Preparation of Magnetorheological Fluids

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Abstract

MRF is a new type of intelligent material with millisecond response speed, which is a suspension of micrometer-sized ferromagnetic particles dispersed in the base fluid. Its response speed, good control, can be widely used in machinery, construction, polishing and other fields. MRF consists of three parts: ferromagnetic particles (dispersed phase), base carrier (carrier), stabilizer, MRF composition to determine its performance [1]**.**

Keywords

Magnetorheological fluid, Ferromagnetic particles, Base liquid, Surfactant.

1. Introduction

MRTD is based on MRF, using its good rheological effect to achieve power transmission, MRF performance directly determines the MRTD transmission stability and security. Shear stress is an important performance parameter of MRF. It is very important to study the influence factors and changes of MRF shear stress on the MRF, which makes it better applied to mechanical braking and vibration reduction.

2. Development Status at Home and Abroad

In 1948, the American scholar Rabinow [2] proposed MRF firstly, and in 1951 on the design of the MRTD patent application. Winslow [3] proposed the use of electrorheological effects in 1949 to pass the power of the transfer, scholars focus on the research of electrorheological fluid on the smart material, the development of electrorheological fluid has been rapid development. In the 1990s, the preparation of magnetorheological fluids was promoted by commercialization at the 5th International Conference on Electromagnetism / Magnetorheological Fluid (ERMR). Among them, the company of the United States, FORD, DELPHI, BASF And other enterprises for the MRF and its products are more well-known companies. In July 2016, the 15th International Conference on Electrorheology / Magnetorheological Fluid was successfully held in Incheon, South Korea. The conference discussed the application status and research progress of ER / MR materials, and promoted the development of electromagnetism / rheology.

LORD [4] is one of the earliest MRF products for MRF-122-EG, MRF-140-CG, as shown in Fig. 1. LORD's commercial MRF product volume ratio between 20% -40%, its dispersion is good, the response time is less than 5ms, the base fluid in the ferromagnetic particle size between 1-20 microns, when the magnetic field strength of 150- 250kA / m, the shear stress of MRF is 50-100 kPa.

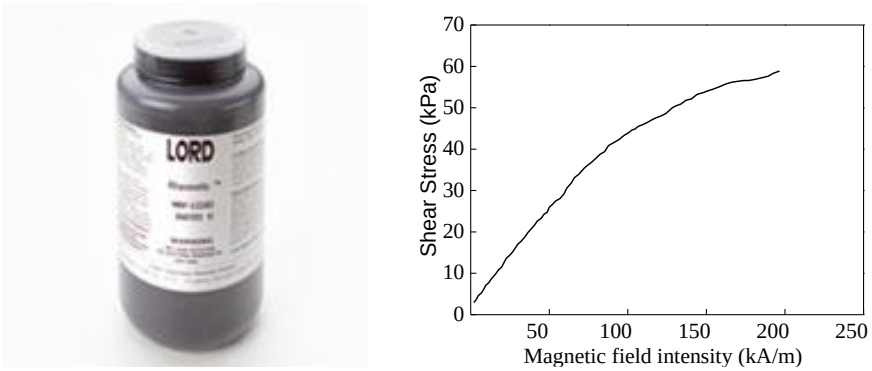

Fig. 1 MRF-140CG and its shear perfermance

The optimum content of sodium dodecylbenzene sulfonate as MRF is 1 ~ 6 wt%. By studying the settling rate of different milling time, combined with long time ball milling The results show that the best milling time of MRF is 10 ~ 13h in the preparation process. The MRF samples of the BGS-1 series are superior to the MRF samples provided by the Chongqing Institute of Instruments, in terms of sedimentation rate and mechanical properties [5].

China University of Mining and Technology Chen Fei [6] , in combination with MRF in the field of transmission needs, the application of surfactant complex method, the prepared MRF thermal properties (particle thermal magnetic properties, thermal oxidation properties, MRF and silicone thermal expansion characteristics, MRF by high temperature Post - settlement characteristics) were studied. It was found that the MRF prepared by the complex method had a higher temperature range and was in accordance with the application requirements in the field of transmission.

