Analytical hysteresis model made on the basis of measured data

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Modeling of modern electromagnetic devices is done mainly with the use of numerical methods, such as the finite element model. To get a precise model which allows accurate modeling, the description of the materials` properties should be as good as possible. Often nonlinear magnetic material is described using a magnetization curve. To make a better material description and consider hysteresis losses, material hysteresis also has to be modeled.

The idea of the model is that both major and first order reversal measured curves could be modeled using the Elliot expression [1]. Based on our experience in working with magnetic materials, we added some parts to the Elliot expression. For each measured curve (left and right part of major hysteresis loop and each first order reversal curve), parameters were determined using Differential Evolution - DE/rand/1/exp [2], and, with that, the best match was achieved between measured and calculated curves. Parameters used for the Differential Evolution are following: the amplification of the differential variation was set at 0.6, and crossover probability was set at 0.8.

The measured hysteresis of material 9S20 with first order reversal curves was used for the tests. The measured and calculated major hysteresis loop and first order increasing reversal curves are presented in Figure 1.

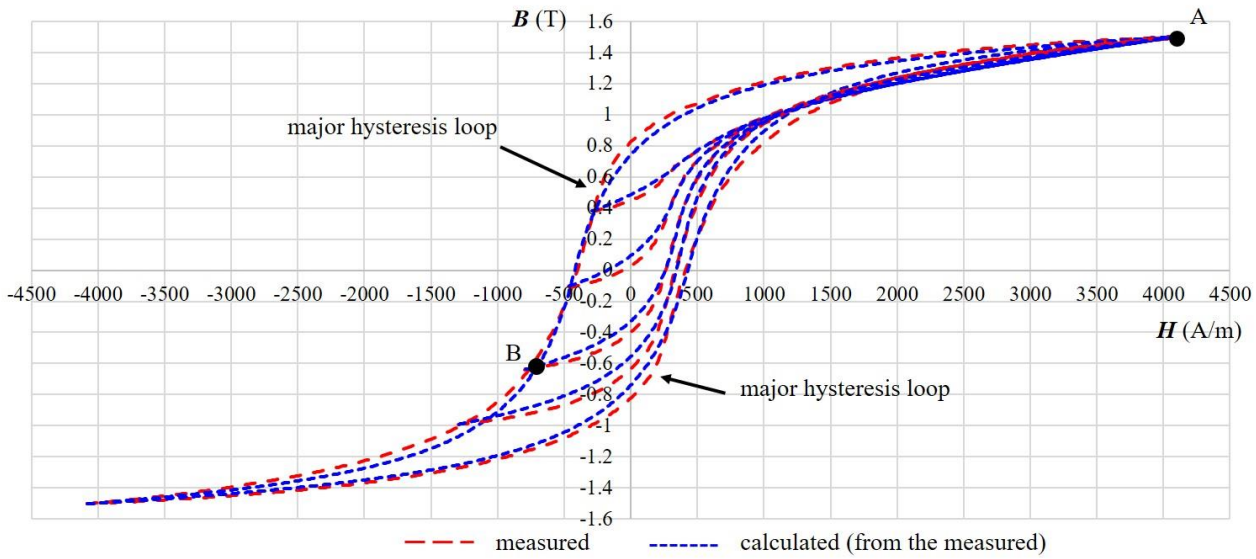

Figure 1: Measured and calculated major hysteresis loop and first order increasing reversal curves.

The main purpose of the presented model is to calculate the magnetization in the area between the measured curves simply. It is impossible to make so many measurements that the calculation of curves in the area between the measurements would not be necessary. To calculate magnetization, only points where the excitation starts to increase after decrease (for example point B marked in Figure 1) and point A (marked in Figure 1) are needed to calculate the increasing magnetization. A detailed description of the process will be given in the final article.

References

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