CONSIDERATION FORWARD FOR MAGNETIC PROPERTIES OF SOME FERROFLUIDS

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Abstract: From among the methods that aim to characterize the ferrofluids from a magnetic viewpoint, we can use one based on determining the magnetic susceptibilities of a sample by measuring the force exerted upon this by a non-homogeneous magnetic field.

1.INTRODUCTION

For the characterization from the magnetic viewpoint of the prepared ferrofluids, we used a method based on determining the magnetic susceptibility of a sample by measuring the force exerted upon this by a non-homogeneous magnetic field - the method of Gouy balance (fig. 1.1).

The principle of the measurement method consists in determining the force that acts lengthwise a cylindrical sample of length *l* and section *S* situated with the lower end in the interferrum of an elecrtromagnet's poles, where the intensity of the magnetic field has the module *Hi*, and with the upper end outside the poles, where the intensity of the magnetic field has the module *He*. This force is given by the expression:

$$F = m_0 S \frac{c}{2} \int_{H_i}^{H_E} \frac{dH^2}{dz} dz \qquad (1.1)$$

where ? is the magnetic susceptibility of the sample (of the ferrofluid).
If *He* << *Hi* so that He^2 can be neglected in relation to Hi^2, then the probe interaction with the considered non-homogeneous magnetic field in measured by the force of whose module in:

$$F = \frac{1}{2} m_0 c S H_i^2 \qquad (1.2)$$

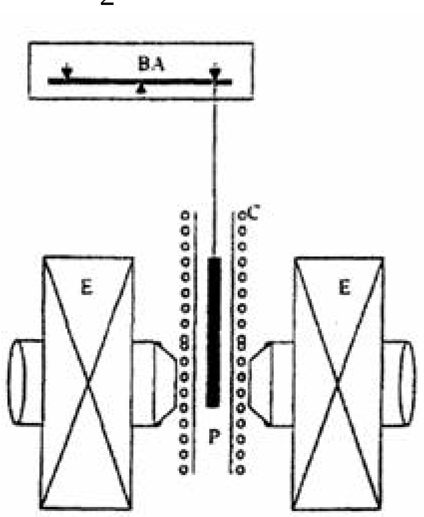

Fig. 1.1. The method of Gouy balance

2.MAGNETIC SUSCEPTIBILITY

The measuring of force *F* is indirectly carried out by a scales weighing the apparent increase ?*m* of the mass of the sample on coupling the magnetic field. Taking into account that *F=g?m*, where *g* is the gravitational acceleration (=9,81 m/s^2), and operating in the relation (1.2), we obtain the value of the magnetic susceptibility:

$$c = \frac{2g\Delta m}{m_0 S H_i^2} \qquad (1.3)$$

This relation is valid if the length of the ferrofluid sample is so great that its upper end is outside the magnetic field created by the electromagnet. The length *l* of the sample that meets this condition is determined by experimental measurements. In the case in which *He* << *Hi* so that the approximation $He \cong 0$, ?*m* will not depend on the length *l* of the sample.

In what we carried out, the tube the ferrofluid is poured into is of glass, the inside diameter is 5 mm, and the length is 15 cm. The section of the tube between the electromagnetic poles has a length of 10 cm. The magnetic field is generated by a lab electromagnet, supplied from a c.c. with a continually adjustable outlet tension. The intensity of the magnetic field is measured by means of Gaussmeter with a Hall sound [Walker Scientific MG SOD]. The weighing of the sample is done by means of an electronic scales ACULAB LA-200, that can weigh with the precision of 1 * 10^{-4} g. For each sample the scales is brought to zero before the coupling of the magnetic field.

To determine the sample length for which $He^2 \cong 0$, we carried out a preliminary study in which we measured ?*m* on applying the magnetic field for lengths of the ferrofluid columns of 12 cm, 14 cm, 16 cm, 18 cm, 20 cm, and 24 cm. The seven groups of the measurements were repeated at 14 values of the intensity *H* of the magnetic field in the center of the electromagnet interferrum. A set of results obtained in this preliminary study is presented in table 1.1.

H(kA/m)	l=12 cm	l=14 cm	l=16 cm	l=18 cm	l=20 cm	l=22 cm	l=24 cm
8	0,211783	0,29476	0,3425	0,36906	0,38103	0,3859	0,386
16	0,164791	0,24688	0,2871	0,302	0,31196	0,332	0,3321
24	0,1368	0,20811	0,24874	0,26	0,2667	0,279	0,2792
32	0,11504	0,l726984	0,21345	0,22465	0,231	0,235	0,2351
40	0,10402	0,15641	0,18159	0,19566	0,2	0,2012	0,2014
60	0,08044	0,11807	0,13901	0,14721	0,15234	0,155	0,1552
80	0,065	0,09726	0,1148	0,1215	0,1277	0,128	0,1283
100	0,05532	0,08063	0,09675	0,10565	0,1069	0,109	0,11
120	0,04781	0,07042	0,08635	0,08954	0,09	0,095	0,096
140	0,0426	0,06205	0,0746	0,07954	0,08325	0,085	0,853
160	0,03824	0,05674	0,06638	0,0689	0,075	0,0725	0,076
180	0,03454	0,05	0,06	0,064	0,0685	0,068	0,069
200	0,03154	0,04629	0,05538	0,05945	0,06274	0,063	0,0634
240	0,02698	0,03966	0,04754	0,0522	0,0544	0,0546	0,0547

Table 1.1 Experimental data

The figure 1.1 shows graphically the dependence of the calculated susceptibility with the relation (1.3) on the length of the ferrofluid sample. The dependence of the magnetic susceptibility of the ferrofluid on the intensity of the applied magnetic field is represented graphically in fig 1.2 for each length of the sample. From these graphs one can see that in our experimental set up a 24 cm length of the ferrofluid column is enough for He^2 to be neglected in the relation 1.3 and consequently the results of the measurements should not be influenced by the length of the sample.