3. Preparation of Magnetorheological Fluids

3.1 The composition of magnetorheological fluids

Ferromagnetic particles are the most important components of MRF. The results show that the maximum shear stress of MRF is proportional to the square of magnetic saturation of ferromagnetic particles [7]. Therefore, ferromagnetic particles should be made of materials with high magnetic permeability and magnetic saturation strength. Existing ferromagnetic materials are iron, cobalt, nickel alloy and oxide, in the material selection, not only to consider the permeability and magnetic saturation strength, but also requires the particles with low coercivity (to ensure a good demagnetization Ability), the appropriate particle shape and particle diameter. The size of the ferromagnetic particles is generally in the range of several micrometers to several tens of micrometers. Therefore, when the particle is selected, the market price and the ease of processing of the pellets are taken into account.

This is the choice of carbonyl iron powder for the ferromagnetic particles, carbonyl iron powder for the spherical particles, with high and stable relative permeability (300 or so), low cost and easy to buy, MRF is the most common ferromagnetic granular material.

The basal carrier is a carrier of ferromagnetic particles, and the basal carrier should have the characteristics of low viscosity (low viscosity of zero field), high boiling point (thermal stability requirement), high density (reduced solid-liquid separation). Commonly used base liquid with silicone oil, water, all kinds of synthetic oil.

This is the use of dimethyl silicone oil shown in Fig. 2 as the base liquid, it is not only non-toxic and tasteless low price, but also has good temperature stability and oxidation stability, the operating temperature range of -50℃ - 300℃, and it is a more ideal base solution.

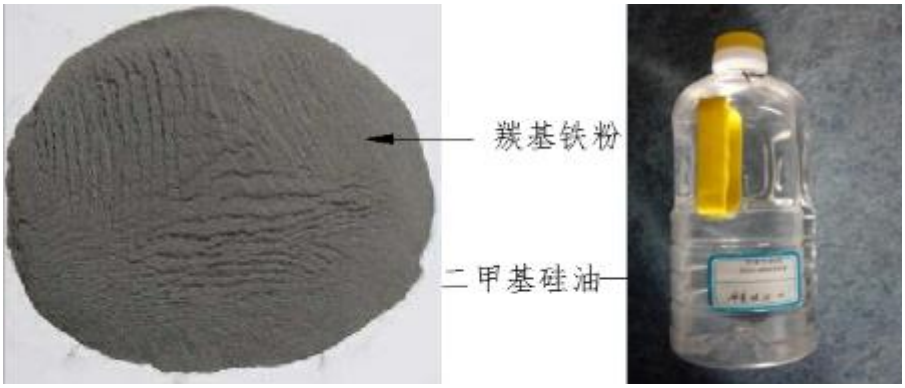

Fig. 2 Carbonyl iron powder and silicone oil

The difference between the density of the ferromagnetic particles and the base liquid is large, and it is easy to cause the solid-liquid separation under long standing and high-speed rotation. Surfactants are coated on the outer surface of the granules to form flocculent adhesives, so that the ferromagnetic particles do not combine and agglomerate, thereby preventing them from settling, and the addition of surfactants can improve MRF stability. There are many types of surfactants, usually based on the type of basal carrier selection, the study found that different surfactants under the MRF stability effect is different, by contrast, sodium dodecyl benzene sulfonate as MRF surfactant Anti-settling effect is best, the best content of 4 ~ 6wt% [8]. Therefore, this study selected sodium dodecyl benzene sulfonate as MRF surfactant, the volume ratio of 5wt%.

3.2 Preparation of Magnetorheological Fluids

Preparation of the process to determine the MRF performance, the selection of carbonyl iron powder (Jiangsu Tianyi ultra-fine metal powder Co., Ltd.) as ferromagnetic particles, dimethyl silicone oil (Industrial Company) as a suspension, sodium dodecyl benzene sulfonate solution The MRF sample was prepared by the traditional dispersion preparation method, and the complete MRF sample was prepared as shown in Fig. 3.

