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A Review on Magnetorheological (MR) Fluid Damper

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Abstract - A Magnetorheological (MR) Fluid Damper is Semi-active vibration control device, consisting Piston Cylinder arrangement, MR fluid and copper coil. The structure of MR Fluid Damper is having fundamentally similar to the conventional damper. MR fluid inside the damper provide controllable yield strength when exposed to magnetic field produced by electromagnetic coil around the Piston. Also, the viscosity of fluid can be modified by varying magnetic intensity. This study summaries fundamental and structural aspects of MR Fluid Damper. Among the different components, this paper reviewed the combination and improvements in magnetic circuit, one of the crucial components of MR Fluid damper.

Keywords – Magnetorheological Fluid Damper, Magnetic Circuit, semi-Active Vibration Control device

1. INTRODUCTION

Driving performance such as driving comfort and stability plays an important role in vehicle dynamic research. It can usually be upgraded with suspension system. That's why the application of semi-active suspension system to vehicle has been widely studied to achieve excellent ride quality and ride stability. There are many types of semi-active suspension system has been developed such as air suspension, throttle variable damper suspension, magnetorheological (MR) fluid damper suspension. Among them, MR Fluid Dampers are actively used in technical field due to its wide range of adjustable dumping force, low cost and high reliability. In late 90s of 20th century the development of MR Fluid Dampers has begun and in next 20 years MR Fluid Dampers are being used in high-speed train[1]; in civil infrastructure like building and bridges [2]; in Aircraft for landing gears [3]; in router system of helicopter[4]; in washing machine[5].

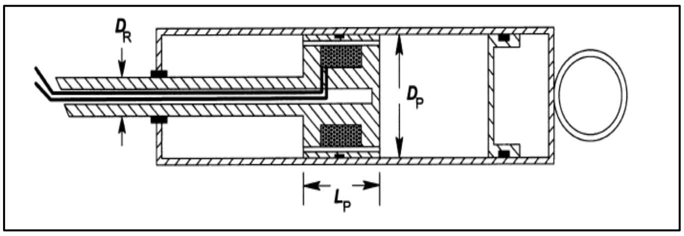
The survey of literature would report that the MR Fluid Dampers is structurally similar with conventional dampers. Though they possess some unique advantage over conventional damper in general the MR Fluid Dampers has cylinder and Piston arrangement, where piston is wounded with coil that excited with electric current to produce magnetic field. This magnetic field affect the property of MR fluid Damper which result in adjustable damping. To overcome the defect; improve range of damping force and for better utilization of the magnetic field, lots of research has been done, such as improvement in number of coil and orientation placement of magnet improvement in damping channel the simulation by using FAE approach has been developed for optimizing parameters during the development of MR Fluid Dampers. This review has presented fundamental structure and approach for development of MR Fluid Dampers

2. SINGLE COIL STRUCTURE

a. Simple Structure

In the proposed simple structure MRP damper by Dixon [6], the main components are Piston rod, Piston, MR Fluid Reservoir, coil of piston, accumulator and compressed gas Reservoir. The illustrated design is as shown in fig-1 to as follows

Fig.-1 Basic Design of Single Coil- Single Tube MR fluid Damper [6]



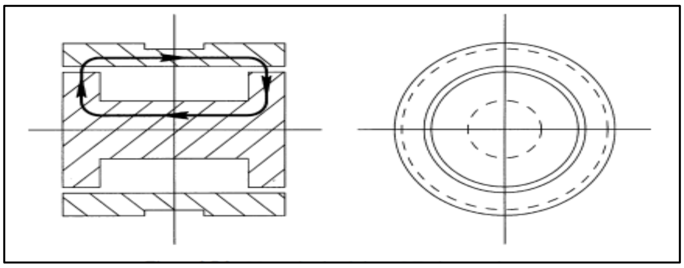
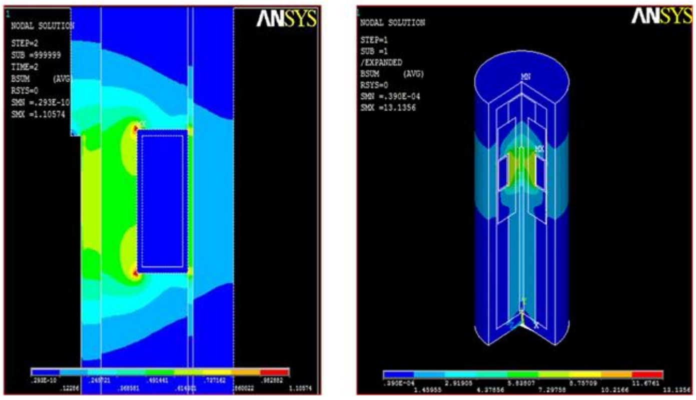


