RESEARCHERID
THOMSON REUTERS

[Yadav* *et al.*, 6(7): July, 2017]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

DESIGN AND MODELING OF AUTOMOTIVE SUSPENSION SYSTEM FOR PERFORMANCE & IMPROVEMENT

Ripujya Yadav[*1], M. Siva Kumar[2]

[*1]Department of Mechanical Engineering, M. Tech CAD/CAM Scholar,Ambalika Institute of Management & Technology, Lucknow-226301, Utter Pradesh INDIA

[2]Professor, Ambalika Institute of Management & Technology, Lucknow-226301, Utter Pradesh INDIA

DOI: 10.5281/zenodo.827498

ABSTRACT

This work proposes the study of automobile active suspension system for the purpose of improving ride comfort to passengers and simultaneously improving the stability of the vehicle by reducing vibration effects on suspension system. Physical model of the vehicle suspension system has been derived using the laws of motions and Simulink building blocks are created by dividing a equations for the different elements. The simulation of the vehicle has been carried out and responses are a plotted. With the increased demand of the fine control of parameters, the mechatronic controller is being introduced for increasing a comfort of the vehicle with their application to the suspension system of the vehicle. This is the prime location for consideration of the inclusion controller and Jerk measure in the active suspension system.

KEYWORDS: Half Car Model Suspension, Active suspension, System modeling, MATLAB Simulation.

I. INTRODUCTION

Every year more than one million (approx.) People lose their lives worldwide in traffic fatalities and Road accidents 50 million (approx.) people suffer non-fatal injuries . The handling capabilities of an automobile and ride safety are mainly determined by its suspension system, which transmits the force between the vehicle and road   Suspension system should not only enable driver to keep authority over the vehicle in critical situations but also should provide a high level of ride comfort to prevent physical fatigue of the driver. Since the suspension system significantly influences the subjective impression of the vehicle, the demand of customer regarding safety and ride comfort of modern automobiles are constantly increasing. These aspects represent a challenge for the design of suspension system in automobiles.

The mean part of passive (conventional) suspension system are the wheels with the tires, the wheel carries systems, spring and demand elements, the steering and the brakes. The dynamic behavior of passive automobile suspension system is principal determined by the choice of the damper (dc damper coefficient) and spring (cc stiffness). For the choice of the damper (dc) and spring (cc) setting, different aspects are taken into account. On the one hand, suspension should provide excellent ride comfort by a soft damper and spring setup isolating the chassis from the road induced vibrations. On the other hand, vehicle should be controllable by the drive to ensure ride safety, which requires a stiff, well damped coupling between the vehicle and the road especially for non-stationary drive maneuvers, e.g. driving a rough road or cornering. consequently, the requirements regarding comfort and conflicting are safety.

There are three basic approaches to control the suspension system as Passive suspension, semi active suspension and active suspension [1, 2]. There are some factors, such as suspension design, quick response against a jerk, intelligence, and the ability to work in real time operating conditions etc., have a very important role for providing the good ride comfort, road holding, and improving the stability of the vehicle [3, 4].Beyond this, a controlled action of force introduced against the suspension travel by means of the external actuator. These additional forces are controlled by various control algorithms using the data from sensor attached to the vehicle body [2].

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

In active suspension system passive components are augmented by actuators that supply additional forces while pulling down or pushing up the body masses for gathering the desired level of comfort in order to suppress the vibrations due to the road irregularities [1] [5]. The systems with active control can improve its qualities through the addition of an active shock absorber, which generates instantaneous forces making it possible to support the loads and to ensure the safety and comfort against the constraints [6]. Main drawback of Active suspension is that actuation energy fed to the system from the external source leading to increase the system cost [7]. So far various control approach introduced for active control in suspension system application such as back stepping control [8].

II. SYSTEM MODELING

A. Modeling of Half Car Model Suspension System

In this section, a complete mathematical model of the passive suspension for a half car model, as shown in Figure 1. Shows derived based on the approach as presented in Yoshimura [9]. The passive suspension for the half car model consist of the front and rear wheels and also the axles that are connected to the half portion of the car body through the passive-springs-dampers combination, while each tire is modeled as a simple spring without damper.

