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Optimization of characteristic angles of front mcpherson strut suspension system using multi body dynamics

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ABSTRACT

When vehicle is taking a turn on circular track or J turn or the hook turn then due to centrifugal force which is acting on the vehicle the tendency of roll steer will occur. This roll steer will reduce the handling performance of the vehicle and will increase the vibration level. The other effect which takes place during turning is variations in characteristic angles like castor angle, camber angle and toe in angle, if these variations are kept optimum then the vibrations will reduce. This will increase handling performance and ride perception of the passenger. The optimization of these characteristic angles is done by using genetic algorithm method. The genetic algorithm method requires most critical inputs, so that the results will be accurate. These inputs are considered based on the kinematic analysis of the Mcpherson strut suspension system. The optimization process is applied to a passenger car with Mcpherson strut suspension as the front suspension.

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I. INTRODUCTION

The objective of a suspension system is to isolate the body and its occupants from the irregularities of the road surface. Ideally the body should not experience vertical motion however bumpy the road surface. Another important feature of suspension is that it should keep the tires on the ground all the time. If there were no suspension the tires would tend to lift off the ground every time they passed over a bump at the same time, the shock as wheels lift up from ground and then come down again, would be transmitted directly to the passengers .ideally the suspension should allow the wheels to move up and down so that they follow the undulations in road while the body rides level .The first requirement therefore is that the wheels should be able to move vertically relative to the body.In the suspension systems there are two types of suspension systems one is dependent and another is independent. Mcpherson strut suspension system is a type of independent suspension system. This system is more popularly used as front suspension system in most of the cars. The main reason for this the simplicity of this suspension system. The system can be designed in accordance with the wheel geometry and overall vehicle characteristics. Advancement in technology has enabled the construction of more refined suspension systems with well defined geometries for whole motion of wheel. This helps in better understanding of operating characteristics of vehicle. For the better behavior and performance of the vehicle on the road in particular in curves, it is very important to determine optimal values of characteristic angles of wheels. Characteristic angles of wheel constitute of camber , castor, king pin and toe in.In the past, the values for the characteristic angles were determined by means of road tests. The determination of these values by road tests increases the development costs. Now a days with increase in numerical methods and simulation software, it is possible to achieve values of these characteristic angles with the help of these numerical simulation software like MSC. ADAMS. This will reduce the development cost. MSC. ADAMS is complex CAD programme formed of several working environments with a wide field of applications.

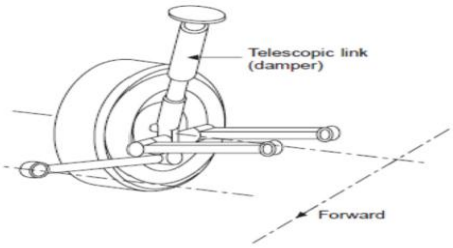

Fig No.1: Mcpherson strut suspension(1)

In recent surveyed studies on optimization of characteristic angles for Mcpherson strut suspension, one of the earliest papers found was published by G. VirziMarriotti [1]. They used visual Nastran software to analyse the variation in the characteristic angles like castor angle, camber angle and toe in angle and also concentrated on the lateral stability of vehicle.HoseinHabibi et al [**2]** In this the roll steer of a front Mcpherson suspension system is studied and the design characteristics of mechanism are optimized using Genetic Algorithm method. The method can be used to design of optimum novel suspension system as well as to improve the kinematic behavior of existing systems.Daniel A. Mantaras et al [3] have developed the mathematical model for kinematic behavior of vehicle using three dimensional model of McPherson steering and suspension mechanism. The model is capable of calculating various angles like castor, camber and toe-in for proper ride and handling characteristics.Ficarra G. et al [4] The author has done the numerical simulation for a vehicle to study the effect of characteristic angles on the ride and handling performance of vehicle. The results which are obtained by simulation are then verified by using pacejkaformulas.M. Raghavan et al [5] have carried out the work on different linkages for independent suspension systems like McPherson strut suspension. The kinematics related to the different linkages which are present in suspension system is explained.Dr. Ing. Giuseppe Carbone et al [6] have studied various types of suspension systems, their functions. The basic theory required to carry out the kinematical analysis of McPherson strut suspension is explained.J. W. Wong[7] have provided the all the basic concepts related to vehicle dynamics. The behavior of ground vehicles in various conditions is explained here.When vehicle is moving along a curve, then it exerts the force on ground. This contact force is between the tire and ground. There is also roll motion of the vehicle. The characteristic angles have effect on the contact forces between tire and ground. Thus the optimal values of these characteristic angles are to be found.The optimization would be carried out on the basic of maximum and minimum contact forces between tire and ground, rather than calculating the values based on ‘state variables’, ‘constraint of the mathematical problem’. When the contact force is maximum or minimum then the values obtained for the characteristic angles are optimum. Generally maximum contact force condition is preferred, as it gives more stability at its point. Second important parameter to be considered is adherence ratio. Adherence ratio should be small as this is associated with a low inclination to slip.

Table No.1: Model Specification

Peugeot 206(hatchback)		
1.	**Length**	**3855mm**
2.	**Width**	**1652mm**
3.	**Height**	**1428mm**
4.	**Kerb Weight**	**1025Kg**

The optimization for characteristics angles is done for the Peugeot 206 hatchback car and specifications are listed in table 1.

