Experimental Analysis Of An Electrically Powered Active Hybrid Suspension (EPAHS) For Vehicle

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Abstract- In this paper, the experimental behaviours of Electrically Powered Active Hybrid Suspension (EPAHS) for vehicle was determined. Vehicle suspension systems have been extensively explored in the past decades, contributing to ride comfort, handling and safety improvements. The suspension systems currently in use can be classified as passive, semi-active and active. However, this system cannot assure the desired performance from a modern suspension system.

The use of electrically powered linear actuators is an alternative for the implementation of active hybrid suspensions. The actuator is made with the help of power screw and electrical motor. In this paper it is proposed an active hybrid suspension system which combines the simplicity of the passive dampers with the performance of an active suspension. Maintaining the passive damper, it is possible to keep the performance of the active suspension, but using a smaller electrically powered actuator.

In this paper, the experimental results indicate that an active hybrid suspension system which will be powered electrically to adjusted damping and leading smooth and comfortable ride of vehicle having ability to blend according to road conditions

Keywords: Active Suspension, hybrid suspension, electrically powered actuator, power screw and damper.

1. INTRODUCTION

The primary function of vehicle suspension is to isolate the vehicle body and passengers from the oscillations created by the road irregularities and produce a continuous road-wheel contact.

At present, three types of vehicle suspensions are used: passive, semi-active and active ones. All the systems known as implemented in automobiles are based in hydraulic or pneumatic operation. However, it is verified that these solutions cannot solve satisfactory the vehicles oscillations problem or they are very expensive and contribute to the increasing of the energy vehicle consumption.

In the last decade, the evolution occurred in power electronics, permanent magnet materials and microelectronics allowed very important improvements in the electrical drives domain. Dynamic and steady state performance, volume and weight reduction, unconstrained integration with the electronic control system, reliability, cost reduction are very important factors justifying a generalized use of electrical drives.

This experimental analysis is carried out by implementing EPAHS systems using electrically powered actuators in order to improve the performance of suspension system without increasing the energy consumption and the costs.

Another point of view is that an active suspension system, which keep the passenger compartment on a flat trajectory as the car wheels bounce over potholes and rough roads is a luxury concept without any practical interest in the near future. However, it must be remembered that the vehicle oscillations will decrease the tire-ground contact lowering the riding safety. In fact, the sprung mass vertical oscillations are not only uncomfortable but also dangerous to the human spine healthy condition.

2. SUSPENSION SYSTEMS DESCRIPTION

As already mentioned, three types of suspension systems are presently used in vehicle suspensions: passive, semi-active and active ones. All of them are constructed using hydraulic or pneumatic cylinders.

2.1 Passive Suspensions

Passive suspension systems are the most common systems that are used in commercial passenger cars. They are composed of conventional springs, and single or twin-tube oil dampers with constant damping properties. Traditional springs and dampers are referred to as passive suspensions most vehicles are suspended in this manner.

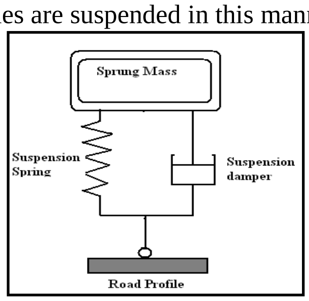


Fig.1 Passive Suspension System

2.2 Semi-active suspension systems

Semi-active suspension systems extend the possible range of damping characteristics obtainable from a passive damper. The damping characteristics of a semi-active damper can be adjusted through applying a low-power signal. Semi-active systems are a compromise between the active and passive systems. They are commercialized recently by means of either a solenoid valve as an adjustable orifice, or MR-fluid dampers.

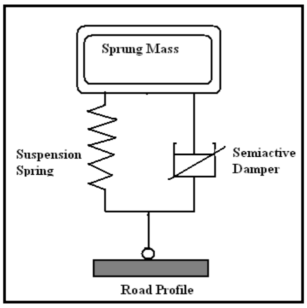


Fig.2 Semi-Active Suspension System

2.3 Active suspension systems

Active suspension system refers to a system that uses an active power source to actuate the suspension links by extending or contracting them as required.

