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Improved iron loss prediction by a modified Bertotti-loss-equation

Daniel Schmidt[a], François Henrotte[b] and Kay Hameyer[a]

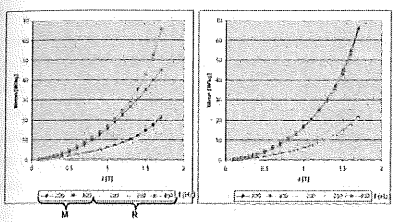
[a] Institute of Electrical Machines, RWTH Aachen University, Germany
[b] Universite catholique de Louvain, Belgium

In electrical machine design iron losses are predicted very often by loss separation based on Bertotti's equation which is valid for a frequency range up to 400 Hz [1]. This formula is inaccurate if predicting the iron losses for high frequencies and high inductions. Though these conditions are especially in the focus for electric high power-density machines. For an optimal design of a high-efficiency electrical machine it is necessary to determine the losses as exact as possible.

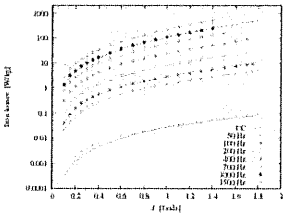
For those reasons an improved iron loss prediction formula is developed. It is based on Bertotti's formula but extended with two additional parameters a_3 and a_4 to take care of the accurate losses at higher induction. The formula is given by eq. (1). The general approach and first results are described in [2]. Fig. 1(a) shows the comparison for low frequencies.

$$W_{impr} = B^2 f\left(a_2 + a_1 f\left(1 + a_3 B^{a_4}\right)\right) + a_5 \left(Bf\right)^{1.5} \tag{1}$$

The aim of this work is to develop an approximationfor which the losses for higher inductions and frequencies can be predicted with an error less than 10 % using parameters determined by standard measurements at an Epstein frame. This approach is tested on two standard non grain oriented soft magnetic materials. Fig. 1(b) gives the first results for improved loss prediction for frequencies up to 1500 Hz and induction up to 1.8 T.



(a) Comparison between 3-parameter (left) and 5-parameter (right) loss prediction formula for low frequencies.
(M: measured, R: calculated)



(b) Accuracy of 5-parameter loss prediction formula for high frequencies.
(dotted: measured, strike-through: calculated)

Figure 1: Results for 5 parameter loss prediction formula.

[1] G. Bertotti, "General Properties of Power Losses in Soft Ferromagnetic Materials", *IEEE Transactions on Magnetics*, vol. 24, no.1, 1988.

[2] F. Henrotte and K. Kameyer, "Modern Methods for iron loss computation", *International Conference on Magnetism and Metallurgy*, Freiberg, Germany, 2010.