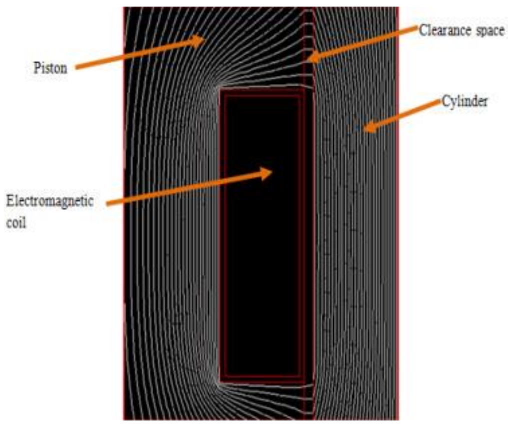
Fig.2- Magnetic loop in MR Fluid Damper [31]

The magnetic flux passes axillary through coin and ideally outward through the Piston at 1 in further through first Mr fluid cap back along the iron casing cylinder radially involved through Piston completing the circuit this is illustrated in Axis symmetric design as shown in Fig.- 2

The range of damping force is comparatively short because of short effective channel. Hence, it is adopted in field where small damping control is required. Design of magnetic circuit is complex. The iron particle in MR fluid may get saturated because of high flux density. To optimize the design magnetic circuit is analyzed in ANSYS APDL. [7] 2D Axi-symmetric model is analyzed using magnetostatic mode and Magnetic flux density and flux lines are studied. The obtained results are helpful in predicting maximum damping force of designed MR fluid Damper.



(a)



(b)

Fig. 3- (a) Magnetic Induction (b) 2D Magnetic Flux line around the electromagnetic coil (result obtained in Ansys) [7]

b. Single Coil – Coil ended MR Damper

The double ended MR Damper has its application in gun recoil because of its effectiveness and simple structure, though has limitation in range of damping force. [8] The double ended MR fluid Damper has two piston rod, rear and front, as shown in fig- 4.

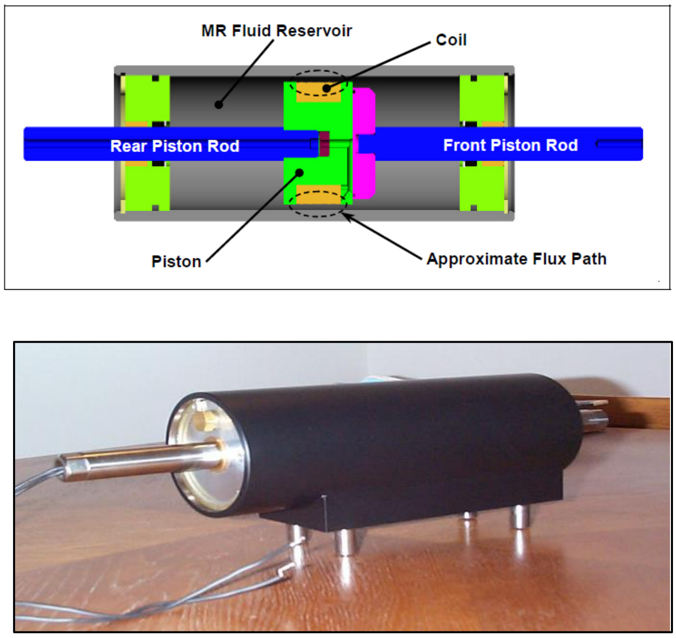


Fig. 4 –Proposed and Developed Single Tube- double Ended MR Fluid Damper [8]

c. Single Coil with one Permanent Magnet

MR damper are introduced with permanent magnet for improvement in magnetic field. [9] the structural design is as shown in fig-5.