(1) The mass of the carbonyl iron powder, dimethyl silicone oil, sodium dodecyl benzene sulfonate solution required for the MRF sample volume ratio is calculated and weighed separately.
(2) A mixture of sodium dodecylbenzenesulfonate solution and carbonyl iron powder were mixed and kneaded at high speed for 12h to obtain a mixture.
(3) The so-called dimethyl silicone oil was added to the above-mentioned sodium dodecyl benzene sulfonate solution - carbonyl iron powder mixture and stirred at high speed for 1.5h.
(4) The mixture obtained in step (3) was ultrasonically dispersed for 30 minutes, and the mixture was evacuated at room temperature for 30 minutes using a vacuum oven as shown in Fig. 4, and the gas in the mixture was withdrawn.
(5) The mixture was evacuated and the mixture was told to stir for 1.5h after bottling and labeled.

Fig. 3 Samples of MRF

Fig. 4 Vacuum drying oven

MRF preparation samples are black and gray due to carbonyl iron powder, the sample volume is relatively large, with a certain viscosity, free flow, the test tube near the permanent magnet, the tube

MRF instantly into a solid, unable to flow freely, MRF instantly returns to the initial free flow state [9]. The prepared MRFs need to be tested for settling stability and shear stress, which can only be applied to magnetorheological devices.

Due to the poor density of the ferromagnetic particles in the MRF and the base liquid, the MRF settles down for a long time, and the solid-liquid separation of the ferromagnetic particles occurs. MRF settling stability is one of its performance parameters. The existing MRF sedimentation stability methods are standing observation method, sedimentation potential method, inductance method, timing quantitative collection method and so on.

In this paper, the stability of MRF samples after preparation was tested by the simplest method of natural sedimentation [10]. The prepared MRF is poured into the test tube and sealed, and the test tube is placed on the tube rack. The clear base load a and the lower black liquid amount b in the upper layer of MRF are observed and recorded periodically, as shown in Fig. 5.

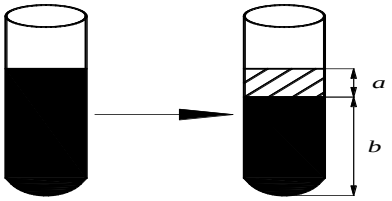

Fig. 5 Static observation of the settlement stability of MRF

4. Conclusion

MRF settling stability is not a uniform evaluation criteria, LORD produced commercial MRF, the required settlement stability of 30 days sedimentation rate of less than 20%. The results showed that the sedimentation rate was 16%, and the results showed that the experimental preparation samples were qualified and the dispersion preparation process was correct.

References

[1] L. J. Xiao, X. B. Gong, Y. R. Chi, et al. Experimental Study on Shear stress of Magnetorheological Fluids [C]. 2016 4th International conference on Machinery, Materials and Computing Technology, Atlantis Press, 2016: 168-171.
[2] Rabinow J. Magnetic Fluid Torque and Force Transmitting Device [P]. US Patent:2575360. 1951.
[3] Winslow W M. Induced Fibration of Suspensions [J]. J Appl Phys, 1949, 20(12): 1137-1140.
[4] Vijay Tripathi, Prof. U.K. Joshi. Experimental Analysis of Fabricated Magnetorheological Damper by Using Different Magnetorheological Fluid: A Review [J]. International Journal of Engineering Sciences and Research Technology (IJESRT), 2014, 3(4): 8025-8034.
[5] Chengjian Yi. Preparation of magnetorheological fluids/ Performance testing and constitutive relations [D], Chongqing: Chongqing University, 2011.
[6] Fei Chen. Preparation of Magnetorheological Fluids and Study on Their Power Transmission Technology [D], BeiJing: China University of Mining, 2013.
[7] G Wang, Y Ma, M Li, et al. Magnesium ferrite nanocrystal clusters for magnetorheological fluid with enhanced sedimentation stability [J]. Solid State Sciences, 2017, (63): 70-75.
[8] Chengjian Yi. Preparation of magnetorheological fluids/ Performance testing and constitutive relations [D], Chongqing: Chongqing University, 2011.
[9] J Liu, X Wang, X Tang, R Hong, et al. Preparation and characterization of carbonyl iron/strontium [J]. Particuology, 2015, 22 (5): 134–144.
[10] Peng Hou. Evaluation of magnetorheological fluid stability [D], Wuhan, Hubei: Wuhan University of Technology, 2008.