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AN OVERVIEW OF RIDE COMFORT ANALYSIS OF QUARTER CAR MODEL ACTIVE SUSPENSION SYSTEM SUBJECTED TO DIFFERENT ROAD EXCITATIONS WITH ACTUATOR DELAY AND NONLINEAR PARAMETERS

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ABSTRACT

Ride comfort is a key issue in design and manufacture of modern automobiles. It is necessary to design finer suspension system in order to improve the quality of vehicles. Most real-world phenomena exhibit nonlinear behavior. In this paper overviews of various works are done. This paper tries to give an idea about the previous researches and their finding about study of ride comfort analysis of active suspension system subjected to different road excitation with actuator delay and nonlinear parameters.

Keywords – Ride Comfort, Active Suspension, Actuator Delay, Nonlinear.

I. INTRODUCTION

A car suspension system is the mechanism that physically separates the car body from the wheels of the car. Suspension system is one of the important part of the vehicle. Therefore, it is quite necessary to design finer suspension system in order to improve the quality of vehicles. Since the disturbances from the road may include uncomfortable shake and noise in the vehicle body, it is important to study the vibrations of the vehicle.

Suspension consists of the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. The main function of vehicle suspension system is to minimize the vertical acceleration transmitted to the passenger which directly provides road comfort. Traditionally automotive suspension designs have been compromise between the three conflicting criteria's namely road handling, load carrying, and passenger comfort. There are mainly three types of suspension system; passive, semi-active and active suspension system. Traditional suspension consists springs and dampers are referred to as passive suspension, then if the suspension is externally controlled it is known as a semi active or active suspension. Current automobile suspension systems using passive components, only by utilizing spring and damper with fixed rates [1].

Most real-world phenomena exhibit nonlinear behavior. There are many situations in which assuming linear behavior for physical system might provide satisfactory results. On other hand, there are circumstances or phenomena that require a nonlinear solution. A nonlinear structural behavior may arise because of geometric and material nonlinearities, as well as change in the boundary conditions and structural integrity. A nonlinear spring has a nonlinear relationship between displacement and force, and a nonlinear damper has a nonlinear relationship between velocity and force. A graph of force vs. displacement and force vs. velocity for a nonlinear spring and damper respectively, will be more complicated than a straight line, with a changing slope. As nonlinear springs have different load-deflection characteristics than the linear spring, there will be difference in the amplitude of main mass obtained by theoretical and experimental methods. The non-linearity in mass arises when mass moves with certain velocity, which is due to change in mass density of the fluid around it [2].

Ride comfort is a key issue in design and manufacture of modern automobiles. Design of advanced suspension systems is one of the requirements, which provide a comfortable ride by absorbing the road disturbances as well as maintain the vehicle stability. A good amount of research activities has been directed to improve the ride comfort especially over the last decade [3].

By considering all above facts, this paper tries to cover literature which deals with ride comfort analysis of quarter car model active suspension system subjected to different road excitation's with actuator delay and nonlinear parameters.

II. ANALYTICAL AND EXPERIMENTAL STUDIES ON ACTIVE SUSPENSION SYSTEM OF LIGHT PASSENGER VEHICLE TO IMPROVE RIDE COMFORT

M. Senthil kumar et al., in 2007, published a paper on Analytical and Experimental Studies on Active Suspension System of Light Passenger Vehicle to Improve Ride Comfort. The work attempts to analyze that active suspension system has improved ride comfort. They developed the active suspension system and carried out experimental analysis. Experimental results show that active suspension system works better than both experimental passive and theoretical active suspension system. They also found that active suspension system improves ride comfort even at resonant frequency [4].