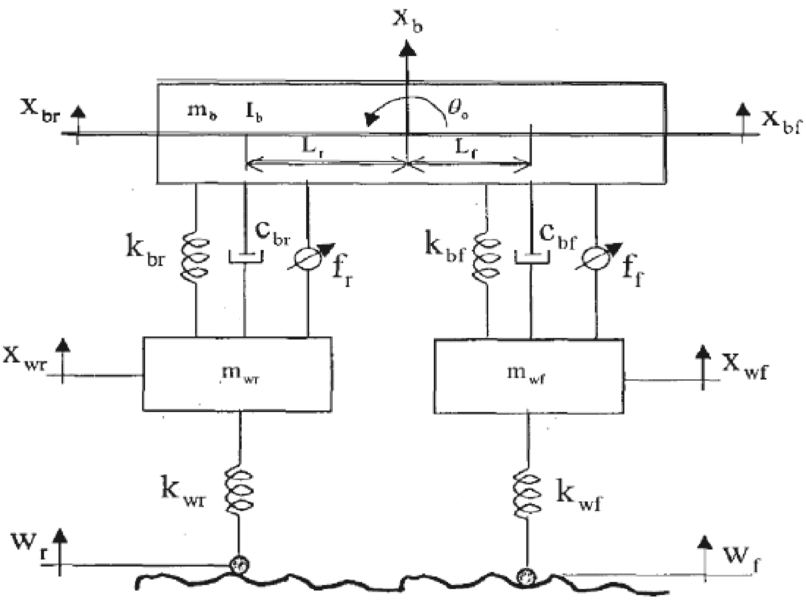


Fig.1:The Half Car Model of Suspension System

Equations of the motion are derived considering different parameters for this proposed system. These differential equations are obtained by utilizing physical laws (Newton's laws of motion) and it will be linear time invariant for the considered linear system. Considered parameters are tabulated in Table 1.

Table 1 Parameters Used In The System Simulation

S.N.	Parameter	Symbol	Unit
1.	Mass of vehicle's body	m_s	Kg
2.	Total Length of the body	L	m
3.	Length of the body front from centre of gravity	Lf	m
4.	Length of the body rear part from centre of gravity	Lr	m
5.	Stiffness of the Tyre material	k_{br}, k_{bf}	N/m
6.	Coefficient of springs	k_{wr}, k_{wf}	N/m

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

7.	Damping coefficients of the dampers	c_{br}, c_{bf}	N-s/m
8.	Moment of inertia for the car body	I_b	kgm^2
9.	Rotary angle of the car body at the center of gravity	θ_b	rad
10.	Un-sprung masses of the suspension	m_{wr}, m_{wr}	kg
11.	Body vertical Displacements (Sprung mass)	x_{br}, x_{bf}	m
12.	Suspension Travel (un-sprung mass vertical displacement)	x_{wr}, x_{wr}	m
13.	Tyre vertical travel due to road disturbance (Jerk Height)	w_r, w_f	m

The motion equation for the passive suspension for the half car model may be derived as follows-

- **Top section:** Initially by considering only top section of the suspension systems following two mathematical equations are derived.

$$m_b \ddot{x}_b + c_{bf}(\dot{x}_{bf} - \dot{x}_{wf}) + k_{bf}(x_{bf} - x_{wf}) + c_{br}(\dot{x}_{br} - \dot{x}_{wr}) + k_{br}(x_{br} - x_{wr}) = 0 \qquad .....1$$

$$I_h\ddot{\Theta}_h + L_f[c_{hf}(\dot{x}_{hf} - \dot{x}_{wf}) + k_{hf}(x_{hf} - x_{wf})] + L_r[c_{hr}(\dot{x}_{hr} - \dot{x}_{wr}) + k_{hr}(x_{hr} - x_{wr})] = 0 \qquad .....2$$

