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"Introduction to Magneto-Rheological Fluid Technology & Its Application"

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Abstract

Magnetorheological (MR) fluid damper are semi active control device that have been applied a wide range of practical vibration control application. In this study, the methodology adopted to get a control structure is based on the experimental results. An Experiment has been conducted to establish the behaviour of the MR damper. In this paper, the behaviour of MR damper is studied and used in implementing vibration control. The force displacement and force-velocity response with varying current has been established for the MR damper. In this paper we investigated theoretically at fabricated Magnetorheological damper by using Magnetorheological fluid. Here MR fluid developed first by mixing of prepared nano size (fe3o4) iron particle by co precipitation method. And a comparative study had done between these iron particles prepared MR fluid. Here an experimental performed on fabricated MR damper and discussed the behaviour of MR damper.

Introduction

MRF stand for Magneto-rheological fluid technology. The essential components of MRF are MR fluid and a magnetic field to control the viscous property of the fluid. The basic principle of MRF is that very small suspended particles having magnetizing properties are introduced in the base fluid. When a magnetic fluid is applied to this fluid, these particles form a chain aligned in the direction of the field which creates a resistance to the fluid flow. Resulting, an increase in the fluid viscosity takes place. Thus in the presence of magnetic field the MR fluid converts into a semi solid with an increase in its yield strength. This work phenomenon takes only milliseconds to occur.

MR Fluid Components

Magneto rheological (MR) fluids are basically non colloidal suspensions of micro sized magnetisable particles in an inert base fluid along with some additives. Thus there are basically three components in an MR fluid.

A. Base fluid, B. Metal particles and C. Stabilizing additives.

A. Base fluid

The base fluid is an inert or non magnetic carrier fluid in which the metal particles are suspended. The base fluid should have natural lubrication and damping features. For better

implementation of MRF technology the base fluid should have a low viscosity and it should not vary with temperature. This is necessary so that MRF effect i.e. variation of viscosity due to magnetic field becomes Dominant as compared to the natural viscosity variation. Due to the presence of suspended particles base fluid becomes thicker. Commonly used base fluids are hydrocarbon oils, mineral oils and Silicon oils.

B. Metal particles

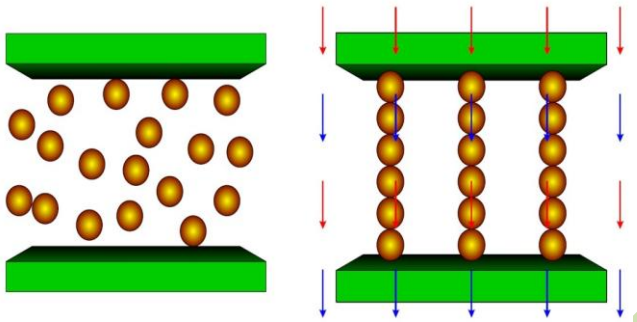
For proper utilization of this technology we need such type of particles which can magnetized easily and quickly therefore we use metal particles. Metal particles used in the MR-technology are very small. Size of the particle is approximate of the order of 1μm to 7μm. Commonly used metal particles are carbonyl iron, powder iron and iron cobalt alloys. Metal particles of these materials have the property to achieve high magnetic saturation due to which they are able to form a strong magnetizing chain. The concentration of magnetic particles in base fluid can go up to 50%. (approx.)

C. Additives

It is necessary to add certain additives to MR fluid for controlling its properties. These additives include stabilizers and surfactants. Surfactants serve to decrease the rate of settling of the metal particles. While the functions of additives are to control the viscosity of the fluid, maintain friction between the metal particles and to reduce the rate of thickening of the fluid due to long term use of the fluid thus additives also increase the life of the MR fluid. Commonly used additives are ferrous oleate and lithium stearate.
All the three components of an MR fluid define its magneto rheological behavior. Changing any one component will result in change in the Rheological and magneto rheological properties of the MR fluid. An optimum combination of all the three components is necessary to achieve the desirable properties of an MR fluid.

