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A REVIEW - EXPERIMENTAL ANALYSIS, OPTIMIZATION OF PASSIVE SUSPENSION SYSTEM USING TAGUCHI METHOD

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Abstract— Design of passive suspension system is challenging task for the automobile designer in a view of multiple control parameters, complex objectives and disturbances having stochastic nature. A passive suspension system is compromise between ride comfort and road holding. In this review paper the passive suspension system and effects of their parameters on ride comfort and road holding are studied. A Quarter car model of two degree of freedom has been used to investigate the performance of passive suspension system and tries to find the researches has done to get the optimized parameters of suspension system such as spring stiffness, damping coefficient, sprung mass for better ride comfort as per ISO 2631-1, 1997 standards.

Keywords: Optimization, Quarter car model, Ride comfort, Taguchi method.

I. INTRODUCTION

In modern automobiles, a key issue in design and manufacture is passenger comfort. Design of advanced passive suspension system is one of the performance requirement which gives better ride comfort and road holding. Due to road irregularities the motions are experienced by the harmful effects of vibration. Vibration may cause the hyperventilation, back pain, osteoarthritis, slipping of disc etc as shown by Kjellberg [12]. In contravention of all the development in vehicle design profession, the designer of automobile still have a subject of conflict in determining the vibration comfort. It is well known that a quarter car model is used to characterized the ride characteristics of passenger vehicles and investigate the performance of passive, semi active and fully active suspension system [9].

A. Passive suspension

Today's commercial vehicles used passive suspension system to control the dynamics of vehicles such as vertical motion, pitch and roll. Passive suspension system cannot supply energy to the suspension system. The motion of body and wheels are controls by the passive suspension system by limiting their relative velocities to the rate that gives desired ride characteristics [5].

B. Quarter car model

A well known model is a quarter car model which used for simulating one dimensional vehicle suspension performance. The suspension system in simplified form consists of a spring of stiffness K and a damper with damping coefficient C. The spring is used to support the static weight of vehicle while damper dissipates the vibration energy and minimized the input from road which is transmitted to the vehicle [5].

C. Ride comfort

In force vibration, caused by road disturbances, the ride of a vehicle is the heaving, pitching and rolling motion. The minimization of passenger discomfort is done by suspension system which minimizes some of the measure of the vehicle body motion by using spring and damper combination. Ride comfort, depends on magnitude and direction of acceleration and the frequency of vibration. Today's world uses four methods to evaluate ride comfort. In Europe, mainly the ISO 2631 standard is used and the United Kingdom uses the British standard BS 6841. VDI 2057 uses by Germany and Austria while the United States of America uses AAP. The time domain and frequency domain may be analyzed the ride comfort. The positions, velocities and accelerations as function of time is predicted by time domain analysis while the characteristics as function of frequency e.g., transmissibility predicts by frequency domain analysis [6].

II. LITERATURE REVIEW

A. Mitra [1] et al. studied and analyzed the dynamic response of ride performance and vehicle handling by using nine degree of freedom half car model. They varied the parameters such as rear mass, damping coefficient, spring stiffness of front and rear suspension, wheel base and the distance of the driver as well as rear mass system from the center of mass of the vehicle and investigate the influences of the randomness of the vehicles parameters. They consider the effects of optimized parameters for better comfort using practical set of parameters and conclude that the improvement in ride comfort is achieved.

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Anirban Mitra [2] et al. studied the quarter car model using Simulink and Bond Graph for ride comfort and vehicle handling. Their aim is to developed and applied the systematic methodology to obtained the ideal combinations of vehicle subjected to road excitation. They developed a four degree of freedom quarter car model to study their effects on passenger body, seating on cushion seat using simulink and bond graph. They studied, over the wide range of road bump, effects of variations of suspension stiffness and damping coeffient on ride comfort, road holding and head displacement.

