A Study on the Optimization of Settling Time in MR Dampers with Different MR Fluid Particles

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ABSTRACT

Magnetorheological (MR) dampers have found many applications in the field of mechanical ,aerospace& automobile engineering etc.with the increasing demand for the noise & vibration control, application of such types of semi-active dampers are bound to increase. The Magnetorheological fluid dampers could offer an outstanding capability in semi-active vibration control due to excellent dynamic features such as fast response, environmentally robust characteristics, low poaer consumption &simple interfaces between electronic input& mechanical output. Magnetorheological fluid are now well established as one of the leading material for use in controllable systems. In this paper different properties of MR fluid & different modes of operations i.e how the MR fluid behaves has been discussed

KEYWORDS: Magnetorheological fluid,properties, flow modes

I. INTRODUCTION

Magneto rheological fluids (or simply "MR" fluids) belong to the class of controllable smart fluids. The initial discovery and development of MR fluids can be credited to Jacob Rabinow (1948, 1951) at the US National Bureau of Standards in the late 1940s. These fluids are suspensions of micron-sized, magnetizable particles in an appropriate carrier liquid. Normally, MR fluids are free flowing liquids having a consistency similar to that of motor oil, when not exposed to magnetic field. It is a fluid of which apparent viscosity increases, with application of magnetic field. MR fluid is composed of oil and varying percentages of iron particles that have been coated with an anti-coagulant material. When unactivated, MR fluid behaves as ordinary oil. When exposed to a magnetic field, micron-size iron particles that are dispersed throughout the fluid align themselves along magnetic flux lines as shown in fig1.1

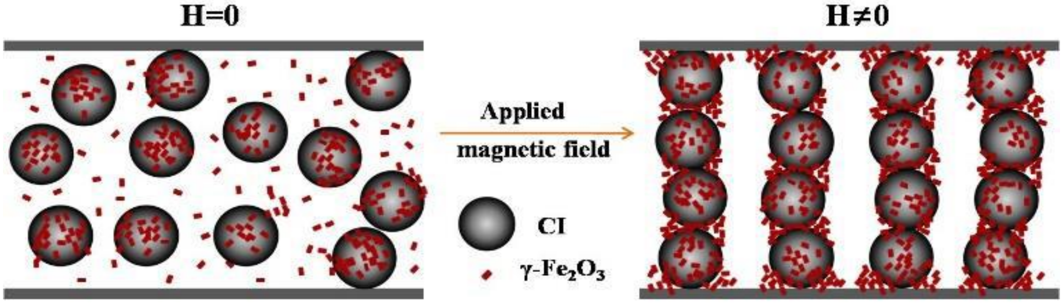

Fig1.1- Effect of Magnetic particle

Magnetic nanoparticle suspensions and their manipulation are becoming an alternative research line and have very important applications in the field of micro scale flow control in micro fluidic circuits, control of fluids in micro scale, and drug delivery mechanisms. In micro scale, it is possible and beneficial to use magnetic fields as actuators of such nanofluids, where these fluids could move along a gradient of magnetic field so that a micro pump without any moving parts could be generated with this technique. Thus, magnetically actuated nanofluids could have the potential to be used as an alternative micro pumping system.

The dampers or shock absorbers are widely used in automotive vehicles to dissipate the vibration energy of sprung and un-sprung mass under resonance conditions. Magnetorehological fluid (MRF) dampers are applied to control unwanted vibrations and shocks for various systems including-landing gear, helicopter lag dampers, vibration isolation systems, vehicle seat suspension systems, civil structures, military equipments, prosthetic limbs. The main advantages are that they need very less control power, has simple construction, quick response to control vibration.

Magnetorheological (MR) fluids fall into a class of smart fluids whose rheological properties (elasticity, plasticity, or viscosity) change in the presence of a magnetic field. MR fluids consist of a carrier fluid, typically a synthetic or silicone based oil, and ferromagnetic particles (20–50 lm in diameter). Magnetorheological (MR) fluids have attracted considerable
interest as these materials exhibit an ability to change their flow characteristics by several orders of magnitude that too in just milliseconds. To successfully apply MR fluids in various
applications, a number of key issues should be addressed. The settling and redispersibility of MR liquid containing micron-sized magnetic particles are intrinsic hindrances for MR applications. MR liquids are composed of high-density carbonyl iron particles (i.e. 7.8 g/cm3) suspended in low-density carrier fluids (i.e. 1 g/cm3) along with surfactants. Due to the density difference between carbonyl iron and carrier fluid, the particles settle and aggregate, and are then difficult to redisperse in the suspension. The main objective of the present work is to analyze the effect of employing a suitable surfactant for the development of MR fluid having good redispersibility with low settling rate without compromising the magnetic property of the MR fluid.

