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STUDY AND ANALYSIS OF PASSIVE QUARTER CAR MODEL BY USING MATALB&SIMULINK SOFTWARE

Engineering

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ABSTRACT

Vehicle suspension system plays a Important role in reducing the Passenger seat as well as sprung mass vibrations, providing comfortable and safe ride and controlled suspension deflection to minimize the road induced vibrations.. The parameters of a passive suspension system are generally fixed, being chosen to achieve a certain level of compromise between road holding, load carrying and comfort. The damping characteristics in such suspension systems can be varied as per intensity of vibrations generated by uneven road surfaces. In the present work, the main task is to introduce in detail a front quarter car suspension model to study the suspension system behavior during a movement over a bump. Good agreement has been obtained when using the equivalent suspension stiffness and damping coefficient as input parameters to quarter car model representing the independent front suspension. The conventional suspension system is modeled in the simulation software MATLAB/SIMULINK. In this paper , Study of Sprung-Mass Variation For Acceleration & Displacement , Damper Variation for Acceleration & Displacement and Spring Variation for Accel. &Disp. for Passive Quarter car Suspension system .

KEYWORDS

Passive Quarter Car Model , MATLAB/SIMULINK , Ride Comfort , Seat Acceleration.

1. INTRODUCTION

Every vehicle moving on the randomly profiled road is exposed to vibrations which are harmful both for the passengers in terms of comfort and for the durability of the vehicle itself. Therefore the main task of a vehicle suspension is to ensure ride comfort and road holding for a variety of road conditions and vehicle maneuvers . This in turn would directly contribute to the safety. Shock absorption in automobiles is performed by suspension system that carries the weight of the vehicle while attempting to reduce or eliminate vibrations which may be induced by a variety of sources, such as road surface irregularities, aerodynamics forces, vibrations of the engine and driveline, and non-uniformity of the tire/wheel assembly Quarter-car model is in use for years to study the car dynamics. The objection of this paper is to examine the dynamics of a car passing a circular hump for sake maintaining ride comfort for the passengers. Important phenomenon evolved from the analysis of the car dynamics which is performed using MATLAB. The mathematical model of the quarter-car model is derived in the state form and the dynamics are evaluated in terms of the sprung mass displacement and acceleration. The effect of suspension damping and car speed on the sprung-mass displacement and acceleration is examined.

The model allows the designer to test the dependency of the design of suspension system on the selected bump form. The model can be used for performance evaluation and can be adapted to fit in a larger vehicle handling model. The results of the present research is to obtained the amplitude, velocity and acceleration of the sprung mass and the angle, angular velocity and angular acceleration of the lower control arm at the nonlinear suspension system. The work also presents the effect of the damping coefficient of the tire on the characteristics of the suspension system. A methodology is presented for optimizing the suspension damping and stiffness parameters of nonlinear quarter-car models subjected to random road excitation. The investigation starts with car models involving passive damping with constant or dual-rate characteristics. Then, we also examine car models where the damping coefficient of the suspension is selected so that the resulting system approximates the performance of an active suspension system with sky-hook damping. For the models with semi-active or passive dual-rate dampers, the value of the equivalent suspension damping coefficient is a function of the relative velocity of the sprung mass with respect to the wheel subsystem. As a consequence, the resulting equations of motion are strongly nonlinear. For the purpose of ride comfort evaluation, a quarter car model with Three degrees of Freedom has been developed. For realistic investigation, the equivalent characteristics of suspension stiffness and the shock absorber characteristics are calculated and incorporated to simulation. Using available quarter car test rig for single independent front suspension, that embodies sprung mass, un-sprung mass, suspension system and tire.

