Braking system with frictionless fluid: A Review

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***Abstract*:** In this braking system the purpose is to obtained constant braking. This can be done by the frictionless fluid i.e MR fluid (magneto rheological) fluid. In this paper design of brake in such way that to increase the braking torque, to use it according to machine requirements. Magneto rheological fluid is prepared by basic component's like carrier oil, Magnetic Particle, additive's. MR fluid is the smart material which get solidify under the application of Magnetic Field This brake can used to slow down the machining speed in the industries, railway wheel's.

Keywords: brake design; MR Fluid.

1.Introduction

This brake system is used to reduced revolution speed by constant braking. As mention in the topic name the frictionless fluid it is basically Magneto rheological fluid.

The properties of smart materials can be controlled by changing the external conditions. A magnetorheological (MR) fluid is a type of smart fluid that has been in

use since the late 1940s. An MR fluid consists of very tiny magnetite particles, a
carrier fluid, and an additive. When a magnetic field is applied to this fluid, its damping viscosity is increased. This is because the magnetic particles are joining
together to form a more rigid body with the existence of a magnetic field. Based on this property, MR fluids have become a hot material in research since the 1980s and many applications that are in use today as the result of these researches. Most of the
applications are in the area of motion damping, shock absorption, and vibration
suppression. For instance, large dampers are currently used in the superstructure of large buildings and bridges to help prevent wind and earthquake damages]. Examples are the Franjo Tudjman Bridge, which was completed in 2001 and extends 6 km over part of the sea north of Dubrovnik, Croatia and the Dongting Lake Bridge in the Hunan province in China both have magneto rheological fluid dampers installed as earthquake and wind protection. MR fluids are also being used in shock absorbers for
military vehicles. It could work as a replacement for the oil inside a shock absorber because the damping effect could be controlled by applying a magnetic field.

Magnetorheological fluid (also known as MR fluid) has been in use since 1947 when Jacob Robinow applied for the patent. MR fluids consist of very tiny magnetite particles, a carrier fluid, and a rheological additive that can stabilize the fluid. This mixture has the ability to flow like an ordinary fluid and, when a magnetic field is present, become a rigid semi-solid. The fluid used in experimentation was composed of a 1: 1: 1 ratio of the three elements. This created a reasonable viscosity when magnetic field was absent, and a high viscosity while under the influence of a magnetic field with reasonable strength. Most of the magnetite particles used in MR fluids has sizes ranging from 0.1 micron to 10.0 microns. If particles are too small, the viscosity changes inconspicuous. If particles are too big, the fluid has precipitate too quick. Both are not good for shock absorbers. During the experiment, the 500nm size particles are chosen. The key particles used in MR fluid are magnetite. Most people use Iron Oxides (*Fe3O4*). This black magnetite is soft magnet and its magnetic hysteresis loop is pretty skinny Which means the residue magnetic dipole is small. This property makes viscosity of MR fluids has big changes. For an MR fluid, the carrier fluids are a key ingredient. Theoretically, the carrier fluid can be almost any fluid especially oil such as gear oil, motor oil and silicon oil. However, these oils have different viscosities. Motor oil and silicon oil, are commonly used carrier fluid in MR for their low viscosity. In this experiment, the semi synthetic 5w-30 motor oil

was used. Synthetic oil was used due to their better high temperature performance. Additives were used to prevent the metal particles from settling down and to add to the rheological properties. Additives also allow the molecules of the carrier fluid to bond to the metal particles. The main type of additive found in MR fluid is a colloidal additive such as organoclay which is an organically modified version of bentonite.

Magnetorheological (MR) fluid consists of micron sized magnetically permeable particles dispersed throughout the non-magnetic fluid carrier. Iron powder, having high saturation magnetization, is the most popular material to be used as magnetic particles. Under the presence of the magnetic field, magnetic dipole moment within particles induces, causing dipole interactions to form chains in the direction of flux paths. The formed particle-chains restrict fluid movement and increase yield strength of MR fluid. Rotational movement of disk (shear mode) and axial movement of pad (compression mode1) affect the particle chains, and therefore the braking torque of MR disk brake.

2.1 Literature Survey of machining processes:

The main working fluid is MR fluid. To enhance the viscosity and the sedimentation properties of MR fluid. This survey show that different proportions of carrier oil, magnetic particle and additives.This additives makes changes in the property of MR fluid according to the requirements.

2.1 Literature Survey on Abrasive water jet cutting of Titanium alloy:

Mukund et al [1] MR fluid is a device to transmit torque by the shear force of an MR fluid. The mechanical part is modeled using Bingham's equation. The geometric design method of a cylindrical MR fluid break investigated theoretically in this paper. The breaking torque developed by MR fluid within the break under different magnetic fluid strength has been analyzed. When the required mechanical power lever the rotational speed of rotor, and the desired control torque ratio are specified. Shreedhar Kolekar et al [2] Magneto rheological (MR) fluids are suspensions of micron-sized magnetizable particles disperse in a nonmagnetic carrier fluid. The essential characteristic of these materials is that they can be rapidly and reversibly varied from the state of a Newtonian-like fluid to that of a stiff semisolid with the application of a moderate magnetic field. It is clear that as the concentration of iron particles varies, the rheological properties also vary. Hardeep Singh et al [3] The aim of this work is that how the MR fluids can be prepared. This paper highlights on the recent development of MR fluids. In this paper it is described that how MR fluid samples can be prepared containing different weight composition. Therefore, with different levels of constituent three samples are prepared. These samples are tested for its sedimentation and thermal properties.