- **Bottom section:** The second approach involved bottom section of the system-

$$m_{wf}\ddot{x}_{wf} - c_{bf}(\dot{x}_{bf} - \dot{x}_{wf}) - k_{bf}(x_{bf} - x_{wf}) + k_{wf}(x_{wf} - w_f) = 0 \qquad .....3$$

$$m_{wf}\ddot{x}_{wr} - c_{br}(\dot{x}_{br} - \dot{x}_{wr}) - k_{br}(x_{br} - x_{wr}) + h_{wr}(x_{wr} - w_r) = 0 \qquad .....4$$

in order to consider the vertical displacement of the front and rear car body, ***xbf*** and ***xbr*** respectively,

$$x_b = (L_f\, x_{bf} + L_r x_{br})/L \qquad .....5$$

$$\theta_b = (x_{bf} - x_{br})/L \qquad .....6$$

Therefore equations (1) and (2) can be rewritten as,

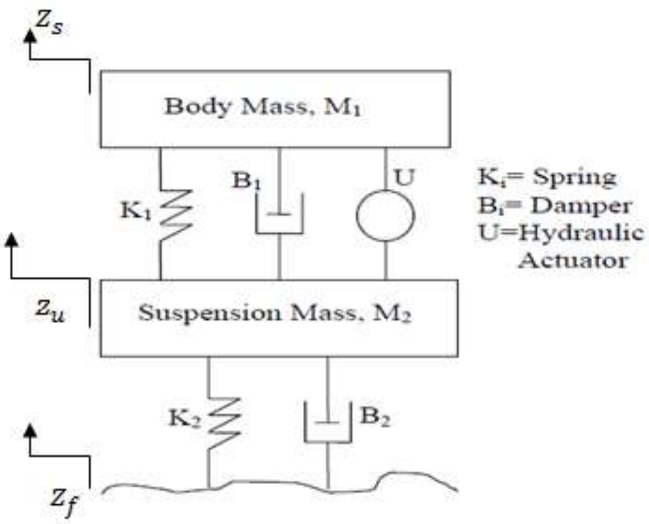
$$\frac{m_b}{L}(L_f\ddot{x}_{bf} + L_r\ddot{x}_{br}) + c_{bf}(\dot{x}_{bf} - \dot{x}_{wf}) + k_{bf}(x_{bf} - x_{wf}) + c_{br}(\dot{x}_{br} - \dot{x}_{wr}) + k_{br}(x_{br} - x_{wr}) = 0 \qquad .....7$$

$$\frac{I_b}{L}(\ddot{x}_{bf} - \ddot{x}_{br}) + L_f[c_{bf}(\dot{x}_{bf} - \dot{x}_{wf}) + k_{bf}(x_{bf} - x_{wf})] - L_f[c_{br}(\dot{x}_{br} - \dot{x}_{wr}) + k_{br}(x_{br} - x_{wr}) = 0 \qquad .....8$$

So far the mathematical modeling for the proposed passive suspension system is done as in above equations (1), (2), (3), (4), (5) , (6) ,(7) & (8).

B. Modeling of Active System

Active suspension system has an ability to store, dissipate and to introduce energy to the system. The hydraulic actuator is connected in parallel with a spring and absorber. While, sensor of the body are located at different points of the vehicle to measure the motions of the body. It may vary its parameters depending upon operating conditions. Figure 2. Shows the active car suspension system.



ISSN: 2277-9655
[Yadav* *et al.*, 6(7): July, 2017] Impact Factor: 4.116
IC™ Value: 3.00 CODEN: IJESS7

Fig.2:The active car suspension system.

A physical active car suspension system in fig.2 is used to analyses the ride performance, where M1 and M2 are spring mass and un-spring mass in kg respectively. Suspension spring stiffness, K1 (N/m) and damping coefficient B1 (N-s/m) are considered as constants, being independent of time since in the present work active suspension system is analyzed. K2 is the tire stiffness in (N/m) and the tire damping coefficient B2 (N-s/m). Displacement of the spring mass, un-spring and road input is designated as Zs, Zu, and Zf respectively. Ordinary differential equation (ODE) are derived from fig2. as Eqs. 1 & 2 corresponding to the spring and un-spring mass respectively.

$M_1\,\ddot{Z}_s + B_1(\dot{Z}_S - \dot{Z}_u) + K_1(Z_S - Z_u) + M_1$g+ U = 0 1
$M_2\ddot{Z}_u$ - $B_1(\dot{Z}_S - \dot{Z}_u)$ - $K_1(Z_S - Z_u) + B_2(\dot{Z}_u - \dot{Z}_f) + K_2\,(Z_u - Z_f) + M_2$g = 0 2
Equation 1 & 2 are solved by a SIMULATION tool box of MATLAB.

