MR Damper for Variable Damping and Stiffness System: A Review

Shubham S. Fawade, Dr. Lalitkumar M. Jugulkar

Abstract — Generally, magneto rheological dampers are used for to gain variable damping in the suspension system. The MR damper generally having a cylinder containing oil and varying percentages of the iron particles which coated with anti-coagulant layers. The viscosity of fluid is changed by passing the magnetic field though it. The excitation of the magnetic field is generally generated by electric circuit and windings which are wound externally on the piston. The change in magnetic field causes the shear stress variation in the MR fluid.
In this paper, review is taken on the various aspects and trends in magneto rheological damper.

Index Terms —Magneto rheological, damping, viscosity, magnetic, circuit, etc.

I. Introduction

In previous era, automotive suspension system design must be designed considering a compromise between the ride and the road holding capacity of the suspension. The design parameters in the suspension such as damping coefficient, damping force, resonating frequency could not be variable but fixed. A passive suspension system is the one which contains a spring which stores the energy. The energy is dissipated through the damper. The spring rate generally depends over the material of the spring. Hence the factor remaining would be the selection of the damper. Lower damping provides a poor resonance frequency but yields in a high isolation required for comfortable ride. On the other hand, the higher damping will reflect in a high resonance frequency but poor isolation. Thus the selection of the system should consider both the high isolation factor and a good isolation frequency. This problem is avoided by the use of Magneto Rheological Damper.

Fig. 1 shows the principle of operation of the MR fluid under the influence of magnetic field. [10]

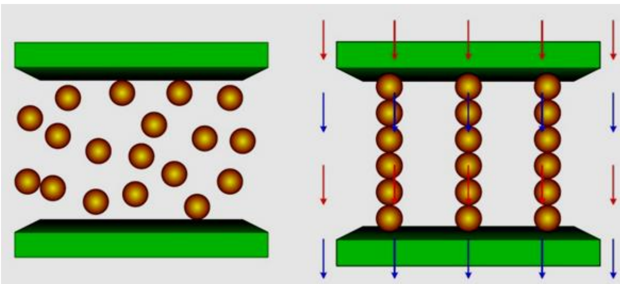

Figure. 1 Principle of operation [10]

II. Methodology

Yun- Juu nam [1] developed a MR damper model as sown in fig.2. It contains a cylinder, a gas accumulator and a piston head comprising of the magnetic circuit. The cylinder is divided into two parts, upper one and the lower one. Following assumptions are provided for a simplified design of the MR damper.

1) The MR ferromagnetic particles are evenly distributed within the fluid.
2) The frictional force is negligible.
3) The velocity distribution is linear within the cylinder.

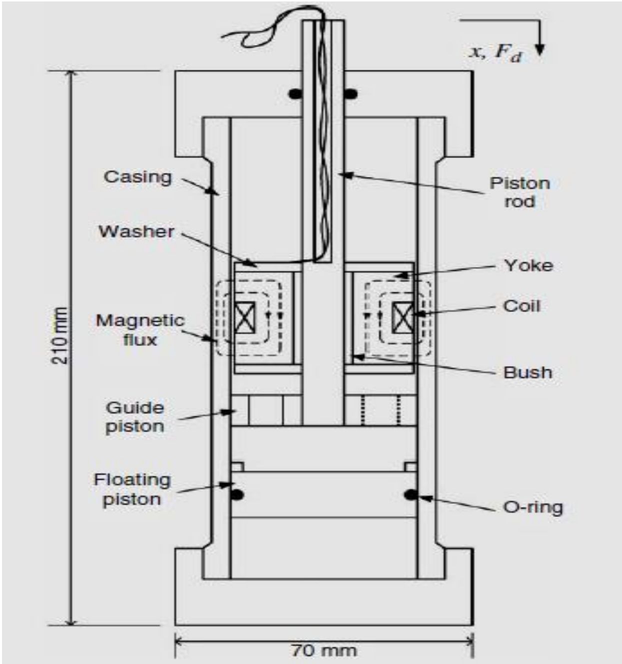

Figure. 2 Construction of a typical MR damper [1]

Weng et al. [2] prepared a mathematical model of the MR damper with annular gap. The various calculations were done for calculating optimum gap size and also shown the various graphs describing the nature of the MR fluid properties while flowing through the annular gap. The relation between shear strain rate and shear stress as well as pressure drop and flow rate was described through graphs.

