Loss Reduction of Laminated Core by Replacing Surface Layers with Different Grade of Electrical Steel Sheets

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1 Introduction

In a magnetic field analysis of a reactor taking account of the laminated structure using homogenization technique [1], it was shown that the flux concentrates in the surface layers of the cores due to the gaps and the laminated structure and it causes the iron loss increase. Then, an improved reactor expanding the gaps around the core corners to make flux distribution uniform was proposed and its iron loss was half reduced in the measurement [2]. However, it is difficult to manufacture insulators adapted in the complex shape of gaps around the core corners.

In this research, to reduce iron loss of laminated core keeping brick shape, the surface layers are replaced by different grade of electric steel sheets.

2 Analysis Models

Fig. 1 shows analysis models of the laminated cores to investigate loss reduction. The cores are assumed to be placed in a row with gaps in the *y*-direction infinitely. Only 1/8 region of a core is analyzed. Each core is constructed by laminating of steel plates in the *z*-direction and the space factor is equal to 0.95. The uniform magnetic field is applied in the *y*-directions so that the average flux density in the core becomes 0.6T. In the original laminated core with 50A470 shown in Fig. 1 (a), the flux concentrates to the surface as mentioned below. Therefore, the surface layer of 5 mm thickness shown in Fig. 1 (b) is replaced by a worse grade 50A1000 to remove the flux concentration and a better material to reduce loss. The losses of the three models at 50 Hz are compared with each other using the 3D nonlinear magnetostatic analysis.

3 Results and Discussion

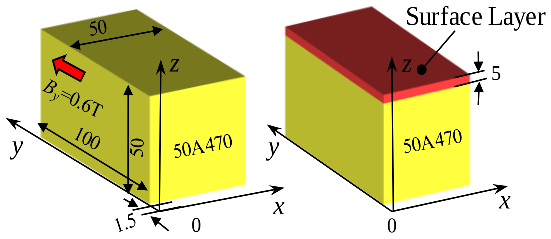
3.1 Flux Distribution

Fig. 2 shows the flux distributions in *yz* plane at *x*=0. The flux densities in the upper layer are larger than those in the other lower layers in ordinary model as shown in Fig. 2 (a). Fig. 2 (b)(i) shows that the flux concentration can be relaxed by replacing the surface layer with worse grade because the permeability of worse grade is also worse. The flux distribution does not change so much by replacing the surface layer with better grade as shown in Fig. 2 (b)(ii) because the magnetic resistance of gap between steel sheets is large.

3.2 Iron Loss

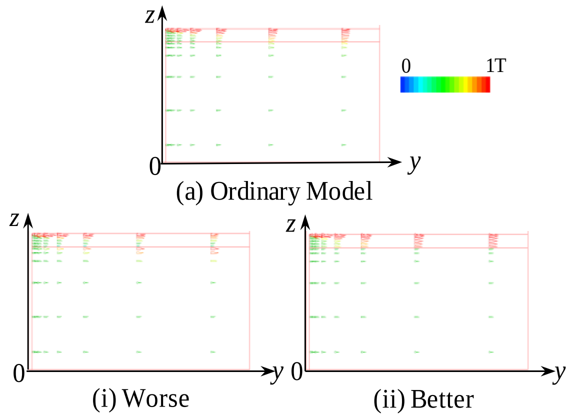
Fig. 3 shows the loss distributions in *yz* plane at *x*=0 and the calculated average iron losses. The average iron loss using worse grade is larger than that of the ordinary model as shown in Fig. 3 (a) and (b)(i). This is because the flux concentration can be removed but the iron loss of worse grade is large. On the other hand, the average iron loss using the better grade can be smaller than that of the ordinary model as shown in Fig. 3 (b)(ii). It can be concluded that, the surface layer should be replaced with better grade to reduce iron loss.

References
[1] K.Muramatsu, et al., *IEEE Trans. Magn.*,40,2,896, 2004.
[2] Y. Gao, et al., *IEEE Trans. Magn.*, 45, 3, 1144, 2009.



(a) Ordinary Model (b) Proposed Model

Fig.1 Analysis models.

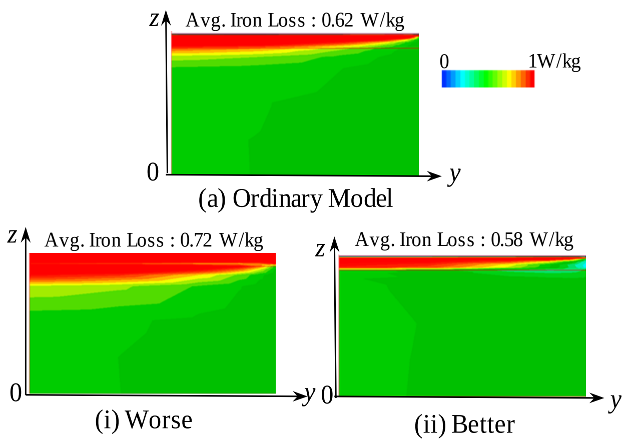


(a) Ordinary Model

(i) Worse (ii) Better

(b) Models replaced by different material in surface

Fig.2 Flux distributions in *yz* plane at *x*=0.



(a) Ordinary Model

(i) Worse (ii) Better

(b) Models replaced by different material in surface

Fig.3 Loss distributions in *yz* plane at *x*=0.