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ANALYTICAL MODELLING OF MR DAMPER

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ABSTRACT

Semi active control system such as magneto rheological damper has drawn significant attention in various fields. Magneto rheological dampers consist of MR fluid which is suspensions of magnetically polarisable particles with a few microns in size dispersed in a carrying liquid such as mineral oil, etc. In this study various factors which affect the magnetic field density are being studied analytically using FEMM software. The various factors studied include number of turns, number of coils, current intensity, piston height, etc. By considering all the factors studied, MR damper which gives the optimised result is being found.

Keywords: FEMM, MR Damper, MR Fluid, Magnetic Flux Density, Optimal Design.

I. INTRODUCTION

Magneto rheological dampers are a type of semi active control system. Semi active control systems use a very small external power source and use the motion of structure to develop the control forces. MR damper uses MR fluid to produce damping force.MR fluid is composed of oil and different percentages of iron particles. When no magnetic field is present the fluid act as ordinary oil. In the presence of magnetic field, the dispersed iron particles align themselves to form chains and become like semi solid material and thus produce a damping force.

Many studies have been carried out considering different number of coil, different piston shape, etc. Guoliang Hu et al [1] studied about the optimal design of double coil MR damper for various pistons and compared with experimental results and found it to validate the result. Parlak et al. [2] presented a method for optimising the design of the target damper force and maximum magnetic flux density of an MR damper; this new approach used an electromagnetic analysis of the magnetic field and a CFD analysis of MR flow together to obtain the optimal value of the design parameters. Nguyen et al [3] presented an optimal design of a vehicle MR damper that was constrained in cylindrical volume, and an advanced objective function that collectively included the damping force, the dynamic range, and an inductive time constant. Yazid et al. [4] developed a new concept for MR damper which combined shear and squeeze working modes. Alan Sternberg et al [5] investigated the design, manufacturing, and testing of a large capacity MR damper and found some discrepancy between measured and tested result. Khan et al. [6] studied about the performance of MR damper with various piston configuration and found single coil with fillet end gave better result. Mohammed et al. [7] optimised MR damper using finite element analysis for different configurations of MR damper piston, MR fluid gap, and Dampers housing.

In this study various factors which affect the magnetic field density are being studied and thus the MR damper which gives optimised result is being found. Finite Element Method Magnetics (FEMM) software was utilised to simulate the magnetic field generated by electromagnetic circuit of the MR damper.

II. ANALYTICAL DESIGN OF MR DAMPER

The dimension of the MR damper taken for study about the magnetic field density is shown in Fig 1. The effect on MR damper due to various parameters was studied. The parameters studied are

(i) Fluid gap size (ii) Current intensity (iii) Number of turns (iv) Number of coils (v) Use of squeeze mode (vi) Height of piston

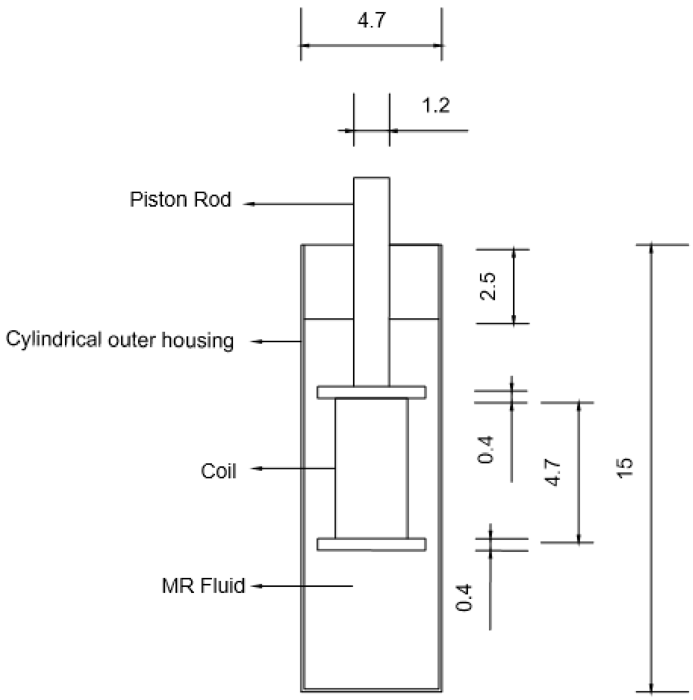

Fig 1. MR damper dimensions in cm

In this study, 20 AWG copper wires were used for the coil. MRF 132 DG was considered as the MR fluid.

