学 位 論 文 の 要 旨

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学位論文題名

Homogenization Techniques Taking Account of Eddy Currents in Magnetic Field Analysis
（磁界解析における渦電流を考慮した均質化手法に関する研究）

要旨

Recently, the three dimensional (3D) magnetic field analysis with the finite element method (FEM) is widely used to develop high performances of electric machines and magnetic devices. However, great efforts toward the finite element modeling and huge computation costs are required in the magnetic field analyses of complete models composed of distributed components, such as a laminated core, and a building, etc. Therefore, the homogenization techniques, which are modeling the distributed components using a homogeneous body, are discussed at this moment.

In this research, homogenization techniques of a laminated core and a model composed of distributed component are improved.

In the homogenization technique of a laminated core, the technique in which a laminated core is modeled by using a 3D solid one (main-analysis) with anisotropic permeability and conductivity and the permeability is determined by using a one-dimensional (1D) steel plate model (sub-analysis), which takes account of eddy currents in the steel plates and the structure of laminations, has already been proposed. However, the proposed technique cannot be applied to motor cores because the rotational flux cannot be taken into account by using the 1D sub-analysis. Therefore, in this research, the 1D sub-analysis is expanded to a 3D sub-analysis which can take account of the direction of the flux density.

In the homogenization technique of a model composed of distributed component, the technique using effective permeabilities based on the energy conservation has already been proposed in magnetostatic analyses. However, the homogenization technique for a periodic conductive components taking account of eddy currents seems not established. Therefore, homogenization techniques for periodic conductive and non-magnetic components with and without gaps are investigated in this research.

In Chapter 1, the research background of this thesis is presented with an important viewpoint that the homogeneous techniques is important for modeling of laminated core and models composed of distributed components.

Chapter 2 expresses the method of 3D linear eddy current analysis with finite element analyses.

Chapter 3 expresses the homogenization technique of laminated cores under rotational fluxes. The 1D sub-analysis is expanded to a 3D sub-analysis. The proposed method is applied to a simple laminated core model under the rotational flux in the linear analysis. Then, the eddy current loss obtained from the developed method is compared with those obtained by the homogeneous solid core model with 1D steel plate model and the real laminated core model. It is shown that error occurs by neglecting the edge of the model but the accuracy is much improved in the eddy current loss calculated by using the proposed method.

Chapter 4 expresses homogenization techniques of models composed of distributed components with and without gaps in linear ac steady-state eddy current problems. Two techniques, using magnetostatic analysis with effective anisotropic complex permeabilities and eddy current analysis with modified anisotropic conductivities, are investigated. Both techniques are applied to two models, in which each component is insulated and connected, and the results are compared. It is shown that the former and latter techniques are suitable for insulated and connected components, respectively. Moreover, the methods for determining the effective permeability and modified conductivity in both techniques are proposed and their validity is shown.

Chapter 5 is the conclusion and recommendation for future work.