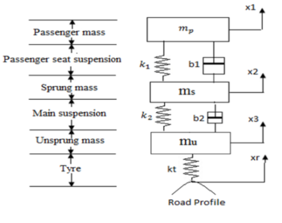
State Space modeling of passive suspension:
The vehicle model considered in this study is quarter car model. The quarter car model suspension system consists of one-fourth of the body mass, suspension components and one wheel for passive suspension system is shown in Figure . The assumptions of a quarter car modelling are as follows:

1. The tire is modeled as a linear characteristics spring deprived of damping,
2. There is no rotating motion in wheel as well as frame,
3. The performance of spring and damper remain linear characteristics,
4. The road wheel is continuously in contact with the lane surface and result of resistance is ignored so that the residual essential damping is not taken into vehicle modeling.

Vibration control requirement plays a major role in enhancing ride comfort of travelling passengers. Present paper is related to ride comfort analysis of passenger body in quarter car model using passive and active suspension system.

2. QUARTER CAR MODEL

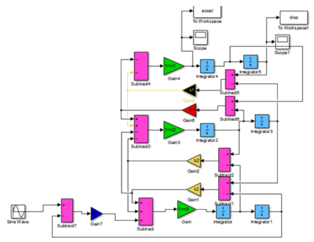
Simulink, an add-on product to MATLAB, provides an interactive, graphical environment for modeling, simulating, and analyzing of dynamic systems. It enables rapid construction of virtual prototypes to explore design concepts at any level of detail with minimal effort. For modeling, Simulink provides a Graphical user interface (GUI) for building models as block diagrams. In present study, for analysis of vehicle systems, a quarter car suspension model is considered as shown in Fig. 1.



(FIG.1: PASSIVE QUARTER CAR MODEL)

where x1, x2, x3 and xr denotes the passenger seat displacement, sprung mass displacement, un-sprung mass displacement and road profile displacement respectively for the quarter car model.
The mathematical equations of active quarter car model with Three-degrees-of-Freedom taking passenger seat dynamics can be derived using Lagrange's equations as follows:

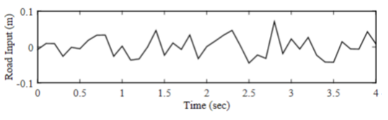
$$m_p\,\ddot{x}_1+b_1(\dot{x}_1-\dot{x}_2)+k_1(x_1-x_2)=0 \quad \ldots\ldots (1)$$
$$m_s\,\ddot{x}_2-k_1(x_1-x_2)-b_1(\dot{x}_1-\dot{x}_2)+k_2(x_2-x_3)+b_2(\dot{x}_2-\dot{x}_3)+\bar{d}=0 \quad \ldots\ldots (2)$$
$$m_u\,\ddot{x}_3-b_2(\dot{x}_2-\dot{x}_3)-k_2(x_2-x_3)+k_t(x_3-x_r)-\bar{d}=0 \quad \ldots\ldots (3)$$



[Fig.2: Simulation Model For Passive Suspension system]

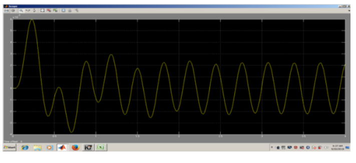
To study the ride comfort issues in graphical and mathematical results, simulation models for passive quarter car systems were designed. The random road profile used in simulation work is shown in Figure. The quarter car model speed was set as 40 km/hr while the simulation was run for 4 seconds. The passive quarter car models performance was evaluated in vibration control of passenger seat, sprung mass and suspension systems respectively. The selected mathematical values of quarter car model for simulation work are as follows: -

Passenger seat mass, *mp*= 78 *kg*; sprung mass, *ms* = 325 *kg* and un-sprung mass, = 45 ; the damping and stiffness parameters of main and passenger seat suspension are b1 = 850 Ns/m , b2 = 1550 Ns/m, k1 = 8550 N/m, k2 = 24000 N/m respectively. The tyre stiffness *kt* is having the value of 190,000 /*m*.

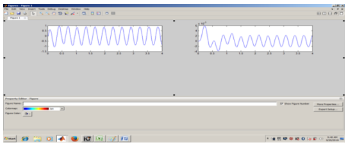


[Figure 3. Random Road Profile]

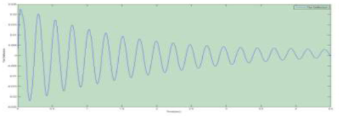
The results obtained after running the simulations in time domain are presented Graphically In the Fig. the yellow line, represent the Passenger Seat displacement .



