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Semi-physical parameter identification for an enhanced iron-loss formula allowing loss-separation

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Abstract:

The accurate prediction of iron losses of soft magnetic materials for various frequencies and magnetic flux densities is eminent for an enhanced design of electrical machines in automotive applications. For this purpose different phenomenological iron-loss models have been proposed describing the loss generating effects. Most of these suffer from poor accuracy for high frequencies as well as high values of magnetic flux densities. Recently the IEM proposed an advanced iron-loss estimation formula which takes the nonlinear material behavior into account [1, 2]. This formula describes the total iron losses as a contribution of hysteresis losses, classical Foucault eddy current losses, excess losses, and a fourth term called saturation losses. The IEM formula represents utilizing this additional loss contribution a significant improvement in loss determination at high magnetic flux densities and high frequencies.

In this paper, a detailed analysis of parameter identification with the aim of physically based parameters, allowing a loss-separation, will be presented.

Possibilities for identifying the parameters are analyzed and presented. The parameters are identified following the statistical loss theory [3], which gives a comprehensive justification from the physical viewpoint. Along with this, the importance of excess losses is investigated in present-day non-grainoriented Fe-Si materials. The new loss term, related to the nonlinear material behavior, will be identified in line with this, resulting in the ability of a loss-separation. Furthermore the frequency dependence of the parameters as well as the directional dependency measuring along and perpendicular to the rolling direction will be studied. Finally the obtained parameter sets are compared and discussed.

Accurate loss calculation including the ability of loss-separation forms the basis for the selection of the most appropriate electrical steel grade which suits best the specific working conditions in the rotating electrical machine. Moreover, such a development gives more insight in the specific trade-offs that are made during the machine design process of such devices in order to identify the particular specifications of electrical steels, which could be further developed for specific applications.

References:

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