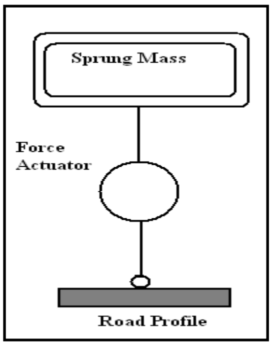


Fig.3 Active Suspension System

In an active suspension, controlled forces are introduced to the suspension by means of hydraulic or electric actuators, between the sprung and unsprung-mass of the wheel assemblies. A variable force is provided by the active suspension at each wheel to continuously modify the ride and handling characteristics.

3. EPAHS SYSTEM MODEL

The Fig.4 represents a model of electrically powered active hybrid suspension system for vehicles.

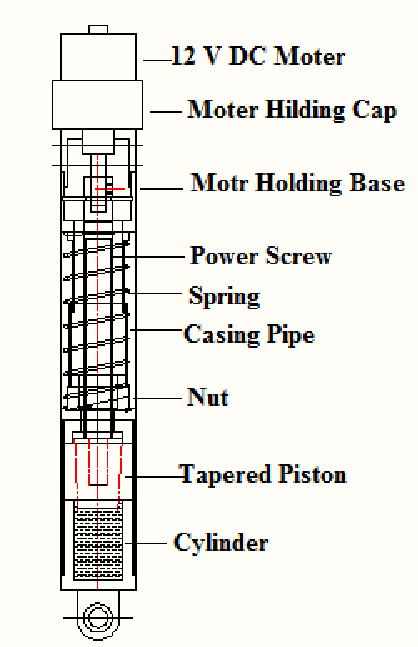


Fig.4 electrically powered active hybrid suspension system

3.1 Working principle of EPAHS SYSTEM

The set-up is an innovation over the conventional Mc-Pherson strut arrangement. The spring used in a helical compression spring with both end ground, the free length of the spring is adjustable. The Free length adjustment will adjust the ground clearance of the vehicle and at the same time make the suspension light thereby increasing the displacement ability of the shock absorber.

The free length adjustment is done using a precision linear actuator in the form of a12 V DC motor, coupled to power screw arrangement with precise displacement and accuracy of motion. The motor drive the power screw and thereby the nut displaces to adjust the free length of spring and also adjust the displacement of the piston of the hydraulic damper arrangement.

The second part of the hybrid system that is the hydraulic damper part, is coupled to the power screw arrangement and it adapts itself as per the motion of the power screw and nut arrangement, thereby adjusting the damping coefficient.

4. Experimentation

For the experimentation the EPAHS System is mounted over the test rig as shown in Fig.5. The response is measured with the help of FFT analyzer for carrying out experimental analysis.

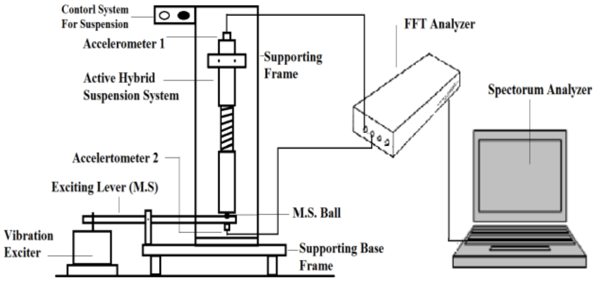


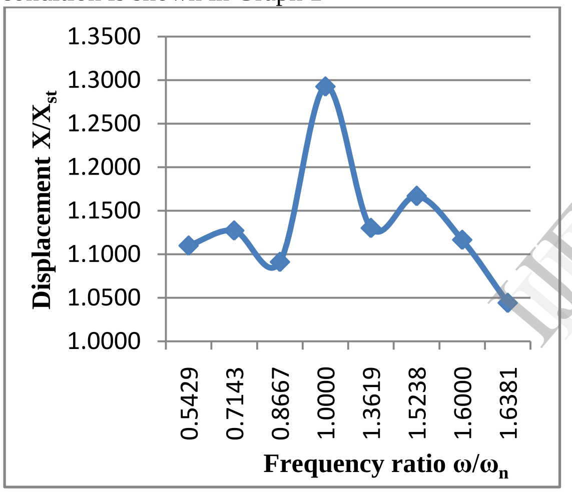
Fig.5 Test rig of EPAHS system

For the two different conditions the piston inside the cylinder is actuated with the help electrically powered motor. The actual experimentation is divided in two different phases out of which first one is normal condition and in second phase piston is moved 5 mm in upward direction.

