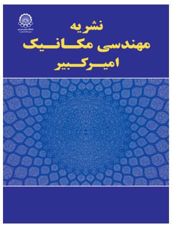

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Experimental Study on Stability of Magnetorheological Fluid by Using of Fe3O4/ Cellulose Nanoparticles

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ABSTRACT: The magnetorheological fluid is a suspension of magnetizable particles in a base liquid with stabilizer. The rheological properties of these fluids change significantly in the presence of magnetic field. In this study, nanomagnetic iron oxide particles were prepared by using co-precipitation method. X-ray diffraction and scanning electron transmission methods were used to characterize these particles. The magnetic properties of the particles were measured by using a vibrator sample magnetometer. The sedimentation rate for a non-additive fluid was reported to be 70% and when the cellulose was added, it was reported to be 55%. The effect of samples contained nanoparticles iron core-shell in various percentages of 0.5, 1 and 2% of nanoparticles with 3% cellulose were investigated. The results showed that almost all of the samples were completely stable after addition of the nanoparticles in the first three days. The results showed that the sample containing 5% by weight of cellulose and 1% by weight of nanoparticle core-shell by cellulose had high stability during more than a month. The increase in shear stress and yield stress in the optimized sample containing the nanoparticle was also significantly higher than the sample without any additive and it was about 10,000 Pa.

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1- Introduction

The magnetorheological fluid is a kind of smart material that its rheological properties can be changed with the magnetic field. These properties are used in many industries such as the building industry (anti-earthquake buildings, holders and smart valves), the automotive industry (intelligent suspension system, clutch, brakes, seat and seat belts), the medical industry (prosthetic leg, splinting, surgical robot and footwear) and other industries (shock absorber, sensors, Sealing system, Orifices and polishing)

2- Experimental Study

Carbonyl iron particles were dispersed in silicone oil to prepare MR fluids. Cellulose and Fe3O4/cellulose nanoparticles were used as a stabilizer. For synthesis of Fe3O4/cellulose nanoparticles, the hydrothermal method was used based on previous studies [5]. The effect of cellulose and Fe3O4/cellulose nanoparticles on MRF stability was investigated.

3- Results and Discussion

The spherical structure and the size of Fe3O4/cellulose nanoparticles were determined by the Transmission Electron Microscopy (TEM). The magnetic properties of particles were measured by using a Vibrator Sample Magnetometer (VSM).

TEM results showed that the particle size was below 50

Table 1. Properties of the MR fluid samples

Sample	Carbonyl iron (wt %)	Silicon oil (wt %)	Cellulose (wt %)	Fe_3O_4/ Cellulose nanoparticles (wt%)
MRF1	60	40	-	–
MRF2	60	37	3	–
MRF3	60	37	2	1
MRF4	60	36.5	3	0.5
MRF5	60	36	3	1
MRF6	60	35	3	2
MRF7	60	34	5	1

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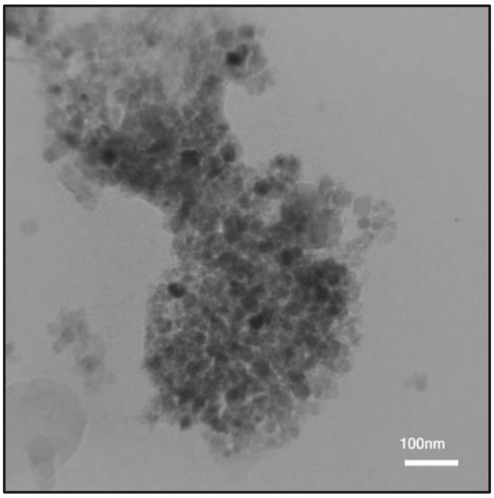

