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Review of Driver Seat Suspension using MR Fluid Damper

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Abstract

Specifically the human perception of the dynamic comfort of a seat is an area that is of importance to automotive manufacturers for a market becoming more and more competitive and sophisticated. A major portion of the vibration experienced by the occupants of an automobile enters the body through the seat. To date significant attention has been paid to the static comfort of seats while work on dynamic seat comfort is limited. Semi-active control systems are becoming more popular because they offer both the reliability of passive systems and the versatility of active control systems without imposing heavy power demands. In particular, it has been found that magneto-rheological (MR) fluids can be designed to be very effective vibration control actuators, which use MR fluids to produce controllable damping force. The objective of this paper is to design and study a driver seat suspension system model with an MR fluid damper under harmonic excitations with finite element (FE) analysis. We have studied the response of MR damper to vibration, which plays a key role in determining the dynamic comfort.

Keywords: *MR Fluid Damper, Car Driver Seat, Driver Seat Suspension System*

INTRODUCTION

Comfort of the driver plays a vital role in the passenger safety, fatigue during long drive, and drivability in heavy traffic. Comfort is nothing but absence of any discomfort. Not only pollution and performance, economy but also safety and comfort are major factors to consider. Seat must avoid the vibration transmitted from the road surfaces and power train, in order to avoid back disorder, hand eye coordination, vision impairment etc. and

also the long time exposure to vibration causes fatigue to the passenger and hence to avoid this vibration we require a vibration isolator i.e. seat suspension system. The work is an attempt towards the study of driver seat suspension necessity for comfort through objective evaluation with the help of MR fluid damper.

As, in automobile industry the comfort level and ride stability of vehicle are two most important factors in evaluation of vehicle. In particular, it has been found that magneto rheological (MR) fluids can be quite promising for vibration reduction applications [8]. MR fluids are magnetic analogs of electro rheological (ER) fluids and typically consist of micrometer-sized, magnetically polarizable particles dispersed in a carrier medium such as mineral or silicone oil. When a magnetic field is applied to the fluid, particle Chains form, and the fluid becomes a semi-solid and exhibits viscoplastic behavior similar to that of ER fluid. This controllable change of state with some desirable features such as high strength, good stability, broad operational temperature range and fast response time gives rise to isolation and suspension system applications. With the use of MR fluid damper and cast iron plates suspension assembly for driver seat have to develop and damping response of damper towards seat vibrations accordingly have to evaluate.

LITERATURE REVIEW

MR fluid dampers which is considered are nothing but semi-active control devices that use MR fluids to produce controllable damping forces.J S Karajagikar, N R Rajhans, B B Ahuja, R G Rajhans [1] in their experimentation for two different cars RMS acceleration range as per ISO comfort index is near to fairly uncomfortable 0.007 - 0.008 and hence we have conclude that suspension system is necessary for any vehicle driver seat. As per reference standard ISO-2631-1[1997] ride comfort index is the qualitative measure of comfort, with the help of this, comparatively we can study seat suspension system with MR damper.

Table 1: Ride comfort index [2]

RMS Acceleration (km/s^2)	Comfort Index
Less than 0.000315	Not
0.000315 to 0.00063	A little
0.0005 to 0.001	Fairly
0.0008 to 0.0016	Uncomfortable
0.00125 to 0.0025	Very
Greater than 0.002	Extremely Uncomfortable

Martin Orecny, Stefan Segla, Robert Hunady, Zelmira Ferkova.In their experimentation they used two models, one with dynamic absorber and other without dynamic absorber. They calculated stiffness, displacement, damping coefficient numerically and hence they concluded that effect of dynamic absorber is negligible because the Magnetorheological fluid damper [3] reduced the maximum amplitude to values that are almost unnoticeable for the driver situated on the seat so by using MR fluid damper alone vibrations can be reduce.

