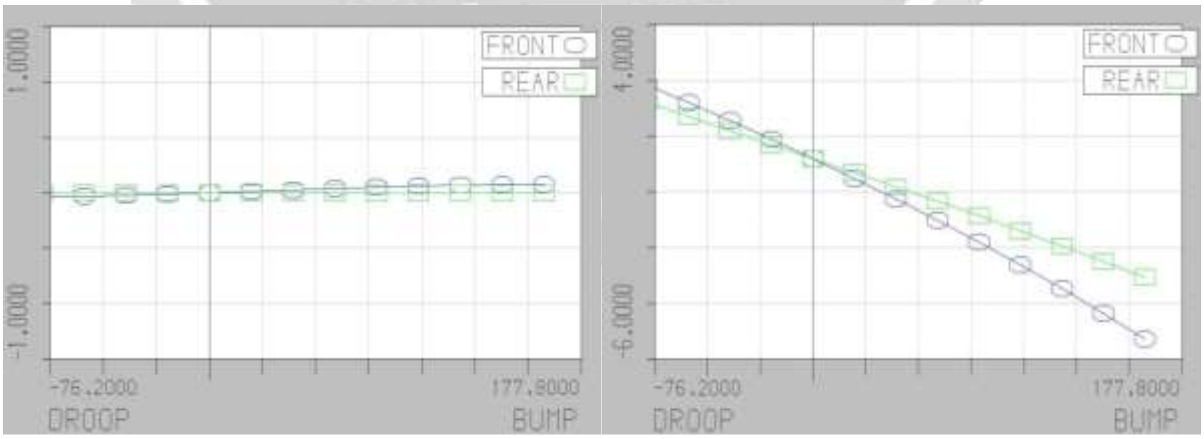

Figure 3 Toe Change over wheel travel and camber change over travel

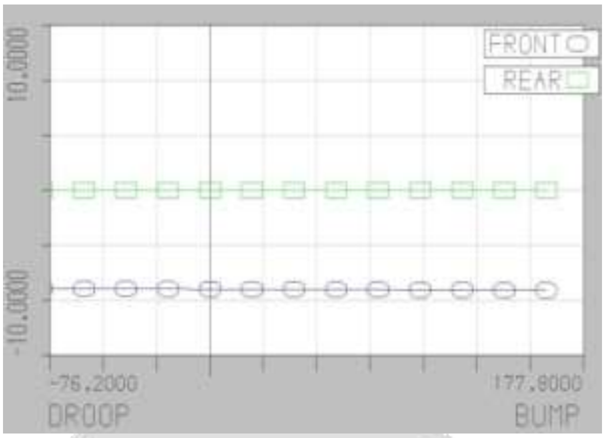

Figure 4 Caster Change over wheel travel

5.1 Interpretation of results

As seen from above graphs we can say that both caster and toe changes over the wheel travel are negligible. Hence overall efficiency and driver comfort wont get affected because of the designed suspension and steering geometries.

6 CONCLUSION & FUTURE REMARK

Any vehicle cannot be complete without the use of steering and suspensions system. And continuous progress in the field of automobile are opening new ways and path for the designers to come up and showcase their talents.

Although being so advanced systems there are still scope of improvements in following field:

1. Although we have developed a new approach and method to synthesise a exact geometry but there are still no single perfect value obtained for a suspension system.
2. Calibration of rolling angle and vehicle stability is a big challenge from future prospective.
3. Latest advancements in the field of automobiles have shown the trending concept of mechatronics, and improvement in the behaviour of systems using electronics.

7 REFERENCES

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