DESCRIPTION OF MAGNETIC HYSTERESIS OF MAGNETITE MICROPARTICLE MEDIUM BY INTRODUCING AN ADDITIONAL TERM INTO THE LANGEVIN FUNCTION

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By introducing a predetermined additional term into the Langevin equation, the magnetic hysteresis of magnetite microparticles is described.

Keywords: magnetization saturation M_{st}, magnetic remanance M_{rm}, coercivity force H_{cr}, hysteresis loop, magnetite microparticles

I. INTRODUCTION

In terms of size, metal microparticles are located between massive and nanoparticles of metal. The physical properties of magnetic microparticles differ from those of massive and nanoparticle metal media. Magnetite nanoparticle media have no magnetic hysteresis, unlike massive magnetite, which has a large magnetic hysteresis. The magnetic characteristics (saturation magnetization, remanent magnetization, coercivity) of magnetic microparticles depend on the size and concentration of the microparticles, as well as the temperature of the medium. [1,2].

II. NUMERICAL RESULTS AND THEIR DISCUSSION

One of the possible ways to describe magnetic hysteresis using an analytical function is to introduce an additional term "*a*" into the argument (*H*) of the describing function without hysteresis magnetization [3].

The Langevin function was used to describe magnetic hysteresis:

$$M = M_s \varphi L\left(\frac{mH}{kT} + a\right) = M_s \varphi \left(Coth\left(\frac{mH}{kT} + a\right) - \frac{1}{\frac{mH}{kT} + a} \right)$$

The additional term "*a*" can be determined from the condition that at $H=0$ the magnetization takes the value $M(0)=M_{rm}$. and at $H=H_{cr}$. takes $M(H_{cr})=0$. The resulting equations of transcendental type with respect to "*a*" were solved graphically.

We also considered the possible dependence of the additional term "*a*" on the external magnetic field: $a(H) = a_0 \frac{1}{1+\frac{H}{M_{ост}}}$.

Figure 1 shows the magnetic hysteresis of a medium of magnetite microparticles with a size of 44.35 μm and a concentration of 0.095 at a temperature of 20^0 °C, obtained experimentally (curve 1), calculated by introducing into the Langevin function a given additional term "a_0", independent (curve 2) and dependent "$a(H)$" (curve 3) on the magnetic field.

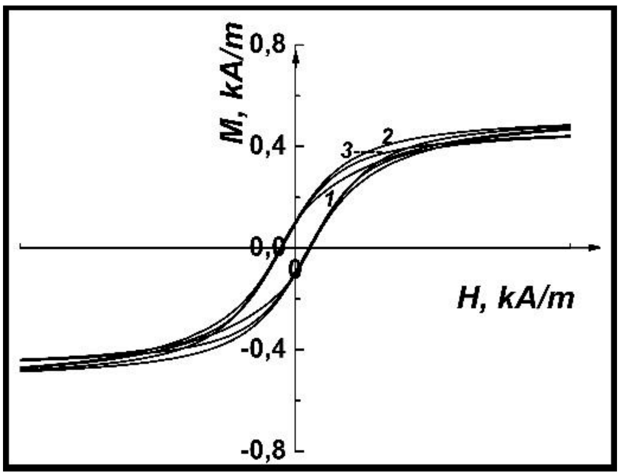

Fig.1

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As can be seen from Fig. 1, in the regions of $H_{cr}M_{rm}0$ and saturation magnetization, the experimental and calculated magnetic hysteresis loops agree well. The agreement in the region of $H_{cr}M_{rm}0$ is likely due to the determination of the additional parameter value based on the H_{cr}, M_{rm}, and M_{st} data. The agreement in the saturation region is related to the Msaturation value and the property of the Langevin function to reach saturation at large arguments. In other regions, the magnetization is calculated from the absolute value of the magnetization above the experimental value.

III. CONCLUSIONS

The Langevin equation with the addition of an additional term describes well the regions of $H_{cr}M_{rm}0$ and magnetic hysteresis saturation. To achieve complete agreement between the experimental and calculated magnetic hysteresis loops, it is necessary to correctly select the approximating function and determine the value of the additional term.

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