Design of rear suspension System for an All-Terrain Vehicle

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ABSTRACT

A common challenge in the rise of off road automobile sector across globe is the involved expenses. To raise the trend of this sector, there is a requirement to improve the existing design of suspension to provide better control of the vehicle. The changes in the design may lead to beginning of a new era in this field with the availability of economical and efficient designs. The objective of this paper is to study and design the static and dynamic parameters of rear suspension system. Here, the design for the rear suspension of an ATV is carried out so that it can be an independent suspension system because it keeps chassis unit in such a manner that rise or fall of one wheel has no effect on the other. Moreover, it can produce maximum wheel travel during jounce and bounce in the road. The system also kept as light as possible for reducing un-sprung mass of the vehicle to meet competition regulation.

Introduction

Suspension system is a crucial element in off-road vehicle which helps to get maximize traction effort between surface and wheels and to offer smoothness to the rider. Due to application of load in the downward direction, the vehicle remains grounded, and load gets passed on to the tires through suspension system [1]. While designing, the two most important parameters to be considered are rough patches of roads and variable conditions.

The different road conditions like hilly areas or rough surfaces which can be defined as high frequency (hilly region) and low frequency (rough road). Fluctuation in load is because of several factors as in case of turning, braking action, sharp turns, sudden rise or fall in speed. Hence, to continue in the given environment, a durable suspension system is required in order to provide a smoother experience for the occupants of the vehicle while driving on any kind of teraain irrespective of load applied [2]. The shock absorber decreases the magnitude of induced reactive force because of obstacles in the way of automobile. The value of the given reaction is directly proportional to the free weight of the carrier [3]. With higher sprung to un-sprung weight ratio, further decrease in reaction force could be achieved thus benefiting both vehicle and the occupants along with better control of the vehicle [4].

Here, double wishbone and semi-trailing suspension system is selected for front and rear respectively, developed in LSA (Lotus Suspension Analysis). In the later stage of design, the hard points are utilized in A-arms and semi-trailing arms so as to complete design by using SOLIDWORKS software.

The whole process of the synthesis is categorized into two parts. In the first phase, the discussion about conceptual knowledge of the elements is carried out followed by modification in design parameters based on approximation of dynamic conditions then execution of static testing and analysis. In the second phase, mathematical modeling of finalized concept is done then dynamic testing and analysis is performed which further leads to modification of design parameters based on dynamic testing results

Rear Suspension design optimization

The shape of rear suspension system is selected as semi-trailing arms. It consists of an extra member compared to that of the trailing, which is responsible to withstand higher lateral force than the conventional trailing arm. The benefits of semi-trailing arm are better lateral load handling capacity, minimal camber change and minimization of plunging of shaft.