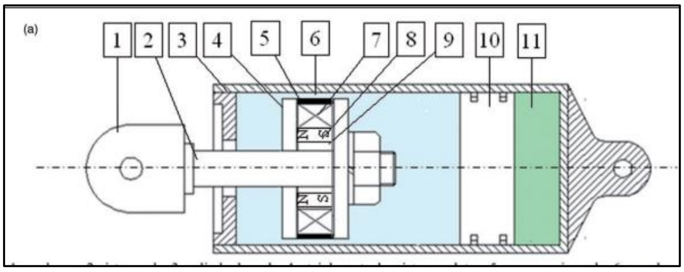


Fig.5 Mechanical Structure of MR fluid Damper with Single coil with permanent magnet [9]

(1. attachment 2. Piston rod 3. Cylinder casing 4. Plate 5. Seal 6. Angular gap 7. Electromagnetic coil 9. Permanent Magnet 10. Floating Piston 11. Compensation chamber)

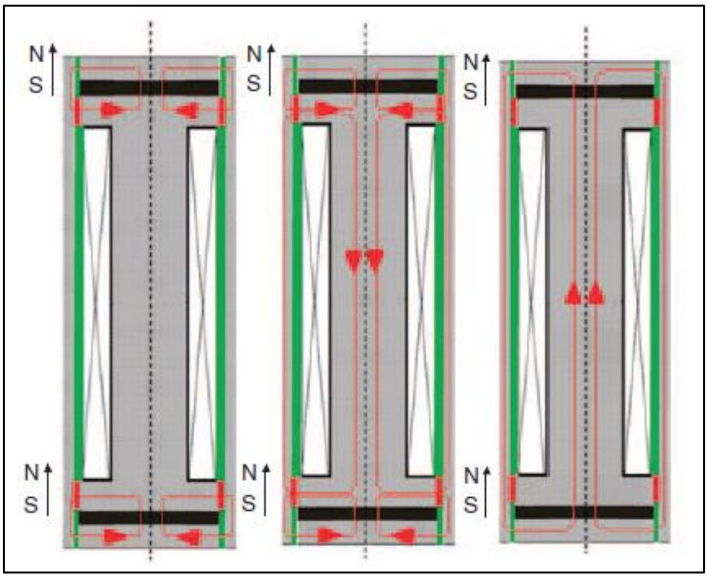
In the proposed design with single coil with permanent magnet, the magnetic field of electromagnetic coil & permanent magnet will superpose, which provide improved control and increased damping force. Also, permanent magnet provides failure protection, in case electromagnetic system is failed.

d. Single Coil with Two Permanent Magnet

To obtain a failsafe behavior the damper is provide with two permanent magnets in case an electric power breakdown. [10]. A damping force of nearly 1400 N was observed in the absence of any external magnetic field from the coil, signifying the powerless damping state. The results showed that the lowest damping force was 400 N at -3 A and the maximum damping force was reported to be 4000 N at 3 A. These findings show the MR damper's improved fail-safe performance in the event of a power breakdown.

a) b) c)

Fig. 6 Schematic of MR fluid Damper with two permanent



magnets. The black disks are permanent magnets, green gap is MR fluid gap, red lines show Magnetic flux lines a) Without current b) with positive current c) with negative current [10]

3. DOUBLE COIL STRUCTURE

The proposed two coil MR damper's schematic layout is shown in Fig-6. [11] The cylinder has three chambers: chamber I and chamber II are filled with MR fluid, while chamber III is filled with compressed nitrogen gas to account for volume fluctuations brought on by the movement of the piston rod. The MR fluid passes through the annular space between chambers I and II while the damper piston rod moves. Additionally, a heat-resistant and electrically insulated double coil of wire is provided for winding inside the piston head. A magnetic field is created around the piston head when a direct current is given to the double coil. It should be noted that the double coil's current flow direction. The maximum damping force or the dynamic range can be somewhat increased depending on whether the current delivered to the double coil is flowing in the same direction or the opposite.