Fluid gap size

The effect of fluid gap size was studied for gap varying from 0.1 cm to 0.45 cm and for different current. The result so obtained is depicted in the graph shown in Fig.2.It was found that as the fluid gap increased, the magnetic flux density increased.

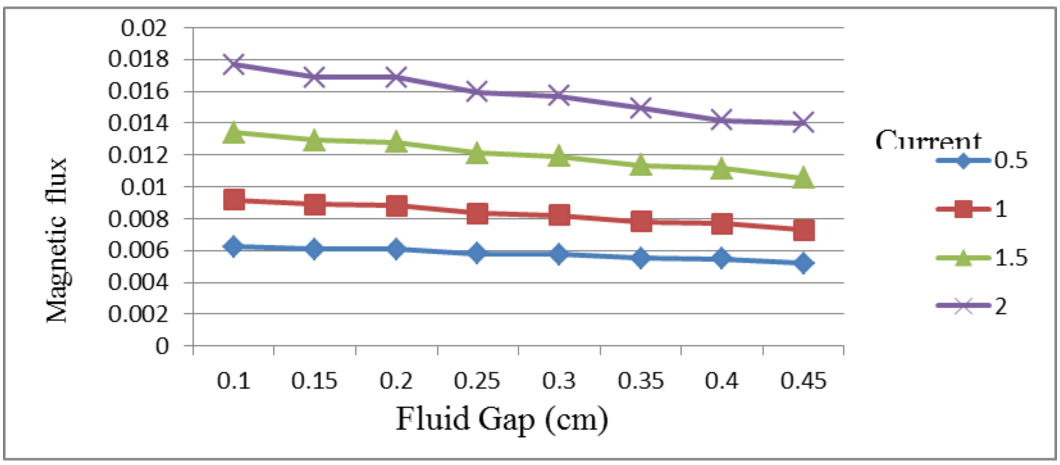

Fig. 2 Magnetic flux density versus fluid gap size for different current applied

Current Intensity

This part of study evaluates the performance of the damper to various operating current intensity. The current intensity was varied from 0.5 A to 2A. It was found that as the current intensity increases the magnetic field strength increases. Fig.3 shows how the magnetic flux density varies as the current is increased for a fluid gap of 0.1 cm.

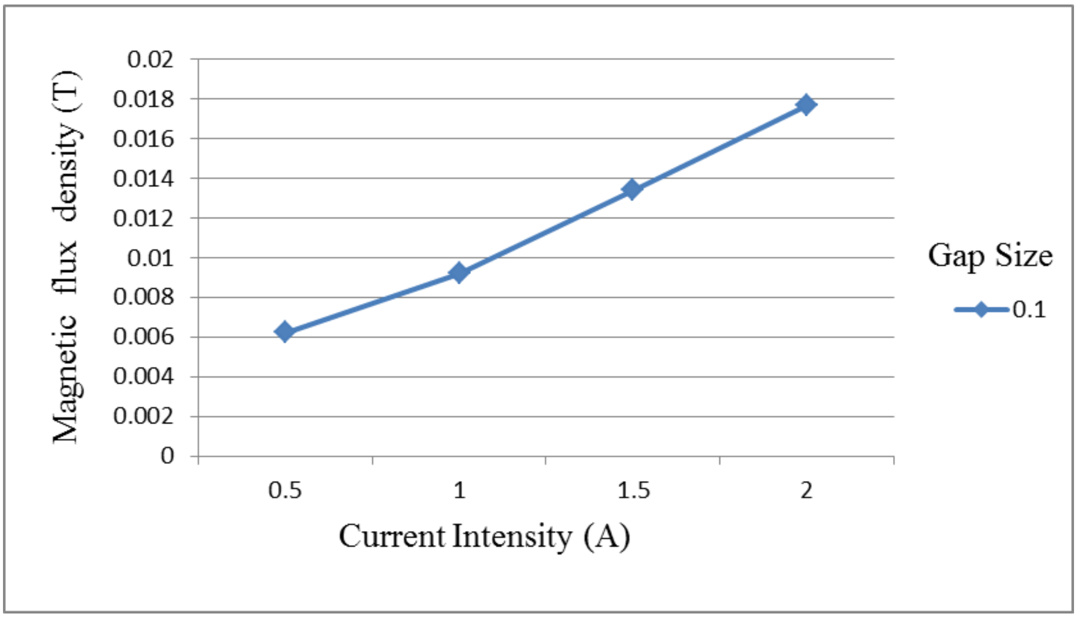

Fig. 3 Magnetic flux density versus Current Intensity for a gap of 0.1 cm

Number of turns

The magnetic flux density for different number of turns was studied. The number of turns was varied from 160 to 460 turns .The effect was studied for a current of 1A and a gap of 0.1 cm. Fig. 4 shows the graph between magnetic flux density and number of turns.