With the susceptibilities obtained in the cases which the sample length does not influence the results of our measurements, we calculated the magnetizing of the ferrofluid by means of the relation *M(H) = ?H* for different values of the magnetic field intensity and we obtained the magnetizing curve in figure 1.4.

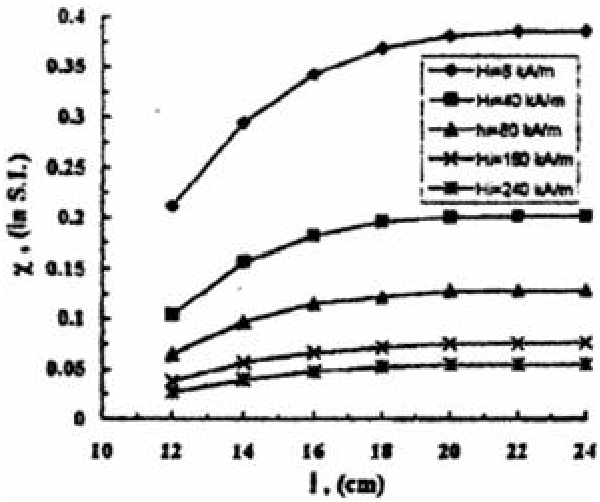

Fig. 1.2. The influence of the sample length of the results of measurement

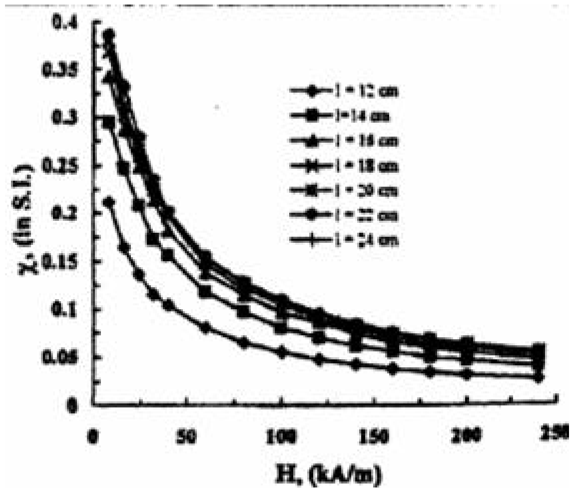

Fig. 1.3. The dependence of the magnetic susceptibility on the intensity of the magnetic field

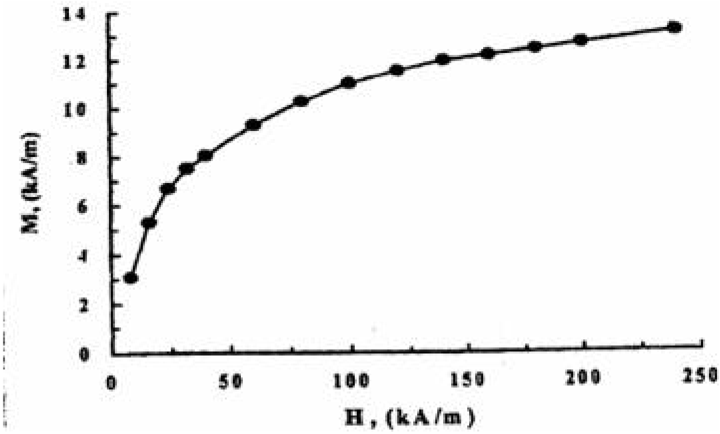

Fig. 1.4. The magnetizing curve M(H) = ?h calculated using the data of the measurements for the sample of the 24 cm length.

The table 1.2 shows the magnetizations of the ferrofluids prepared by us and measured for an intensity of the applied magnetic field of 400 kA/m.

Ferrofluid	**K -1**	**K -5**	**K -8**	**K -12**	**K -13**	**K - 16**
Magnetization at saturation (A/m)	$16 * 10^3$	$8 * 10^3$	$4 * 10^3$	$20 * 10^3$	$24 *10^3$	$30 * 10^3$

Table 1.2. The magnetization of the prepared ferrofluids

3.Conclusions: On the basis of the values of the susceptibilities experimentally obtained, the magnetization of the ferrofluid was calculated using the relation M(H)=?H for different values of the magnetic field intensities – making up the corresponding diagrams.

References:
[1] Olaru R., Cotae C., *Translating and magnetofluid devices for measurement and control*, Ed. Bit, Iassy, 1997
[2] Calugaru Gh., Cotae C., *Magnetic liguids* Ed.St.and Enc. Bucharest 1978
[3] Dragoi D.D., *Researches concerning the use of translating devices and the magnetofluidic devices in machines construction* – Doctorate thesis Iassy, 2004