Preparation and Experimental Study of Magnetorheological Fluids for Vibration Control

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Magnetorheological (MR) fluids are a new kind of smart vibration mitigation material for vibration control, whose shear yield stress can change in magnetic field, and the change can occur only in a few milliseconds. The rheological properties, anti-settlement stability, and redispersibility are the very important properties of MR fluids. In this paper, a kind of preparation process of MR fluids is introduced and MR fluids with different grain diameter ratios of carbonyl iron particles are produced. Then, the properties of self-prepared MR fluids are tested, including the sedimentation stability test, viscosity test, and shear yield stress test. The results of the MR fluid property tests show that the adding of 10 µm-carbonyl iron particles will improve the magnetic effect of MR fluids, increase the zero magnetic field viscosity of MR fluids, and increase shear yield stress of MR fluids in same magnetic field, but the anti-settlement properties will be degraded.

1. INTRODUCTION

MR fluids are a kind of controllable fluid that were identified by the US National Bureau of Standards in 1948. MR fluids usually consist of micrometer-sized magnetic particles, a dielectric carrier fluid, and some additives. When they are placed in an adjustable magnetic field, their yield stress changes with the magnetic field intensity changes in a few milliseconds. Because of this kind of smart feature of MR fluids is that they have been concerned by more and more researchers. Furthermore, MR fluids can be designed as MR dampers to reduce the different vibration. And MR fluids have been successfully used in intelligent vibration control, such as the building structures, the bridge structures, the automobile suspension system, the prosthetic limb, some military equipment or magnetorheological fishing. A large-scale and 20 ton MR fluid damper has been designed and built to reduce vibration for civil engineering applications. Carlson used the MR damper to develop an artificial limb. Lord Corporation used MR dampers for the vibration control of armored vehicles. Xu et al. used the MR damper for mitigating earthquake responses of building structure under the neural networks control strategy.

The properties of MR fluids will directly influence the vibration absorption performance of MR dampers, so many researchers have studied how to prepare MR fluids to improve the properties of MR fluids. In 2004, Ulicny and Mance studied the anti-oxidation property of MR fluids and proposed the method with plating ferromagnetic particles coated in a layer of nickel to improve the long-term oxidation resistance of MR fluids. In 2010, Jiang et al. coated the poly (methyl methacrylate) (PMMA) to the surface of carbonyl iron (CI) particles getting the composite particle CI-PMMA. The prepared MR fluids based on CI-PMMA particles had better sedimentation stability. In 2010, Du et al. chose the surfactant by hydrophilic-lipophilic balance (HLB) parameters and discovered that the surfactant could hardly change the magnetic properties of magnetic particles and rheological properties of MR fluids, while increasing the sedimentation stability of MR fluids significantly. In 2012, Iglesias et al. tested the influence of the volume fraction of nanoscale magnetic particles on the sedimentation stability. Powell et al. synthesized MR fluids by replacing a part of the magnetic particles with nonmagnetic microscale glass bead, and the sedimentation rate was reduced by about 4%. In 2011, Lee et al. applied tribological characteristic to improve the stability and performance of MR fluids by mixing and adding the additives. In 2013, Liu et al. proposed a preparation method of silicone oil-based MR fluids and tested the properties of the prepared MR fluids. However, due to the density mismatch between the ferromagnetic particles and the carrier liquids, the particle sedimentation caused by...