A Comparative Study between the Vehicles' Passive and Active Suspensions – A Review

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ABSTRACT

The objective of this study is a comparative study between passive and active suspension systems of the motar vehicle. Passive suspension system design is a compromise between ride comfort and vehicle handling. This is the conflicting criteria while designing any suspension system. This also applies to modern wheel suspension and therefore a break-through to this problem seems to be found only in the development active suspension system. The passive and active suspensions are studied in a large number of investigations. In this paper tries to give an idea about the previous researches and their findings about response of passive and active suspension also important improvements in the dynamic behavior (in terms of stability and comfort) being observed.

Keywords – **Active suspension system, control system, dynamics, passive suspension, vehicles.**

I. INTRODUCTION

When designing a suspension system, the dual objectives are to minimize the Vertical forces transmitted to the passengers and to maximize the tire-to-road contact for handling and safety. Comfort ability of passenger is very much related to the vertical forces that transmitted from the car body. This objective can be achieved by minimizing the vertical car body acceleration. An excessive wheel travel will result in non-optimum attitude of tyre relative to the road that will cause poor handling and adhesion. Furthermore, to maintain good handling characteristic, the optimum tyre to-road contact must be maintained on four wheels. In conventional suspension system, these characteristics are conflicting and do not meet all conditions. So there are various investigations are going on for the study of improvement in active suspension over passive suspension system. The purpose of a car suspension system is to improve ride quality while maintaining good handling characteristics subject to different road profile. Different suspensions satisfy the above requirements to different degrees. Although significant improvements can result from designers ingenuity, on the average, suspension performance mainly depends on the type or class of suspension used. Here one distinguishes, in an ascending order of improved performances, between passive, semi active and fully active suspension system, the force input usually provided by hydraulic actuators. As an alternative approach to active suspension system design electromechanical actuators would provide a direct interface between electronic control and suspension system. Active suspension, that includes the hydraulic actuators which create a force in the suspension system. The force generated by the hydraulic actuator is used to control the motion of the sprung mass and relative velocity between sprung and unsprung masses. [1]

In this paper overview of various works are done. This paper tries to give an idea about the previous researches & their finding about study of passive and active suspension system considering suspension nonlinearities, ride comfort and car holding as parameter.

II. DESIGN OPTIMIZATION OF QUARTER –CAR MODELS WITH PASSIVE AND SEMI-ACTIVE SUSPENSIONS UNDER RANDOM ROAD EXCITATION

G. Verros & S. Natsiavas in year 2005 studied Design optimization of quarter car models with passive and semi-active suspensions under random road excitation. In this paper they investigated a methodology for optimizing the suspension damping and stiffness parameter of nonlinear quarter car models subjected to road disturbance. The investigation carried out for car models involving passive damping with constant and dual characteristics. They found out the value of damping coefficient which approximates the performance of an active suspension. The value of suspension damping coefficient considered as the function of relative velocity of sprung mass to wheel subsystem. They presented systematic methodology for the optimizing suspension characteristics with respect to ride comfort, vehicle handling and working space of suspension taking in to account the random nature of the variability of the road profiles. They examined for the car models with linear suspension damper, bilinear suspension damper and skyhook model. The control strategies were applied to each model by employing appropriate methodology because the models were strongly nonlinear. Also the numerical investigation is carried out for typical quarter car models and different combination of the weighting factors in suitable defined performance index and observed the effects related to quality of road profiles because nonlinearity and wheel hop were examined and important observation were made. Based on the above information obtained from the all cases examined they concluded that semi-active controlled vehicle represent the better designs over the car models with passive dual rate dampers which in term exhibit a better performance the models with the linear suspension damper.[2]

III. ACTIVE SUSPENSION CONTROL TO IMPROVE VEHICLE RIDE AND STEADY-STATE HANDLING

In year 2005 Jun Wang et.al presented work on Active suspension control to improve vehicle ride and steady state handling. They made study on H ∞ control of active suspension for full car model. They designed two types of vehicle models namely linear suspension model and nonlinear handling model. The link between suspension model and vehicle steady state handling characteristics analyzed and the H ∞ controller used for active integrated ride comfort and handling control. The controller for both these model is verified by computer simulations.

A schematic diagram of a full vehicle model with active suspension is shown in fig. 1. Each quarter car model consists of spring and damper with force generating actuator connected in parallel. The force generator actuator is regulated by controller to improve vehicle ride and handling.