III. ANALYTICAL METHOD FOR OPTIMIZATION

The analytical process given to the optimization of the characteristic angles is based on the Pacejka formulas. Pacejka has developed a series of tire design models and the the formulas are also called as Magic Formula as there is no particular physical basis for the structure of the equations chosen, but they fit wide variety of tire construction and operating conditions. Each tire is characterized by 10-20 coefficients for each important force that it can produce at the contact patch, typically lateral and longitudional force and self aligning torque as the best fit between experimental data and model. These coefficients are then used to generate equations showing how much force is generated for given verticle load on tire, camber angle, and slip angle

IV. MULTI BODY SIMULATION

MSC ADAMS is a complex CAD program formed of several workingenvironments with a wide field of applications, which are Adams / Car, Adams / Chassis, Adams / Driveline, Adams / Insight , Adams / Flex, Adams / Engine, Adams / Postprocessor.,Adams / View. Applications of these different modules of ADAMS are different, as this project is based on suspension system Adams/Car module is required for this project. Adams/Car has different templates to create the subsystems like suspension, steering and after this, all subsystems are assembled to create full vehicle assembly.Mcphersonstrut suspension has different parts and to build them in Adams first step is to get the hard point data from geometry of selected model of Mcpherson strut suspension and then to model the part in Adams.

V. ADAMS MODEL

The Mcpherson strut suspension is modelled in the Adams car.The model is created using the the hard point data which is very essential in modelling the system in the the Adams Car.The various parts for the Mcpherson strut suspension are having different hard point location and hence the data required is quiet large. The model of Mcpherson is built without the bushing as it will increase the complexity of the problem.

1. Mcpherson Model

The Mcpherson strut suspension model is built in Adams Car which is used as the front suspension in the selected vehicle.

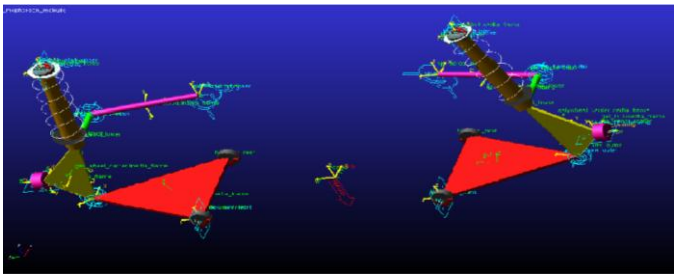

Fig No.2: Mcphersonstrut Model

3. Variation in Angles

The figure 3shows the mean and the maximum values of the fitness of the chromosomes in each generation on the basis of index changes of the toe angle. According to this graph, the program execution is completed:

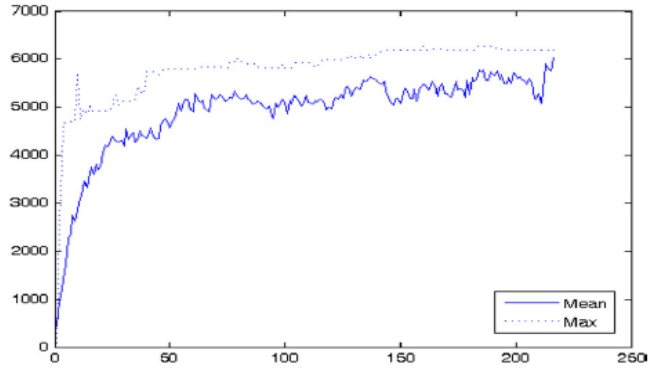

Fig No. 3: Toe in Variation

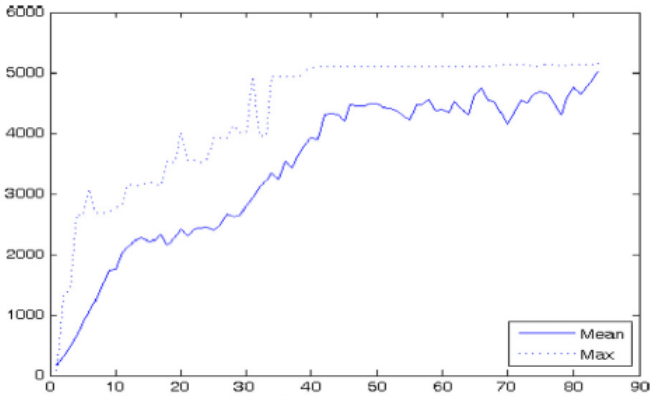

Fig No. 4 variation in castor

The variation in the castor angle is shown in figure 6.

4. Optimization Results:

The optimization process is carried out and results are listed following table.

Table No. 2: Optimization Result

Performance Index	**Kinematic Parameter**		
	Variation of toe angle	**Variation of Camber Angle**	**Variation of Castor Angle**
Length of control arm(mm)	**456.75**	**457.55**	**456.99**
Initial angle of control arm	**-8.90**	**-8.84**	**4.311**
Initial length of strut(mm)	**450.85**	**452.01**	**608.77**
King Pin angle	**11.85**	**17.09**	**15.69**

VI. RESULTS AND DISCUSSION

It can be found that the optimum value of the length of control arm for the three performance indices of the problem is similar, whereas for some other parameters the optimum values are quite different.

VII. CONCLUSIONS

During the turning maneuver, the characteristics angles such as castor angle, camber angle and toe-in angles varies and they cause the problem of roll steer which causes the bad handling of the vehicle. If the variation of these angles is controlled and kept to the optimum value the problem of roll steer can be reduced. The optimization of these angles is carried out through the genetic algorithm method. The input which is roll steer angle is given and by selecting critical linkages of the Mcpherson strut suspension depending on kinematic analysis the population space for genetic algorithm is defined. The effect of castor angle variation is more on the roll steer as compared to other angles.

ACKNOWLEDGEMENTS

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