Comparison of Magnetic Field Analysis Models Considering Magnetic Anisotropic Properties

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The model considering magnetic anisotropic properties should be used to analyze magnetic field in magnetic anisotropic material such as grain-oriented silicon steel. Since it is difficult to calculate magnetic field in magnetic anisotropic material, many two-dimensional models are proposed. In this paper, we compare the magnetic fields in virtual simple material calculated by some analysis models, which are (1) isotropic model, (2) two-axis isotropic model, (3) two-axis anisotropic model, (4) ϕ anisotropic model [1], and (5) θ_{HB} anisotropic model [2].

In the isotropic model, only one averaged BH curve is used and it is assumed that flux density $\boldsymbol{B}$ and magnetic field $\boldsymbol{H}$ are parallel. In the two-axis isotropic model, $\boldsymbol{B}$ is separated to components of an easy axis and a hard axis, and each component of $\boldsymbol{H}$ is calculated from each component of $\boldsymbol{B}$ using the one averaged BH curve. In the two-axis anisotropic model, it is assumed that BH curves on an easy axis and a hard axis are different. In the ϕ anisotropic model, different BH curves in $\boldsymbol{B}$ directions are used and it is assumed that $\boldsymbol{B}$ and $\boldsymbol{H}$ are parallel. In the θ_{HB} anisotropic model, the angle $\boldsymbol{\theta_{HB}}$ between $\boldsymbol{B}$ and $\boldsymbol{H}$ is considered.

Fig. 1 shows the analysis model. The sample is grain-oriented silicon steel sheet of 80 mm x 80 mm and is set in the coil of 200 mm length and 80 mm diameter. The easy axis of outer area of the sample is X-axis, and the easy axis of center area of 30 mm x 30 mm is inclined at an angle of 30 degrees of X-axis. The total number of coils is 800 turns, and the electric current of coil is 100 A.

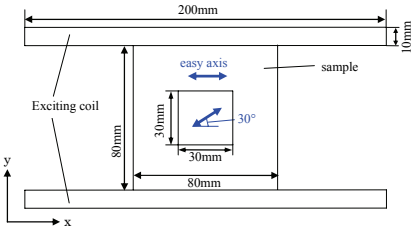


Figure 1: Analysis model.

Table 1: Analysis results

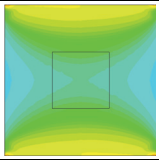
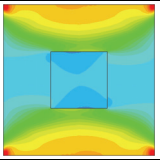
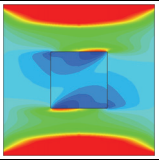
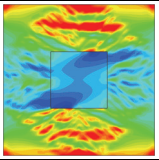
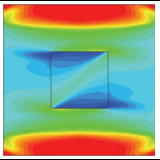
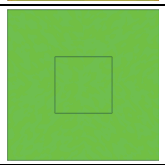
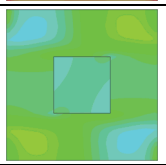
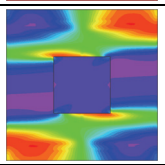
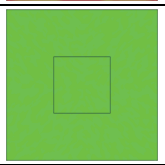
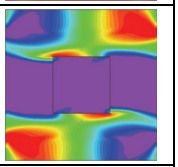
	model (1)	model (2)	model (3)	model (4)	model (5)
magnetic flux density $\boldsymbol{B}$					
angle $\boldsymbol{\theta_{HB}}$ between $\boldsymbol{B}$ and $\boldsymbol{H}$					

Table 1 shows the analysis results on distributions of flux density $\boldsymbol{B}$ and angel $\boldsymbol{\theta_{HB}}$. The result of model (1) is considered to be quite expected, because model (1) is isotropic model. However, the result of model (2) is anisotropic in spite of isotropic model. The reason of anisotropy in model (2) is to separate $\boldsymbol{B}$ and $\boldsymbol{H}$ to components of an easy axis and a hard axis. Models (3), (4), and (5) are anisotropic models. The distribution of angel $\boldsymbol{\theta_{HB}}$ by model (3) is similar to that by model (5) although the angel $\boldsymbol{\theta_{HB}}$ is not taken account of in the model (3). It is obvious that the model (4) has no distribution of the angel $\boldsymbol{\theta_{HB}}$ from model definition. However, patchy pattern is appeared, which is much different from model (3) and (5). In analysing the magnetic field in the material which has large magnetic anisotropy, it is necessary to select the proper model.

[1] K. Fujisaki and S. Satoh, "Magnetic Anisotropic Calculation Model by Finite Element Method," 9th Joint MMM/Intermag Conference, AT-14, pp.65 (2004).
[2] K. Fujiwara, T. Adachi, and N. Takahashi, "A Proposal of Finite-Element Analysis Considering Two-Dimensional Magnetic Properties," IEEE Trans. Magn., vol. 38, no.2, pp.889-892 (2002).

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