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A Testing & Simulating performance of MR Damper

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ABSTRACT

The vehicle suspension is used to mitigate the vibration transferring from the uneven road surfaces. The control of these vibrations is still to be the flourishing field for the researchers. The increasing demand of ride comfort and road stability leads to the development of suspension systems with new control strategies and actuating devices which can provide the robust performance. Hence to achieve this semi active control system is adapted to overcome the limitation of active and passive suspension system. Semi active control is well known for its low implementation cost, simplicity in construction and lower power consumption than active control. The actuation devices mostly used for semi active control are piezoelectric dampers, tuned liquid column damper, magneto rheological damper and electro rheological damper, out of witch the mr damper as a semi active control have been recognized over last several years. Mr fluids consist of the oil with iron particles in it. The device forces are adjusted by varying the strength of magnetic field. The devices will become compact and reliable because of less number of components. In addition to this response rate is very high(respond in milliseconds) with low power requirement, hence now a days this device the focus of industry towards it. The proposed work is to compare the various control strategic for semi active vehicle suspension by using magneto rheological damper as element of semi active control and propose the controller which would provide optimal performance of all.

Keywords— **mr damper, vehicle comfort, semi active control system,**

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I. INTRODUCTION

The vehicles suspension is used to mitigate the vibration transferring from the uneven road surfaces. The control of these vibrations is still to be the flourishing field for the researchers. The increasing demand of ride comfort and road stability leads to the development of suspension systems with new control strategies and actuating devices which can provide the robust performance. Considering these demands the suspension system with active control has been introduced by many authors and proved successful because of its robust performance but it is not widely used due to its cost, necessity to have more external energy supply and heavy weight. Hence to overcome the limitations of passive control i.e, fixed damping and stiffness and difficulties in active control, a novel control, a semiactive control, has been introduced by Karnoop et al and subsequently studied by many authors. The semiactive control is well known for its low implementation cost, simplicity in construction and lower power consumption than active control. The semiactive system can provide the performance comparable to that of the fully active system Karnoop D.C. et al, 1974.

The actuation devices mostly used for semiactive control are piezoelectric dampers, tuned liquid column damper, Magneto rheological damper and electro rheological damper. In this electro hydraulic system (tuned liquid column damper) are most used but the overwhelming response, simplicity and low power requirement the MR dampers the use of these damper in semiactive suspension is expected to grow in coming days. The semiactive control has its wide applications in civil structures, automobile (trucks, earth moving equipment's, tractors, motorcycles, cars etc.), mechanical industries, biomedical (prosthetic leg), space shuttles etc.

The MR dampers as a semiactive control have been recognized over last several years. The MR fluids used in these dampers were developed in 1940's which consists of the oil with iron particles in it. The device forces are adjusted by varying the strength of magnetic field. The device is compact and reliable because of less number of components. In addition to this the response rate is very high (respond in milliseconds) with low power requirement, hence now a day this device has changed the focus of industry towards it.

The most challenging task in the use of semi active technology is to develop a nonlinear control algorithm for achieving robust performance of the system. Hence different controls have been developed and implemented since 1974, the first semiactive technique with skyhook controller has been introduced by Karnoop D.C. et al (1974) and subsequently the tremendous technological developments have taken place in the last two decades. The control strategies developed and implemented considering different applications are explain below.

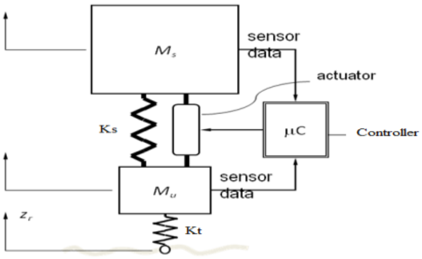

Fig (1): Semi active control.

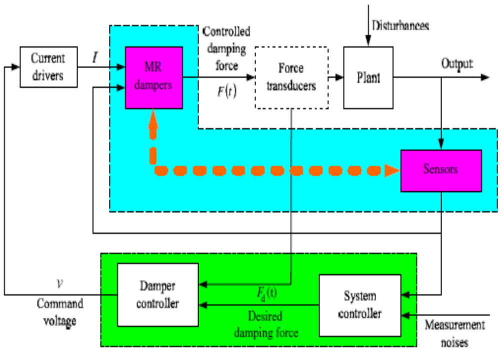

Fig (2) Layout of semi active Control System

Semi-active control of flexible structures using electro-and magneto-rheological fluids was recently proposed. The particularity of these fluids lies in their varying viscosity with respect to the electric or magnetic field in which they are plunged. Since no energy is transferred to the controlled system, these techniques are robust and reliable while offering a vibration reduction level similar to active techniques. Also the semi-active control system needs limited power and is normally operated by a battery. As shown in fig (1) & (2), the semi active system comprises of a controller, sensor, damper and a spring. When it is used in an automobile, the amplitude of vibration is sensed with the help of sensor connected to a vehicle body frame. The controller is then reads the sensor data and measures the amount of current required. The measured amount of current is transferred to the coil present in the valve body. The MR fluid consists of the iron particles get magnetized and arrange into line into the valve passages which restricts the flow of fluid from one chamber to another. Thus the damping ration get varies with the use of MR damper in the system.

