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The influence of temperature and of a longitudinal magnetic field upon the electrical conductivity of magnetorheological suspensions

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Abstract

The magnetorheological suspension (MRS) is based on mineral oil, stearic acid and iron micro-particles. The mean diameter of the iron micro-particles is 2.10 μm. MRS becomes conductive only in magnetic field, starting from intensities of 72 kA/m. By means of an experimental installation, described in this paper, the MRS function of temperature is measured ($300\,K \leqslant T \leqslant 400\,K$) for intensities of the longitudinal magnetic field of 72, 112, 148 and 175 kA/m. From measurements of electrical resistance the electrical conductivity of MRS is determined, and the results obtained are discussed.

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Keywords: Magnetorheological suspension; Mineral oil; Electrical conductivity; Iron micro-particles; Magnetic field

1. Introduction

The magnetorheological suspension (MRS) resembles electrorheological fluids (ERF). Both modify their rheological properties dramatically—the former, in magnetic field, the lather, in electric field.

In both cases, chains of micro-particles are formed [1–3] along the field lines. There results the growth, by some magnitude orders, of the value of the apparent viscosity. This phenomenon is used in various applications [4–7].

Of great interest is the study of the electrical conductivity of the metal micro-particles systems dispersed in non-conductive matrices. Thus, Ref. [8] details a method of prediction of the actual electrical conductivity of such systems. On the other hand, Refs. [9,10] detail methods for determining the electrical conductivity of MRS, while Ref. [11] describes a method for the simultaneous measuring of viscosity and electrical conductivity of ERF.

The phenomenon of electrical conductivity of MRS, in the presence of magnetic field of well-chosen intensities and directions, is used for the devising of sensors for detection of fringe fields in magnetic fields [12], as well as of warfare agents [13], etc.

In considering these applications, we set ourselves to show how the temperature and longitudinal magnetic field influence the electrical conductivity of MRS.

2. MRS

MRS is obtained by the thermal decomposition of $Fe_2(CO)_9$ in mineral oil mixed up with stearic acid. The experimental installation and the procedure are described in Ref. [14]. At temperatures of $423\,K \pm 10\%$ for 150 s, the thermal decomposition of $Fe_2(CO)_9$ in the liquid matrix (mineral oil with stearic acid) occurs. On this occasion, a mixture of iron micro-particles and liquid matrix (Fig. 1a), called MRS, is formed. The mean diameter of the micro-particles is $d_m = 2.10\,\mu m$ (Fig. 1b), at a standard deviation of 0.42 μm. MRS with volume fractions Φ fixed, set at pre-established values, are obtained by the modification or the ratio between the liquid matrix and the volume of the iron micro-particles.

The magnetisation curve of MRS (Fig. 2) is raised by means of the magnetometer type VSM-880 (Physica).

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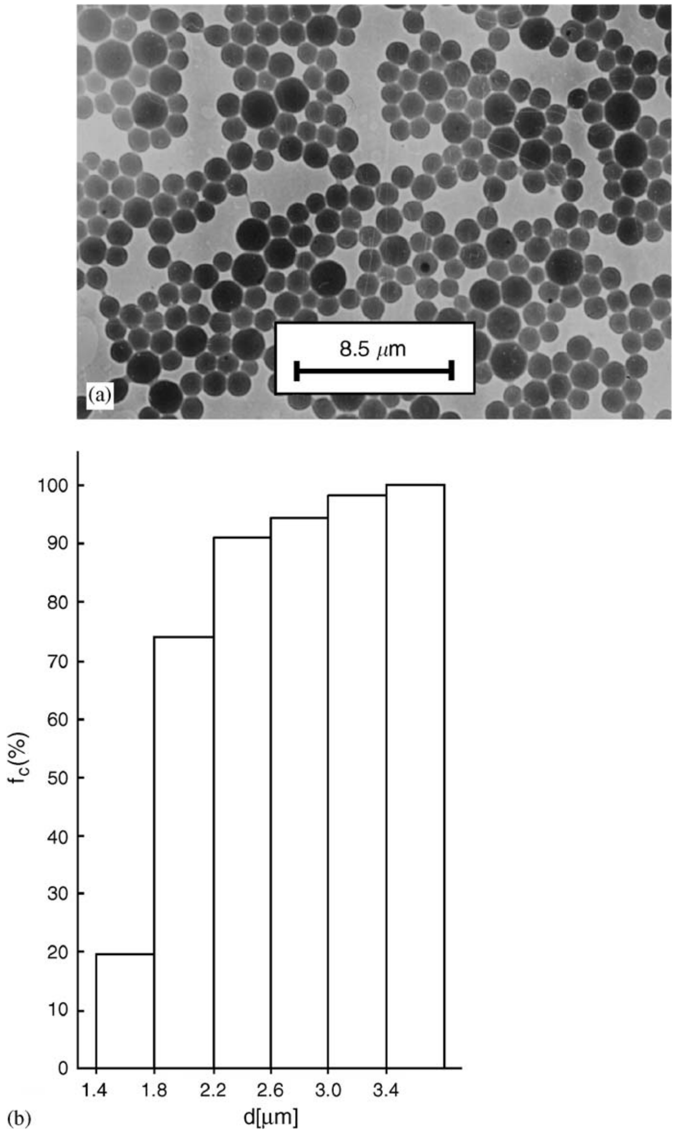

Fig. 1. MRS diluted 1:10: (a) the optical microscope picture and (b) the dependence of the cumulative frequency f_c(%) on the diameter of the iron micro-particles d(μm).

