ISSN 2395-1621

Design and Development of Electrically Operated Semi-active Suspension System

#1Arvind Kale, #2C.S.Dharankar

AISSMS College of Engg. ,Shivajinagar,Pune

ABSTRACT

Semi-active suspension system is an automotive technology that controls the vertical movement of the wheels with an onboard system rather than the movement being determined entirely by the road surface. The system virtually eliminates body roll and pitch variation in many driving situations including cornering, accelerating, and braking. This technology allows car manufacturers to achieve a greater degree of ride quality and car handling by keeping the tires perpendicular to the road in corners, allowing better traction and control.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

An Electrically powered suspension for a vehicle including a road wheel and tire assembly in this suspension unit having one end attached to wheel-tire assembly and other end attached to chassis of the vehicle with suspension unit including 12VDC motor for positioning the road–wheel assembly with respect to chassis and a controller for operating electric motor so as to control the vertical movements. The electric motor is in parallel with a static load carrying device such as fluid-coil spring .The adjustment of the free length is done using ball and screw arrangement and supported by the nut. The semi-active system designed is simple and effective. The damping properties also adjusted with respect to road conditions by the current suspension system. [7]

II. SUSPENSION SYSTEM

Active suspensions can be generally divided into two main classes: pure active suspensions and semi-active suspensions.

A. Active Suspension System

Active suspensions, the first to be introduced, use separate actuators which can exert an independent force on the suspension to improve the riding characteristics. The drawbacks of this design (at least today) are high cost, added complication/mass of the apparatus, and the need for rather frequent maintenance on some implementations. Maintenance can be problematic, since only a factory-authorized dealer will have the tools and mechanics with knowledge of the system, and some problems can be difficult to diagnose. [1]

B. Semi-active Suspension System

Semi-active systems can only change the viscous damping coefficient of the shock absorber, and do not add energy to the suspension system. Though limited in their intervention (for example, the control force can never have different direction than that of the current speed of the suspension), semi-active suspensions are less expensive to design and consume far less energy. In recent times, research in semi-active suspensions has continued to advance with respect to their capabilities, narrowing the gap between semi-active and fully active suspension systems. Following are the few types of the semi-active suspension system

*1) **Solenoid valve actuated system***

This type is the most economic and basic type of semi-active suspensions. They consist of a solenoid valve which alters the flow of the hydraulic medium inside the shock absorber, therefore changing the damping characteristics of the suspension setup. The solenoids are wired to the controlling computer, which sends them commands

depending on the control algorithm (usually the so called "Sky-Hook" technique). [5]

2) Electro-rheological damper

Another fairly recent method incorporates magneto rheological dampers with a brand name Magne-Ride. It was initially developed by Delphi Corporation for GM. In this system, the damper fluid contains metallic particles. Through the onboard computer, the dampers' compliance characteristics are controlled by an electromagnet. Essentially, increasing the current flow into the damper raises the compression/rebound rates, while a decrease softens the effect of the dampers. Information from wheel sensors (about suspension extension), steering, acceleration sensors and some others is used to calculate the optimized stiffness. [2]

I. Electrically Operated Semi-Active System

The set-up is modification 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 re-circulating ball screw arrangement with precise displacement and accuracy of motion. The motor drive the re-circulating 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 screw arrangement and it adapts itself as per the motion of the screw and nut arrangement, thereby adjusting the damping coefficient.

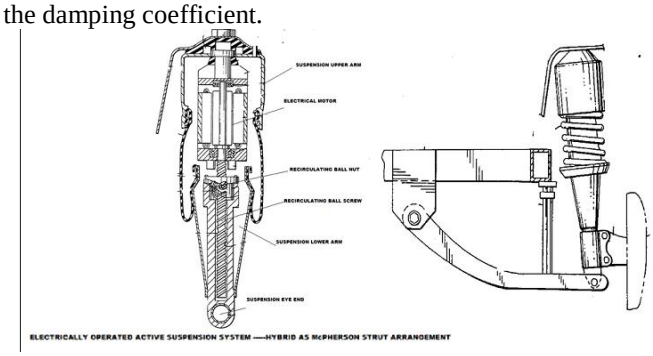

Fig.1 Electrically operated semi-active suspension system

The proposed system is as shown figure 1 in the sketch above, the system components are as follows:

- Electrical motor -12VDC with thyrister control for speed and direction control
- Upper Suspension arm
- Lower suspension arm
- Suspension eye end
- Recirculation screw
- Recirculation ball nut.
- Arrangement of conventional Mc-Pherson with spring.

To keep safety of vehicle, it is very important to reduce wheel load variations. Wheel load influence matrix can be induced by considering every possible state of damper movement. Wheel load influence matrix is shown in Table I [5]

TABLE I
WHEEL LOAD INFLUENCE MATRIX

Shock abs. stage / Switching of shock abs.	Compression	Rebound
Hard to soft	Decrease in wheel load	Increase in wheel load
Soft to hard	Increase in wheel load	Decrease in wheel load

The control circuit will be controlled by close loop system using LVDT for tire load. Figure 2 shows the detail of circuit.