MR-damper

The robustness and the simple mechanical design of magneto rheological (MR) dampers make them a natural candidate for a semi-active control device. They require minimal power while delivering high forces suitable for full-scale applications. They are fail-safe since they behave as passive devices in case of a power loss. MR fluids are suspensions of small iron particles in a base fluid. They are able to reversibly change from free-flowing, linear viscous liquids to semi-solids having controllable yield strength under a magnetic field. When the fluid is exposed to a magnetic field, the particles form linear chains parallel to the applied field as shown in Fig. 3. These chains impede the flow and solidify the fluid in a matter of milliseconds. This phenomenon develops a yield stress, which increases as the magnitude of the applied magnetic field increases [10].

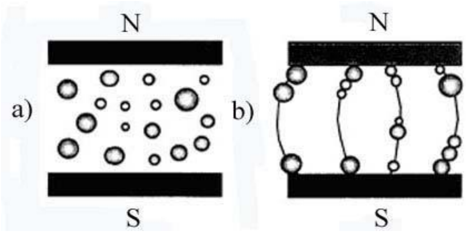

Fig. 3. Magneto rheological fluid

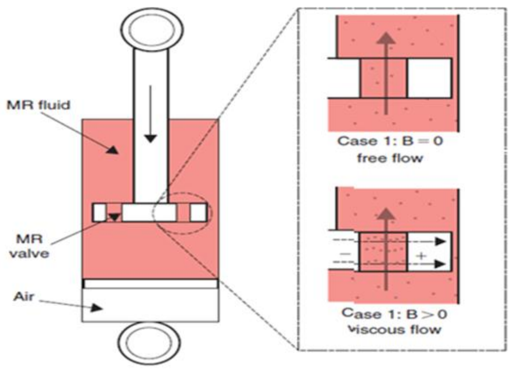

Fig (4) MR Damper

MR devices can be divided into three groups of operational modes or a combination of the three based on the design of the device components. In the valve mode, of the two surfaces that are in contact with the MR fluid, one surface moves relative to the fluid. This relative motion creates a shear stress in the fluid. The shear strength of the fluid may be varied by applying different levels of magnetic field. In the direct shear mode, the fluid is pressurized to flow between two surfaces, which are stationary. The flow rate and the pressure of the fluid may be adjusted by varying the magnetic field. In the squeeze film mode, two parallel surfaces squeeze the fluid in between and the motion of the fluid is perpendicular to that of the surfaces. The applied magnetic field determines the force needed to squeeze the fluid and also the speed of the parallel surfaces during the squeezing motion. A magnetic circuit is necessary to induce the changes in the viscosity of the MR fluid. By using Kirchoffs's Law of magnetic circuits, the necessary number of amp-turns (NI) is

$NI = \Sigma H L = H g + H L i i f s,$

Where, Hf and Hs are the magnetic field intensity of the fluid and the steel, respectively, g is the length of the gap where the fluid flows, and L is the total length of the steel path.

II. LITERATURE REVIEW

The use of Magneto rheological damper in semi active suspension system is increasing worldwide because of its advantages over other actuating devices. R. S. Prabhakar [2] and team from IIT Madras have studied the optimal semi-active preview control response of a half car vehicle model with magneto rheological damper in 2009 and proposed a new approach of controlling the stationary response of a half car vehicle model traversing a rough road with constant velocity with semi-active MR damper suspensions. But in certain cases the system proposed does not perform well.

Maiti D. K. et al [3] and team from IIT Kharagpur worked on application of MR damper in close loop active suspension system. K. Kamalakannan et al [4] have proposed the development of a simpler and cheaper semi active suspension system which will allow its fitment in comparatively affordable cars. A. Ashfak et al [5] have been Designed, Fabricated and evaluated the MR Damper to study rheology and the theory behind MR fluids and their use on vibration control were studied. S K. Faruque Al et. al [6,7] and team studied MR damper as an actuating device for controlling the vibration in civil structures. Through the detailed survey, it has been observed that the work performed on this technology in India is more on the structural vibration control and very less work is on the develop control. Parameter is investigated using this model.

