Optimization of Key Parts of Front Suspension System of Three Wheeler

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ABSTRACT

Front suspension system of three wheeled vehicle includes suspension arm, steering column, shock absorber and suspension spring. One of the issues about this vehicle is that it drifts towards right side. It is due to the more weight of the suspension components. To solve this problem the front suspension is require redesign and optimize to reduce the weight. The purpose of this paper is to provide information about the optimization of front suspension system of three wheeled vehicle by using Finite Element Analysis.

Keywords: *steering column, suspension arm, suspension spring, three wheeler*

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1. INTRODUCTION

When people think of automobile performance, they normally think of horsepower, torque and 0-100kmph acceleration. But all of the power generated by a piston engine is useless if the driver can't control the car. That's why the suspension system in an automobile is important and so much attention is given to it. The vehicle suspension system is responsible for the vehicle control, driving comfort and safety as the suspension carries the vehicle body and transmits all the forces between the road and the body.

The job of the suspension system is:

- To maximize the friction between the tires and the road surface
- Provide steering stability with good handling
- To ensure the comfort of the passengers

If a road were perfectly flat, with no road irregularities, suspension would not be necessary. But the roads are far from flat. Even the freshly paved highway roads have subtle imperfection that can interact with the wheels of a car. It's these imperfections that apply forces to the wheels that result in wheel acceleration. According to Newton's laws of motion, all forces have both magnitude and direction. A bump in the road causes the wheel to move up and down perpendicular to the road surface. The magnitude, of course, depends on whether the wheel is striking a giant bump or a tiny speck. Either way, the car wheel experiences a vertical acceleration as it passes over an imperfection without an intervening structure, all the wheels vertical energy is transferred to the frame, which moves in the same direction. In such a situation, the wheels can lose contact with the road completely. Then, under, the downward force of gravity, the wheels can slam back into the road.

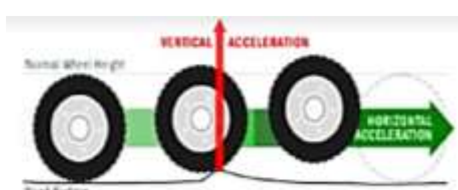

Figure 1: Concept of Suspension Working

Thus, what we need is a system that will absorb the energy of the vertically- accelerated wheels, allowing the frame and body to tide undisturbed while the wheels follow bumps in the road.

2. LITERATURE REVIEW

In the past very few researches have been carried out on the optimization of three wheeler front suspension system. Tausif M. Mulla *et al* (2012) pointed out that the stress analysis of a helical coil compression spring, which is employed in three wheeler's auto-rickshaw belonging to the medium segment of the Indian automotive market. In the design of this kind of spring both the elastic characteristics and the fatigue strength have to be considered as significant aspects. In addition to this particular elastic property, as a consequence of the research effort in reducing the mass of components typical of the automotive industry, these springs have to face very high working stresses. The structural reliability of the spring must therefore be ensured. So for this purpose the static stress analysis using finite element method has been done in order to find out the detailed stress distribution of the spring.

Manish Dakhore *et al* (2013) discuss about locomotive suspension coil springs, their fundamental stress distribution, materials characteristic, manufacturing and common failures. Investigation on the premature failure of suspension coil spring of a locomotive, which failed within few months after being put into service, has been carried out analytically and using FEA software. Inherent material defect in association with deficient processing led to the failure of the spring.

Arindam Pal *et al* (2013) discussed Optimized Suspension Design of an Off-Road Vehicle Suspension system is the term that defines the transmissibility of an off-road vehicle. They describes the development of the suspension and steering geometry design that is fast enough to be used at off-road circuit giving us appropriate camber and caster variations toe angles, Ackermann geometry, proper flow of forces from chassis to ground and shock absorber characteristics when running on the challenges posed by a rugged off-road track. Designing and optimization of an off-road Buggy car was done using simulation and analysis with software's.

S. N. Gundre *et al* (2013) revealed that a finite element analysis of helical compression spring Electric Tricycle Vehicle Automotive Front Suspension. They discussed the finite element analysis of a helical compression spring, which is employed in electric three wheelers as per considering various road conditions in India. In the design of this kind of spring both the elastic characteristics and the fatigue strength have to be considered as significant aspects. In addition to this particular elastic property, as a consequence of the research effort in reducing the mass of components typical of the automotive industry, these springs have to face very high working stresses. The structural reliability of the spring must therefore be ensured. So for this purpose the static stress analysis using finite element analysis gives Von-Misses stresses and total deflection of helical compression spring at various loads. The shear stress produced in the spring at the loading condition is in safe. The deformation produced by the spring is also in given limit value so we can implement this spring to our electric tricycle. The results obtained by a fully 3D FE analysis also highlighted the poor accuracy that can be provided by the classical spring model when dealing with these spring geometries. Relative errors on maximum shear stress ranging from 1.5 to 4 per cent, with reference to the applied loads, obtained when compared with the values calculated by using simple analytical model which is found in textbooks. The stress distribution clearly shows that the shear stress is having maximum value at the inner side of the every coil. The distribution of the stress is similar in every coil. So the probability of failure of spring in every coil is same except end turns. In such case residual stress in every coil may be important factor which influence the failure.

