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Analysis Of Active Suspension System Using Genetic Algorithm

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ABSTRACT

Vehicle suspensions have been a hot research topic for many years due to its important role in ride comfort, vehicle safety, road damage minimization and the overall vehicle performance. To meet these requirements, many types of suspension systems, ranging from passive, semi active recognized that active suspensions have a great potential to meet the tight performance requirements demanded by users. Therefore, in recent years more and more attention has been devoted to the development of active suspensions and various approaches have been proposed to solve the crucial problem of designing a suitable parameters for active suspension systems .In the project an attempt is made to use genetic algorithm for analysis of the active suspension to obtain the optimal parameters of the system using Mat lab tool for the optimization. It will be compared and validated from the review experimental results.

Keywords— **Suspension system, Active suspension, Genetic algorithm, Optimal parameters**

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I. INTRODUCTION

A high-quality suspension should provide a comfortable ride and good handling within a reasonable range of deflection. Moreover, these criteria subjectively depend on the purpose of the vehicle. For example, a sports car driver will accept a relatively hardride as a compromise for high speed handling and safe fast cornering. But the same ride would be intolerable for the passengers of abig saloon car. From a system design point ofview, there are two main categories of disturbances on a vehicle, namely road and load disturbances. Road disturbances have the characteristics of large magnitude in low frequency (such as hills) and small magnitude in high frequency (such as road roughness).Load disturbances include the variation ofloads induced by accelerating, braking and cornering. Therefore, a good suspension design is concerned with disturbance rejection from these disturbances to the outputs (e.g. Vehicle height etc) in which we are interested. Roughly speaking a conventional passive suspension needs to be "soft" to insulate against road disturbances and "hard" to insulate against load disturbances. Therefore, suspension design is an art of compromise between these two goals. Nowadays, there exist three types of suspension: Passive suspension, active suspension and semi-active suspension. Most vehicles have a passive suspension. Generally speaking, this involves a parallel mounting of a spring and damper. Passive suspension is linear in nature. It is based on the principle of energy dissipation by the damper. The force acting on the car body results from relative motion and relative velocity of the suspension. Despite the fact that this suspension type is used by most manufacturers, it is limited when attempting to improve road vehicle comfort and road holding capability has demonstrated that increasing of the passive suspension damping coefficient enhances vehicle comfort. Yet, in this case, the wheel deflection increases, which then decreases the quality of tire road contact. These limitations on the performance of passive suspensions have led to the implementation of other types of suspension systems. Active suspension is characterized by the need for an external energy source. This energy makes it possible to activate a control system which will continuously control the force generated by the suspension system. Very often, the control system reacts to vehicle parameters (velocities and displacements). By adapting the formulation of the control system, both road holding capability and comfort are affected. Many researchers have worked on active suspension in order to advance research in this field have demonstrated that it is possible to apply the principle of active suspension in the area of road vehicles. Thompson has demonstrated that the performance of active suspension is definitely superior to that of classical suspensions. But from a technical point of view, an active suspension cannot be applied without a host of parametric measurements including velocities and deflections, which complicate the implementation of such systems, as despite its performance, the adding on of an external energy source complicates the system and increases costs as compared with the classical model. However, active suspension can use various control algorithms, and different variables can be measured and combined to dictate the control force between the body and the wheel; also it has wide scope for the optimization and various tools are available for the optimization.

II. PROBLEM STATEMENT

A quarter car model with sprung and unsprung mass is considered. The model willbe used to form the mathematical equationsfor the active suspension system aftergenerating the governing equations they will be solved by TF and SS approaches the program will be generated in the MATLAB and the response will be checked for various road profiles .Various tools have been used for the optimal design of the active suspension system for the superior ride comfort of the person along the ride and road handing of the vehicle. The new optimization tools viz. genetic algorithm and the neural network is to be applied to the quarter car model of active suspension system to incorporate the additional method for the optimization and to checked whether the method is simple and economic by validating it with review experimental results. The main objective of the present study is to develop and apply a systematic methodology leading to optimum combinations of the suspension damping and stiffness parameters of a ground vehicle subjected to random road excitation. Most of the previous studies on the subject have dealt with car models possessing linear characteristics or mechanical models subjected to deterministic road excitation.

