JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Active Suspension System for Quarter Car Model Using Fuzzy Logic

[1]Dr. A. D. Diwate. [2] Dr. S. B. Thakre, [3] Dr. M D Pasarkar

[1]Associate Professor, [2]Professor, [3]Professor
[1]Mechanical Department,
[1] TSSM's Bhivrabai Sawant College of engineering and Research, Pune, India

Abstract: Improve control and ride comfort in a suspension system is achieved by controlling the state variables for reducing the influence of road input displacement. Study of ride performance of 7- DOF car model and validation is the aim of paper. Passive and active car model is fabricated to reduce roll over effect and enhance ride ease. In MATLAB Simulink software, simulation model is established. Using automobile dynamics software the car model is authenticated. The simulation results are validated by Simulink. Fuzzy logic concepts are introduced to develop active suspension method. Body acceleration, tyre distance and working space is considered as input variables. Utility of inputs is resulting from the control signal. Results show noteworthy enhancement over active suspension system as compare to passive suspension system.

***IndexTerms* - MATLAB, PID Control, DOF, Fuzzy Logic, Input Vibration .**

I. INTRODUCTION

The capacity of an auto suspension is to guarantee the solace of the travellers and give guiding strength great taking care of with augment the contact between the tires and the street appearance. It is realized that street roughness deliver motions of the automobile wheels is transferred to their axles. This turns out to be certain that the part of suspensions framework, interfaces axles to a body, is to lessen a vibrations and stuns happening in the task. The defect that apply powers to the wheels. As per newton's laws of movement all powers is direction and size. A hindrance made the wheel to move up and down, opposite to the street terrain. The auto wheels vertical strength is exchanged to the case, which moves a like manner. In these condition, the wheels is free contact totally with the street. Under the descending power of magnitude, the wheels was hammer once more into the street terrain. The suspension framework is assimilate vitality of the perpendicularly quickened wheel, enabling casing and body to the drive uninterrupted while it take after hindrances the plan of automobile suspension is an issue that requires arrangement of computations in light of the reason. Suspension frame work is characterized in the notable terms of latent a semi dynamic and dynamic and different in the middle of frameworks. Latent frame work is the most common. The principle assignment of a 4w suspension is guarantee riding solace and street hold for an assortment of street disorders. Any suspension framework in the vehicle must be delicate against street unsettling influences and hard against stack aggravations.

A Basic car suspension that is known as a detached suspension framework comprises of a vitality putting away component ordinarily a spring and a vitality disseminating component regularly a safeguard. The principle shortcoming of the uninvolved suspension is that it can't enhance both ride solace and wellbeing factor at the same time. In the uninvolved suspension framework, there is dependably exchange off between vehicle ride solace and wellbeing factor. To enhance the ride comfort, the wellbeing factor must be relinquished, and the other way around. As of late, an incredible number of studies have been occupied with the exploration about the control of suspension field. Ideal control is utilized as a part of dynamic suspension framework since 1960s. Most outline strategies for car dynamic suspension frameworks depend on ideal control. The fluffy intelligent control is raise another technique for outline of car dynamic suspension framework. Use of dynamic suspension controller by the LQR and PID controllers are as yet utilizing generally for straight suspension display since they are moderately effectively in structure and tune. The execution of the straight controllers, progress toward becoming unrobust when the parameters of the framework are changing thus they require re-tune its additions.

In this paper it is an endeavor is made to build up a dynamic suspension with strong PID controller to enhance the execution of suspension framework. The additions of the PID controller are made as an element of mass and recurrence of excitation of the street profile (which relies upon vehicle speed) to keep away from the unrobust of PID controller when the mass and speed are evolving. The present controllers is test against various sorts of street profile (knocks) and distinctive estimations of the mass and the speed of the vehicle while the distributed works, test their proposed controllers at certain street profile and steady estimation of the mass and the speed.