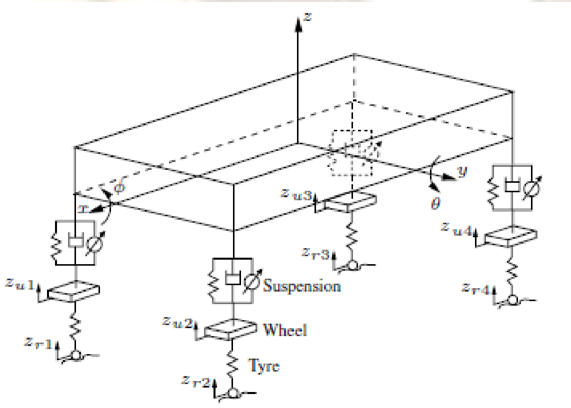

Fig.1. Schematic diagram of a full vehicle model

While the spring and damper are employed to support high frequency vibration above the bandwidth of the force generator. The computer simulation is carried out to evaluate the ride and steady state handling performance of vehicle of active suspension with H ∞ controller is compared to the passive suspension and active suspension with ordinary H ∞ controller.

Fig. 2 shows frequency responses of vehicle vertical, pitch angular, roll angular acceleration to front left road distribution. It is observed that the acceleration of active suspension system with integrated H ∞ controller (IAS) and active suspension with ordinary H∞ controller (AS) is considerable lower than

that of passive one in frequency range where human are more sensitive to vibration so both active suspension systems effectively improve the vehicle ride and handling characteristics. In summary the integrated H ∞ controller

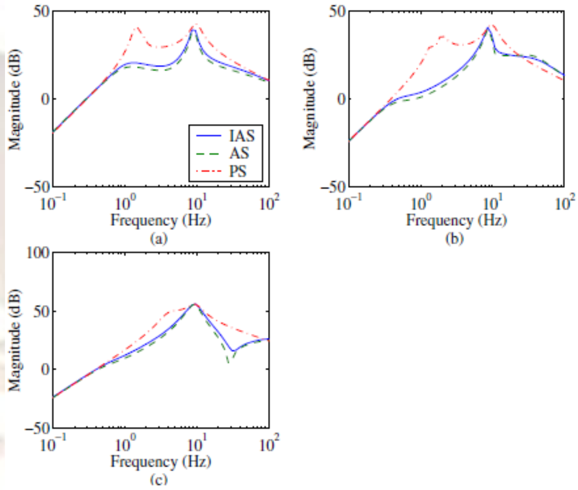

fig.2 Magnitude of the frequency response of vehicle acceleration to front-left road displacement for vehicle vertical, pitch angular, roll angular acceleration.

simultaneously improves vehicle ride comfort and handling performance with low actuator energy consumption. [3]

IV. MODIFIED SKYHOOK CONTROL OF SEMI-ACTIVE SUSPENSIONS

Keum-Shik Hong & Hyun-Chul Sohn in year 2002 studied the Modified Skyhook Control of Semi-Active Suspensions.demonstrates the connection between optimal one and two degree of freedom vehicle structure incorporating active suspensions. It is shown that the resulting, special one DOF structure represents the limits of the best possible performance attainable with two degree of freedom counterparts.

They present a detailed study of possible ride and handling improvements with active suspensions and design changes for the case of liner, quarter car vehicle models. The structural design includes the introduction of passive dynamic absorber for unsprang mass vibration control, which is further enhanced with active means. [4]

V. A COMPARATIVE ANALYSIS BETWEEN THE VEHICLES' PASSIVE AND ACTIVE SUSPENSIONS

In year 2011 Catalin Alexandru et.al made study on a comparative analysis between the passive and active suspension system of the motar vehicles. They carried out study for a half car model, which corresponds to the guiding suspension system for rear axle. The active suspension designed by placing actuator parallel to passive suspension system. The goal being to minimize the effect of road disturbance. The passive and active suspension analyzed on passing over bumps dynamic region. The response of active suspension is compared with passive suspension, the important improvements in the dynamic behavior are observed in the active suspension system. For the simulation, the simulation contains two linear actuator systems which are attached to rear wheels. The driving elements executing vertical motion relative to the fixed structure for simulating the road profile. The connection between the wheel and the sustaining plates are made using contact forces which are

Table no.1

parameter \ RMS		passive suspension	active suspension
roll angle	[dgr]	0.9394	0.0578
pitch angle	[dgr]	0.2578	0.0273
roll velocity	[dgr/sec]	7.6409	0.4878