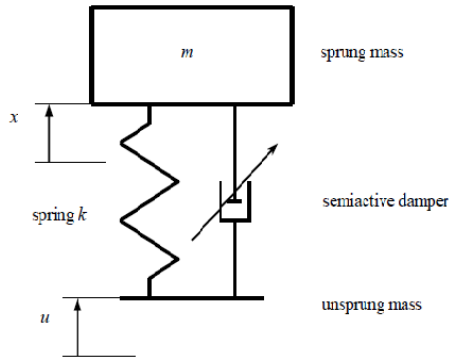

Figure 1: Seat Suspension

Mahmoud El-Kafafy, Samir M. El-Demerdash, Al-Adl Mahamed Rabeih [4] analyzes 3 types of damper namely Active type, Passive type and Semi-Active type i.e MR damper to get best ride comfort through suspension system in any vehicle for passengers and driver. In this the results are plotted in the form of graphs by experimentation, time and frequency domains using MATLAB/Simulink software. There are 3 types of mechanical models in which neural network and fuzzy models are not used because with its non linearity, complexity and only applicable to achieve the desirable damper force in an open loop control system.So they used Bouc-Wen which is described by Spencer et al, used commonly to describe the MR damper hysteretic characteristics.In this by experimentation the controlled MR damper has high vibration compensation in comparison with the passive-on MR damper also controllable MR damper has better vehicles road holding by 24% on fully active and 22% on ideal semiactive suspension system.

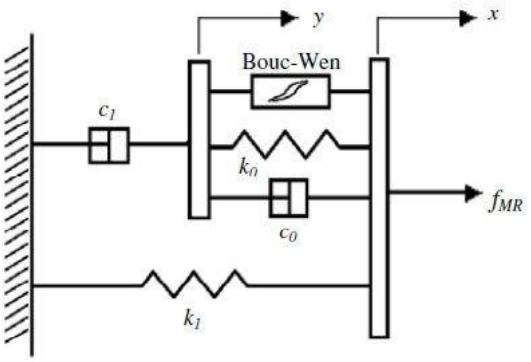

Figure2: Mechanical model of MR damper

The hysteretic behavior in the MR damper was described by the Bouc–Wen model. The mechanical realization of the MR damper is shown in figure 2. The

phenomenological mechanical model is governed by the following equations. [10]

$y = 1/c0+c1\ [\alpha z + ko(x - y) + cox\ ]$ (1)

$z = -\gamma|x - y \parallel z|^{n-1}z - \mu(x - y)|z|^{n} + A(x - y)$ (2)

$fMR = c1y + k1(x - x0)$ (3)

W H Liao1 and C Y Lai [5] in their paper did harmonic analysis of MR damper to investigate characteristics of SDOF system with MR damper through experimental studies. Spencer et al uses the mathematical model of MR damper. Bouc-Wen model used for determine hysteretic behavior in the damper. Least square optimization method is used to optimize different parameters. In experimental setup dynamic response of damper can measure for prescribed wave forms and frequencies. Vibration system (labworks Inc. LW-127-500) is used to produce excitation for damper. Laser vibrometer is used for measuring velocity and displacement.

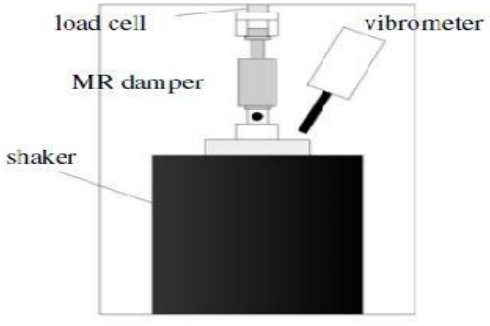

Figure 3: Schematic test setup for the MR damper

From this experimentation author developed force- displacement, force-velocity loop. In this paper author compared effect of simple viscous damper, MR damper and Semi-active MR damper and concluded that Semi- active MR damper is more effective for vibration control.

Also, Attia E. M., Ayman .F.Z, El Gamal H.A, El Souhily B.M in their experimentation, by using Spencer's MR damper model suspension using MR damper and conventional damper the frequency and amplitude of vibration is determined. The results are plotted at constant speed, voltage and height of hump with considering different types of road. They concluded that MR damper is more efficient to reduce vibration as compare with classical type of damper also the use of MR dampers increases the performance of vehicle suspension and reduces the effect of road irregularities on passengers.

With reference of papers, The MR damper used in this study is RD-1005-1[6], which was manufactured by Lord Corporation. The length of the damper is 20.83 cm in its extended position. It has a 5 cm stroke. The maximum current to the

electromagnet in the magnetic choke is 2 A and the coil resistance is 5ohm.To evaluate the performance of MR dampers in vibration control applications and to take full advantage of the unique features of these devices, a model is needed to accurately describe the behavior of the MR damper.