II. LITERATURE REVIEW

A PID controller is intended to a quarter auto model of traveler auto to enhance solace ride and street hold capacity. Zeigler and Nichols tuning rules are utilized for genuine of tunings to enhance the ride solace and street holding capacity. For step of 0.08 m, the sprung mass dislodging is diminished with 47.79% which demonstrates the change in ride comfort and bounced mass increasing speed reduced by 89.9%.The suspension travel is decreased by 74.64% and tyre avoidance is decreased with 89.7%. For arbitrary street input, most extreme increasing speed of the sprung mass is lessened by 87.22%

which demonstrates the change ride comfort. The most extreme sprung mass dislodging is diminished by 72.86%. The greatest suspension travel is decreased by 76.45% which will enhance the life of the suspension framework. Dynamic suspension lessened the tire diversion by 61.3% which demonstrates the better street holding capacity of the dynamic suspension framework. Hence, it is reasoned that the dynamic suspension framework is better execution abilities over aloof suspension system.[1] The procedure of building up the controller, utilizing the test comes about, is appeared, with the points of interest of the piece graph of the control calculation. At initial, a straightforward PID controller is tuned and mimicked. Its controlled yield is contrasted and the uncontrolled yield. PID controller works exceptionally well for step and motivation street unsettling influence inputs. In any case, it can't adjust when the condition changes. At the point when the unsettling influence is shifting conditions, PID controllers neglect to give great controlled yield, because of its settled PID gains.[3] It should be re-tuned when the encompassing condition changes. For this situation, it is watched that PID controller does not give attractive outcomes, with a similar increase utilized for the progression and motivation input. To accomplish versatile tuning of the pickup parameters, a fluffy based PID controller is utilized, which indicates enhanced outcomes. Fluffy PID controller can adjust to the circumstance in light of the fluffy standards, and gives the controller another arrangement of pick up parameters. This, obviously, works superior to anything the PID controller having settled pick up parameters.

There after effects of recreation performed utilizing Simulink and SimMechanics demonstrates that, the execution of PIDC diminishes body increasing speed of dynamic suspension to half of aloof suspension. Ride relief of traveler be in this manner enhanced by actualizing PID controller. The outcomes likewise demonstrate that, body quickening increments by the extension in spring firmness and declines by damping coefficient expansion. Comparison of both the outcomes demonstrates that, amplitudes of body increasing speed of dynamic, detached suspension are comparable at the same time, body quickening of aloof suspension sets aside more opportunity to scatter in Simulink than in SimMechanics. The utilization of GA for streamlining a PID control parameters as introduced, offers focal points of diminished overshoot rate, and expanded ascent and settling times. At the point when contrasted with the regular tuning factors, the GA have demonstrated better in accomplishing a unfaltering reaction state and execution files.[2] Numerical demonstration been performed employing a 2 level of-opportunity quarter auto display for active and passive framework by considering bob movement to evaluate the implementation of suspension as for unlike adverse plan objectives. PID controller approach is use for the active suspension. Suspension travel in dynamic case is revealed reduced to the greater part. By including a dynamic element in the suspension. The improvement of the quarter auto in the practical condition can give a real condition knowledge. Just a single controller is employed to test the frameworks carrying out is PID. PID is planned by PSO for one forth auto dynamic suspension framework to enhance additional agreeable ride examination with inactive model, by expanding cycles in PSO calculation it seen that the bounced mass relocation by 75%, indicates great change in ride comfort and sprung and 95% on account of street knock 0.08 m.[4]

The PID controller is effectively actualized in a dynamic suspension framework through reenactment think about Three techniques for tuning PID controller have been connected in this framework. The relative evaluation comes about demonstrated that the PID controller dynamic suspension framework with water powered actuator utilizing an iterative learning calculation is performed superior to anything PID controller utilizing other tuning calculations.[5] The exchange capacity of pressure driven actuator for dynamic suspension framework is recognized utilizing framework distinguishing proof technique. All through the exploration, the latent and dynamic suspension framework is created and the execution of dynamic suspension framework is demonstrated to perform superior to anything the detached suspension framework gave the PID parameters are tuned appropriately. The real commitment of this work is that a novel TAEI PID control is produced for dynamic suspensions.[6] The control exhibitions under the ostensible and a knock street running conditions are assessed through relative recreations and the outcomes demonstrate that the displayed TAEI PID control is a powerful, relentless and hearty approach for a dynamic suspension framework.

III. OBJECTIVE

Without loss of ride comfort, suspension system provide stability, directional control effective isolation from road surface during handling.

Conventional suspension frameworks are made out of spring and dampers. Vehicle suspension planners are in search with the issue of deciding spring and damping coefficients. Therefore, Development of Fuzzy logic control design in active suspension System for purpose of stability, ride comfort & directional Control.

- Develop and design the quarter car mathematical model of passive and active suspension system.
- Develop, design and program strategy for fuzzy logic control.
- Develop and fabrication of prototype of quarter car suspension system to compare both active and passive systems
- Controlling and simulating the active system.