Mukul Kataria et al [4] Magnetorheological (MR) fluid is a smart material whose flow behavior can be altered with the application of magnetic field. The MRF technology has ability to transmit force in a controllable manner by application of magnetic field. The magnetic field that controls the stiffness of MR fluid during shearing plays the most significant role in finishing of the surface in MRFF. At high magnetic flux density, MR fluid shows high resistance before yielding. As magnetic flux density increases, magnetic interaction force between two magnetic particles increases significantly. Ganapathy Srinivasan et al [5] Surface fining is most important properties in Machining process. Due to bad surface fining process we have Low quality product. The quality is most important precision devices. In traditional machining process cannot get cost effective finishing and also not in flexible. The Magnetorheological Fluid can be applied in effective finishing process such as optical material in complicated shapes.

Noor Jahan et al [6] The fluids physically properties like crystalline phase, shape size distribution and magnetization of both the fluids were studied individually. Thereafter, magnetic stimuli-response of ferro fluid doped MR fluid on rheological properties was determined in static and dynamic modes. In this work, we have improved fluid stability and yield stress of the MR suspension with Nano particles incorporation. Nano particles are adsorbed on the surface of the flake shaped iron particles and reduces the inter particle friction. Wanquan Jiang et al [7] A type of dimorphic magnetorheological (MR) fluid was prepared by adding wire-like iron nanostructures into the conventional carbonyl iron based MR fluid. The Fe nanowires were synthesized through reducing Fe^{2+} ion with excessive sodium borohydride in aqueous solution. A type of dimorphic MR fluids was prepared by adding Fe nanowires into the conventional CL based MR fluids. Jianrong Liu et al [8] The heat transfer oil-based magneto rheological fluid (MRF) was prepared using oleic acid-modified micron carbonyl iron powder as a magnetic dispersed phase and strontium hexaferrite ($SrFe_{12}O_{19}$) nanoparticles as an additive. To improve the stability of MRF, a certain amount of $SrFe_{12}O_{19}$ was added to the traditional carbonyl iron powder based-MRF.

Prabhat Ranjan et al [9] Advanced Nano finishing is an important process in manufacturing technologies due to its direct influence on optical quality, bearing performance, corrosion resistivity, bio-medical

compatibility and micro-fluidics attributes. During CMMRF operation, MR fluid applies polishing pressure on the work surface. This pressure depends on properties of MR fluid, working gap and rotational speed Guangshuo Wang el at [10] Magnesium ferrite ($MgFe_2O_4$) nanocrystal clusters were synthesized using an ascorbic acid-assistant solvothermal method and evaluated as a candidate for magnetorheological (MR) fluid. The present study synthesized superparamagnetic magnesium ferrite ($MgFe_2O_4$) nanocrystal clusters with an average diameter of about 376 nm by an ascorbic acid-assistant solvothermal method.

