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Loss Analysis and Validation of Laminated Core Joints

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This paper presents an efficient approach for simulating the loss of the laminated core joints in power transformers. Two laminated core models, with the same material and joint type but different leg length, are established for validating the specific total loss inside the joint region.

Introduction

In power transformer cores, the joints are generally the 45° mitred step-lap joints, and the flux loci is very complex in the joint zone. The conventional method is difficult to adequately model the overlap joints [1-3], therefore a 3-D EM analysis is really needed to well understand the magnetic flux distribution there.

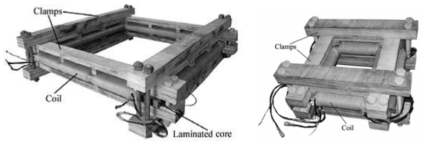
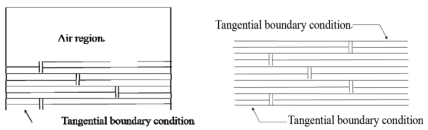


Fig. 1. Two laminated core model with different leg length.



(a) Top layer (b) Middle layer

Fig. 2. Laminated core joint model.

Two 3-D FE loss analysis models are proposed in this paper, considering the air gap between the sheets, i.e., modeling the core sheet by sheet in three dimensions. An engineering-oriented approach is implemented to separate the loss of joints from the total loss. The specific total loss of the joint zone is validated by the two laminated core model, as shown in Fig. 1.

Laminated Core Joints Model

Two 3-D models, as shown in Fig. 2, are established taking the insulated coating of the sheets and air gaps between sheets into account, as well as the magnetic anisotropy of the grain-oriented silicon steel, and the 3 step-lap joints. In the model (a) shown in Fig. 2 contains an air region to analyze the leakage flux in the top layer of the joints; while model (b) is used to simulate the flux in the middle layer of the joints. The total loss can be yielded by summing up all the loss caused in the two layers.

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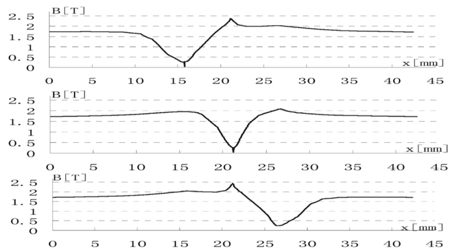

Fig. 3. Distribution of transient flux density at the center of sheet.

Simulation Results

The models have been solved by 3D solver of MagNet, Infolytica Co.. The transient flux densities at the specified potions of the joints are shown in Fig. 3.

Validation Based on Two Core Models

Total loss of the models can be separated into two parts based on two core models, such as the loss of laminated core leg and that of the joints. The measured and calculated results are shown in Table 1.

Table I. Measured and Calculated Results of Specific Loss of Joints and Relative Error.

Average flux density Bav(T)	Measured loss $p_{meas.}$(W/kg)	Calculated loss $p_{calcu.}$(W/kg)	$(p_{calcu.}- p_{meas.})/p_{meas.}$ (%)
1.60	1.3398	1.3112	2.13
1.62	1.3960	1.3516	3.18
1.64	1.4183	1.3938	1.73
1.66	1.4312	1.4382	0.49
1.68	1.5122	1.4847	1.82
1.70	1.5818	1.5323	3.13

Conclusion

An efficient approach is investigated to simulate the laminated core joints. The flux distribution can be observed clearly in the 3-D models. The calculated results of the specific total loss are in good agreement with experiment ones. The core joint loss modeling will be detailed in full paper.

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