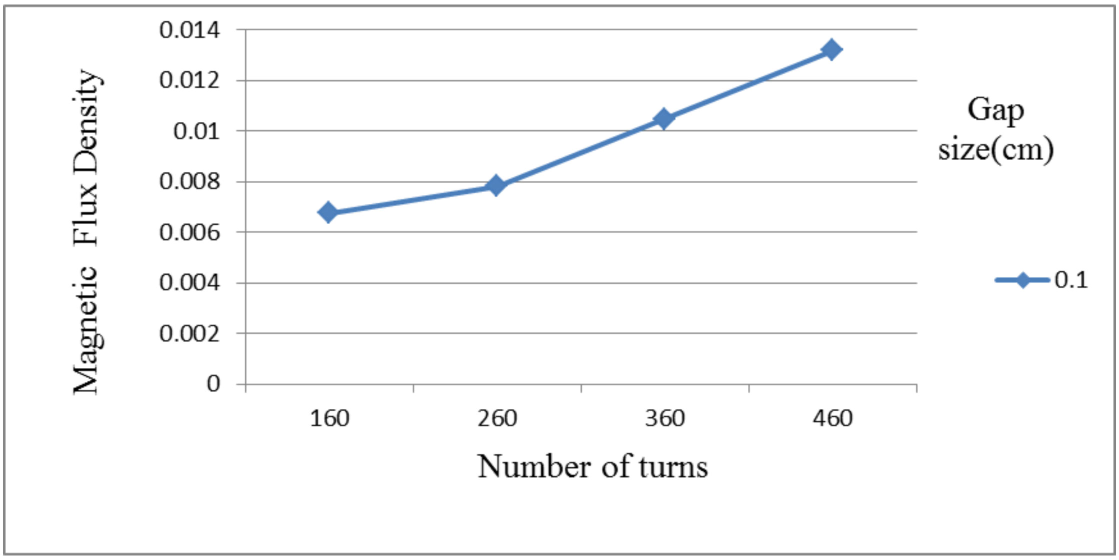

Fig. 4 Magnetic flux density versus Number of turns

Number of coils

Performance of MR damper on increasing the number of coils was studied. Single, double and triple coil were used. Keeping the total number of turns to be constant, double coil gives the maximum magnetic density, slightly greater than triple coil. When the number of turns per coil was increased, the magnetic flux density increased and triple coil gave the maximum result. On turning the direction of wire in each coil, the magnetic flux density was found to decrease. Table 1 shows the magnetic flux density for various numbers of coils and direction of wire.

Table 1 Magnetic flux density for different number of coils and directions

Conditions	Magnetic flux density (T)
Single coil with 270 turns	0.00844
Double coil with 135 turns each	0.006788
Double coil with 135 turns each wound in different direction	0.00532
Double coil with 270 turns each	0.013575
Double coil with 270 turns wound in different direction	0.010655
Triple coil with 90 turns each	0.006625
Triple coil with 90 turns each wound un different direction	0.004566
Triple coil with 270 turns each	0.01988
Triple coil with 270 turns wound in different direction	0.0137

Use of squeeze mode

The effect of using squeeze mode in addition to shear mode is studied. The magnetic flux field decreased for single and triple coil while for double coil it was found to increase. Fig. 5 depicts how the magnetic flux changes with the use of squeeze mode.