IV. MEHTODOLOGY

Fuzzy logic is the compilation of the results on the basis of the degree of the truth rather than the true or false and 0 or 1 (basic logic). So in fuzzy logic, we evaluate results on different values the final value, it can the more accurate evaluation of the system rather than basic logic in the suspension system. There is mainly two types passive and active suspension. In passive suspension, frame level is directly proportional to road level but in the active suspension, frame level depends upon the suspension level and suspension level proportional to road level.

In the design stage creating a mathematical model on a quarter wheel vehicle for active suspension and fuzzy logic control strategy which simulate and develop active suspension model with fuzzy logic. Developing a test setup to conclude the concept. Mainly components are procured that are available in the market. There is no specific specification for any components as a design.

Evaluating deflection of the frame level for different road level. Cam and follower method to generate different road level. For different road level, we will change the frequency of the cam or speed of cam so that we generate different road level to analyze the deflection of the frame level after getting the deflection of the frame level on the given frequency, plot a graph and compare the result of passive and active suspension of the fuzzy logic.

V. DESIGN ANALYSIS AND ASSEMBLY

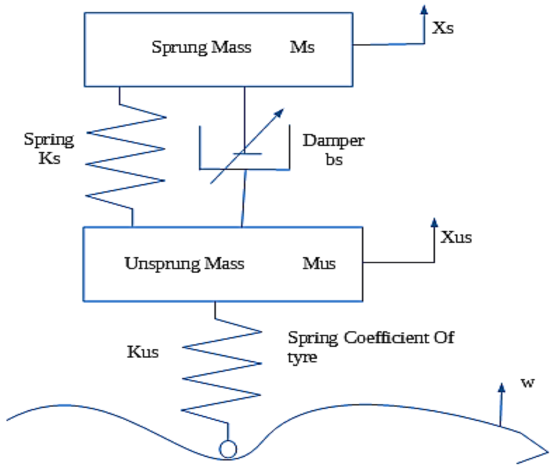


Figure 1. Passive suspension

For sprung mass,
Mus*X"us + bs*X'us + Ks*Xus + Kt*Xus= bs*X's +Ks*Xs + Kt*w –(1)
For unsprung mass,
Ms*Xs" + bs*X's + Ks*Xs = bs*X'us + Ks*Xus –(2)

ACTIVE SUSPENSION

On *Skyhook Theory* Active suspension is based states, the idyllic suspension would let the vehicle keep a stable position as if suspended by pretended hook in the sky, unaffected by path conditions.

Since a real skyhook is unrealistic, real active systems are based on operations of actuator. An acceleration sensor installed on the vehicle body and imaginary line (of vertical zero acceleration) is calculated based on the value provided by sensors. To control vertical motion of sprung mass, in active suspension a force actuator of value (F) is used, placed parallel to spring & damper.

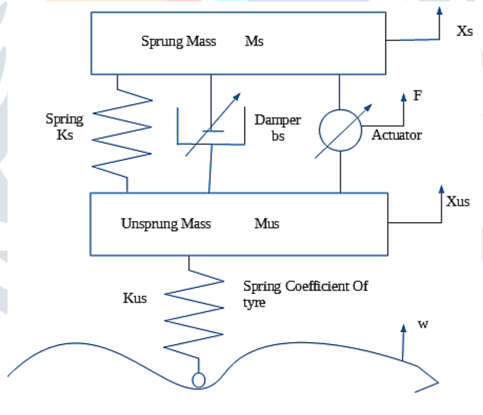


Figure 2. Active suspension system

For sprung mass,
Ms*Xs + bs (Xs'-Xus') + Ks (Xs-Xus) - F= 0 --- (3)
For unsprung mass,
Mus*Xus + bs (Xus'-Xs') + Ks (Xus-Xs) + Kt (Xus-w) - F= 0 --- (4)
Therefore,
From equations 3 & 4, by having all the values, we can calculate the amount of force F, necessary to control & reduce vertical movement of sprung mass i.e. body of quarter car model.

