MODELLING MAGNETIZATION PROCESSES IN SINGLE-AND MULTI-DOMAIN ROCK SAMPLES USING THE PREISACH DIAGRAM

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Summary: The paper presents the results of identifying a model of the Preisach type for haematite grains of the single-domain as well as multi-domain size. Due to the phenomenological conception of the model, the relations between the parameters of the model and actual parameters are very complex, however, impressive accuracy and stability of the modified model indicate the need to resume studies of this problem. The model parameters also confirm the adequate properties of the vibrating-sample magnetometer (VSM) used and developed in our laboratories.

1. INTRODUCTION

In the course of the sixties, the Preisach diagram was regarded as one of the best approaches to solving the problem of interactions of fine particle assemblies. The model was primarily applied in the domain of magnetic media, e.g. [1–2], but it was also used in rock magnetism [3]. In the following period, however, interest in the model greatly declined because its stability and accuracy of representation were found unsatisfactory, and the experimental identification was inadequately complex. Inconvenient parameters were explained as a result of a physically incorrect simplification of the magnetization processes.

In the eighties, the interest in the models of the Preisach type was rekindled first of all in connection with magnetic recording media. The studies of some authors (Del Vecchio [4], Mayergoyz [5–6], Kádár and Della Torre [7], etc) reported new findings on the model, which led to a great improvement of its basic parameters, i.e. its stability and representation accuracy together with a considerable simplification of its own identification. Since the models are phenomenological, it is not possible any more to infer in a simple way the connections between the model parameters and the actual physical parameters in the classical Preisach-Néel conception [3], [8].

Due to the facts mentioned, the use of this model would, therefore, lack any sense unless the representation accuracy of such models attained the noise value of the measurement proper, which in top VSM amounts to a few percent of the maximum value. Of importance is also the relatively simple process of identifying the model with the use of VSM under the assumption of adequate physical and system parameters. That is why we consider it important to continue dealing with this type of modelling and seeking the relations between the model parameters and actual physical parameters.

2. NEW VIEW ON MODELS OF PREISACH TYPE

The classical Preisach-Néel model describes a simple system of single-domain uniaxial interacting grains. The interaction between particles is expressed by the interaction field \( H_i \), which displaces the rectangular hysteresis loop of the \( i \)-th particle.
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along axis $H$ by the value $H_i$ without any effect on the shape of the loop \[3\], \[8\]. The magnetization process is characterized by the density function $p(a, b)$ of the distribution of hysteresis loops, where $a$ and $b$ are the values of the magnetic field intensity at which magnetization reversal occurs (see Fig. 1). Mayergoyz \[5\] presented a mathematical analysis of the Preisach model with a generally defined hysteresis process. He presented and proved the general properties of the modelled hysteresis process as the conditions necessary and sufficient for the process to be described by the model of the Preisach type. He demonstrated that the traditional model only described irreversible processes that satisfied the conditions of the so-called wiping-out and congruency property. Subsequent studies \[6\], \[9–10\] showed that the model also allowed a description of reversible processes provided the identification of the model started with the use of the Everett function defined as

$$E(H_1, H_2) = \int_{H_1}^{H_2} q(a) \, da + \int_{H_1}^{H_2} p(a, b) \, db \, da, \tag{1}$$

where

$$q(a) = \left[ \frac{\partial E(b, a)}{\partial a} \right]_{b=a} \tag{2}$$

represents the reversible processes and

$$p(a, b) = -\frac{\partial^2 E(b, a)}{\partial b \, \partial a} \tag{3}$$

the irreversible processes. As regards the Everett function

$$M(H) = \frac{1}{2}E(-H_1, H_1) + E(H_1, H_2) + \ldots + E(H_n, H) =$$

$$= M(H_s) + E(H_n, H), \tag{4}$$

where $H_1, H_2, \ldots, H_n$ are the previous local extrema of the magnetic field intensity.