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Simulation of Magnetization Errors using Conformal Mapping Field Computations

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Abstract:

Due to their production and magnetization process, rare earth magnets, e.g. NdFeB, exhibit a deviation from the targeted ideal remanent magnetic flux-density. The manufactured magnetization direction may vary from a requested, pure radial or parallel magnetization as well as its main alignment may be biased with an offset angle [1]. As a consequence, the calculation of cogging torque, load torque and force computations of a permanent-magnet synchronous machine (PMSM) by means of finite-element (FE) analysis are at best in a fair agreement to measurements, since the mentioned variations of the PM-material are not covered by standard simulation models. Actual solutions to consider these variations in the simulation of a PMSM consist either of full-factorial Monte-Carlo simulation or advanced stochastic analysis techniques as the creation of polynomial-chaos meta-models [2]. For these meta-models the Sobol-indices are subsequently calculated for performing a sensitivity analysis. Even this technique results in an exponential growth of FE-calls for a rise in the used polynomial's degree or an increment of the input variables. Both techniques furthermore lack the possibility of cause-effect separation. In order to include cause-effect correlation analysis and reduce computation time, this paper unveils a methodology to build a PM-rotor field distribution with consideration of magnet faults semi-analytically for calculating arbitrary machine operation points with an conformal mapping (CM) approach [3, 4]. Therefore it is shown, how to overcome the CM-assumption of symmetrically field conditions (e.g. the field distributions of different magnetic poles differ in function of the stochastic input parameters). As a result, the CM-field computation can be directly applied to the computation of the polynomial-chaos coefficients and moreover even to traditional Monte-Carlo simulation, bringing valuable insight for sensitivity analysis by adding cause-effect correlation and reducing computation times for stochastic magnet error simulation at the same time.

References:

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