III. ART OF AUTOMOTIVE ACTIVE SUSPENSIONS

X. D. Xue et al., in 2011 studied The Art of Automotive Active Suspensions. In this study, research and development of automotive active suspensions are reviewed. Structures and models of various automotive suspensions are described. Furthermore, typical commercial products of automotive suspensions are illustrated. Based on the reported studies and development, the authors discussed the comparisons between various vehicular suspensions from the aspects of structure, weight, cost, ride comfort, handling performance, reliability, dynamic performance, energy recovery, and commercial maturity. Consequently, it is deduced that electromagnetic active suspensions are the future trend of automotive suspensions due to simple structure, high-bandwidth, accurate and flexible force control, high ride quality, good handling performance, and energy regeneration. At the same time, the issues of future research and development of electromagnetic active suspensions are proposed [5].

IV. SIMULATION AND ANALYSIS OF PASSIVE AND ACTIVE SUSPENSION SYSTEM USING QUARTER CAR MODEL FOR NON-UNIFORM ROAD PROFILE

Abdolvahab Agharkakli et al., in 2012 published paper on Simulation and Analysis of Passive and Active Suspension System using Quarter Car Model for Non-uniform Road Profile. In this study the active suspension system is synthesized based on the Linear Quadratic Regulator control technique for a quarter car model. They compared passive and active suspension system by using road profile. The performance of the controller is compared with the LQR controller and the passive suspension system. The performances of this controller were determined by performing computer simulations using the MATLAB and SIMULINK toolbox. They found that active suspension can give lower amplitude and faster settling time compare to the passive suspension [1].

V. RIDE COMFORT AND VEHICLE HANDLING OF QUARTER CAR MODEL USING SIMULINK AND BOND GRAPH METHOD

Anirban. C. Mitra et al., in 2013 studied the Ride Comfort and Vehicle Handling of Quarter Car Model using SIMULINK and Bond Graph Method. They analysed quarter car model by using SIMULINK and Bond Graph Method. For that purpose they developed 4 Degree of Freedom quarter car model to study important effects on passenger body (Head, Thorax-pelvis), seating on a cushion seat. They also examined the effects of variations of suspension stiffness and damping coefficient on ride comfort, road holding and head displacement, over wide range of road bump and optimized the various parameters to getting ride comfort [3].

VI. A COMPARATIVE ANALYSIS BETWEEN THE VEHICLES PASSIVE AND ACTIVE SUSPENSIONS

Catalin Alexandru, and Petre Alexandru, in their published paper, presented a comparative analysis between the passive and active suspension systems of the motor vehicles. The study was performed for a half-car model, which corresponds to the guiding - suspension system of a rear axle. The active suspension system was obtained by placing

a force actuator in parallel to passive suspension, the goal being to minimize the effect of the road disturbances. The passive and active suspensions were analyzed in the passing over bumps dynamic regime. The response of the active suspension is compared with the passive suspension, important improvements in the dynamic behaviour (in terms of stability and comfort) were observed for the active suspension [6].

VII. EXPERIMENTAL VERIFICATION OF PASSIVE QUARTER CAR VEHICLE DYNAMIC SYSTEM SUBJECTED TO HARMONIC ROAD EXCITATION WITH NONLINEAR PARAMETERS

Prof. S. P. Chavan et al., in 2013 performed the Experimental Verification of Passive Quarter Car Vehicle Dynamic System Subjected to Harmonic Road Excitation with Nonlinear Parameters. For this, nonlinearities of spring and damper are considered while preparing quarter car model. Authors compared the sprung mass acceleration response obtained by FFT analyzer at sprung mass of quarter car model with the results obtained by linear and nonlinear MATLAB/Simulink models. From the simulation results they observed that there is considerable difference in sprung mass acceleration of nonlinear suspension spring and damper quarter car model compare with linear suspension spring and damper. From Experimental results obtained they observed that the results obtained by theoretical analysis for quarter car passive suspension system are approximately same as that of experimental results [7].

VIII. PERFORMANCE EVALUATION OF ACTIVE SUSPENSION FOR PASSENGER CARS USING MATLAB

K. S. Patil et al., published the paper on Performance Evaluation of Active Suspension for Passenger Cars using MATLAB. Authors developed mathematical model for the passive and active suspension systems for quarter car model and constructed an active suspension control for a quarter car model subjected to excitation from a road profile using PID controller. They found that suspension travel in active case has been reduced to more than half or almost null of their value in passive system. They also examined the potential for improved ride comfort and better road handling [8].