Xiaogu Wang et al [11] Rotodynamic coefficients of a controllable floating ring bearing (FRB) are measured in the presented study. Controllability of the bearing is achieved by using magnetorheological fluid (MRF) as lubricant along with external magnetic field. A controllable floating ring bearing lubricated with magnetorheological fluid is proposed in this study. The FRB is introduced to avoid excessive shear-thinning effect of the MRF by utilizing the rotating
ring in it. S.Elizabeth Premalatha[1,2] et al [12] The main aim of this article is to prepare MR fluids, composed of iron particles and analyse their flow behaviour in terms of the internal structure, stability and magneto rheological properties. The particle size of iron power is confirmed by Optical Scanning Microscope. The magnetic properties of iron particles dispersed in silicone oil measured. Mr.Vaibhav et al [13] The Magneto Rheological (MR) fluid and iths basic properties. The main aim of this paper is to prepare the magneto rheological fluid for the MR damper which is used in vehicle suspension system.MR fluids are a class of smart material. Magneto rheological fluid for its very necessary in magneto rheological damper to reduce the vibrations or shocks. Monika Kciuk et al [14] Science and technology have made amazing developments in the design of electronics and machinery using standard materials, which do not have particularly special properties (i.e. steel, aluminium, gold). The development of smart materials will undoubtedly be an essential task in many fields of science and technology such as information science, microelectronics, computer science, medical treatment, life science, energy, transportation, safety engineering and military technologies. Chi Ranjit Sarkar et al [15] Magnetorheological (MR) fluids are smart materials with shear strength ranging between zero to 100kPa under the influence of magnetic field. The present paper discusses the synthesis of MR fluid and its application in brake. The CI- based MR fluid prepared by mixing oleic acid tetramethylammonium hydroxide as additives show superior performance. SA Wahid et al [16] Magneto-rheological fluid is the colloidal suspension of micron sized magnetic particle s in a carrier fluid where defects and failures occur at many circumstances. This paper presents a review on defects and failures of magneto-rheological fluid in engineering application. The applications of magneto-rheological fluid in various sector showed good technology improvement nowadays. S.K. Mangal et al [17] Magneto Theological (MR) Fluids possess on – state rheological properties like yield strength and viscosity which are dependent on the strength of the applied magnetic field. This paper presents the comparison of on-state magnetic flux density of MRF122-EG fluid using different Techniques. Tae Hong Min et al [18] in this paper To achieve better chemical affinity between conducting polyaniline (PANI) and soft magnetic carbonyl iron (CI) microspheres, we initially attached hydroxyl groups to the surface of CI using *p*-toluene sulfonic acid monohydrate. The PANI-coated CI composite particles were then fabricated via a chemical oxidation polymerization method.
Korade D. N et al [19] This paper deals with literature review on MR fluid and to explore the effect of different configurations of magnetizable particles and carrier fluid a comparison of different concentrations (65%, 50% and 35% by weight) of magnetizable micrometer sized particles is studied over here. Rheometer is the instrument which gives shear rate versus shear stress graph of MR fluid. In this paper the shear stresses of those MR fluids samples have been studied using ANTON PAAR MCR-102 Rheometer. M. Ashtiani et al [20] The main focus of this study is to present a comprehensive review on different methods of preparation and stabilization of MR fluids. Furthermore, rheological models and application of MR fluids are discussed briefly in this study. Antonio Bicchi et al [21] in this paper we present an innovative application of magnetorheological (MR) fluids to haptic interfaces. These materials consist of a suspension of a micron-sized, magnetizable particles in a synthetic oil. Exposure to an external magnetic field induces in the fluid a change in rheological behavior turning it into a near-solid in few milliseconds. Chao Guo et al [22] The beneficial properties of magnetorheological fluids are applied in the design and testing of a prototype suspension system. Because viscosity of these fluids increased tremendously under the influence of a magnetic field, a suspension shock absorber containing magnetorheological fluids fluid is proposed. X.Z. Zhang et al [23] This paper presents an experimental approach to study the effect of friction on magneto rheological (MR) fluids. Both steady and dynamic modes were employed to investigate MR fluid behaviors. The experimental results indicate that the total MR effects are dominated by two factors:

magnetic force and friction force. H. Abdullah et al [24] This paper presents a modern design of multi-disks Magnetorheological braking system (MR brake) for automotive application considering the magnetic saturation in both electromagnetic core and MR fluid. A one-dimensional analytical model is developed to calculate the braking torque of the proposed system. Y. Yang et al [25] In this paper, the design method of the cylindrical MR fluid brake is investigated theoretically. The equation of the torque transmitted by the MR fluid within the brake is derived to provide the theoretical foundation in the cylindrical design of the brake. Based on this equation, after mathematical manipulation, the calculations of the volume, thickness and width of the annular MR fluid within the cylindrical MR fluids brake are yielded. E. Dragoni et al [26] this paper investigates the behavior of MR fluids under pressure when a rotation is applied to shear the fluid. The system is designed in order to apply both the magnetic field and the pressure and follows a Design of Experiment approach. The experimental apparatus comprises a cylinder in which a piston is used both to apply the pressure and to shear the fluid. The magnetic circuit is designed to provide a nearly constant induction field in the MR fluid. Kang Boseon et al [27] Based on the properties that yield stress would increase as an applied magnetic field increased, magnetorheological(MR) fluids were used on glass polishing. MR fluids were considered as a polishing fluid whose rigidity could be adjusted. Therefore, different polishing effects could be achieved by adjusting the strength of magnetic field. The mathematical model of this technology was established and based on this model, the effects of several parameters on MR fluids polishing were investigated. Suresh Kaluvan et al [28] this paper discusses about the novel electrical current measurement technique using MR fluid in shear mode of operation. This paper discusses on the design of novel variable resistor using the behavioral change of MR fluid in third. Suryawanshi Ravishankar et al [29] This paper presents the current status of MR devices and their applications in mechanical engineering. There is great potential that this revolutionary material might open up many new frontiers of applications. The development of smart materials will undoubtedly be an essential task in many fields of science and technology such as information science, microelectronics, computer science, medical treatment, life science, energy, transportation, safety engineering and military technologies. Sunil Kumar Paswan et al [30] A newly magnetorheological fluid based honing process is developed for internal surface finishing of ferromagnetic cylindrical workpiece as existing magnetorheological fluid based finishing processes are not found suitable to finish the ferromagnetic internal surfaces .The performance of the present developed finishing process in terms of reduce wear and improve the functional application of cylindrical components, mainly depends on the normal force acting on abrasive particles due to magnetic behavior of carbonyl iron particles in magnetorheological polishing fluid.

Conclusion:

A new approach to designing an MR brake using a small steel roller is propose, fabricate to verify the performance of the new and the conventional MR brakes in comparison with the same input conditions.

Future Scope:

In future studies, the different structure of the MR zone should be focused on to improve this study.

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