Fig.3 represents the relation between shear stress and shear strain rate.

Yao et al. [3] designed a MR damper working in the flow mode. Shown and concluded that the damping coefficient increases with an increase in the magnetic field. Shown the various graphs from the analysis those are, tire deflection vs frequency, acceleration response of sprung mass vs frequency and suspension travel with vs frequency. These graphs conclude that the performance of the semi active suspension with MR damper is better than the passive control and nearer to the constant control.

The graph showing a relation between the suspension travel and frequency is shown in Fig.5.

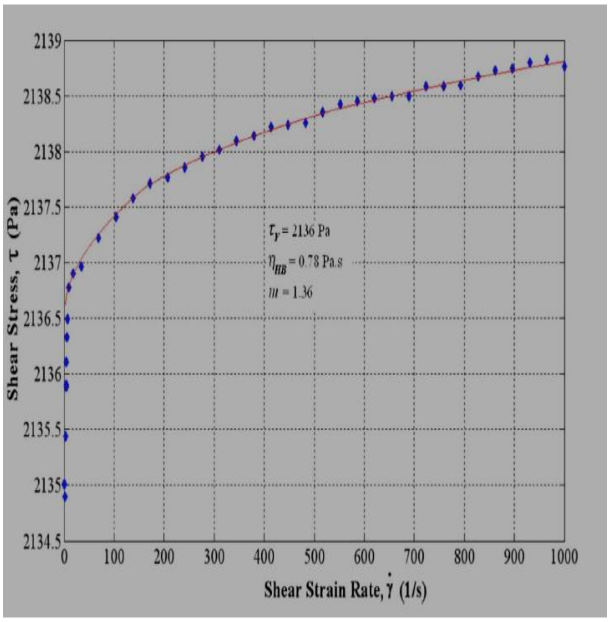

Fig.3 Relationship between shear stress and shear strain rate [2]

Fig.4 represents the acceleration performance of the sprung mass.

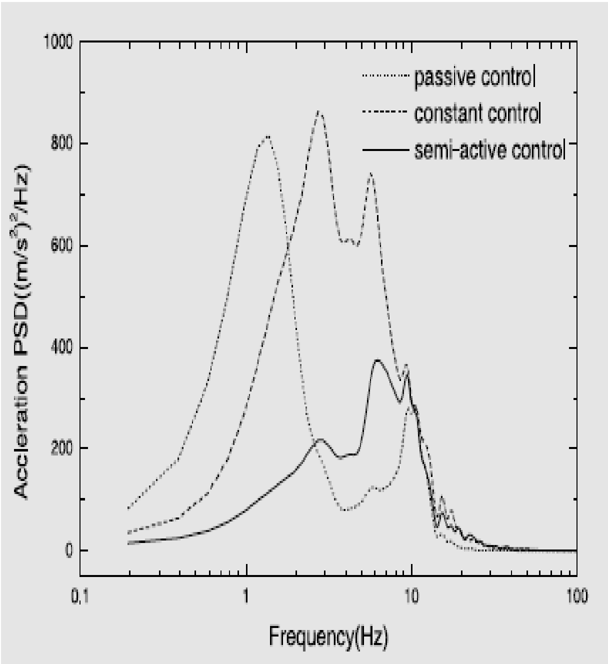

Fig.4 Acceleration performance of sprung mass [3]

Dong et al. [4] MREs i.e. magneto rheological elastomers were used to analyze the response of the MR damper. The procedure of making the elastomer was given in a detailed way. Developed the mathematical model for MRE damper. Also shown the relation between the shear modulus and magnetic field density.

Shuaishuai et al. [5] developed a MR damper not only giving variable damping but also a variable stiffness. Various calculations were done and plotted the analysis through the various graphs.