Fig. 1. The TEM image of Fe3O4/cellulose nanoparticles

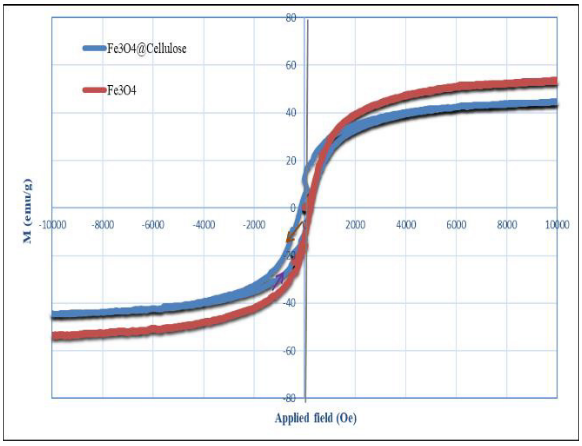

Fig. 2. VSM results of nanoparticles

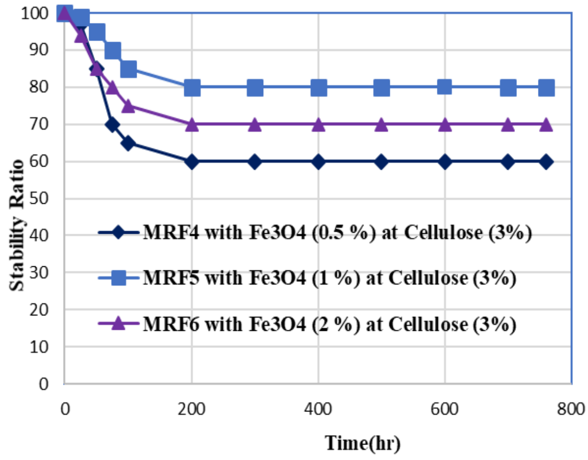

Fig. 3. Effect of different percentages of nanoparticles

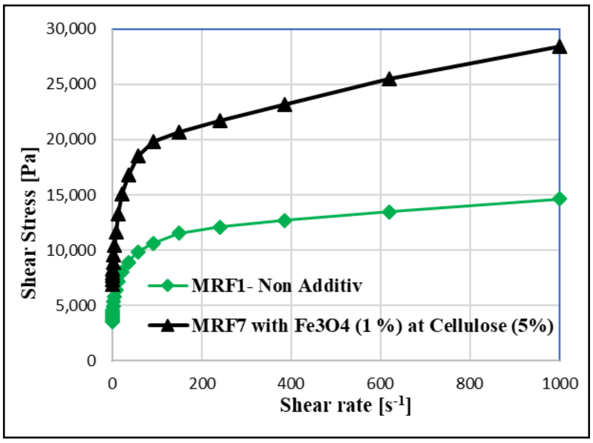

Fig. 4. Shear stress versus shear rate

nm. VSM result showed that saturation magnetization of the Fe3O4/cellulose nanoparticles reached 50 emu/g at 8 kOe, while it was about 60 emu/g for the Fe3O4 nanoparticles. A slight decrease in magnetism has been seen.

fluid stability has a direct proportion with cellulose percentage. Increasing the amount of core-shell nanoparticles by more than 1 wt% due to high fluid weight causes suspension sedimentation and thus the stability of MR fluid will be decreased. The sample containing 5 wt% cellulose and 1 wt% of the core-shell nanoparticle is desirable for future applications requiring long-term stability of these fluids.

As can be seen in Fig. 4, the amount of shear stress has been increased for the sample containing nanoparticles and also increased the yield stress. Bingham plastic model was used for modeling the shear stress relationship in terms of shear rate. The yield stress of Fe3O4/cellulose nanoparticles sample is 28400 Pa and the non-additive sample is 14615 in the 43 kA/m2 magnetic field. The Yield stress increased significantly for stable MRF Sample.

4- Conclusions

In this research, stability and the rheological properties of the suspensions of carbonyl iron microparticles in silicone oil were studied by using cellulose and Fe3O4/cellulose nanoparticles. Stability and rheological properties have been determined for different samples; the following results were obtained

- Improvement of stability by adding Fe3O4/cellulose nanoparticles
- Stable MRF for all samples in the first three days by adding modified nanoparticles
- stability reduction by increasing nanoparticles to more than 1%
- High shear stress for modified nanoparticle samples
- Increase of over 10,000 Pa yield stress of sample containing modified nanoparticles over sample without additive

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