DESIGN OF PROJECT

1. ASSEMBLY

Figure 3. Assembly

2. FRONT REAR VIEW

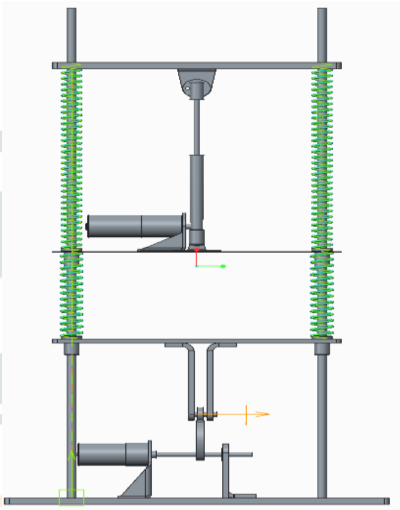


Figure 4. Front Rear View

3. TOP VIEW

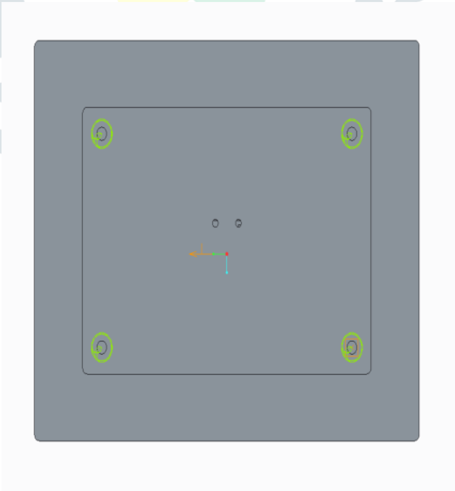


Figure 5. Top View

4. SIDE VIEW

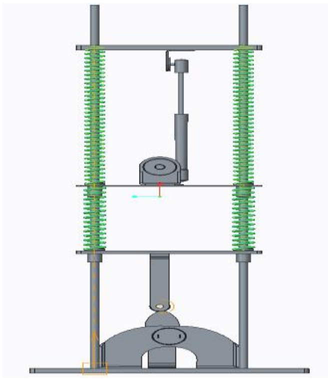
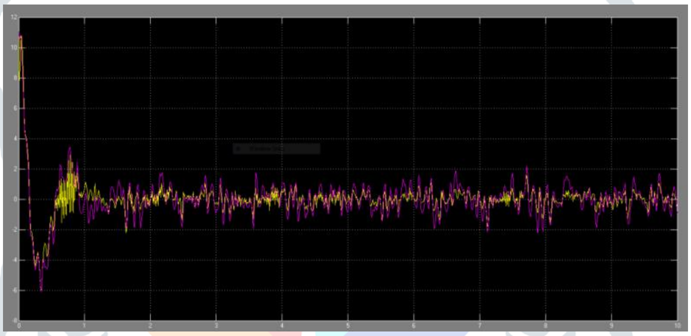


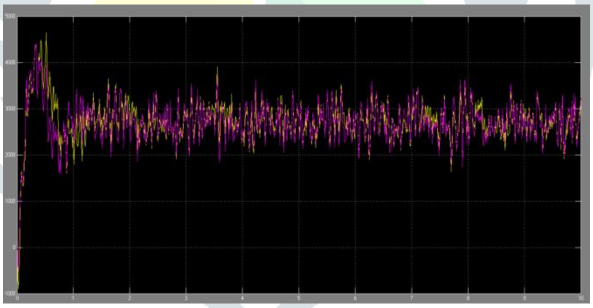
Figure 6. Side View

VI. SIMULATION IN MATLAB

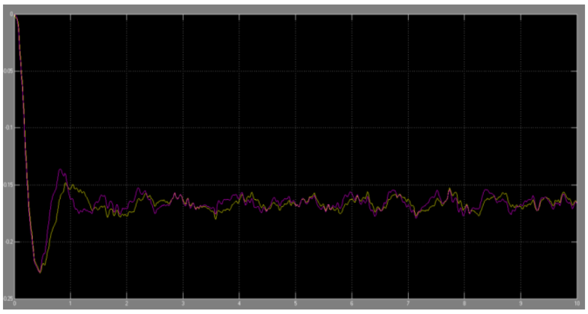
After generating regression models for active and passive system simulation work is done using MATLAB-Simulink, where the fuzzy logic is used as function to operate the undulate inputs to the wheel of car. The MATLAB code is generated for both of the suspension systems that fuzzy logic is control active and passive suspension. Further using MATLAB Simulink, the code is operated separately for passive suspension system under normal road condition and active suspension system whose input parameters are processed through fuzzy logic optimizations and fed to the active system. After running both the models of suspension systems in Simulink graphical results for body acceleration, tire deformation and suspension distortion is extracted. Comparative graphical data of results of both suspension systems have obtained, which are presented below, in which pink streak indicates values for passive suspension system of that particulate and yellow streak shows values for active suspension system controlled by fuzzy logic of the same particulate.