A.C.Mitra [3] et al. studied the optimization of vehicle suspension parameters for ride comfort based on RSM. RSM is one of the methods of DOE and implemented for finding the optimal settings of spring and damper. They proposed a simulation model to analyze the ride comfort as per Box-Behnken design of RSM. They developed a prediction model of response variable Rc using regression analysis which have good agreement with simulated model. They evaluated the optimal settings of spring stiffness and damping coefficient by using fitted model with the help of response optimization of high desirability value.

A. Mitra [4] et al. Their objective is to analyze the ride comfort and vehicle handling by developing a MatLab/Simulink model of full car. They developed a state space matrix by studying the mathematical model step by step. They validated the simulink model with analytical solution of state space matrix

P. Senthil Kumar [5] et al. present an optimum concept to design passenger friendly vehicle suspension system with the help of Taguchi. They demonstrate the concept and process of optimization by using a quarter car suspension test rig. They conduct the experiments by varying input parameters such as damping coefficient and stiffness of shock absorber and seat. They investigate the effects of input parameters on seat displacement and settling time by using analysis of variation. They predicted the optimum system parameters by using taguchi analysis and validated by the MSC-ADAMS.

Saeed Mostaani [6] et al. investigate and determine the spring and damper settings for optimal ride comfort of vehicle with different speeds using DOE. They used seven degree of freedom model with speeds ranging from 60 to 90 Kmph and optimization is performed with the DOE method.

Mehrda N. Khajavi [7] et al. compared the ride and handling performance of a specific automobile of passive suspension system with the proposed fuzzy logic semi active suspension system. They developed a quarter car model of two degree of freedom. They used matlab / simulink for Simulation and controlled design.

M.J.Mehmoodabadi [8] et al. introduced a novel combination of particle swarm optimization (PSO) and Genetic algorithm (GA). The operators such as mutation, traditional or classical crossover, multiple crossover and PSO formula uses the hybrid algorithm. For the pareto optimal design of five degree of freedom vehicle vibration model, the proposed multiobjective hybrid algorithm is used.

T. Ram Mohan Rao [9] et al. described the modeling and testing of skyhook and other semi active suspension control strategies. They investigate the control performance of a three degree of freedom quarter car semi active suspension system by using Mat lab/Simulink model. Their objective is to present a analysis of novel hybrid semi active control algorithms and compare the semi active and passive system.

G. Verros [10] et al. presented a methodology for optimizing the damping and stiffness parameters of suspension system of non linear quarter car models subjected to random road excitation. They investigate the effects of road quality and examine effects related to wheel hop. They compare the results obtained for vehicles with passive linear or bilinear suspension damper and semi active shock absorber.

T.P.Gunston [11] et al. Their study considered the dynamic responses of the various components of seats for optimizing the isolation characteristics of a suspension seat. They optimized seat component using numerical model of the seat. The two alternative methods of modeling dynamic behavior of two suspension seats whose dynamic characteristics were measured in laboratory, compared. The concluded that for developing the overall design of suspension seats the lumped parameter model is best fitted.

Manoj K. Mahala [12] et al. studied the responses of different models and compared for different road conditions. They considered a mathematical model of a quarter car model (2DOF), half car model (4 DOF) and full car model (7 DOF) and analyzed by using Simulink for pitch and roll modes of input. They concluded that seven degree of freedom model can simulate pitch and roll accurately. They found that the models with higher number of parameters are better than lesser parameters.

III. CONCLUDING REMARKS

Following points to be noted from all the above study-

- In this paper we introduced the techniques for optimizing the passive suspension system of vehicle.
- We studied the different parameters that have been used to optimize the ride comfort as per ISO-2631:97,1standard.

From the above study we have seen that the researches done on the passive suspension system for optimizing the ride comfort by only varying the sprung mass, damping coefficient and spring stiffness. With the help of above study, It is planned to prepare a Quarter car test rig for analyzing and optimizing the passive suspension system for ride comfort and proposed to use a two sensors, two accelerometer and Data acquisition system. Using the developed test rig, parameter tests will be conducted to obtain the optimal settings of spring stiffness and damping coefficient for optimized the passive suspension system. The obtained results should improve the performance of passive suspension system.

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