III. SIMULATION IN MATLAB

The development of controllers in simulation by MATLAB program is used to view the suspension system performance by simulation responses [10].

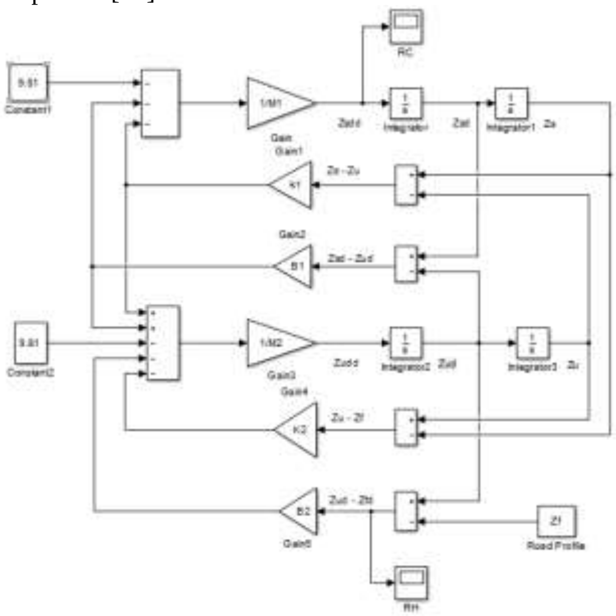


Fig.3:Block diagram active car suspension system SIMULATION in MATLAB

Table 4.1numerical values for the model parameters.

S.N.	**Parameter**	**Value**	**Unit**
1.	M1	430	Kg
2.	M2	30	Kg
3.	B1	150	N-s/m
4.	B2	6666.67	N-s/m
5.	K1	500	N/m
6.	K2	1000	N/m
7.	Zf	2	N/m

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

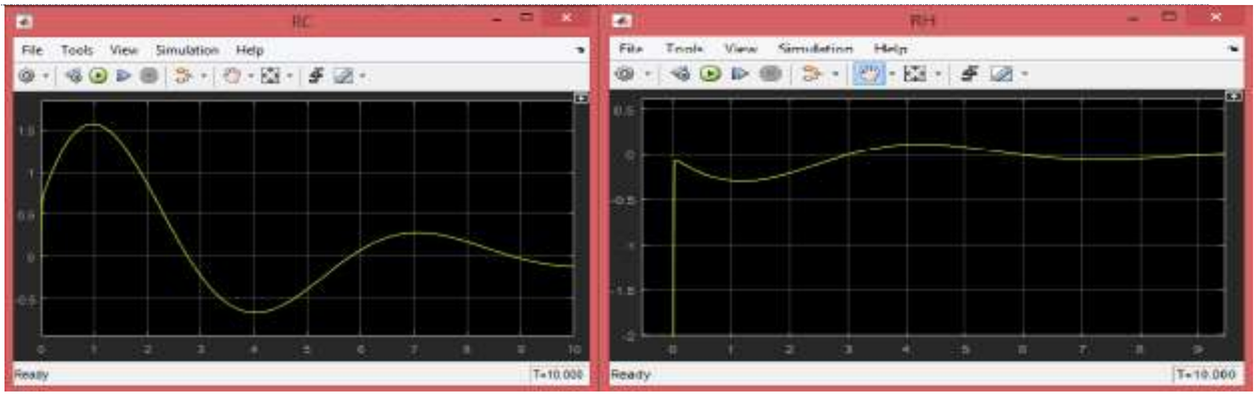
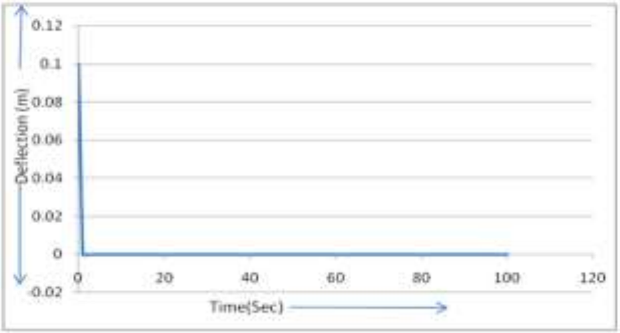
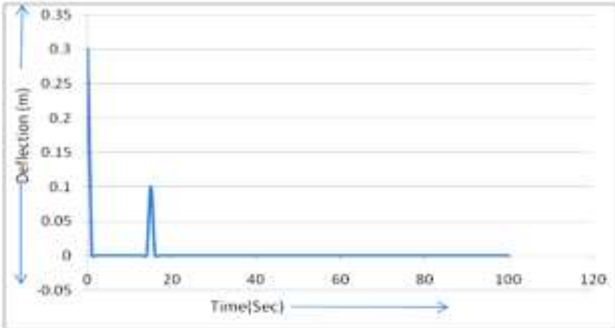