In recent decade due to the improvement in MR technology, researches on MRFs and/or their effects are growingly increased and also some reviews papers are published in this area. In most of this papers preparation and applications MRFs have been studied. Unfortunately, stabilization methods of these fluids have not fully covered in the literature. Taking into account the ever increasing applications of MR fluids in today's modern industries, it seem necessary to launch a comprehensive study on the preparation and stabilization of MRFs as well as their magnetorheological effect. The most important problem reported about MR fluid in associated with sedimentation of heavy iron particles in the carrier fluid. Accordingly, in this study the main focus is to present a comprehensive review on composition of these fluids in addition to introduce and compare the most widely used stabilization techniques of these fluids.
An MR fluid is used in one of three main modes of operation, these being
a) Flow mode

b) Shear mode

c) Squeeze flow Mode.
a)Flow mode:

These modes involve, respectively, fluid flowing as a result of pressure gradient between two stationary plates as shown in Fig. The magnetic field is perpendicular to the planes of the plates, so as to restrict fluid in the direction parallel to the plates.

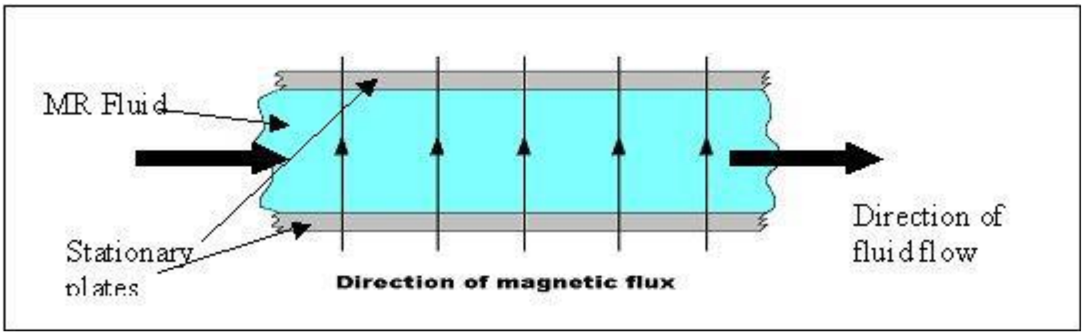

Fig 1.2- Flow mode

b) Shear mode:
These modes involve, respectively, fluid flowing between two plates moving relative to one another.

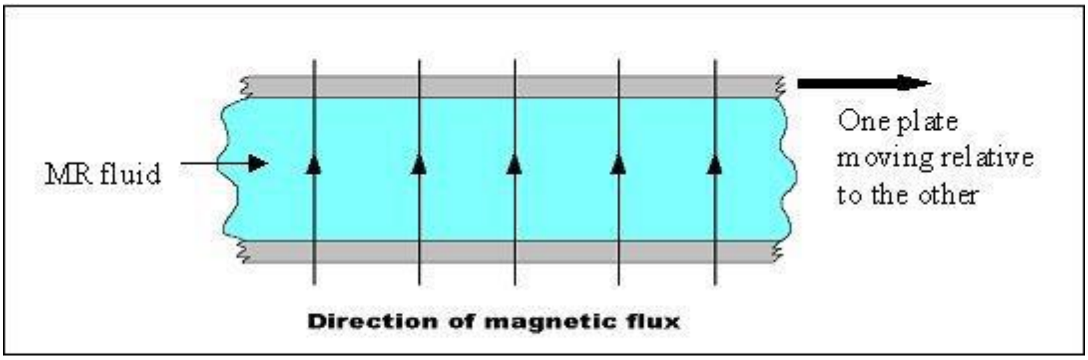

Fig 1.3- Shear mode

C) Squeeze-flow mode:

These modes involve, respectively, fluid flowing between two plates moving in the direction perpendicular to their planes.