Metered et al. [6] given the calculations of the modeling on the non parametric semi active suspension models which do not take any assumptions into account but are real time basis. Shown the non-linearity in the response of the semi active suspensions graphically.

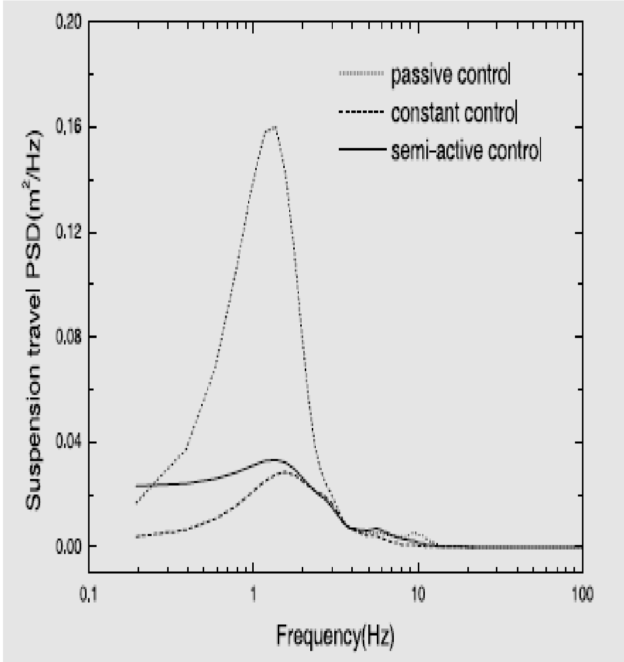

Figure.5 Suspension travel response [3]

Metered et al. [7] developed a mathematical model to represent the MR damper behavior using the trial and error method. The results from the model response are to be fast and reliable to estimate the damping force.

Choi *et al.* [8] designed a cylindrical MR seat damper based on Bingham. After the fabrication of the MR damper, the evaluation of the damping force characteristics was done. He also formulated the skyhook model for reduction of the vibration at the seat of driver. The control responses as acceleration, transmissibility, etc. are inspected in both time and frequency domains.

Fig.6 represents the construction of MR seat damper prepared.

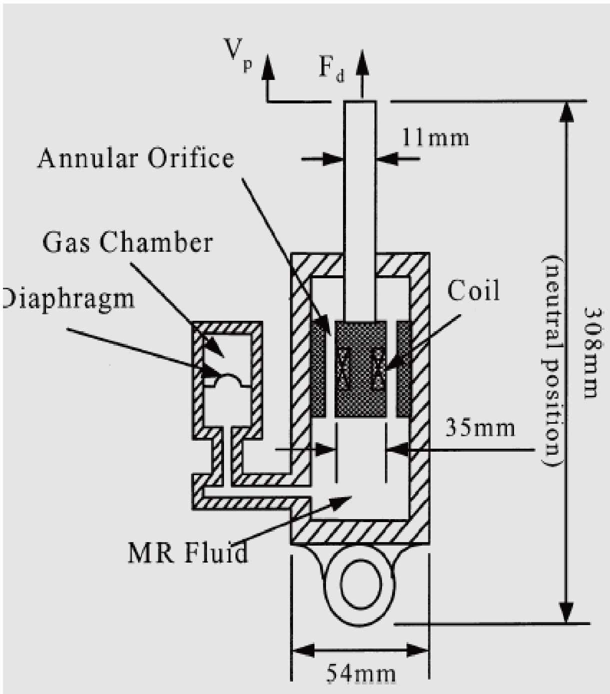

Figure.6 Construction of MR seat damper [8]

Guan *et al.* [9] derived ordinary differential equation (ODEs) of a physical MR damper with compressibility of MR fluid considered. Then he developed the lumped parameter model, which is nothing but a quasi-static MR model having a connection in series with a spring that is expressing the compression of MR fluid. He derived the expression for the calculation of the hysteretic width neglecting the viscous element and the dynamic design method especially for MR dampers is proposed.

