Qualification protocol for hysteresis model of magnetic materials in static and dynamic modes. Application in design software.

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The magnetic material modeling plays an important role in the electromagnetism simulation, especially the losses computation. However, it is a complex problem because of the material hysteretic characteristics.

This paper proposes a characterization step to be applied in soft magnetic materials modeling that allow modeling them in both static and dynamic function. The model used here is called global model [1] . Its main advantage is that it takes into account the global aspect of material hysteresis (static and dynamic) characteristics, represented by the equation:

$$H_{exc} = H_{stat}(B) + \gamma \frac{dB}{dt} \quad (1)$$

with H_{exc} the excitation field, H_{stat} virtual field, this correspond the static mode and γ a coefficient depending of the electrical and magnetic properties (resistivity, permeability, etc.) of the material.

The term H_{stat} can be modelled by different static models. One analytical, quick and quite simply is the chemical model [2] give good results on some FeSi GO. In this model, different microscopic movements in magnetic material as wall rotation, displacement, etc. are traduced by the equations that are analogical with chemical reaction equations:

$$J' = J'_0 \cdot \tanh\left[(\beta/2.\gamma)\cdot \ln(\exp(H.\gamma)+b) - \beta \cdot H_c/2\right] \quad (2)$$

$$k_1 \cdot sh(k_2(\theta - \pi/2)) + h' \cdot \sin(\theta) - p_1 = 0 \quad (3)$$

$$B(H)_{statique} = J'(H) + J''(H) + \mu_0 H \quad (4)$$

In the same process, other models can be implemented. By an analysis of many of the existing models, some appropriate ones can be evaluated and validated with user criterion on induction field response and losses calculus. The idea is to bring a material model library for user, in function of his application.

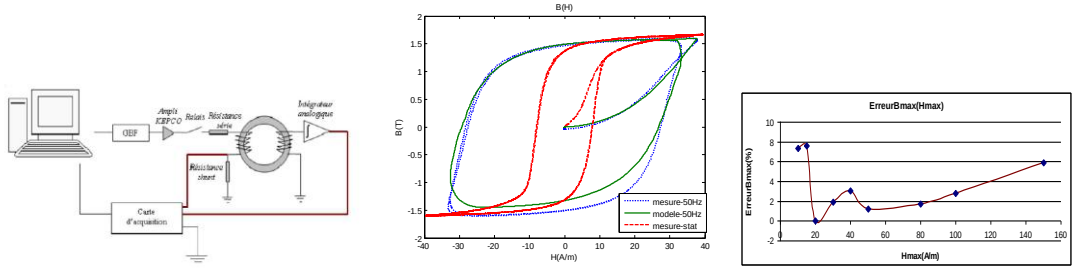

Figure 1: Left: test bed. Center: Hysteresis loops in static and dynamic test. Right: comparison between simulation and experimental results with relative error in B max

[1] Raulet MA, Sixdenier F, Guinand B, et al., "Limits and rules of use of a dynamic flux tube model", COMPEL, Vol. 27 Issue: 1, p. 256-265, 2008

[2] A. Nourdine, G.Meunier, A. Lebouc, "A New Hysteresis Model Generation—Application to the Transverse Axis of GO SiFe Sheet », IEEE Transactions on Magnetics, vol.37, No.5, September 2001