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Research and Development of Magneto-Rheological Fluid

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Abstract: Magneto-rheological fluid is a new kind of intelligent material which has been paid more attention in recent years. In the magnetic field, its rheological properties can be made rapidly responseand easily controlled. Magneto-rheological fluid has been used in some successful applications, and has great development prospects. The purpose of this paper is to introduce the composition, rheological properties and application of magneto rheological fluids.

Key words: Magneto-rheological fluid; rheological properties; research and development

I. INTRODUCTION

Magnetorheological fluid (MRF) is a kind of new intelligent fluid material with engineering application value. It is in the absence of an applied magnetic field, showing good Newtonian fluid flow, but in the external magnetic field,the rheological properties of fluid occurred great changes, and the apparent viscosity can be increased by several orders of magnitude in 10ms, and showed similar to solid mechanics properties and viscosity change is continuous and invertible, after removing the magnetic field, and become liquid flows[1]. Magneto-rheological fluid effect has the characteristics of continuous, reversible, rapid and easy to control, so it is widely used in automotive industry, aviation, hydraulic transmission, precision machining, sealing and so on. The aim of this paper is to introduce the composition, rheological properties and application of magneto rheological fluids.

1. Composition of magneto-rheological fluids

Magneto rheological fluid is mainly composed of three parts: magnetic particles, carrier and additives.

1.1 Magnetic particles

Magnetic materials are mainly Fe_3O_4, Fe_3N, Fe, Co and other micro particles and their alloys, in which the magnetic saturation strength of Fe Co alloy can reach the maximum(2.4T), but its price is expensive. At present, most of the magnetic particles are pure iron and carbonyl iron powder, because of its low price and excellent performance. In addition to thesaturation magnetization, magnetic particles alsoshould have the following characteristics: high permeability, low magnetic coercivity, that is, in zero magnetic field, the particles substantially no residual magnetism; narrow hysteresis loop, cohesive force is small; volume appropriate [2].

1.2Carrier fluid

The function of the carrier is to make the magnetic particles evenly dispersed to form a suspension. There are two kinds of the carrier fluid of the magneto-rheological fluid: the non magnetic carrier and the magnetic carrier, the most commonly used is the non-magnetic carrier liquid.

1.3 Additives

The effect of surfactant is mainly to change the properties of the magnetic particles in the magnetic rheological fluid and the properties of the solid / liquid interface. Surface active agenton the surface of the

particles occurs directional adsorption, increaseselectrical double layer thickness . At the same time, the particle surface charge increased, so as to improve the properties of the particle surface,increasethe electrostatic repulsionbetween the particles andalso improvethe aggregate stability of the system[3].

II. RHEOLOGICAL PROPERTIES OF MAGNETO-RHEOLOGICAL FLUIDS

There are several theoretical explanations for the viscosity increase of the magnetic flow variations in the applied field strength, which is represented by the theory of phase nucleation and the field induced dipole moment [4].

2.1 Phase transition nuclear theory

According to the theory, when the applied field strength is increased from zero, the solid particles are dispersed in the base fluid, and their migration and rotation are affected by the heat wave. When the field strength increases to a certain degree, the particle magnetization, the heat wave and the field intensity of the two aspects of the influence, some particles are close to each other into an orderly arrangement, called the ordered phase (or nucleation). With the increase of the field strength, these ordered connected growth chains, and the long chain as the core, absorb short chain, so that the chain becomes thick, constitute the solid phase. Phase change point of view can explain part of the phenomenon of MR, but still need experimental verification.

2.2 Field induced dipole moment theory

The theory is that under the applied magnetic field, the particles are polarized magnetic dipole, each dipole attract each other to form chain (or fiber), strength MR rheological effect and the dipole chain force size related, Static magnetic interaction is the basis of the theory. The theory can explain the factors that affect the intensity function relation is single stranded, can also explain the evolution of the chain of the applied field of three areas, but the theory cannot explain chain becomes coarse process and the strength and the particle volume percentage relationship also cannot explain the relationship between the MR intensity and particle size (single domain and multi-domain).

III. DEVELOPMENT AND APPLICATION OF MAGNETO-RHEOLOGICAL FLUIDS

American scholar Winslow[5] invented the ER material in 1947. In 1948, the American scholar Rabinow[6]studied the magneto-rheological materials, and applied the patent of the magnetic rheological fluid transmission technology in 1951[7]. However, subsequent studies mainly concentrated in electro rheological materials, relatively few studies of magneto rheological materials, until the eighties of the 20th century scholars to will focus on the study of magneto rheological materials. In recent years, magneto rheological technology rapid development.

3.1 Magneto rheological fluid damper

The medium filled with MR fluid damper is a magneto rheological fluid, which is a new type of smart damper with damping force produced by the magnetic rheological effect. The utility model has the advantages of simple structure, low energy consumption, small volume, work continuously and reversibly, etc. It can meet the needs of various occasions and achieve real-time active and semi-active control, particularly suitable for on the weight and space for the limit of the mechanical device, which is widely used in all kinds of the vibration control system.

The magnetorheological fluid damper produced by American Lord has good performance, and it is applied in civil engineering field, and developed the size and strength of the magnetic rheological fluid damping device[8]. Yang systematically tested the 200kN magneto-rheological fluid damper damping force

performance[9];University of Nevada in the United States led by Professor Gordaninejad's CIML research team laboratory developed a double piston magnetic rheological fluid damper[10]; in China, application of magneto rheological fluid damper in automobile suspension control's related research were carried out by Meng Keming etc.[11] ; Wang Hongtao[12] designed a disc-shaped slit type binoculars magneto rheological fluid damper based on passive tube Shock Absorber deduced disc-shaped slit type of binoculars MRD damping force calculation model; Wang Xiuyong et al.[13] designed and produced the damping force that can be a large range of adjustment, displacement unrestricted rotational shear mode MR damper.

3.2 Magnetorheological fluid polishing

Magneto-rheological fluid polishing is a kind of MRF polishing fluid power technology media, compared with the conventional polishing techniques, magneto-rheological fluid having a polishing surface easily damaged, highly polished quality, convenience and control computer only high processing efficiency advantages [14]. Based on combination of electromagnetism, fluid dynamics theory, analytical chemistry, optics processing, Kordonski et al.[15]invented the magneticrheological polishing (MRF) technology. This method is used to polish the rheological properties of magneto rheological fluid in magnetic field. In the high strength gradient magnetic field, the magneto rheological polishing liquid becomes hard, and becomes the Bingham medium with the viscosity and plasticity. When the medium by a small gap forming workpiece and movement plate, the surface area in contact with great shearing force, so that the workpiece surface material has been removed. In 1997, Jacobs[16]had analyzed and studied for various types of "standard" polishing magneto rheological fluids. The advantages and disadvantages were found out and improved. The improved MRF has a more excellent performance in polishing.

IV. SUMMARY

In summary, the research of magneto rheological technology has made further progress, and its engineering application has attracted the interest of experts and scholars in various countries. Along with the decrease of the magnetic rheological liquid price, the localization of the magneto rheological fluid and the breakthrough of the research of the stability of the magneto rheological fluid, the magnetic rheological technology will have broad application prospects in the engineering application.

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