1). Simulation of suspension Geometry in Lotus software

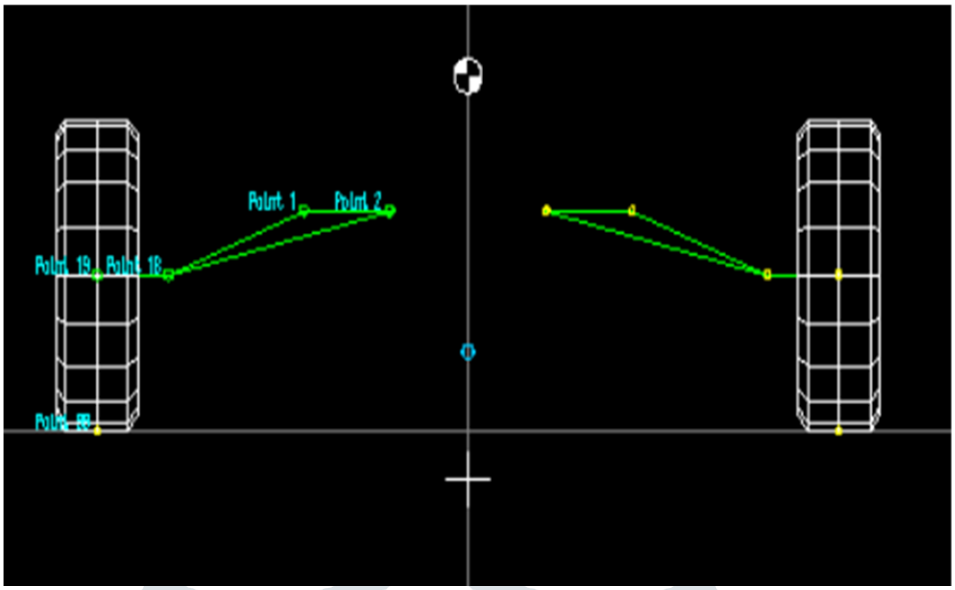

Figure1: Rear view of the rear suspension design without load

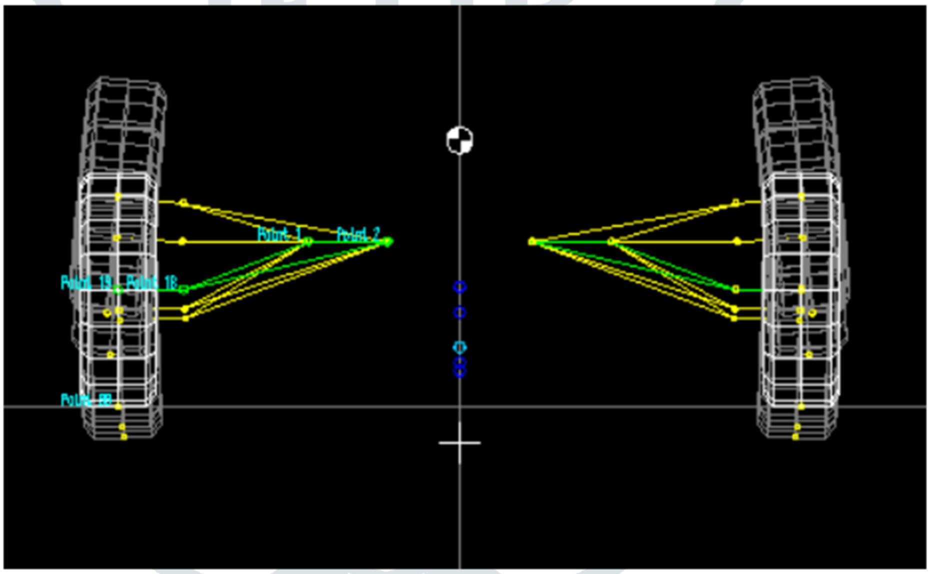

Figure2: Rear view of the rear suspension design with load

2). Simulation of suspension Geometry in Motion view

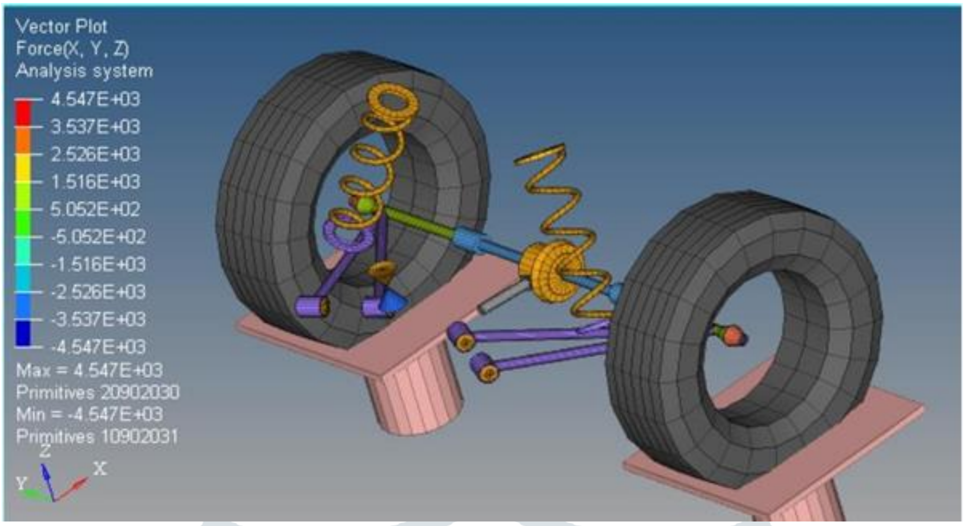

Figure3: Two post analysis of rear suspension

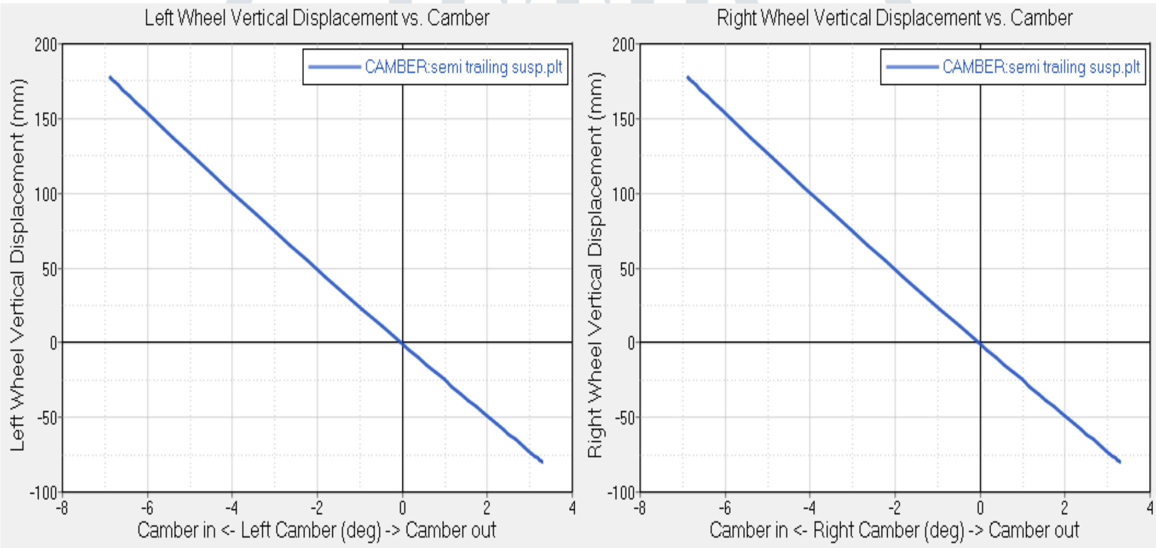