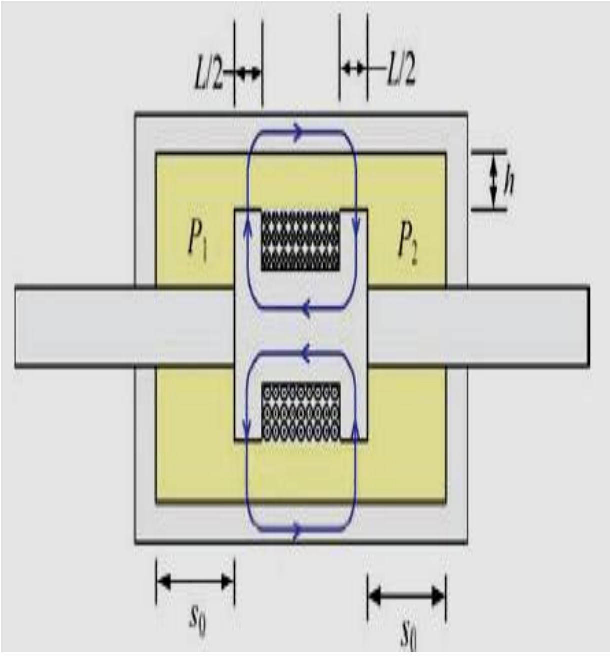

Figure.7 Typical structure of MR damper circuit [9]

Conclusions

Magneto rheological damper has a variety of uses in the modern era of the automotive industry. These are used as the passive suspension devices in various luxury and semi luxury cars, military tanks, off road vehicles, etc. The various properties of MR fluid such as the viscosity, shear strength and magnetism are having a greater influence on its performance. The magnetic circuit of the MR damper is generally prepared having windings over the piston, but the use of cylinder can also be done for the winding, rather such work has not been done yet.

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References

[1] Yun-Joo Nam, Myeong- Kwan Park, Electromagnetic Design of a Magnetorheological Damper, Journal of Intelligent Material Systems and Structure, 2008

[2] Wang, E.R., Ma, X.Q., Rakheja, S. and Su, C.Y.,Semi-active control of vehicle vibration with MR-dampers 42nd IEEE Conference , 2003 (Vol. 3, pp. 2270-2275).

[3] G.Z. Yao, F.F. Yap, G. Chen, W.H. Li, S.H. Yeo, MR damper and its application for emi active control of vehicle suspension system, Elsevier Journal of Mechatronics, 2002, pp.963-373

[4] Dong Xiao –min, Yu Miao, LIAO Chang-rong, CHEN Wei-min, A new variable stiffness absorber on magneto-rheological elastomer. Elsevier Transactions of Non-ferrous Metals Society of China, 2009, pp.611-615.

[5] Shuaishuai Sun, Xin Tang, WeiHua Li, Hiaping Du, Advanced vehicle suspension with variable stiffness and damping MR damper, Transactions of IEEE, 2017.

[6] H. Metered, Application of nonparametric MR damper model in vehicle semi active suspension system, SAE International Journal of Passenger Cars and Mechanical Systems, 2012

[7] H. Metered, S. Mostafa, S. El-Demerdash, M. Hmmad, M-El Nashar, Testing, modelling and analysis of a linear MR fluid damper under sinusoidal condiyions, Transactions of SAE, 2013.

[8] Choi, S.B., Nam, M.H. and Lee, B.K., Vibration control of a MR seat damper for commercial vehicles. Journal of Intelligent Material Systems and Structures, 2000, pp.936-944.

[9] Guan, X.C., Guo, P.F. and Ou, J.P., Modeling and Analyzing of Hysteresis Behavior of Magneto Rheological Dampers. Procedia Engineering, 2011, pp.2756-2764.

[10] Navin Shankar G. M., Mohammad Aslam M., Characterization of Magnetorheological Fluid and It's Application in Semi- Active Vibration Control System in Automobiles, International Journal on Engineering Technology and Sciences, Vollume-III, 2016.

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