# Magnetic Material Modeling and Simulation Technology for Loss Calculation

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Soft magnetic materials such as an electrical steel, ferrite core, and dust core are widely used in an inductor and transformer. To achieve high efficiency and downsizing, a simulation technology for accurate core loss is highly demanded in the industry. However, core loss is strongly related to complex magnetization dynamics, and magnetic material modeling is one of the recent fields in which progress is being made. In this presentation, we introduce a magnetic material modeling technique based on micromagnetics for electrical steel, and microstructure for ferrite core.

For electrical steel, hysteresis loss accounts for a large portion of core loss of motors. In addition, vector property due to grain structure is observed in B-H loop measurement. To model this property, we adopted a grain magnetics (GM) model(1). Fig. 1 shows the conceptual diagram of the GM model. The magnetization of one grain is approximated by one magnetization vector. This formulation cannot treat a domain-wall and its related dynamics, and therefore, artificial magnetization change such as magnetization flip is introduced. Fig. 2 shows the simulation results for grain-oriented electrical steel. Anisotropic B-H loops are well-reproduced by considering the effect of domain-wall motion and crystal anisotropy.

For high frequency applications, soft ferrite cores are an important material, but these core losses are strongly related to eddy-current, dimensional resonance, and excess loss due to the magnetization dynamics. To evaluate core loss of Mn-Zn ferrite, we studied the magnetic field simulation with the effective permittivity that comes from the microstructure of Mn-Zn ferrite(2). Fig. 3 shows the simulation result of core-size dependence of complex permeability. The core sample with diameter size 12.7 mm has a clear peak in its real part due to the dimensional resonance. In this presentation, we will discuss the comparison of core loss with experimental measurement and loss mechanism.

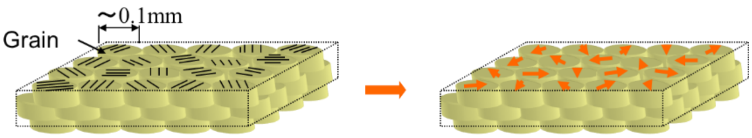


Fig. 1: Grain magnetics model for electrical steel

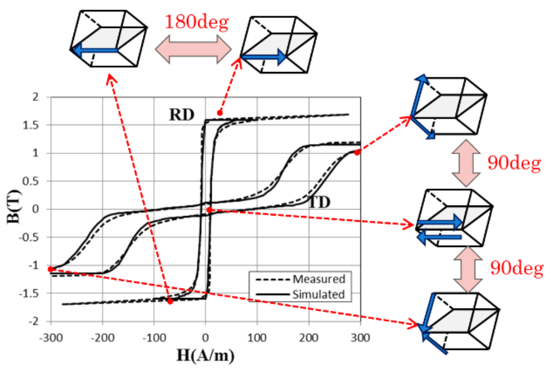


Fig. 2: B-H loops of grain-oriented electrical steel

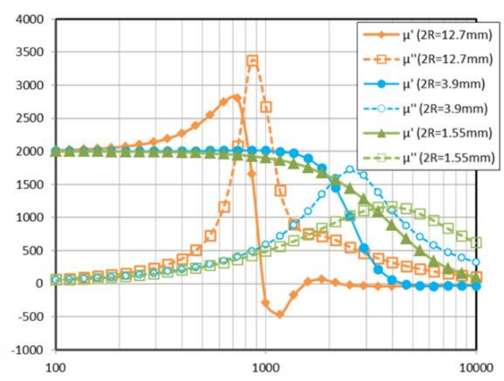


Fig. 3: Complex permeability of Mn-Zn core

Reference

1) A. Furuya,J. Fujisaki,Y. Uehara,K. Shimizu,H. Oshima, and T. Matsuo, IEEE Trans. on Magn., vol. 50,(2014),7300604

2) A. Furuya, Y. Uehara, K. Shimizu, J. Fujisaki, T. Ataka, T. Tanaka and H. Oshima", IEEE Trans. on Magn., vol. 53,(2017), 7301004