In this literature researched analyzed different models in ANSYS by FEA approach. The maximum force obtained under excitation of 1A current is1.3 kN

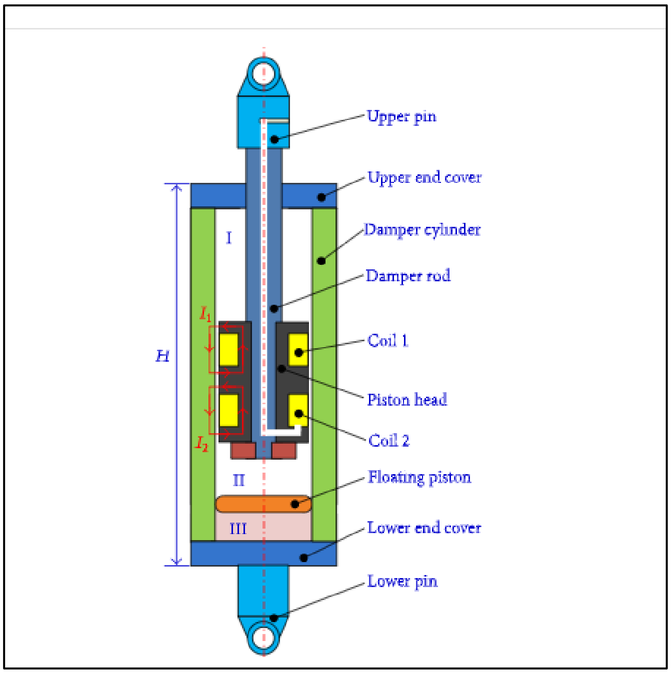


Fig. – 7 Schematic Layout of MR fluid Damper with two coils [11]

4. FOUR COIL STRUCTURE

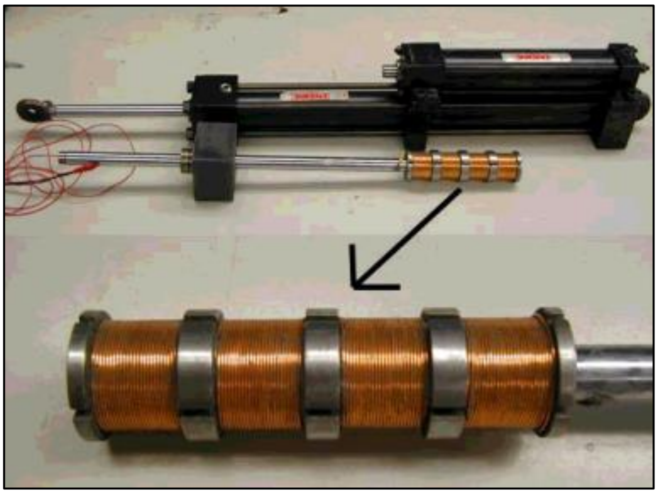


Fig-8 Four coil MR Fluid [12]

Gavin et al. [12] suggested a damper having four coils, as shown in Fig-8. The minimal damping force is only 300 N [12] in the absence of magnetic eld. Under a 10 A current, the maximum force is 4 kN [12]. The controllable range is appropriate for minor damping control requirements, such as for automobile suspension.

However, this damper identified two clear issues. One is the decreased damping force, which contradicts the multicoil structure's intended function. The increased energy use is another. For instance, if the resistance is at least a few ohms, the maximum demand will be hundreds of Watts; consequently, the structural characteristics of this damper should also be optimized.

5. CONCLUSION:

Despite still managing viscosity in a constrained axial channel, the damping ranges and force will be somewhat increased due to the various coil turns and placements, as well as improvements to specific magnetic flux pathways and other techniques. Such structural alterations cannot totally overcome the damping range and other restrictions.

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