Figure 4: Camber change during jounce and rebound of rear Suspension.

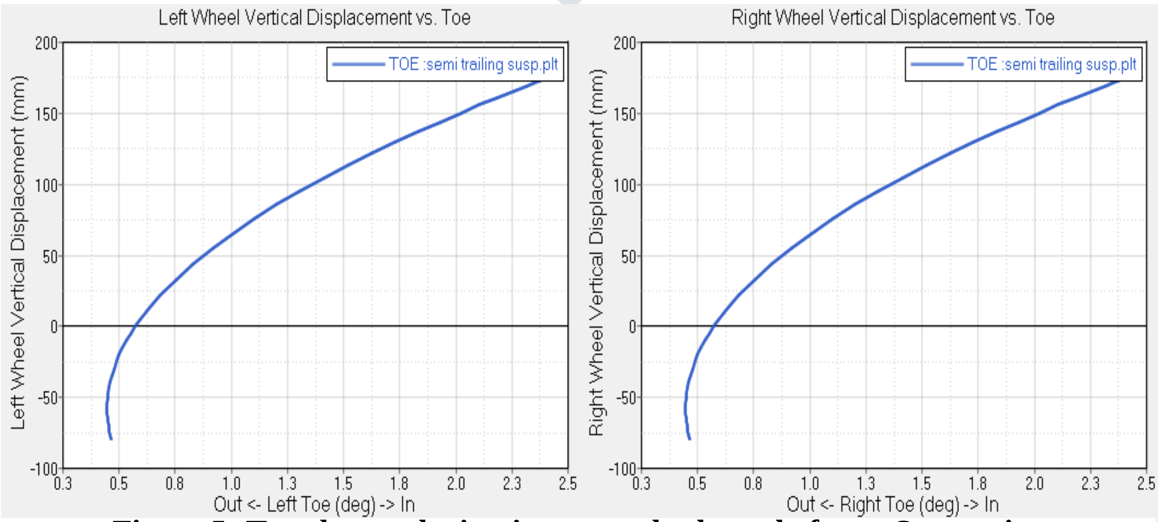

Figure 5: Toe change during jounce and rebound of rear Suspension

3). 2-D designing of geometry in Solidworks

Using all the data from Lotus software, model is created in Solidworks module to validate iterated values. All the hard-points are validated in order to ensure its usefulness in the design.