Mehdi Bakhshesh *et al* (2012) discussed Optimization of Steel Helical Spring by Composite Spring. Springs that can reserve high level of potential energy, have undeniable role in industries. Helical spring is the most common element that has been used in car suspension system. In their research, steel helical spring related to light vehicle suspension system under the effect of a uniform loading has been studied and finite element analysis has been compared with analytical solution. Afterwards, steel spring has been replaced by three different composite helical springs including E-glass/Epoxy, Carbon/Epoxy and Kevlar/Epoxy. Spring weight, maximum stress and deflection have been compared with steel helical spring and factors of safety under the effect of applied loads have been calculated. They found that spring optimization by material spring changing causes reduction of spring weight and maximum stress considerably. In any case, with changing fibre angle relative to spring axial, composite spring properties have been investigated.

Lihui Zhao *et al* (2012) focused Dynamic Structure Optimization Design of Lower Control Arm Based on ESL. Structure optimization techniques under static load conditions have been widely used in automotive industry for lightweight and performance improvement of modern cars. However, these static load conditions could not represent all the severe situations of automobile parts which subjected to complex loads varying with time, especially for lower control arm of front suspension. In this study, dynamic optimization of lower control arm was performed by combing traditional static load optimization techniques and multi-body dynamics by Equivalent Static Load (ESL). And the best draw-bead distribution of the stamped lower control arm was attained. Comparing the MBD analysis results of the new design derived from dynamic optimization and original structure. Their results show that the strength and stiffness was increased significantly while the mass was almost unchanged.

Aurel P. (2009) in his paper presents the optimal design method of the helical springs of the automobile suspensions according to the criterion of the minimum mass. For this purpose, at a given spring rate, the torsional stress corresponding to the maximum force applied to the spring, the fatigue stress, the buckling stability condition and the constraints relating to the spring index and to the outer coil diameter are considered. The work example allows also drawing more general conclusions. He has elaborated a nonlinear programming model with constraints for the optimal design of an automobile spring suspension according to the criterion of the minimum mass. The optimization method is associated with the solving of certain algebraic systems by means of usual computer programs.

Koona Ramji *et al* (2007) discussed Optimum design of suspension system of three wheeled motor vehicles. Three wheeled motorized vehicles play an important part in city transport of developing countries. In the present work, the results of an optimum design of suspension system using 9 degrees-of-freedom (DOF) analytical model for coupled motion of commercial three - wheeled motor vehicles of Bajaj rear engine (RE) and Vikram front engine (FE) vehicle over road of various degree of measured roughness are presented. Using ride comfort criteria, the significant design variables affecting system behaviour namely spring stiffness and viscous damping values of the front and rear suspension, wheelbase and track width were optimized using random search optimization technique (RST). The resulting ride behaviour has been compared with International Standard Organization (ISO) 2631 values. In this optimization method, the sensitivity of the eight design variables towards the minimization of root mean square acceleration spectral density using two methods is ascertained and is reported.

From all above discussion it is observed that the optimization phenomenon depends upon material properties, tool geometry, static loading, Ackermann geometry, proper flow of forces from chassis to ground and shock absorber, fatigue strength, structural reliability etc.

After going through literature it is found that the different Authors have focused on various suspension system parts optimization by considering one-two parameters and various methods, our aim is to focus on all the parameters simultaneously so as to get optimized front suspension for three wheeled vehicle.

3. RESEARCH GAP

Yet no more work has been carried out in optimization of front suspension system of three wheeled vehicle. Our aim is to optimize the suspension parts by reducing weight. Minimum weight reduction achieve should be 10%.

4. PROBLEM FORMULATION

From the research objectives the research problem is formulated in following manner:

1. Modelling of suspension system components using CAD software.
2. Development of mathematical model for optimization.
3. Optimization using FEA.
4. Validation of FEA results.

A detailed assessment of the problem of the vehicle was done and was found that the vehicle drifts towards one side i.e. towards the right side. This is due to the weight of the suspension components is more, causing the vehicle to drags towards one side. To solve this problem the front suspension was redesigned and optimized.

5. OBJECTIVE

The objective is to optimize the suspension components with due considerations of directional stability and structural strength by achieving minimum of 10% reduction in weight without effect on performance. The project also involves solving the problem of straight line stability by improving the caster trail of the vehicle under consideration using Finite Element Analysis software like ansys, hyperworks etc.

6. METHODOLOGY

Arindam Pal *et al* (2013) in there paper discussed designing and optimization of an off-road Buggy car. It was done using simulation and analysis with software's.

Firstly the vehicle considered to optimisation was tested for its straight-line stability. Then finite element analysis (baseline analysis) of the existing front suspension configuration and that of the competitor vehicle was done. Correlating both the test data and the data obtained from finite element analysis it was found that the weights of the front suspension components are more and the front suspension components need to be optimised for their weight. The components considered for optimisation are:

- Steering column
- Suspension arm
- Suspension spring

Components like Steering column and suspension arm has to be optimised by finite elements methods but the suspension spring had to be redesigned in order to optimise their weight. After optimisation the components were checked for their structural strength and if they did not meet the strength requirements the components had to be redesign until the strength was meet. Once optimisation of the mentioned above components was done prototype of the components were made. The vehicle was then tested for its optimised front suspension was tested to quantify its straight-line stability.

7. CONCLUSION

Stability of vehicle provides comfort for the passengers, but due to excess weight of the system increases also disturb the stability of the vehicle. After reviewing literature review from the optimization point of view, the research objective is formulated. From the objective the research problem is formulated. The problem of optimization can be solving by various parameters like changing material, geometry etc. without affecting the performance. The model can be validated using simulated analysis and experimental work.

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