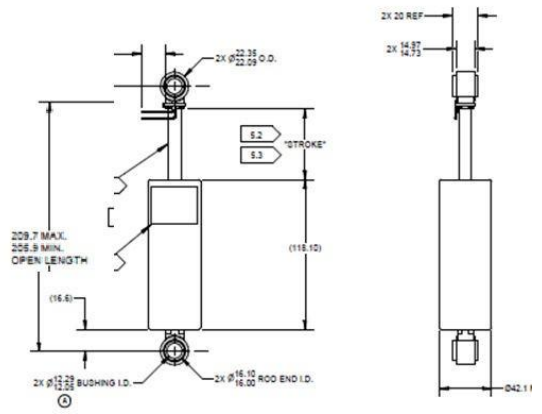

Figure 4: MR damper assembly short stroke [6]

Francis Joseph, Dr. Jason Isaac, T J Paulson concluded that according to different road conditions dynamic comfort of seat, Ride Comfort Index and Transmissibility of car seats, The work ―Low Frequency Vibration Analysis on Passenger Car Seat‖ [7] was done successfully to find the dynamic comfort of the passenger car seat under varying road terrains. A test setup for measuring the vibration transmissibility of the passenger car seat in real time condition has been developed. Using the test methodology, transmissibility of the seat under specified test conditions were identified and the relation of transmissibility with road terrain is found. From the experiment conducted under rough and smooth road terrain, it is found that the transmissibility will vary with respect to terrain. ISO 2631 effectively characterizes the different vehicles for their ride comfort. Ride comfort index calculated from the acceleration value has identified the comfort of each car in the rough and smooth terrain.

Hence with the above mentioned literature survey, we studied how MR damper is providing sufficient damping for driver seat vibrations.

DISCUSSION

After studying the different research papers of MR damper and automotive ride comfort control system, with different approaches, methodologies and experimentations the suspension system will overcome the problem that occurs in the car or automobile related to the driver discomfort.

Methodology

Suspension system uses MR fluid damper as it is semi active control and MR damper filled with magneto rheological fluid which provides sufficient damping with

changes in its viscosity. With the same principle, we are developing suspension system to absorb driver seat vibrations coming from foundation. We use cast iron plates to support MR damper assembly and for better response we use 2 dampers in parallel configuration.

Scope

Driver seat is one of the main aspects to be considered while defining comfort in a moving vehicle. Comfort of the driver plays a vital role in the passenger safety, fatigue during long drive, and drivability in heavy traffic. Comfort means absence of any discomfort, so designing driver seat suspension system with MR fluid damper to improve the human comfort is a necessity and much research are going with the same objective In future every vehicle will have good comfort and safety in every perspective. So this project will serve as one of the advanced technology in future and will be installed in every vehicle.

Seeing towards our basic version, there are some ideas for the future development of driver seat suspension System.

1. Use one MR damper and use different springs for system arrangement for cost reduction.
2. With the considerations of bio mechanics parameter, suspension system may develop with respective sensors to increase sensitivity.
3. Develop a system consist of MR damper and Dynamic absorber which also consist of MR damper for good performance.

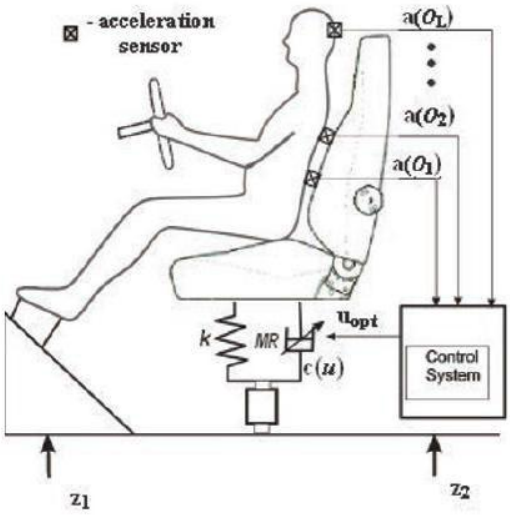

Figure 5: MR damper suspension system for seat [9]

CONCLUSION

Almost within some year every automobile admirer wants car with advanced technology, comfort and safety. People want something new in their life. For seat vibration control, a model consisting of MR damper, the performances and characteristics of the seat suspension

system with different literatures experimentation have been evaluated through. Based on results achieved, the following conclusions have been drawn, development of system which gives better damping for seat vibrations. Also, as per driver seat position damper gives appropriate performance. So to reduce discomfort and instability the research and development of DESIGN AND VIBRATION ANALYSIS OF DRIVER SEAT BY USING MR FLUID
DAMPER system improves driver comfort and ride stability.

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