Review Article

A REVIEW ON VIBRATIONAL ANALYSIS OF SUSPENSION SYSTEM FOR QUARTER AND HALF CAR MODEL WITH VARIOUS CONTROLLERS

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ABSTRACT

Suspension system of an automobile not only supports the body of the vehicle, engine and passengers but also absorbs shocks arising from the roughness of the road. So, tremendous research carried out on vibrational analysis for active and passive suspension system. This paper includes review of vibrational analysis for active and passive suspension for linear and nonlinear system. Vibrational analysis usually carried out with quarter car, half car and full car model. Also uses various optimization techniques for optimum parameters for suspension system.

KEYWORDS— Passive and active suspension system, Quarter, half car model, FFT analyser, PID controller, MATLAB.

INTRODUCTION

Conventionally Automobile suspension strategies have been a compromise among three contradictory criteria of road holding, rattle space requirements and ride comfort of passenger. The suspension arrangement need to take care of the vehicle handling parameters during vehicle moving over a terrain and be responsible for effective separation of passengers from road disturbances (Robert L.W 1997). Though a passive suspension system has the capacity to collect the energy through a spring and to drive away it via a shock absorber, their factors are normally fixed. These fixed parameters support to attain a definite level of settlement among road holding and comfort by the selection of different stiffness and damping parameters (Robert L.W 1997).The passive suspensions have inherent limitations as a consequence of the choice of elastic and damping characteristics to ensure an acceptable behavior for the entire working frequency range. The need to obtain a compromise between the conflicting requirements among different vibrations modes of the vehicle justify the research of the active suspension systems, the intelligence being determined by a controller that takes data from the vehicle dynamics. The response of the passive suspension is only affected by the external excitations and the system parameters that have a direct action on the suspension. Instead, the intelligent suspension is affected by indirect parameters, such as acceleration of the roll, pitch or vertical oscillations. The way to implement intelligence in a suspension system is to use variable damping – semi-active suspension, or to create a counter-force system – active suspensions.

LITERATURE SURVEY

Shpetim Lajqi [1] et al. studied, design and optimization procedure for active and semi-active non-linear suspension systems regarding terrain vehicles. Their objectives were the ability to quickly analyze vehicle's suspension performances resulting from passive, active, or semi-active systems. They represent vehicle by mathematical model regarding a quarter of it, and equations for motion are derived and solved by using MATLAB/Simulink.

Anirudh R. Iyer [2] et al. studied, cars provided with independent suspension for the front wheels and conventional suspension for the rear wheels. When the automobile is moving, the roughness of the road keeps giving excitations to the suspension system through tyres. They discussed optimum parameters of suspension system. They shown variation in three dimensional figures.

Florin Mailat [3] et al. their study is based on the fact that the vibratory behavior of the system with motion-dependent suspension force is considerably different than that exhibited by damped systems with constant-magnitude suspension force. They studied semi active suspension system with quarter car model. They applied simultaneous optimization technique to transform the ill-posed problem into a well posed one.

S. Prabhakar [4] et al. The aim of their study is to simulate the passive suspension system for quarter car model with variable damping and stiffness parameters. They studied that, The disturbances are mostly in the form of various modelled road profiles (terrains) that the un sprung mass (wheel) comes in direct contact with and which in turn are transmitted to the sprung mass (body) of the system causing undesirable vibration or shaking that may cause discomfort to passenger.

Cătălin Alexandru[5] et al. Their study is representing a comparative analysis between the passive and active suspension systems of the motor vehicles. Their study is performed for a half-car model, which corresponds to the guiding - suspension system of a rear axle. The optimization is carried out with the Matrix Algebra Tool. For the optimization they used two stages performing parametric studies, and optimizing the controller.

Amit A. Hingane[6] et al. The aim of their study is to representing vehicle primary suspension system along with the analysis of a semi active suspension system with Bingham model for MR damper. Also they compared the ride and handling performance of a specific vehicle with passive suspension system with semi active suspension system. They show that Semi active suspension system gives lower value of maximum sprung mass acceleration for given random road excitation.

Swati Gaur[7] et al. Their study is based on the application of PI and PID controller to control the vibration occurred in the bus suspension system. In this paper they used Proportional Integral (PI) and Proportional-Integral-Derivative (PID) controllers to control the vibrations to give smooth response of the bus suspension system and carry-out their comparison on the basis of time and frequency using Matlabenvironment. Also they compared the response of open-loop, PI and PID controllers.