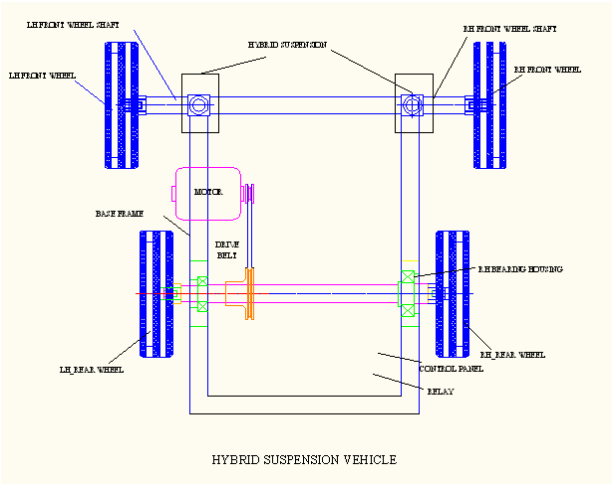

Fig. 2 Close loop circuit

An electrically powered active suspension for a vehicle comprises a road wheel and tire assembly. An electrically driven suspension unit having one end attached to road wheel and tire assembly and the other end attached to the chassis of the vehicle with the suspension unit comprising an electric motor for positioning the road wheel with respect to chassis and control means for operating an electric motor so as to control vertical movement of wheel and tire assembly with respect to chassis. The motor employed herein may comprise a permanent magnet motor, a variable reluctance motor, an induction motor, a synchronous motor or other types of motor known to those skilled in the art and suggested by this disclosure. An electric motor in a suspension unit according to present may comprise either electric motor or a linear motor. In the event that a linear motor is employed, the motor's plunger may be operatively connected with either the wheel and tire assembly or with the chassis, with the stator operatively connected with remaining component so that sliding movement of the plunger with respect to the stator will be accompanied by vertical movement of the road wheel and tire assembly with respect to the chassis. The plunger may comprise either permanent magnet or a coil means excited by the system control means. Similarly the stator may comprise either permanent magnet or a coil means, it being understood that at least one of the plunger or stator must be wound. In a preferred system, the linear motor comprises an induction

motor having a wound plunger and a hollow metallic stator. Alternatively, the motor may comprise a rotating electric motor having a rotating armature driving a gear set so that rotary motion of armature will be converted into vertical movement of the road wheel and tire assembly with respect to chassis. As before the armature may comprise either a permanent magnet or a winding. A suspension unit according to this system further consists of electrical energy connected with the control means and with electric motor so that the energy source will both supply energy to the first load bearing means and absorb energy there from when the motor is operated regeneratively. In a second part an electrically powered suspension for a vehicle according to present system consist a road wheel and tire assembly, a suspension unit comprising first and second load bearing means interposed between the road wheel and tire assembly and chassis of the vehicle, with the first means being electrically powered and control means for operating both load bearing means so as to control the vertical movement of wheel and tire assembly with respect to chassis. As before the first load bearing means could comprise a linear electric motor operated by the system controller and having a plunger ad stator interposed between the chassis of the vehicle and the wheel and tire so that sliding movement of plunger with respect to stator will be accompanied by vertical movement of the road wheel and tire assembly with respect to chassis. Finally, the linear motor may be combined with second load bearing means consisting an adjustable spring which could for example contain a fluid spring. [7]

CONCLUSION

The current paper has described the detail operating and working of the electrically operated hybrid suspension system. Hybrid suspension system is reliable suspension system. It uses the simple components effectively to provide difficult operating conditions during driving. Various modifications will no doubt occur to this system in the arts to which this system becomes better than conventional system. By switching circuits or other conventional devices increases ride comfort and safety of the vehicle. Further the choice of particular suspension in which to employ a system according to present invention is left.

ACKNOWLEDGMENT

I would like to thanks to Mr.C.S.Dharankar for timely guidance and Mr. Dhande for helpful contribution towards developing this short article.

REFERENCES

[1] Car suspension control system: Basic principles, International journal of control, Automation and system vo.1 no.1,JanuaryAyman A.Aly

[2] Electro-rheological Fluid-Dampers,Testing,modeling and applications in vibration and seismic protection of structures by
Nicos Makris and Davide Hill University of Notre Dame
Notre Dame, IN 46556 and Douglas P. Taylor, Taylor Devices, Inc.
North Tonawanda, NY 14120

[3] Analytical and Experimental studies on active suspension system of light passenger vehicle to improve ride comfort by M.Senthil Kumar and S.Vijayarangan ISSN1392-1207,Mechanica2007 Nr.3(65)

[4] A comparative analysis between the vehicles passive and active suspension By Catalin Ale andru and Peter Alexandru International journal of Mechanics,Issue 4 Vol.5,2011

[5] Comparison between Skyhook and Minimax control strategies for semiactive suspension system by Hongkun Zhang,Hermann Winner and Wenjun Li,World Academy of Science, Engineering and Technology 31(2002) The IEEE website. [Online]. Available: http://www.ieee.org/

[6] Designs and Optimizations of Active and Semi-active Non-linear suspension System for a Terrain Vehicle by Shpetim Lajqi and Stanislav Pehan Journal of Mechanical Engineering 58(2012),732-743

[7] Electrically operated active suspension for a vehicle by Roy I. Davis, Ypsilanti, Prabhakar B. Patil US patent no 5,060,959 dated-29 oct 1991.

