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Modelling of magnetic anisotropy in electrical steel sheet by means of cumulative distribution functions of Gaussians

Guilherme Costa Ayres Tolentino, Jean Viane Leite, M Rossi, Olivier Ninet,
Guillaume Parent, Jonathan Blaszkowski

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View Abstract

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AUTHORS (LAST NAME, FIRST NAME): Tolentino, Guilherme C.¹; Leite, Jean V.²; Rossi, Mathieu¹; Ninet, Olivier¹; Parent, Guillaume¹; Blaszkowski, Jonathan³

INSTITUTIONS (ALL): 1. Univ. Artois, UR 4025, Laboratoire Systèmes Electrotechniques et Environnement (LSEE), Béthune, France.

2. Universidade Federal de Santa Catarina, GRUCAD, Santa Catarina, Florianópolis, Brazil.

3. Thyssenkrupp Electrical Steel, Isbergues, France.

ABSTRACT BODY:

Abstract Body: Developing a model of magnetic materials, such as electrical steel, that allows to account for both their nonlinear and anisotropic behavior remains a challenge.

The approach presented in this paper is based on the use of a Gaussian function whose cumulative distribution function's shape is very similar to that of a first magnetization curve.

This approach has been introduced in the 90s for the study of isothermal remanent magnetization acquired by rock samples containing magnetic minerals [1,2,3].

The main drawback of this approach lies in the fact that a given magnetization curve is derived from one Gaussian function only, which is itself defined by three fixed parameters only [1], leading to non-negligible differences when compared to experimental data.

Moreover, this approach has never been adapted to account for the anisotropic behavior of electrical steel.

In this paper, we propose to enhance this method by using a function which results from the sum of four Gaussian functions, as illustrated in Fig. 1. To account for the anisotropy, all the parameters used to define the Gaussian functions depend on the angle between the magnetic field H and the rolling direction of the steel, denoted θ .

Fig. 2 shows the comparison between first magnetization curves for three different magnetization directions (θ) obtained from experimental data (M530-50A electrical steel), from the original model based on the use of one Gaussian function only and from the proposed enhanced model.

The work presented in this paper shows multiple originalities and improvements. Firstly, it shows that using more than one Gaussian function allows for a better approximation of first magnetization curves (Fig. 2).

Secondly, it shows that considering θ -dependent parameters to define the Gaussian function allows the method to account for magnetic anisotropy (Fig. 2). Thirdly, it highlights that those parameters follow a polynomial trendline.

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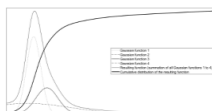


Fig. 1 First magnetization curve derived from a Gaussian function defined as the sum of four subfunctions.

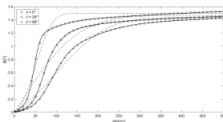


Fig. 2 Comparison between curves obtained from experimental data (markers), from the original model (dashed) and from the enhanced proposed model (solid).

KEYWORDS: Magnetic anisotropy, Electrical Steel.

SUBMITTER (NAME ONLY): Guillaume Parent

SUBMITTER (EMAIL ONLY): guillaume.parent@univ-artois.fr

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