Case I

Piston is at its normal condition inside the cylinder

The displacement transmissibility curve for normal condition is shown in Graph 1

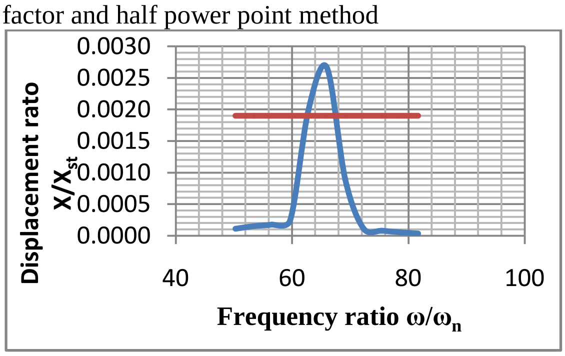


Graph 1 Displacement ratio vs Frequency ratio

From above graph 1 we get the displacement transmissibility for various excitation frequencies.

Damping factor for case I

Damping factor was calculated by using quality factor and half power point method



Graph 2 Displacement ratio vs Frequency ratio

We know that damping factor is given by

$$\xi = \frac{\omega_{n2} - \omega_{n1}}{2 \times \omega_n}$$

From above equitation we get

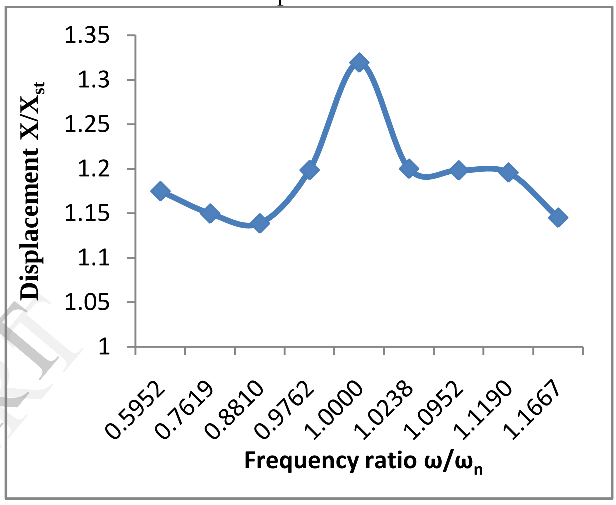
$$\xi = 0.037894$$

From above value it's cleared that system is satisfies the under damping condition.

Case II

Piston is moved in upward direction from normal condition by 5 mm

The displacement transmissibility curve for normal condition is shown in Graph 2

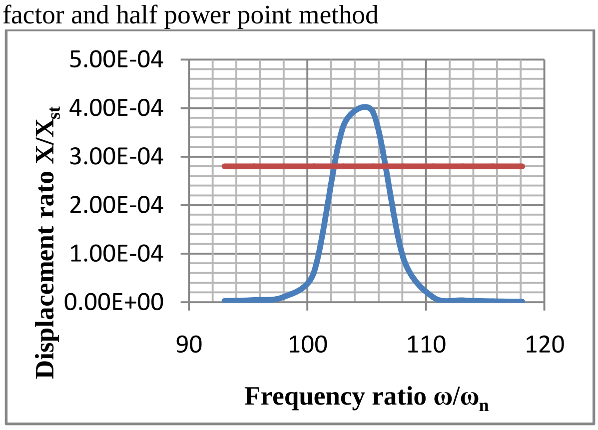


Graph 3 Displacement ratio vs Frequency ratio

From above graph3 we get the displacement transmissibility for various excitation frequencies

Damping factor for case II

Damping factor was calculated by using quality factor and half power point method



Graph 4 Displacement ratio vs Frequency ratio

$$\xi = 0.023684$$

From above value it's cleared that system is satisfies the under damping condition.

Form the both case which are experimented, it's cleared that damping factor changes with respected to the height of piston inside cylinder which was adjusted by using the power screw and electrical motor.

5. Conclusion

In this paper, the behavior of an Electrically Powered Active Hybrid Suspension (EPAHS) System for vehicle was investigated through an experimental program. Some of the significant factors were examined experimentally. This work supports the following conclusions,

1. The dampening factor was less than 1, so it satisfies the condition of under damping.
2. The coefficient of damping changes with respect to height of piston inside the cylinder which is adjusted by using power screw and motor.
3. So the Electrically Powered Active Hybrid Suspension (EPAHS) System has ability to change according to road condition.
4. Form result it is concluded that Electrically Powered Active Hybrid Suspension (EPAHS) System is effectively used on road and off road conditions.

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