Haiping Du et al [8], have been given a robust controller design approach for vehicle suspension with ER damper. The sprung mass variation, ER damper time constant uncertainty, and control input constraints are considered in the controller design process. It has been observed that the designed controller is insensitive to the parameter variations and can keep good suspension performance under constrained control input.

N. R. Fisco et al [9], have presented a review on the smart structures viz, semi active and active and stated the shortcoming of an active control system that it requires considerable power source whereas the semi-active control system needs limited power and is normally operated by a battery.

C. Collette A. et al [10], have been studied a simple model of a quarter-car, the isolation properties of a semi-active suspension using the SA1 sky-hook like algorithm. It has been observed that the isolation provided by the suspension is degraded by the nonlinearity of the semi-active algorithm, which tends to generate high frequency components at the harmonics of the unsprung mass resonance. Hence, an alternative semi-active algorithm has been presented to overcome this problem in which the smooth variations were imposed to the damper constant, and found that, for a similar reduction of the body resonance, the isolation at high frequency is improved compared to the continuous semi-active sky-hook.

AndrzejMilecki et al, [11], have presented the theoretical and simulation model of an MR shock absorber, as well as the complete stopping model. The design and investigation results of a real MR absorber and its controller are shown. The investigations have proved that the use of MR fluid in industrial shock absorbers enables an electronic control circuit to match the braking characteristic to the stoppable mass kinetic energy. The MR shock absorbers can be built in the control loop of modern fully automated production lines, in which different elements are moved with different energy in the same time. The investigations have confirmed the positive influence of control methods on the braking process.

N. Aguirre, et al [12] dealt with a new semi active control strategy which results from a PI controller along with an adjusting voltage rule designed in order to make the MR damper to mimic the active control force as close as possible. The gains of the PI controller have been computed in such a way to guarantee system stability, minimization of the closed loop system response and controller robustness against modelling errors. This semi active controller is very attractive as it does not require a MR. damper model and uses only obtainable acceleration and force measurements making it quite implementable. The controller design has been illustrated using a three degree-of-freedom structure; however, the methodology can be applied for a more general case. The numerical results show that this simple control law can achieve performance levels comparable to that of more complex algorithms.

C. Poussot Vassal, et al [13] have been devoted to the presentation of a methodology allowing for a comparative analysis of the performance limits of a semi-active suspension, both in terms of handling and comfort. The main interest of the presented results of this paper is the definition of a methodology, useful for benchmarking any of semi-active control algorithms with respect to the best performance. The method also can be extended to more complex suspension models.

ArashBahar, et al [14] has been worked to control the vibration response of a numerical three- dimensional benchmark building. A new inverse model of an MR damper has also been proposed to overcome the difficulty of commanding the MR damper to output the desired control force. The performance indices demonstrate that the proposed semi-active method can effectively suppress structural vibration caused by earthquake loading and can provide a desirable effect of structural performance.

Recently FengchenTu et al [15] have given the promising method for the experimental study and design on automobile suspension made of MR damper. The Finite element method is used analize the magnetic circuit of MR damper. The properties of designed damper were investigated by experiments, and the relationship between damping force, circuit and speed was fitted by the experimental results.

C. Poussot-Vassal et al [16] have provided a picture as complete as possible of the present state of the art in the semi-active suspension control field in terms of comfort and road-holding performance evaluation and trade-off.

The conclusion of the overall survey is that the many researchers have studied the semi active control for the vehicular suspension system but still the system with good performance, in terms of comfort and road holding, within the economic cost cannot be suggested. Hence the work is focused on the developing a suspension system considering the cost factor with comfort and road good holding capabilities.

III. PROBLEM STATEMENT

The aim is to compare the various control strategies for semi active vehicle suspension system by using Magneto rheological damper as an element of semi active control and propose the controller which would provide the optimal performance of all. The study will mainly focused on the design of system using Mix H2/H∞ and frequency based QFT controller and, implementation by Modified Bouce-Wen model, which are not yet been studied. Further, the simulation and experimental test will be conducted to evaluate/compare the performance of the proposed system

IV. Proposed Work

1) To establish a numerical modeling capability for vibration control using magneto rheological damper.
2) investigate the performance of the controller to be used by different techniques viz., frequency based QFT, Mix H2/H∞.
3) Explore design alternatives to existing MR damper designs so that performance can be improved.
4) Experimental validation.

ACKNOWLEDGMENT

The present study has been carried out in order to find out different control strategy for MR damper.

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