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Abstracts

Representation of microstructural features and magnetic anisotropy in an energy-based vector hysteresis model of electrical steel

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The accurate modeling of iron losses in electromagnetic devices containing laminated cores is still an open question nowadays. This problem is of critical importance for the design of power efficient and high power density electrical machines. To achieve this, electrical steel manufacturers are interested not only in the knowledge on their product under prescribed standardized conditions, but also under the actual realistic conditions they will be subjected to in electromagnetic devices.

The dynamics of magnetization and the correlative iron losses result from a combination of several physical intertwined phenomena: eddy currents, skin effect, saturation and hysteresis [1]. Those phenomena are strongly influenced by the microstructure of ferromagnetic materials, and by the laminated structure of magnetic cores. This complexity calls for a multi-scale analysis, i.e., including the effect of macroscopic eddy currents determined at the level of individual laminations and the effect of microscopic eddy currents due to the jerky motion of domain walls affected by microstructural features [1].

The energy-based lamination model proposed in [2] encodes a true thermodynamic balance of the material, and offers therefore a sound theoretical basis for the computation of iron losses in arbitrary regimes. The models parameter takes the form of a statistical pinning field distribution $\omega(\mathbf{h})$, which can be identified systematically from standard Epstein measurements. This identification process is done for different non-oriented and grain-oriented electrical steel grades. An interesting feature is that these parameters are tightly correlated with microstructure features of the material, in particular grain size and dislocation density [3, 4]. Moreover, the orientation distribution function (ODF), which describes the magneto-crystalline texture, can also be related to the parameters of the anisotropic extension of the vector hysteresis model [5].

The full paper will elaborate on the relation between the microstructural features and material parameters in the energy-based hysteresis model [2] and investigates the effect of microstructural features under real-life conditions. Along with this comparisons of measured and theoretical quasi-static hysteresis loops at different angles to the rolling direction will be shown.

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