Overlapping Domains in 2-D Finite Element Analysis of Electrical Machines with Eccentricities

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During the production process of an electrical machine different manufacturing tolerances are induced to the final product at various processing steps. Therefore, a realistic modeling of an electrical machine must take the uncertainties due to these tolerances into account. One important category of uncertainties are geometry based deviation of the machine including static and dynamic eccentricities resulting from bearing tolerances.

Widely-used approaches to consider eccentricities in finite element models of electrical machines require a new discretization of the geometry for every quantity of the eccentricity. Due to the stochastic nature of the uncertainties many different values have to be considered resulting in a many different time consuming discretizations. To avoid this long lasting procedure we present in this paper an overlapping domain approach, which requires only one fixed discretization. The stator and a suitable airgap geometry on the one hand and the rotor geometry on the other hand are discretized independently. The rotor mesh can be placed at an arbitrary position and center of rotation overlapping the stator/airgap mesh for every rotor angle respectively time step.

To ensure the continuity of the fields between both independent discretizations a previously presented approach to handle sliding interfaces (E. Lange, F. Henrotte, and K. Hameyer, “Biorthogonal Shape Functions for Nonconforming Sliding Interfaces in 3-D Electrical Machine FE Models With Motion”, *IEEE Transactions on Magnetics*, vol. 48, no. 2, pp 855-858, 2012) is modified to allow for overlapping domains. The mortar element method is applied in combination with Lagrange multipliers to couple both domains. This results in a similar approach as presented in (A. Christophe, L. Santandrea, F. Rapetti, G. Krebs, and Y. Le Bihan, “An overlapping nonmatching grid mortar element method for maxwell’s equations”, *IEEE Transactions on Magnetics*, vol. 50, no. 2, pp. 409-412, 2014) but in contrast preserves the numerical properties of the conforming non-overlapping formulation. The application of the mortar element method with Lagrange multiplier in combination with standard shape functions produces a saddle-point problem. This saddle-point problem is transferred to a positive definite system by application of bi-orthogonal shape functions.

The full paper will include a detailed description of the proposed method and an application to a permanent magnet synchronous machine. Furthermore the effects of different types of eccentricities on the machine’s behavior will be evaluated with respect to radial electromagnetic forces and unbalanced magnetic pull.