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Barkhausen noise and high induction losses in non-oriented electrical steel

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Abstract

In this work Barkhausen noise of non-oriented electrical steel is investigated. The Barkhausen noise measurements and RMS value were obtained as function of the induction. The results shows that the Barkhausen noise is present in almost all parts of hysteresis loop, including the high induction level. The results obtained are related with the magnetization process and magnetic losses.

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Keywords: Barkhausen noise; Electrical steels; Magnetization process

The study of the magnetization process of non-oriented electrical steels is a topic of interest because of the importance of decreasing magnetic losses for saving electric power in a global scale. Non-oriented steels are used in most of the home appliances and are a significant source of loss in the electric power system.

Barkhausen noise is an effect that occurs when a ferromagnetic material is subject to an external magnetic field. It is detected as a time series of voltage impulses, available in a sensing coil wound in a ferromagnetic material [1]. The pulses are associated to the sudden topological and geometrical changes occurring in the domain structure of the material as the field is changed. In the case of electrical steels, the study of Barkhausen noise is useful as a tool in the investigation of the loss mechanism along the hysteresis curve, in particular, of the magnetization process at high induction levels [2]. The hysteresis loss can be separated in two components using the criteria proposed in reference [3]: the low induction loss (for $B < B[\mu_{max}] \sim 0.8\,T$) is in general related to 180° domain wall (DW) motion. The high induction loss ($B > B[\mu_{max}]$) could be wrongly associated to the rotation of the magnetization. However such a process cannot explain the fact that around 50% of the total losses are high induction losses. Despite these facts, only a few works addressing the Barkhausen noise and its correlation with the losses in non-oriented electrical steels can be found in the literature [4].

In this work, the results of Barkhausen noise studies measurements performed in non-oriented electrical steel used in low power motors for home appliances are presented. BN was studied in samples of non-oriented FeSi with dimensions $30 \times 1 \times 0.5$ mm (thickness) placed in an open magnetic circuit. The sample was cut in the rolling direction. The exciting field was provided by a long solenoid with compensation for the border. The samples were cycled in their hysteresis loops (not shown here) excited by a 200 mHz sinusoidal field. The Barkhausen noise signal was detected by a small sensing coil with 80 turns wound around the central part of sample. The signal was preamplified by a Stanford low pass preamplifier (model SR560). The signal was digitized by a ComputerBoards AD (PCI-DAS8040-12) card with a resolution of 12 bits. Digital signal processing was performed with software package HPVee. The waveform generator, current source and preamplifier were fed by packs of 12 V batteries in order to increase the signal-to-noise ratio.

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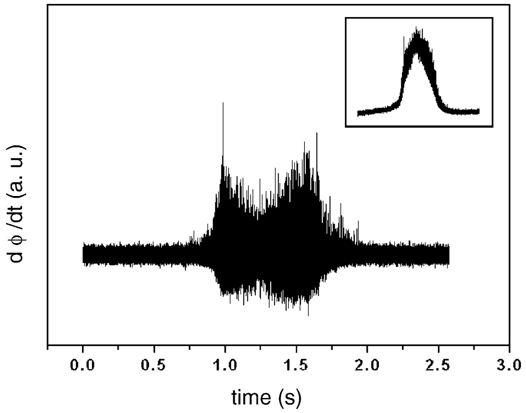

Fig. 1. Barkhausen noise signal for non-oriented electrical steel obtained at 200 mHz. Inset: original curve before the subtraction of the base line.

Fig. 1 shows the Barkhausen noise as a function of time. This curve corresponds to half cycle of hysteresis loop and it was obtained after discounted a base line of the curve shown in the inset of this figure.

In order to quantify the BN, the root mean square voltage (V_{RMS}) of the time serie as a function of B was obtained, as shown in Fig. 2.

It can be seen from the Fig. 2 that the Barkhausen noise is present in almost all parts of hysteresis loop, including the high induction region. The V_{RMS} maximum value was obtained at ~ -1.2 T.

Below the knee of the magnetization curve ($\sim$0.8 T in our sample), domain wall motion is the main magnetization process, whether domain rotation dominates above it. Is well accepted that the reversible domain rotation do not generate losses [5]. Therefore, the Barkhausen noise observation can be related to the motion of 90° domain walls, and possibly to nucleation of a new domain structure at high induction levels.

In conclusion, we have studied the Barkhausen noise in non-oriented electrical steels. It was observed that the noise occurs even at high induction region. The magnetic losses in this region can be related with the motion of 90° domain walls and also to the nucleation of a new and different domain structure.

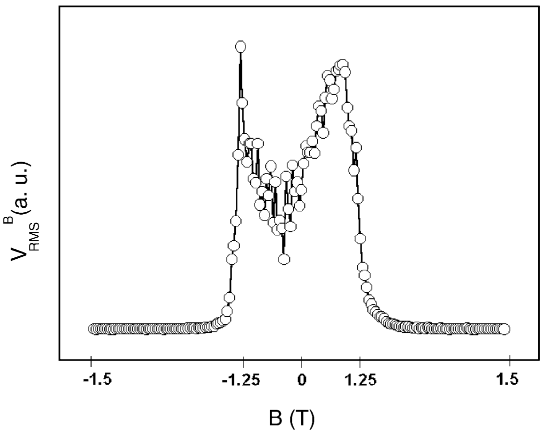

Fig. 2. RMS voltage of the Barkhausen noise as a function of induction.

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