



FIGURE 1: MRF test-bed.

TABLE 1: Three MRF samples' index and the corresponding parameter of particles.

Index	Particle model	D_{av} (average diameter)/ μm	Particle size distribution		
			D (0.1)	D (0.5)	D (0.9)
MRF-15	MPS-MRF-15	3–5	≤ 2.5	≤ 4.5	< 8
MRF-25	MPS-MRF-25	2.5–3.5	≤ 2.0	≤ 4.0	< 7
MRF-35	MPS-MRF-35	1.5–2.8	≤ 1.5	≤ 2.5	< 5

MRFTD work under the effect of constant magnetic field by regulating the exciting current at 3.5 A. The exciting current is produced by adjustable DC power source. And the load of this system is set by adjusting the exciting current of MPB to 0.4 A. Besides that, the torque sensors are used to get the torque and the rotative speed difference of working disks, and the data is collected by the computer. All experiments are carried out at room temperature.

2.2. Preparation of MRF. The preparation of MRF can be realized by existing technology [18, 19]. The detailed steps can be described as follows. Firstly, carrier liquid and surfactant are mixed with certain proportion in a container. The mixture is stirred evenly under water-bathing at 50°C in a blender for 2 hours. Then, soft magnetic particles are poured slowly into the container while the blender is running. The particles are evenly distributed in the compound liquid after this step. Secondly, the mixture is milled in a planetary ball mill for about 10 h. The aim of this step is to ensure that soft

magnetic particles are coated sufficiently by surfactant. The whole process can be shown in Figure 2.

Keep the ingredients of MRF samples identical except for particle size. And the volume fractions of soft magnetic particles are 20%. The details of soft magnetic particles (carbonyl iron powder, purchased from Jiangsu Tianyi Ultrafine Metal Powder co., Ltd.) and the index of samples are given in Table 1.

3. Results and Discussion

3.1. Shear Stress of MRF. The relation between shear stress (γ) and transmitted torque of MRF (T) can be expressed as follows [20, 21]:

$$T = \frac{2}{3} \pi \tau (r_2^3 - r_1^3) + \frac{\pi \eta \Delta \omega}{2h} (r_2^4 - r_1^4). \quad (1)$$

Here, r_1 is the inner radius of actuator disk, r_2 is the maximal radius of actuator disk, η is the viscosity of carrier liquid in zero magnetic fields, $\Delta \omega$ is the rotative speed difference of