Fig.4 Result of Road Profile in jerk measure RC & RH.





The wheel deflection responses for single step input of 0.1m , The wheel deflection responses for double step inputs of 0.3 m & 0.1 m

IV. CONCLUSION

The simulated model is analyzed after running it to predefine time and different observations are drawn in light of the performance and behavior of suspension system.

- This results are show in jerk measurement top to bottom show the diagrams RH & RC.
- The observation drawn from the analysis is carried out with the help of software, the practical simulation may differ which can be further supported by MATLAB Software.
- Considering Single jerk as road input, bump having average height = 0.1m.
- Considering Double jerk as road input with time delay between each other 15 seconds and bumps heights 0.3 m and 0.1m respectively.

V. REFERENCES

[1] Mohammad Ali Nekoui , Parisa Hadavi, “Optimal control of an active suspension system” 14th International Power Electronics and Motion Control Conference, EPE-PEMC 2010.

[2] M. Appleyard, P.E. Wellstead, “Active suspensions: some background” IEE Proc.-Control theory Appl., Vol. 142, No. 2, March 1995.

[3] Mouleeswaran Senthil kumar, Member, IAENG, “Development of Active Suspension System for Automobiles using PID Controller” World Congress on Engineering London, U.K Vol II WCE 2008, July 2008.

[4] Luis C. Felix-Herran, Jose de Jesus Rodriguez-Ortiz, Rogelio Soto and Ricardo Ramirez-Mendoza, “Modeling and Control for a Semi-active Suspension with a Magnetorheological Damper including the actuator dynamics” IEEE Computer society, Electronics, Robotics and Automotive Mechanics Conference, pp. 338-343, 2008.

[5] Mohd. Avesh, PG student, Srivastava, Associate Professor, Department of Mechanical Engineering, Motilal Nehru National Institute of Technology, Allahabad- 211004, India 978-1-4673-0455-9/12/$31.00 ©2012 IEEE.

[6] M. Khemliche, I. DIF, S. Latreche and B. Ould Bouamama, “Modelling and analysis of an active suspension ¼ of vehicle with bond graph” IEEE, pp. 811-814, 2004.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

[7] Massimo Canale, Mario Milanese and Carlo Novara IEEE Transactions on control systems technology, Vol.14, No.6, November 2006.

[8] J. Campos, F. L. Lewis, L. Davis, and S. Ikenaga, "Backstepping based fuzzy logic controller of active vehicle suspension system" American Control Conference Chicago, Illinois, pp.4030-4035, June 2000.

[9] Maziah Mohamad, Musa Mailah, Abdul Halim Muhaimin, The "Vibration Control of Mechanical Suspension System Using Active Force Control"

[10] Mohd. Avesh, Rajeev Srivastava, "Modeling Simulation and Control of active suspension systemMIT International Journal of Mechanical Engineering, Vol. 4, No. 2, August 2014, pp. 90-93 90 ISSN 2230-7680 © MIT Publications..

CITE AN ARTICLE

Yadav, Ripujya , M. Siva Kumar, and Jai Pratap Dixit. "DESIGN AND MODELING OF AUTOMOTIVE SUSPENSION SYSTEM FOR PERFORMANCE & IMPROVEMENT." ***INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*** **6.7 (2017): 296-301. Web. 15 July 2017.**