Working Principle of Mr Fluid Technology

The MR fluid is a smart fluid whose properties can be controlled in the presence of magnetic field. In the absence of magnetic field, the rheological properties of the MR fluid are similar to that of base fluid except that it is slightly thicker due to the presence of metal particles.
In the absence of magnetic field, these metal particles align themselves along the direction of flow (figure 1(a)) however when a magnetic field is applied each metal particles becomes a dipole aligning itself along the direction of magnetic field (Figure 1(a) and (b)). Thus a chain like structure is formed along the line of magnetic flux which offers mechanical resistance to the flow resulting in an increase in the viscosity of fluid .This mechanical resistance created due to the chain column imparts yield strength to the fluid, making it stiff like a semi-solid. This stiffness and hence the yield strength depends on the strength of the magnetic field and also the quality and quantity of metal particles.



a)without magnetic field b)with magnetic field

Fig.1. Working principle of MR fluid technology

The MR effect is reversible. When the magnetic field is removed the fluid returns to its original condition. The MR fluids with their controllable properties are found to be useful in the implementation of smart fluid concept. Where the fluid motion is controlled by varying its viscosity with the help of magnetization. The simpleness of MR fluid technology, the controllability and the quick response of the rheological properties makes it a smart fluid with application areas where fluid motion is controlled by varying the viscosity.

Magneto-Rheological (MR) Damper

Magneto-rheological (MR) dampers are semi-active control devices that use MR fluids to produce controllable dampers. They potentially offer highly reliable operation and can be viewed as fail-safe in that they become passive dampers should the control hardware malfunction. To develop control algorithms that take maximum advantage of the unique features of the MR damper, models must be developed that can adequately characterize the damper's intrinsic nonlinear behavior.

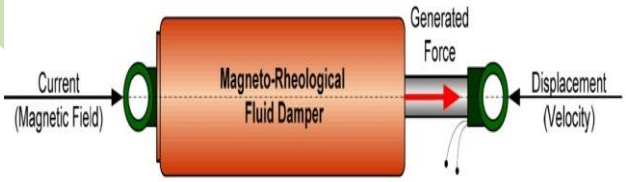


Fig.2. Magneto-Rheological (MR) Damper

Features and Benefits

Fast Response Time – responds instantly and reversibly to changes in a magnetic field.

Dynamic Yield Strength – provides high yield strength in the presence of a magnetic field and very low yield strength in the absence of a magnetic field; allows for a wide range of controllability.

Temperature Resistant – performs consistently throughout a broad temperature range, meeting the requirements of demanding applications such as automotive shock absorbers.

Hard Settling Resistant – provides high resistance to hard settling; easily redispersed.

Non-Abrasive – formulated to not abrade the devices in which the MR fluid is used.

Applications

The application set for MR fluids is vast, and it expands with each advance in the dynamics of the fluid & they are as follows,

A. Mechanical engineering

Magneto rheological dampers of various applications have been and continue to be developed. These dampers are mainly used in heavy industry with applications such as heavy motor damping, operator seat/cab damping in construction vehicles, and more.

B. Military and defence

The U.S. Army Research Office is currently funding research into using MR fluid to enhance body armor.

C. Optics

Magneto rheological finishing, a magneto rheological fluid-based optical polishing method, has proven to be highly precise. It was used in the construction of the Hubble Space Telescope's corrective lens.

D. Automotive

If the shock absorbers of a vehicle's suspension are filled with magneto rheological fluid instead of a plain oil or gas, and the channels which allow the damping fluid to flow between the two chambers is surrounded with electromagnets, the viscosity of the fluid, and hence the critical frequency of the damper, can be varied depending on driver preference or the weight being carried by the vehicle - or it may be dynamically varied in order to provide stability control across vastly different road conditions. This is in effect a magneto rheological damper.

E. Aerospace

Magneto rheological dampers are under development for use in military and commercial helicopter cockpit seats, as safety devices in the event of a crash. They would be used to decrease the shock delivered to a passenger's spinal column, thereby decreasing the rate of permanent injury during a crash.

F. Human prosthesis

Magneto rheological dampers are utilized in semi-active human prosthetic legs. Much like those used in military and commercial helicopters.

Conclusions

Magnetorheological (MR) fluid dampers have provided technology that has enabled effective semi active control in a number of real world applications. Because of their simplicity, low input power, scalability and inherent robustness. MR Fluid & MR Fluid devices have been greatly advanced in the last decade & there some commercial products have been developed. This technique has been developing competitively in the main industrialized countries, especially in the United States, Belarus, France, Japan & Germany. In addition to the application in Mechanical engineering, MR fluid damper will get practical use in Civil engineering for seismic response control & MR fluid has potential application prospects in medical equipment & therapeutic procedure.

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