A SEMI-ANALYTICAL METHOD FOR CHARACTERIZING GRAIN-ORIENTED FERROMAGNETIC MATERIALS

Hans Vande Sande, Kay Hameyer and Ludo Froyen
KULeuven, Dept. ESAT, Div. ELECTA, Kasteelpark Arenberg 10, B-3001 Heverlee-Leuven
E-mail: hans.vandesande@esat.kuleuven.ac.be

It is customary in computational electromagnetics to directly implement material characteristics under the form under which they are given by the steel factories. As the measurements of such characteristics involve generally only scalar quantities, their implementation as such in a magnetic field finite element program constitutes a 'de facto' generalization, which is not backed by any arguments nor even mentioned. Measurements give only a partial view on the complex behavior of matter (and in particular that of iron and steel). They need therefore to be interpreted in the context of the mechanisms in play at the microscopic level. The purpose of this paper is to propose such an interpretation in the case of the analysis of the anisotropy of laminated steels.

For anisotropic materials, the vectors representing the magnetic field H and the flux density B are not parallel. When measuring the magnetization curves along a fixed angle α with respect to the magnetic easy axis, only the component of B parallel to the field is obtained with a single sheet tester [1]. It is impossible to determine the angle between B and H, solely by means of such measurements. The paper focuses on grain-oriented ferromagnetic materials having a Goss-texture like most transformer steels [3]. A material composed of cubic crystals has a Goss-texture if for every single crystal, one of the magnetic easy axes is aligned with the rolling direction while the magnetic hard axis is in the rolling plane. For low magnetic fields, all magnetic domains are magnetized parallel or anti-parallel to the rolling direction. From intermediate fields on, they are magnetized in the same direction and the magnetization vector starts to rotate towards the direction of the applied field [2].

The paper demonstrates a way to a posteriori compute the rotation angle of the magnetization vector, by a combination of single sheet measurements and a physical anisotropy model. The knowledge of this angle together with the measurements allow the determination of the actual orientation of the flux density B. In this way, a relation between H and B can be obtained (Fig. 1), which can be used to compute the components of the reluctivity tensor. The results are used for the finite element computation of the magnetic field in the core of a transformer.

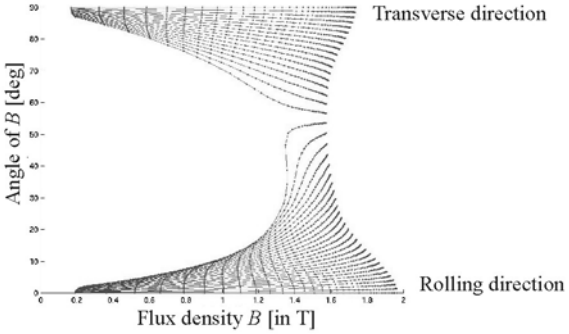

Fig. 1: Lines of constant angle α of the field H with respect to the rolling direction, with the magnitude of the field as a parameter, for different flux density levels B and angles β.

REFERENCES

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