[Fig.4: Passenger Seat Response Displacement]



[Fig.5: Passenger Seat Response (a) Acceleration (b) Displacement]



[Fig.6:Tire Deflection]

Vibrations transmitted from road surfaces to vehicle structures also affect the body parts of travelling passengers. Such vibration exposure with high intensity and long duration can lead to health risk, injury to body parts as well as discomfort to sitting occupants in running vehicle. Hence, whole body vibration measurement is performed using ISO 2631-1. Here, the criterions selected for ride comfort evaluation are frequency Weighted RMS acceleration (WRMS) and Vibration Dose Value (VDV) respectively. the theme of evaluating dynamic load increases that the vehicle transfers to the road pavement, due to the generation of vibration produced by surface irregularities. Method The study starts from the generation, according to the ISO 8608 Standard, of different road roughness profiles characterized by different damage levels.

In the Fig. the line from the graph above, represent the Passenger Seat Acceleration . The second fig. line is the Passenger Seat displacement.

Table: Variation of Quarter Car Parameters

Parameter	Nominal Value	Variation
ms	325 kg	± 50 kg
*c*2	1550 N/m/s	± 250 N/m/s
*k*2	24000 N/m	± 3500 N/m

The Simulink values are obtained at different sprung mass variation for Acceleration and Displacement.

TABLE.1: Sprung Mass Variation For Accel. & Disp.					
		Acceleration		Disp.	
		Max. value	RMS value	Max. value	RMS value
1	Min.	0.8275	0.5595	0.8275	0.5595
2	Nominal	0.7122	0.4893	0.7122	0.4893
3	Max	0.8990	0.5999	0.8990	0.5999

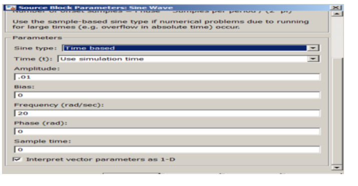
The Simulink values are obtained at different Damper variation for Acceleration and Displacement.

	TABLE .2:DAMPER VARIATION FOR ACCEL.& DISP.				
		ACCELERATION		DISPLACEMENT	
1	Min. value	0.8896	0.6005	**0.0059**	0.0019
2	Nominal value	0.9842	0.6573	0.0060	0.0020
3	Max. value	1.0865	0.7183	0.0061	0.0021

The Simulink values are obtained at different Spring variation for Acceleration and Displacement.

TABLE .3: SPRING VARIATION FOR ACCEL&DISP.					
		ACCERERATION		DISPLACEMENT	
1	MIN. VALUE	0.9177	0.6216	0.0057	0.0018
2	NOMINAL VALUE	0.9842	0.6573	0.0060	0.0020
3	MAX. VALUE	1.0641	0.6979	0.0064	0.0021

Sine Wave is the excitation signal representing the road surface, in our case is a step type signal, its parameters are represented in Fig.



[Fig.7 : Step signal parameters]

CONCLUSIONS

The parameters of a passive suspension system are generally fixed, being chosen to achieve a certain level of compromise between road holding, load carrying and comfort. We Obtained the values of Sprung Mass Variation For Accel. & Disp. On Max. value 0.8275 , 0.7122,0.8990. Damper Variation for Acceleration.& Displacement On Max. Value 0.8896,0.9842, 1.0865 and RMS value 0.6005, 0.6573, 0.7183 for displacement value 0.0059, 0.0060, 0.0061and Spring Variation For Acceleration & Displacement. On MAX. Value 0.9177, 0.9842, 1.0641 rms value 0.6216, 0.6573, 0.6979and Displacement value is 0.0057, 0.0060, 0.0064 and displacement value is 0.0057, 0.0060, 0.0064 RMS value 0.0018, 0.0020, 0.0021. From the Graphs represent the Passenger Seat Response Acceleration and Displacement , Tire Deflection in the passive quarter car suspension system .

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