# MSFEM and MOR to simulate one laminate for electrical machines

Karl Hollaus, Joachim Schöberl, and Markus Schöbinger
Institute for Analysis and Scientific Computing, Technische Universität Wien, Vienna. E-mail: karl.hollaus@tuwien.ac.at

Accurate prediction of the losses in electrical machines is increasingly gaining importance because of growing energy efficiency requirements.
Simulations of electrical machines make frequently use of the fact that the overall dimensions of a laminated core are essentially larger than the thickness of a laminate and that the end effect, i.e. the stray field at the end region, is ignored so that the solution in each laminate can be assumed to be the same.
The brute force way is to exploit the standard finite element method for three-dimensional problems and time stepping for nonlinear eddy current problems of one laminate. Simulations with such models are usually more expensive than those with the $2-D/1-D$-method.
The $2-D/1-D$-method is an attractive alternative option. A $2D$ FEM is used to solve a static magnetic field problem in the plane of the laminate using a single component magnetic vector potential (MVP) perpendicular to the plane of the laminate enforcing a magnetic flux parallel to the laminate. Eddy currents are incorporated into the $2D$ model by solving a $1D$ diffusion equation.
Although the $2-D/1-D$-method allows rather efficient simulations the aim of this work is to reduce the computational costs even further. To this end the $2-D/1-D$-method is replaced by an approach based on the multiscale finite element method (MSFEM), see (Hollaus, K. and Schöberl, J. (2017). "Some Two-Dimensional Multiscale Finite Element Formulations for the Eddy Current Problem in Iron Laminates", in IEEE Trans. Magn., accepted for publication.) in the first step. MSFEM approach considers also the edge effect. In the second step model order reduction is applied to the model arising from MSFEM, Farzamfar, M., Belahcen, A., Rasilo, P., Clenet, S., and Pierquin, A. (2017). "Model order reduction of electrical machines with multiple inputs". IEEE Trans. Ind. Appl., 53(4), 3355-3360. This work focuses on the structural MOR enabled by the MSFEM approach.