M.J. Pable[8] et al. They studied to find the best parameters of the passive system which provides a performance as close to the active system as possible.cAlso they give approach for design of the passive suspension parameters through the Linear Quadratic Regulator (LQR) based active suspension design technique.

Rosmazi Rosli[9] et al. Their study is based on the practical implementation of a new hybrid control method to a vehicle suspension system using Active Force Control (AFC) with Iterative Learning (IL) and proportional-integral derivative (PID) control strategy. Also they proposed AFCIL scheme has been designed, simulated and practically implemented for the control of a vehicle quarter car active suspension system.

Pankaj Sharma[10] et al. The aim of their study is to isolating the vibrations produced because of road disturbances from being transferred to driver. For this study they used a quarter car model with 2DOF is designed. They developed Matlab Program to analyze overshoot and settling time of a 2DOF quarter car model.

Yi Chen [11] et al. They studied a skyhook surface sliding mode control method and applied to the control on the semi-active vehicle suspension system for its ride comfort enhancement they show that, there was an enhanced level of ride comfort for the vehicle semi-active sus-pension system with the skyhook surface sliding mode controller.

Prof. S. P. Chavan [12] et al. considered nonlinearities in suspension parameters for proper designing of suspension system. They consider nonlinearities of spring and damper for quarter car model. They give deterministic impulses due to road profile by harmonic shaker which gives input motion to shock absorber. The sprung mass acceleration response obtained by FFT analyser at sprung mass of quarter car model is compared with the results obtained by linear and nonlinear MATLAB Simulink models.

Abdolvahab Agharkakli [13] et al. studied simulation and analysis of passive and active suspension system. Their objectives was to obtain a mathematical model for the passive and active suspensions systems for quarter car model and construct an active suspension control for a quarter car model subject to excitation from a road profile using LQR controller. They used Linear Quadratic Regulator (LQR) control technique for a quarter car model. The performance of LQR controller,they determined by performing computer simulations using the MATLAB and SIMULINK toolbox.

Panshuo Li [14] et al. studied suspension performance with semi-active control under the assumption that the inertance may be adjusted in real-time. They design suspension system to attenuate the vertical acceleration of the sprung mass. They considered quarter car model and install inerter parallel to the spring and damper. Their Simulation results show that comparing with the passive suspension with a fixed inerter, the designed$H2$ controller realized by adaptive inerter can achieve good improvement of ride comfort at the sprung mass natural frequency at the expense of a relatively small deterioration at the un sprung mass natural frequency.

Suresh A. Patil[15] et al. describes a prototype Hydraulic Active Suspension System for Road Vehicles, with an objective to analyse the feasibility and effectiveness for approach. The physical system, which models a quarter-car suspension, consists of a wheel, coil springs, a Hydraulic Actuator for active damping, position, and velocity sensors, and a Direct Current (dc) motor for simulating road disturbance input signal. They used FFT Analyser and MATLAB SIMULINK Modelling.

Arshad Mehmood [16] et al. gives an insight on the suspension dynamics of the two most widely used models for vehicle dynamics with their complete state space analysis, simulated by using Matlab platform. They investigate the responses of the quarter car and a half car model as the vehicle ride performance is generally assessed at the design stage by simulating the vehicle response to road excitation.

T. Ram Mohan Rao [17] et al. they described the modelling, and testing of skyhook and other semi active suspension control strategies. Also they investigated the control performance of a three-degree-of-freedom quarter car semi active suspension systems using Matlab/Simulink model. They present a comprehensive analysis of novel hybrid semi-active control algorithms and to compare the semi-active and passive systems in terms of human body vibrational displacements and accelerations.

Jin Liu [18] et al. they present two methods for parameters optimization of traditional passive suspension based on the invariant point theory. They compare the control performances of the two improved passive suspension systems with those of the original passive suspension, the active suspension, and the semi-active suspension by some performance indexes. They show the two optimization methods could greatly improve the control performance of passive suspension systems.

Ali Reza Toloei [19] et al. they design Proportional Integral Derivative classical controller based on Bees Intelligent Algorithm as the optimization technique for nonlinear model of active landing gear system that chooses damping and stiffness performance of suspension system at touchdown as optimization object.

CONCLUDING REMARK

- Wide research has done in active and passive suspension system.
- Many researchers are used quarter car model for their experimentation.
- Most common controllers used are FFT analyser, Linear Quadratic Regulator (LQR) control and proportional-integral derivative (PID) control.
- For simulation widely used MATLAB Simulink software package.
- Although PID controller is widely used, there may use fuzzy logic controller for better accuracy.
- Wide research had done for parametric optimization using various optimization techniques like simultaneous optimization.

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