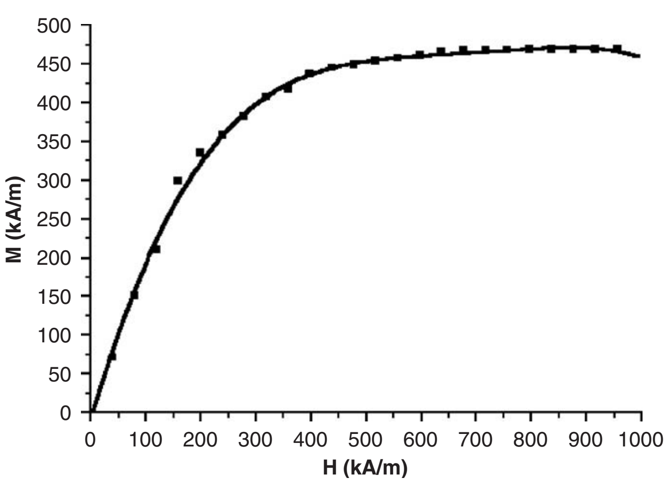

Fig. 2. MRS magnetisation curve for $\Phi = 0.3$.

3. Experimental installation

The block scheme of the experimental installation, used for the study of the influence of magnetic field and temperature upon the electrical resistance is described in Fig. 3.

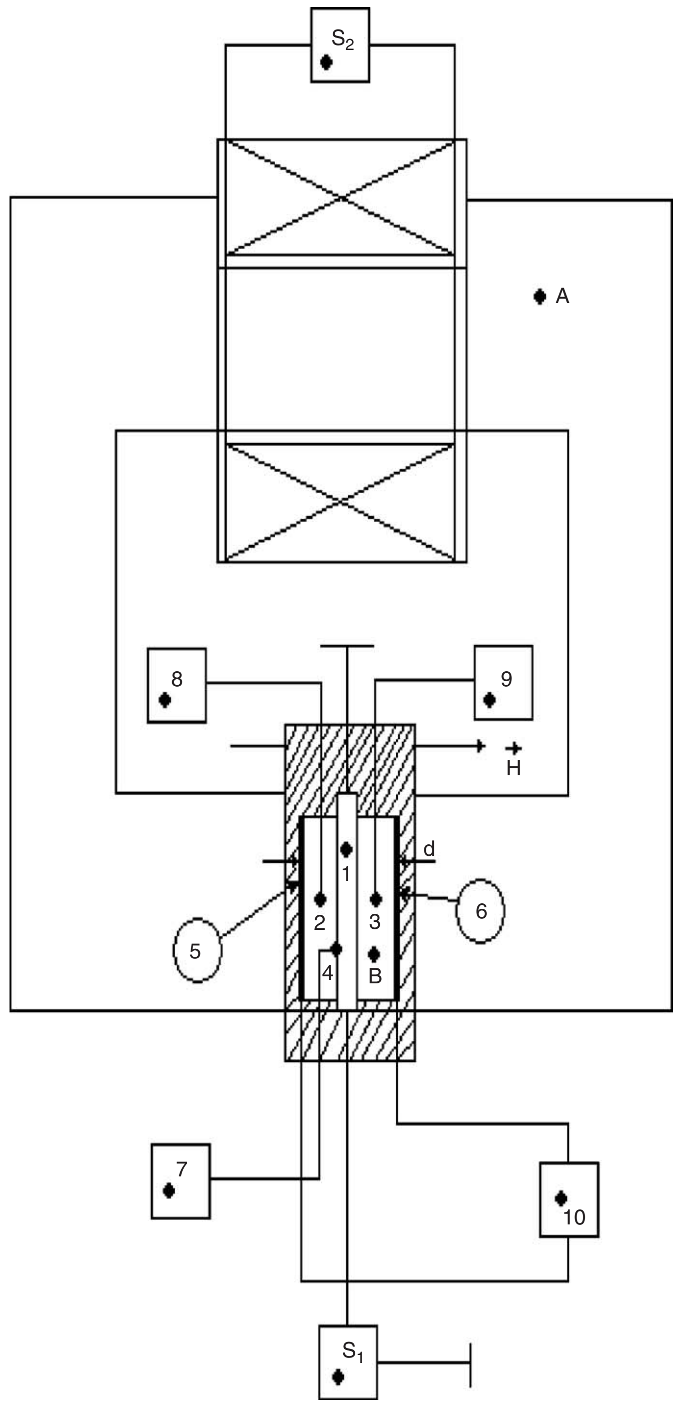

Fig. 3. Experimental equipment (block scheme): A—electromagnet; B—measuring cell; S_1—alternative current supply (0–220 V/0–10 A); S_2—current supply (0–40 V DC/0–10 A DC); 1—electric heater 5.1 kΩ/10 W); 2, 3, 4—thermocouples type K; 5, 6—copper electrodes; 7, 8, 9—digital thermometer (type DT838); 10—digital ohm-meter (type DT9208A); d—distance of the cooper electrodes; H—intensity of the magnetic field.