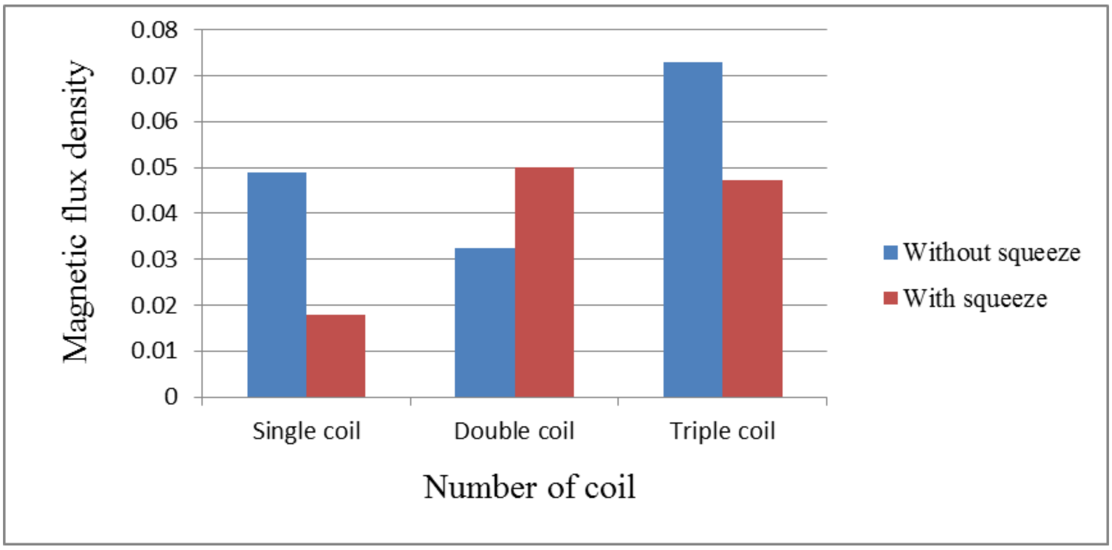

Fig. 5 Bar graph for damper with and without squeeze mode for various coils

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Length of piston

The change in magnetic flux density with the change in length was studied. The study was done for single, double and triple coil for a current of 2A and a gap of 0.1 cm for piston heights of 5.8, 4.9, 4, 3.7 cm. The maximum density was obtained for piston height of 3.7 cm. When the height becomes 5.8 cm an increase was seen but this is lesser than magnetic flux for 3.7 cm piston height. Fig 6 depicts the relation between height of piston and magnetic flux density

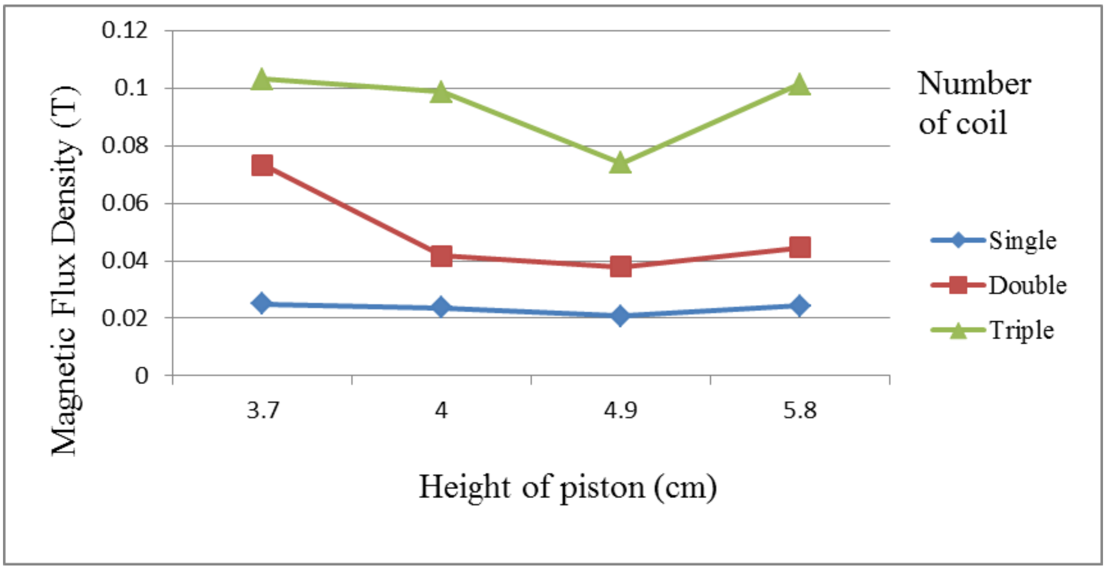

Fig. 6 Graph between magnetic flux density and height of piston for various coils

III. CONCLUSION

The performance of the MR damper is affected by various factors. Some of the factors which affect the damper were studied. FEMM software was used to study about how the magnetic flux density changes with these various factors. An increase in the magnetic flux density indicates the improvement in the damper performance.