A. THE WORK INVOLVES

1. The study of the suspension system viz. passive and the active suspension systems. 2. Modelling of both the suspension systems with sprung and the unsprung mass of a quarter car model. 3. The formulation of transfer function of a quarter car model by solving governing equations for both passive and the active suspension system. 4. Transmissibility responses against frequency ratio for different values of the damping ratios, to glimpse the effect on the system transmissibility using MATALAB (M-file)5. The use of genetic algorithm a by MATLAB tool boxes for the active suspension system. 6. The results obtained from the MATLAB are to be validated with the *experimental review papers and the other optimization techniques.*

2. MATHEMATICAL MODELING

The mathematical model is used to represent the important features of the system for the purpose of deriving the mathematical (or analytical) equation, for governing the system's behavior. The mathematical model should be able to describe the system in terms of equation without making it too complex. Thus great deal of engineering judgments is needed to come with a suitable mathematical model of vibrating system. A typical vehicle passive suspension system can be modeled . The model represents a single suspension from one of the four corners of the vehicle. This is a linear two degree of freedom system that is often referred to as the "quarter-car" model. The input to this model is a displacement input which is representative of a typical road surface (Xr). The input excites the first degree of freedom mass called unsprung mass (Mu) of a quarter of the vehicle, which representing the mass of wheel, tire, and some suspension components through a spring element which represents the tire stiffness (Kt). The unsprung mass (Mu) is connected to the second degree of freedom mass called sprung mass (Ms), which represents the mass of car body of the vehicle through the primary suspension that consists of a simple spring having stiffness Ks and a damper having damping coefficient C. Notation Ms: Sprung mass (car body mass) Mu: Unsprung mass (tyre mass) Xs: Body mass displacement Xu: Wheel mass displacement Xr: Road surface amplitude Ks: Body mass stiffness Kt: Tyre stiffness C: Damping coefficient FORMULATION OF GOVERNING EQUATIONS Once the mathematical model is created, use the principle of dynamic and derive the equations that describe the vibration of the system. The equations of motion can be derived conveniently, by drawing the free body diagrams of the masses involved in the system.

FOR SPRUNG MASS;

$$-Ms\ddot{x}s - Ks\,(Xs - Xu) - C\,(\dot{x}s - \dot{x}u) = 0$$

$$Ms\ddot{x}s = -Ks\,(Xs - Xu) - C\,(\dot{x}s - \dot{x}u)$$

$$Ms\ddot{x}s = -KsXs + KsXu - C\dot{x}s + C\,\dot{x}u \quad (1)$$

FOR UNSPRUNG MASS;

$$-Mu\ddot{x}u + Ks\,(Xs - Xu) + C\,(\dot{x}s - \dot{x}u) - Kt\,(Xu-Xr) = 0$$

$$Mu\ddot{x}u = KsXs - KsXu + C\dot{x}s - C\dot{x}u - KtXu + KtXr \quad (2)$$

3.MATHEMATICAL SOLUTION OF THE GOVERNING EQUATIONS

The equations of motion must be solved to find the response of the vibratory system. Depending on the nature of the problem, there are different techniques for solving the governing equations such assolving differential equation (DE), transfer function method (TF), matrix method, numerical method and state space method (SS). Out of which the work involve, transfer function method (TF) . Transfer Function Approach Transfer function is the ratio of Laplace transform of the output (response function) to the Laplace transform of the input (driving function). This is commonly used to characterize the input-output relationships of a components or systems. Above equations be arranged in the form of;

$Msx¨s + Cx˙s + KsXs = C x˙u + KsXu$ (1)

$Mux¨u + Cx˙u + (Ks + Kt) Xu = Cx˙s + KsXs + KtXr$ (2)

By applying Laplace transform to equation (1) and (2), a linear differential equation can be transformed into an algebraic equation in a complex variable S. Thus equation becomes,

(((CS + Ks) / MsS2 + CS + Ks) Xu) / Xr = (CS+Ks) Kt / MuMsS4 + (Ms+Mu) CS3 + (MsKt + (Ms+Mu) Ks) S2 + KtCS + KsKtXu / Xr = (MsS2 +CS+Ks) Kt / MuMsS4 + (Ms+Mu) CS3 + (MsKt + (Ms+Mu) Ks) S2 + KtCS + KsKt (3)

Xs / Xu = CS + Ks / MsS2 + CS + Ks (8)

III. CONCLUSIONS

1. Active suspension has optimal outing and managing over other suspensions. The system is multifaceted and patron has to disburse superfluous for stuff and enlargement price tag for the system, redundant weight of the system and fuel cutback.

2. Gradient-based optimization algorithms, for vehicle suspension optimization is used which also boosts the vehicle's recital.

3. Apart from these optimization methods the active Suspension system has a lot of other optimization tools which can swell the concert of the system.

4. Mathematical modelling of the passive and the active suspension system is done by the TF.

5. Using genetic algorithm optimal parameters will be find out and will be validated with review experimental papers.

6. other algorithms will also be used and compared with GA.

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