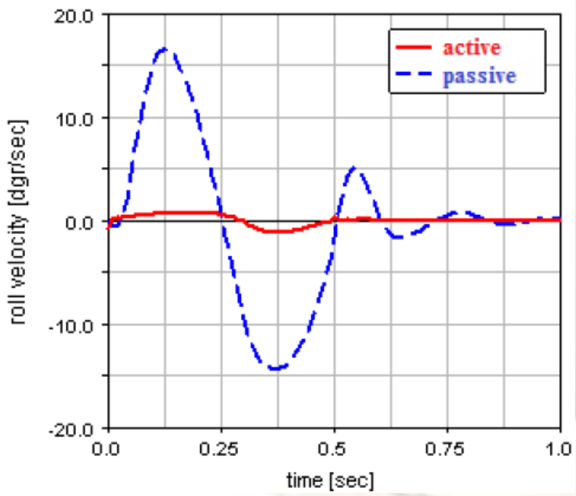

Fig.3 time-history variation of roll velocity

modeled as unilateral controls. The response of active and passive suspension system is compared on same testing conditions. In accordance with the dynamic behavior (in terms of stability and comfort) active suspension system gives improved performance over passive system. The improvement in terms numerical value is shown in table no. 1. Which represent the root mean square (RMS) of the interest parameter and the graphic simulation frame of one of the parameter is shown in fig.3. [5]

VI. ALTERNATIVE CONTROL LAWS FOR AUTOMOTIVE SUSPENSIONS

C.Yue et al. in year 1990 discussed on the alternative control laws for automotive active suspension system. They evaluate the control laws by using 2DOF quarter car model. The control laws considered are full state feedback sprung mass absolute velocity feedback and LQG regulator using suspension deflection measurement. They found that, all three yields improved performance but overall the LQG regulator using suspension deflection provides the best compromise between ride comfort, suspension travel and tire force variation. as a baseline case for comparison purposes is given for the passive system acceleration with standard values of vehicle parameters. In full state feedback control law the linear optimal control theory has been used for design. They found that several interesting characteristics. It is shown that the transfer functions for a design that emphasized ride comfort. The active suspension greatly improves the l Hz region while the invariant point (10.6Hz) eliminates any effect at the tire hop mode. Also they found that the high frequency performance of the active system is worse than the passive System. They also found that the tire deflection transfer function has been improved at 1Hz only. The absolute velocity feedback gives the same performance and also eliminates the problem of high frequency harshness. The best overall designs were achieved by the LQG compensator using the easiest and most inexpensive variable to measure, suspensions deflection.

In a controls sense the system using actuator force as the control and suspension deflection as the measurement is both controllable and observable thus we can design for either ride quality or road holding. It was shown that the design for ride quality captured all the nice features of the full state design and eliminated or reduced some of the bad features. [6]

VII. CONCLUSION

By the literature review it is seen that compare with passive suspension system, active suspension can give improved vehicle characteristics. (in terms of road holding and ride comfort). In earlier recherchés for the design of the suspension system linear parameter were considered but in actual practice the suspension behaves nonlinear characteristics. So it is necessary to consider the nonlinearities of the suspension system while designing any type of the suspension system. From the above study it is seen that in case of active suspension system, both of the control objectives, ride comfort and car holding performance have been improved.

REFERENCES

[1] D.H.Rovat, Optimal Active Suspension for Quarter Car Vehicle Models, *Automates, Vol.26.No.5*, 1990, pp.860.

[2] G. Verros, S. Natsiavas, Design optimization of quarter-car models with passive and semi-active suspensions under random road excitation, *Journal of vibration and control, 11,* 2005, 581-606.

[3] Jun Wang, David A. Wilson, Wenli Xu, David A. Crolla, Active suspension control to improve vehicle ride and steady-state handling, *Proc. 44th IEEE conf. on decision and control, Seville, Spain , dec 12-15, 2005,*1982-1987.

[4] Keum-Shik Hong,Hyun-Chul Sohn, J. Karl Hedrick, Modified skyhook control of semi-active suspensions: A new model, gain scheduling and hardware in the loop tuning, *Journal of dynamic system and control division, 124*,2002,158-167.

[5] Catalin Alexandru and Peter Alexandru, A comparative analysis between the vehicles passive and active suspensions, *international journal of mechanics, 5(4),* 2011, 371-378.

[6] C. Yue, T. Bustsuen, J. K. Hedrick, Alternatives control laws for automotive suspensions, *Automates, 26(5),* 1990, pp 860.