In this study, it was found as the fluid gap decreases, the magnetic flux density increases. As the current intensity increases the magnetic flux density increases. As the number of turns increased the density increased. When the number of coils was increased and the directions in which they are wound are same the density was found to increase. In this case the number of turns for each coil was kept same. Use of squeeze mode in combination with the shear mode was found to be effective only in the double coil case. In both the single and triple coil the magnetic flux was found to decrease. By decreasing the height of piston it was found that the magnetic flux density can be increased.

By considering all these factors the parameters which give the maximum magnetic flux density is being found. Triple coil with a fluid gap of 0.1 cm and piston height 3.7 cm was found to give better result. As the number of turns was increased the flux density increased.

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FEMM result of various parameters giving optimised result.

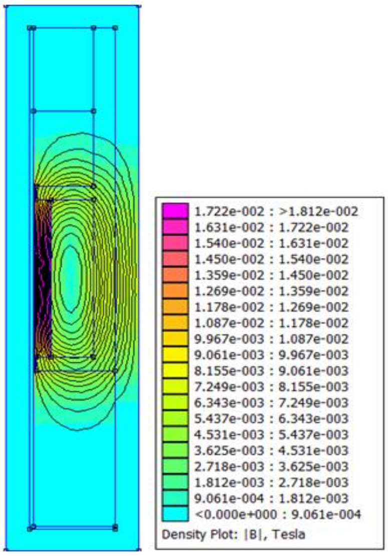

Fig 7 Gap 0.1 cm & current 2A

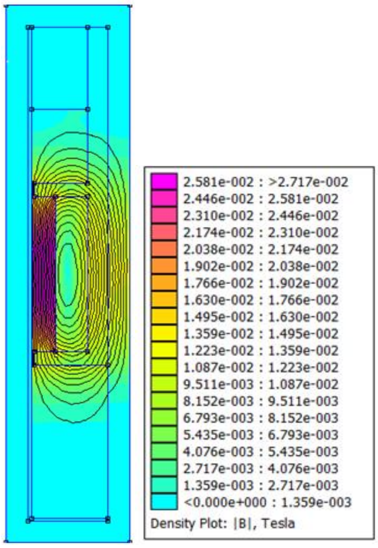

Fig 8 Turns 460

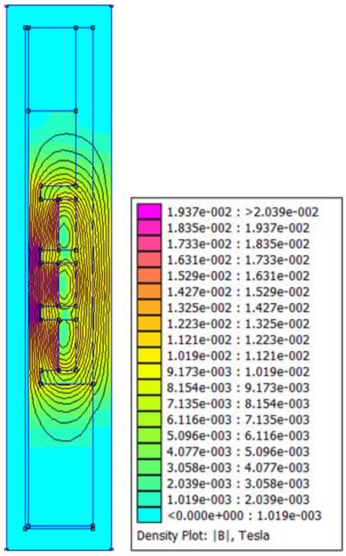

Fig 9 Triple coil with 270 turns each

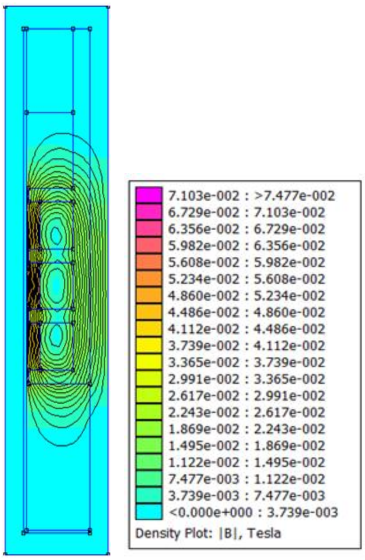

Fig 10 Triple without squeeze mode

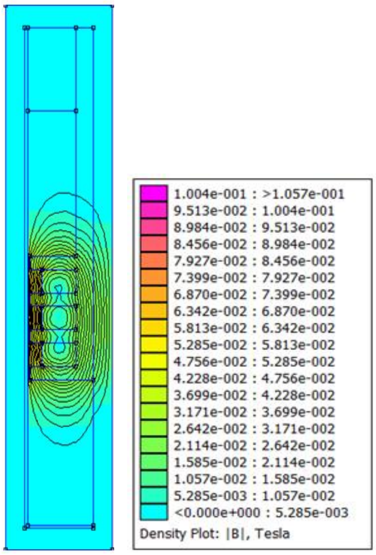

Fig 11 Piston height 3.7 cm, triple coil

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