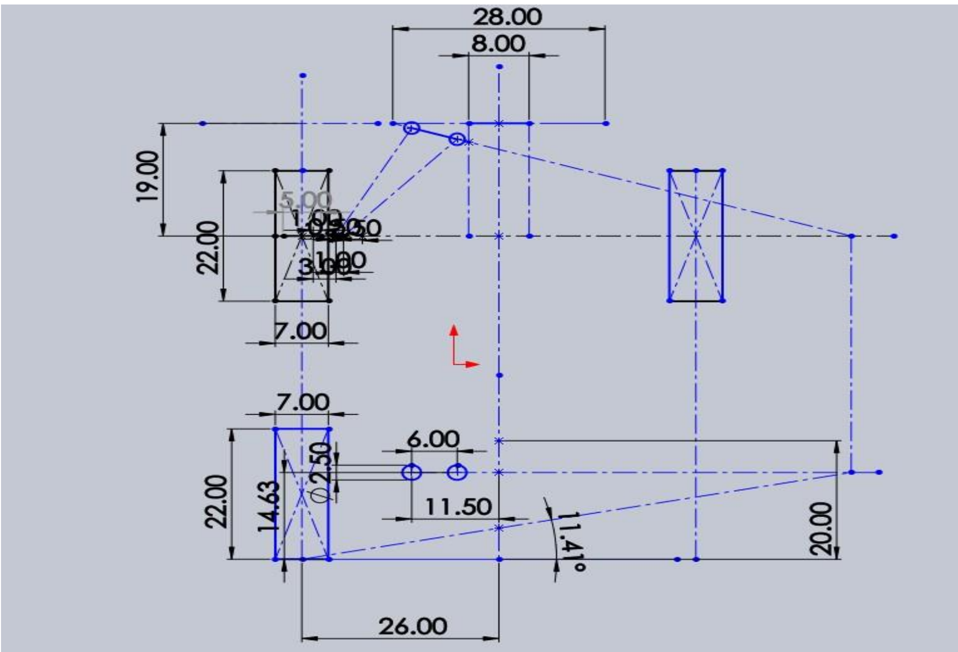

Figure 6: 2-D designing of rear suspension geometry in Solidworks

Results and Conclusions

With the proposed change in the design of rear suspension, the new values after calculations are presented below

Force on wheels

After letting the ATV fall from 2 m height. The

velocity at impact $=\sqrt{2 * g * h}$

$= \mathbf{6.26\ m/s}$

Change in momentum

dp = Sprung mass*(change in velocity)

= 155*(6.26-0)

= 970.3 kg-m/s.

$F = \frac{dp}{t} = \frac{970.3}{0.2} = \mathbf{4851.5\ N}$

Considering vehicle falls on two wheels then the

Force on 1 wheel, $F_1 = \frac{4851.5}{2} = \mathbf{2425.75\ N}$

Maximum deflection in spring= 152.4 mm

Motion ratio:

Motion Ratio (MR) = $\frac{Spri\ avel}{Wheel\ Travel}$ Cos(β)

Rear MR = 0.59

Desired Ride Frequency (f):

Only after the approximation of static deflection, the rider frequency can be known.

Rear, f_r= 2.2 Hz

Higher the ride frequency, Stiffer the ride gets and vice versa. Usually ride frequency of Rear suspension is chosen more than that of the front in order to stabilize the Vehicle as soon as it hits a bump. Whenever the vehicle comes across a bump the Front wheels undergoes vibration and after a time lapse the rear wheels vibrate. So if the ride frequency for rear is chosen more so that both the wheels will stabilize at same time

The rear Frequency is Kept 10% Higher.

Spring stiffness (acc. to desired frequency)

Rear, $k_r = 4\pi^2 * (2.2)^2 * (100.75) * \frac{1}{0.59^2}$ **=55.71 N/mm**

Wheel Rate (WR)

WR = Stiffness*$(M.R)^2$ Rear = 55.71 *$(0.59)^2$ =

19.39 N/mm

Roll Angle Calculation Roll angle=Torque/Rsf

Roll angle=Torque /Avg roll stiffness

=110.14/64.63

=**1.7 deg**

The paper presents the design of rear suspension of an All-terrain Vehicle (ATV). The dynamics of vehicle is the main factor in designing. The main aim of the given work is to find the relevant parameters of the rear suspension design which resulted in significant improvement of its performance .

References

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