

contain finite number of elements and the Galerkin method is now applied only in compact regions. This adds numerical stability to the developed algorithm. We have applied the developed numerical routines to calculate the wave propagation parameters of a ferrite slot line. We have also fabricated two identical slot lines with different lengths so that, after normalizing the measured transmission data with respect to each other, wave propagation in a "generic" ferrite slot line (without coupling to feeder line effects) can be experimentally determined. Our calculations apply to the whole applied field regime, including FMR, for the applied field direction to be along either an axial or an off-axis direction. Calculations compare nicely with measurements. For a transversely biased slot line we found that wave propagation is mainly comprised of the Voigt mode, rendering similar functional dependence of the calculated parameters on the bias magnetic field. For off-axis bias wave propagation in the slot line requires more modes to operate, exhibiting a wider width at FMR. For all the bias-fields considered, the splitting between waves subject to biased fields in opposite directions is very small, to the extent of only 2 to 3%, suggesting that only a small fraction of surface waves are participating in wave propagation in a ferrite slot line. This finding is in agreement with previous measurements.²

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¹H. How and C. Vittoria, Phys. Rev. B **39**, 6823, 1989.

²G. H. Robinson, J. L. Allen, IEEE Microwave Theory Tech., **MTT-17**, 1097, 1969.

AU-04. HOMOGENIZATION OF LAMINATED CORES FOR EDDY CURRENT CALCULATIONS. Anders Bergqvist and Goeran Engdahl (Teknikringen 33, SE-10044 Stockholm, KTH, Sweden)

An approach to calculating eddy current losses in laminated cores is described. For net frequency applications, soft iron cores are usually laminated in order to reduce induced eddy currents. To calculate eddy current losses in such a geometry by spatial discretization of individual laminates is computationally very expensive. A common alternative method is to first find the flux distribution when eddy currents are neglected and then calculate eddy current losses a posteriori as $(1/12)\sigma d^2 \int \dot{B}^2 dt$ where σ is the conductivity and d the sheet thickness. This approach fails to take into account that eddy currents influence on one hand the flux density distribution and on the other hand the field intensity distribution which in turn affects coil losses. In this work, laminated cores are treated by replacing them with an equivalent homogenous medium. This medium has zero conductivity and thus no eddy currents which are instead accounted for by a time-dispersive constitutive law which is found from approximate analytical solution of the diffusion equation for an individual sheet. In the simplest case, when field dispersion is negligible, a magnetic constitutive law $H=f(B)$ for a sheet is replaced by the time-dispersive constitutive law $H=f(B)+(1/12)\sigma d^2 \dot{B}$ for the homogenous medium. The method is incorporated in a finite element scheme and solved in the time domain. An example geometry is demonstrated where coil and iron losses are calculated and compared with results when using the method of a posteriori calculation of losses.

AU-05. NUMERICAL SIMULATIONS OF THE MAGNETIZATION STRUCTURES IN THIN POLYCRYSTALLINE FILMS WITH RANDOM ANISOTROPY AND INTERGRAIN EXCHANGE. D. V. Berkov (INNOVENT e.V., Goeschwitzstr. 22, D-07745, Jena, Germany) and N. L. Gorn (IPHT e.V., D-07745, Jena, Germany)

The evaluation of the demagnetizing (stray) field still remains the most time-consuming step in any micromagnetic algorithm which uses the effective field concept despite the Fast-Fourier-transformation (FFT) technique recently introduced for its evaluation. The problem is especially serious for periodic systems (i.e. for finite lattices with the periodic boundary conditions applied) because in this case analytic expressions for the Fourier-components of the dipolar field should be used. These components do not tend to zero for large wave vectors so that the unavoidable sharp cut-off of the Fourier spectrum (at the wave vectors corresponding to the

number of the lattice cell used) leads to large unphysical oscillations of the stray field. An introduction of some artificial smooth magnetization distribution inside each cell (leading to the fall-off of the stray-field Fourier spectrum) normally used to avoid this problem results in the increase of the number of Fourier-components which should be taken into account thus strongly increasing the computation time. We have developed a new algorithm which enables a fast and exact evaluation of the demagnetizing field in such cases. The algorithm uses the combination of the FFT-evaluation of the stray field with the modified version of the Ewald method known from the calculations of the Coulomb lattice sums. Using our algorithm we have performed numerical simulations of the remagnetization processes in polycrystalline thin magnetic films with the random single-grain anisotropy and the intergrain exchange. The well known ripple-like structures forming during the remagnetization process are observed. The dependence of the ripple spectrum on various model parameters is analyzed.

AU-06. FEM ANALYSIS OF THE INFLUENCE OF FATIGUE CRACK ON MAGNETIC PROPERTIES OF STEEL. Yiming Shi and David Jiles (Ctr. for NDE, Iowa State Univ., Ames, IA 50011)

Fatigue can affect the magnetic properties of materials due to microstructural changes. Previous investigations on steels have shown that several structure sensitive magnetic properties, such as coercivity H_c and remanence B_r , changed systematically throughout the whole fatigue life. When approaching failure, the cumulated microstructure changes resulted in the occur of fatigue crack on the surface. The magnetic properties showed dramatic changes which mainly resulted from the geometrical changes of samples due to cracks. It was found that the remanence B_r still traced the changes of stress very well, while the coercivity H_c sometimes showed different trends. In this paper, the influences of the size and the position of fatigue crack on magnetic field and magnetic induction were studied with FEM method using a commercial software package. Nonlinear models were constructed to simulate the physical geometry of the test sample and sensor. It was found that the magnetic induction was mainly determined by the size of the crack, while magnetic field was influenced by both the size and the position of the crack. The results were correlated with the fatigue experiments of low carbon steel.

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AU-07. APPLICATION OF WAVELET IN EIGENVALUE PROBLEMS. J. C. Yang,* K. R. Shao (Huazhong Univ. of Sci. and Technol., Wuhan, 430074, P.R. China), and J. D. Lavers (Univ. of Toronto, Toronto, Ont. M5S 3G4, Canada)

Eigenvalue problems are common in the field of electromagnetism, such as steady state eddy current problems at low frequencies and determination of the natural frequencies of waveguide. In these problems, to get the eigenvalues of the system is very important, especially those small ones. Nowadays, numerical methods have been developed for those purposes such as Finite Element Method (FEM) and Method of Moments (MoM). However, one has to choose subsectional basis if complex boundary conditions are met, and the finer the mesh is, the higher order equations derived. But it is ridiculous to solve such a high order equation just to get a few small eigenvalues. Thus, the use of transformation to get a reduced order equations without suffering too much precision is valuable. The presented method is an order reduced method. Essentially, wavelet may be regarded as a low pass filter¹. As transformation continues, high frequency components are split out of the original signals. Thus, it may be used to get the small eigenvalues of a matrix. By way of wavelet transform of the original matrix, the derived one is a quarter of the original one. This procedure can be taken successively, with each process one has a reduced order matrix. Some numerical results are also presented to demonstrate its feasibility.

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