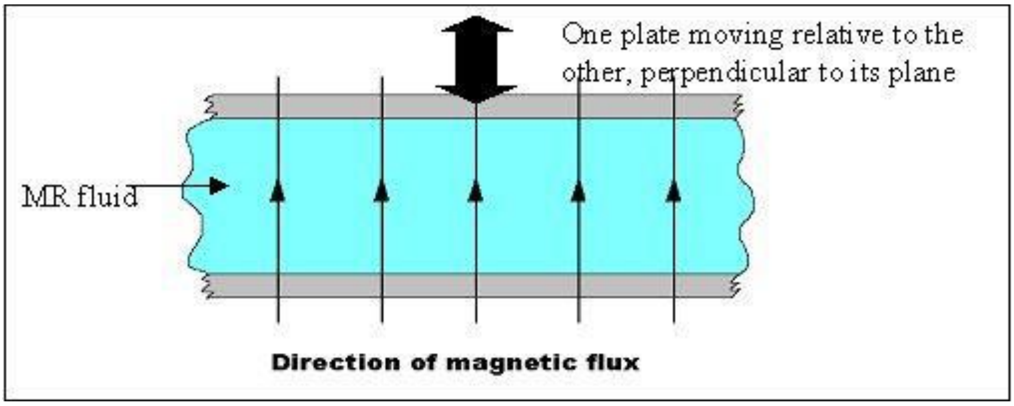

Fig 1.4- Squeeze-flow mode

The ideal MR fluid would never settle, but developing this ideal fluid is as highly improbable as developing a perpetual motion machine according to our current understanding of the laws of physics. Surfactant-aided prolonged settling is typically achieved in one of two ways: by addition of surfactants, and by addition of spherical ferromagnetic nano particles. Mostly surfactants are added to the fluid to obtain the desired settling time.

MR material compositions should be optimized for maximum yield stress magnitude changes, temperature operating range, durability, minimum settling, oxidation and paste formation.
The application set for MR fluids is vast, and it expands with each advance in the dynamics of the fluid. It finds its applications in Mechanical engineering, military and defense, optics, automotive, aerospace and human prosthesis, etc .Magnetic nano particle suspensions and their manipulation are becoming an alternative research line and have very important applications in the field of micro scale flow control in micro fluidic circuits, control of fluids in micro scale, and drug delivery mechanisms. In micro scale, it is possible and beneficial to use magnetic fields as actuators of such nanofluids, where these fluids could move along a gradient of magnetic field so that a micro pump without any moving parts could be generated with this technique. Thus, magnetically actuated nano fluids could have the potential to be used as an alternative micro pumping system. The smart materials such as magneto rheological (MR) fluids are gaining wide popularity due to their superior control abilities. These abilities are strongly dependent about the stability of the MR fluid which needs to be sustained for the useful life of the system.

II. LITERATURE REVIEW

Harshal m.bajaj et al [1], Magneto Rheological is a branch of rheology that deals with the flow and deformation of the materials under an applied magnetic field. These types of materials change their rheological properties under the application of magnetic field applied and turn from liquid to solid in just few seconds. The MR damper is one of them using the smart material i.e.
magneto rheological fluid. This paper shows the various applications of magneto rheological fluid dampers and its Social impact on human life.

A.G. Olabi et al [2], This paper presents the state of the art of an actuator with a control arrangement based on MRF technology. The study shows that excellent features like fast response, simple interface between electrical power input and the mechanical power output, and controllability make MRF the next technology of choice for many applications. Magneto-rheological fluid technology has been successfully employed already in various low and high volume applications. A structure based on MRF might be the next generation in design for products where power density, accuracy and dynamic performance are the key features.

Min Wook Kim et al [3], Magneto rheological behavior was observed using a rotational rheometer along with the dispersion stability test of the MR fluids using a Turbiscan. Sedimentation properties of the MR fluid with and without the hard magnetic nano-particle additive were further tested using a Turbiscan, and showed improved dispersion stability with the additive.