Graph 1. Body acceleration comparison between active and passive suspension



Graph 2. Tyre deformation Comparison between active and passive Suspension system



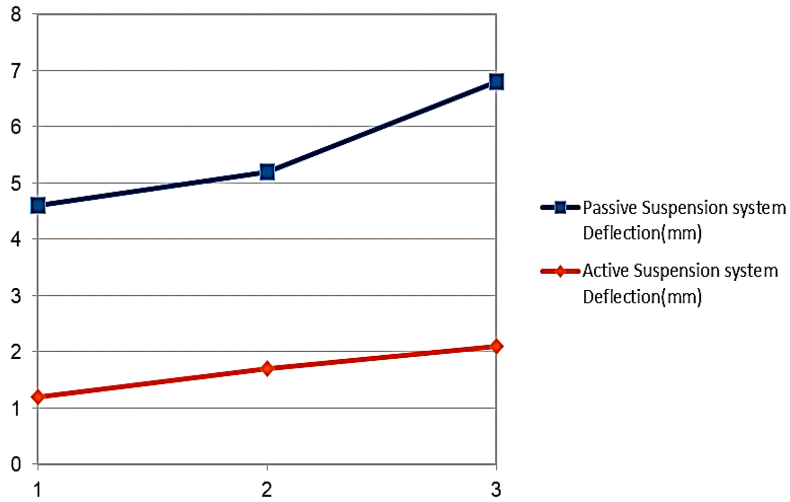
Graph 3. Comparison of Suspension distortion between active and passive suspension

Studying above results obtained by simulation of suspension systems, output of passive suspension systems are not better than active. The suspension distortions of both the systems can be compared, and it is showing that active suspension system gives comparatively better outcomes. With simulation results obtained, the model is manufactured for experimental validation of the study so far done.

VII. RESULT TABLE & GRAPH

Table 1 Suspension system vs. Deflection in mm

	Speed	Passive Suspension system	Active Suspension system
Sr. No.	**Speed of Motor RPM)**	**Deflection (mm)**	**Deflection (mm)**
1	30	4.6	1.2
2	45	5.2	1.7
3	60	6.8	2.1



Graph 4. Passive vs. Active Suspension system

VIII. CONCLUSION

The conclusion of the testing is that there is minimum deflection occurred at frame level in fuzzy logic with the active suspension as compared to passive suspension. Active suspension is more efficient as compared to the passive suspension for better comfort in the vehicle. Future Scope will be this system can be used in Automobile industries where there is need for minimizing damping effect & enhancing comfort of passenger truck in industries, Volvo & Luxury car making companies may implemented active suspension system.

REFERENCES:

[1] Anand Tandel, A.R.Deshpande, S.P.Deshmukh, K.R.Jagtap ScienceDirect, 'Modeling, Analysis and PID Controller Implementation on Double Wishbone Suspension Using SimMechanics and Simulink' 12th Global Congress Manufacturing And Management, Gcmm 2014.

[2] Nitish Katal, Sanjay Kr. Singh, 'Optimization of PID Controller for Quarter-Car Suspension System using Genetic Algorithm', International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 1, Issue 7, September 2012.

[3] K. S. Patil, Vaibhav Jagtap, Shrikant Jadhav, Amit Bhosale, Bhagwat Kedar , 'Performance Evaluation of Active Suspension for Passenger Cars Using MATLAB', IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).

[4] Wissam H. Al-Mutar, Turki Y. Abdalla, 'Quarter Car Active Suspension System Control Using PID Controller tuned by PSO,' Iraq J. Electrical and Electronic Engineering,Vol.11 No.2 2015.

[5] Tameshwer Nath, Rastogi Vikas, 'Quarter/Half/Full Car Models for Active Suspension (with PID controller)', Research gate NOVEMBER 2012.

[6] Mahesh Nagarkar, Dhiraj Bhaskar, Ajaykumar Thakur, "Design of passive suspension system to mimic fuzzy logic control active suspension system", Beni-Suef University Journal of Basic and Applied Sciences volume 11, article number:109 (2022).