61st Annual Conference on Magnetism and Magnetic Materials

NEW ORLEANS, LOUISIANA | OCTOBER 31 – NOVEMBER 4, 2016

ABSTRACTS

MMM 2016

New Orleans

op. 61

AIP Publishing

IEEE MAGNETICS

Jointly sponsored by AIP Publishing, LLC and the IEEE Magnetics Society

FQ-03. Rate-Dependent Extensions of the Parametric Magneto-Dynamic Model with Magnetic Hysteresis. S. Steentjes[1], M. Petrun[2], G. Glehn[1], D. Dolinar[2] and K. Hameyer[1] *1. Institute of Electrical Machines, RWTH Aachen University, Aachen, Germany; 2. FERI, University of Maribor, Maribor, Slovenia*

The accurate description of magnetization processes in non-oriented electrical steel remains until today a largely unsolved physical and engineering problem. In a thin sheet the simulation of the magnetization process is reduced to the solution of the one-dimensional diffusion equation that links the magnitudes of the magnetic field strength *H* and magnetic flux density *B* in a material with conductivity σ_e. With the help of the parametric magneto-dynamic (PMD) in combination with a static hysteresis model the diffusion problem can be solved effectively [1]. The PMD is especially convenient when the lamination model has to be incorporated into an electric circuit such as, e.g., for the simulation of dc-dc converters. Both field- and flux-driven versions exist [2-4]. However, all approaches that solve the discussed diffusion problem underestimate the total power loss, especially for materials with a coarser-grained structure. This underestimation originates from not considering microscopic eddy currents around moving domain walls in the original problem description. These eddy currents can become unacceptably large and lead to a lag in the flux density *B* behind the applied field *H* [5]. This difference resembles a viscous-like friction and can be accounted for in the PMD model by introducing the notion of the “fast” magnetic viscosity similar to the Landau-Lifshitz-Gilbert equation for magnetic viscosity [6,7]. Alternatively also the rate-dependent model [8] can be applied. The proposed solver appears to be more versatile than existing models and can predict the total losses under arbitrary magnetizing conditions as well as reproduce any frequency dependence of the excess losses. The model was tested on non-oriented (NO) electrical steels under sinusoidal and non-sinusoidal flux density waveforms, e.g., 50 Hz fundamental with added 5th harmonic in Fig. 1 and PWM-like in Fig. 2. The model parameters are thought to be material dependent so it is reasoned that the model can be used to accurately predict losses in a wide range of materials magnetized under arbitrary flux waveforms.

[1] M. Petrun, S. Steentjes, K. Hameyer, and D. Dolinar, *IEEE Trans. Magn.*, vol. 52, no. 3, 2015, no. 7002904. [2] M. Petrun, V. Podlogar, S. Steentjes, K. Hameyer, and D. Dolinar, *IEEE Trans. Magn.*, vol. 50, no. 4, pp. 1-4, Apr. 2014. [3] M. Petrun, V. Podlogar, S. Steentjes, K. Hameyer, and D. Dolinar, *IEEE Trans. Magn.*, vol. 50, no. 11, pp. 1-4, Nov. 2014. [4] M. Petrun, S. Steentjes, K. Hameyer, and D. Dolinar, *IEEE Trans. Magn.*, vol. 51, no. 1, pp. 1-4, Jan. 2015. [5] M. Celasco, A. Masoero, P. Mazzetti, and A. Stepanescu, *J. Appl. Phys.*, vol. 57, pp. 4238-4243, 1985. [6] S. E. Zirka, Y. I. Moroz, P. Marketos, and A. J. Moses, *IEEE Trans. Magn.*, vol. 42, no. 9, pp. 2121-2132, Sept. 2006. [7] S. E. Zirka, Y. I. Moroz, P. Marketos, and A. J. Moses, *Physica B*, vol. 343, iss. 1-4, pp. 90-95, Jan. 2004. [8] J. Füzi, *COMPEL*, vol. 18 no. 3, pp. 445 - 457, 1999.

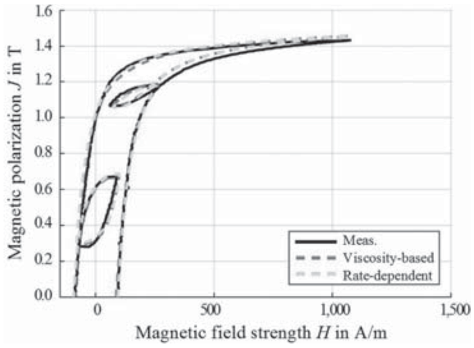

Fig. 1 Comparison of dynamic hysteresis loops using non-sinusoidal excitation.

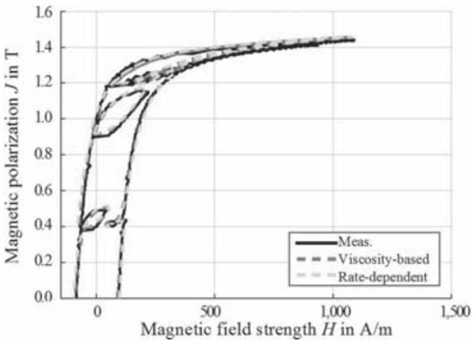

Fig. 2 Comparison of dynamic hysteresis loops using PWM-like excitation.