IX. COMPARATIVE ANALYSIS OF VEHICLE SUSPENSION SYSTEM IN MATLAB/SIMULINK AND MSC ADAMS WITH THE HELP OF QUARTER CAR MODEL

S. J. Chikhale and Dr. S. P. Deshmukh in 2013 published the paper on Comparative Analysis of Vehicle Suspension System in MATLAB/Simulink and MSC ADAMS with the help of Quarter Car Model. They prepared two quarter car models, one in the Simulink and other is in MSC ADAMS. Also at first the mathematical model for quarter car is prepared using state space representation. This paper also discuss the development of quarter car model in Simulink first and then in MSC ADAMS. They validated the quarter car models analysis results from both the MATLAB and MSC ADAMS software by keeping input variables and basic properties same [9].

X. CONCLUSION

By the literature review it is seen that importance of ride comfort analysis of quarter car model active suspension system subjected to different road excitations. It also seems that active suspension gives more ride comfort than passive one. In earlier researches linear parameter of active suspension were considered but in practice the spring behaves with nonlinear characteristic and some amount of delay is present in actuator. So it is important to consider the nonlinearities of spring as well as actuator delay while designing the active suspension system.

REFERENCES

1. *Abdolvahab Agharkakli, Chavan U. S., Dr. Phvithran S., "Simulation and Analysis of Passive and Active Suspension System Using Quarter Car Model for Different Road Profile", International Journal of Engineering Research and Applications, Vol. 2, Issue 5, pp. 900-906, 2012.*
2. *A. A. Hingane, Dr. S. H. Sawant, "Vibrational Analysis of Undamped Dynamic Vibration Absorber Subjected to Harmonic Excitation with Nonlinear Parameters", International Journal of Emerging Science and Engineering, Vol. 2, Issue 2, 2013.*
3. *Anirban. C. Mitra, Nilotpal Benerjee, "Ride comfort and Vehicle handling of Quarter Car Model using SIMULINK and Bond Graph", 1st International and 16th National Conference on Machines and Mechanisms, 2013.*
4. *M. Senthil kumar, S. Vijayarangan, "Analytical and Experimental Studies on Active Suspension System of Light Passenger Vehicle to Improve Ride Comfort", MECHANIKA, Nr. 3:65, pp. 34-41, 2007.*
5. *X. D. Xue, K. W. E. Cheng, Z. Zhang, J. K. Lin, D. H. Wang, Y. J. Bao, M. K. Wong, and N. Cheung, "Study of Art of Automotive Active Suspensions", 4th International Conference on Power Electronics Systems and Applications, pp. 360-366, 2011.*
6. *Catalin Alexandru, and Petre Alexandru, "A Comparative Analysis between the Vehicles Passive and Active Suspensions", International Journal of Mechanics, Issue 4, Volume 5, 2011.*
7. *Prof. S. P. Chavan, Prof. S. H. Sawant, Dr. J. A. Tamboli, "Experimental Verification of Passive Quarter Car Vehicle Dynamic System subjected to Harmonic Road Excitation with Nonlinear Parameters", Second International Conference on Emerging Trends in Engineering, IOSR Journal of Mechanical and Civil Engineering, pp. 39-45, 2013.*
8. *K. S. Patil, Vaibhav Jagtap, Shrikant Jadhav, Amit Bhosale, Bhagwat Kedar, "Performance Evaluation of Active Suspension for Passenger Cars using MATLAB", Second National Conference on Recent Developments in Mechanical Engineering, IOSR Journal of Mechanical and Civil Engineering, pp. 06-14.*
9. *S. J. Chikhale, Dr. S. P. Deshmukh, "Comparative Analysis of Vehicle Suspension System in Matlab-SIMULINK and MSC-ADAMS with the help of Quarter Car Model", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 8, pp. 4074-4081, 2013.*