Harish hirani et al [4], MR fluid known for their variable shear stress contain magnetisable micrometer-sized particles (few micrometer to 200 micrometers) in a nonmagnetic carrier liquid. To avoid settling of particles, smaller sized (3-10 micrometers) particles are preferred, while larger sized particles can be used in MR brakes, MR clutches, etc. as mechanical stirring action in those mechanisms does not allow particles to settle down. The particle size distribution, mean sizes and standard deviations have been presented. The nature of particle shapes has been observed using scanning electron microscopy. To explore the effect of particle sizes, nine MR fluids containing small, large and mixed sized carbonyl iron particles have been synthesized. Three concentrations (9%, 18% and 36% by volume) for each size of particles have been used. the MR fluids synthesized using "mixed sized particles" show better shear stress compared to the MR fluids containing "smaller sized spherical shaped particles" and "larger sized flaked shaped particles" at higher shear rate.

Piotr pawlowski et al [5], A convenient implementation of the model involves a decomposition of the compressible viscous fluid into a primary incompressible viscous fluid and a secondary fluid characterized by compressibility and thermal expansion.

James a. Norris et al [6], the results show that at large impact velocities, the peak force does not depend on the current supplied to the damper, as is commonly the case at low velocities. This phenomenon is hypothesized to be the result of the fluid inertia preventing the fluid from accelerating fast enough to accommodate the rapid piston displacement. Thus, the peak force is primarily attributed to fluid compression, rather than the flow resistance (‘‘valving’’) associated with the fluid passing through the MR valve.

Jaime rodríguez lópez et al [7], when magnetic field is applied, important features regarding the change of the microstructure have been found with the help of ultrasonic waves propagating in the direction of the magnetic field. Three different particle volume fraction regions are found identifying a critical particle volume fraction predicted in the literature. Ultrasounds are confirmed as an interesting tool to study MR fluids in static conditions.

H. Metered et al [8], The validation test results clearly show that the proposed neural networks can reliably represent both the direct and inverse dynamic behaviours of an MR damper. The effect of the cylinder's surface temperature on both the direct and inverse dynamics of the damper is studied, and the neural network model is shown to be reasonably robust against significant temperature variation.

K.P. Lijesh et al [9], The experimental studies focusing on aggregation, redispersibility and settling of carbonyl iron-based MR fluids have been conducted to analyze the effect of surfactants on controlling settling and redispersibility. The experimental investigations were conducted by preparation of nine MR fluids samples using three types of surfactants (oleic acid, citric acid and tetramethylammonium hydroxide) and three different carrier fluids (water, silicone oil and DTE light mineral oil). The samples were prepared by mixing on rotational machine for 24 h and the homogeneity of the samples was visually inspected. The shear stress and viscosity variation of the homogenous mixture with respect to shear rate was obtained using magnetic rheometer. A new method is presented for measuring the settling of homogenous mixtures by measurement of the change in the magnetic field strength due to settlement of particles. The effect of surfactant type and its quantity on the stability of MR fluid is explored and the results of settling and redispersibility have been presented.

Miroslav Mrlík a, et al [10],presented paper on Improved thermooxidation and sedimentation stability of covalently-coated carbonyl iron particles with cholesteryl groups and their influence on magnetorheology.this paper relates to Prepared carbonyl iron (CI) microparticles coated with a low density substance, cholesteryl chloroformate, via a two-step reaction and immersed in silicone oil,exhibit three positive aspects,which result is that improvement in thermal stability under oxygen atmosphere, as well as in improved sedimentation stability and redispersion of the suspensions in silicone oil. MR suspensions consisting of 80 wt.% of the coated particles provided material with promising MR performance suitable for real applications in industry.

III. CONCLUSION

-For applications which needs control of fluid motion by varying the viscosity, a structure based on MRF might be an improvement in functionality and costs.

- MR fluids are one of the most attractive intelligent and smart soft materials because of their ease of handling, tunable and reversible properties. MR fluids show a Newtonian-like flow behavior in the absence of a magnetic field. However, in the presence of an external magnetic field, they exhibit a phase change from a liquid-like to a solid-like state because of the formation of a chain structure along the direction parallel to the direction of the magnetic field applied because of magnetic polarization interaction between the dispersed magnetic particles. As a result, MR fluids show enhanced and controllable rheological properties such as shear viscosity, yield stress, and dynamic modulus, with the increase in the strength of the applied magnetic field.
- This remarkable controllability and reversible change in the mechanical characteristics has received significant attention in both academic and industrial areas such as active dampers, shock absorbers, and MR polishing.
- An improvement of the long-term stability can be made by adding various surfactants,. This results in a partial decrease in particle density and an enhanced mutual compatibility between the particles and the carrier liquid that reflects in improved MR performance.

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