Experimental verification of deletion and congruency property in Si-Fe magnetic steels

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I. Introduction

Recently a model of vector magnetic hysteresis called DPC model (Della Torre - Pinzaglia – Cardelli model) has been introduced. As described in previous works, this model is phenomenological, "rate-independent", and is based on Preisach theory. This model uses suitable distributions of mathematical operators called "hysteron" defined as closed surfaces in the 3-D $\boldsymbol{H}$-space. For a sake of simplicity and clarity, it is treated here the 2-D case [1] [2] [3]. Currently are in progress studies to determine procedures for the model identification using experimental data measured on soft magnetic materials. An example of a procedure to numerical identification of the model is presented in [4]. We remark here that the DPC model can be identified in rigorous way only for materials that satisfy the "deletion" and "congruency" properties. Details about the definitions and the prove of these properties can be found in [5].

In this paper the experimental verification of the properties above for the commercial Si Fe steel is presented.

II. Experiments and preliminary results

We used a “single disk tester” to characterize the magnetic behaviour of disks of Fe-Si magnetic steel [6]. The experimental system is driven by a programmable board which generates and records arbitrary waveforms. The signals generated are amplified by a set of linear amplifiers operating in four quadrants in the frequency range DC - 5 kHz. The amplifiers feed the stator of an induction motor with two poles, which generates on the sample of magnetic material a magnetic field drived in modulus and direction. The probes for the detection of the magnetic field and the magnetization components x and y are placed on the sample and connected to the driver board. The applied field frequency is less than 5 Hz, so we can neglect the effect of eddy currents.

In this section we present a preliminary test carried out to verify the deletion property on a Fe-Si non-oriented steel. In Figure 1 a) we show the magnetic field applied to the sample in two different paths called “loop 1” and “loop 2”. In a first test, starting from the virgin state, we applied in sequence the field of loop 1 and loop 2. The magnetization attained in correspondence of the loop 2 is shown in Figure 1 b), and is the curve called "test 1". Successively, after a suitable demagnetization of the sample, starting again from the virgin state, we applied directly the magnetic field of the loop 2. The magnetization attained is shown in Figure 1 b), and is the curve called "test 2". In this example we can verify that the larger cycle (loop 2) that is external to the previous loop 1 erases completely the memory of the magnetic material. In fact, the two responses of the two different inputs are coincident. A more complete experimental study on the "deletion" and "congruency" properties of these materials will be presented in the full paper, showing a possible set of experimental data that can be used for the identification procedure of the DPC model.

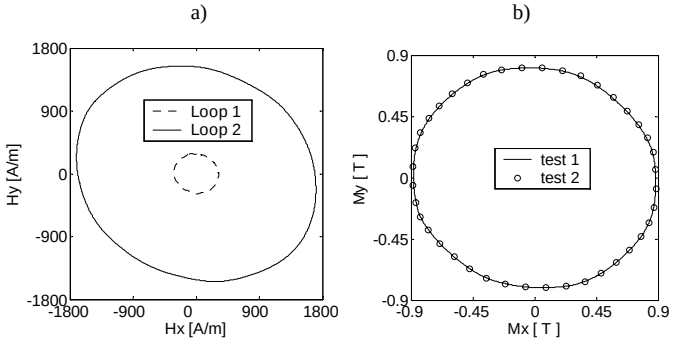

Fig. 1. a) Magnetic field measured. b) Magnetization measured.

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