Simulating rigid body motion occurring in eddy current problems by parametric model-order reduction

D. Klis[1], O. Farle[2], and R. Dyczij-Edlinger[1]

[1]Chair for Electromagnetic Theory, Saarland University, Saarbrücken, Germany
[2]CST AG, Darmstadt, Germany

In the numerical modeling of eddy current problems, such as wireless power transfer (WPT) systems, one commonly encounters geometrical parameters, especially rigid body motion. One way of tackling this class of problems is by a coupled finite-element boundary-element (FE-BE) scheme [2], which does not require a mesh between the rigid bodies. The FE-BE method involves assembling and solving a large system of equations. Projection-based methods of parametric model-order reduction (MOR) greatly reduce computational times and thus enable tasks that require large numbers of function evaluations, like numerical optimization or response surface modeling. However, such MOR methods require the underlying model to exhibit affine parameterization, which is not the case for the boundary-element part of the FE-BE method. To make the model accessible to MOR, we propose to approximate the Green's function in affine form by means of the empirical interpolation method [1].

We consider an inductive WPT system where the lateral position t and angle α of the receiver coil are variable; see Figure 1. The resulting FE-BE model has about 250,000 degrees of freedom (DoF). Figure 2 shows the inductive coupling factor k versus the geometrical parameters at $f = 1$ Hz, using a reduced-order model (ROM) of 232 DoFs. The absolute error in k with respect to the full model, depicted on Figure 3, confirms that the ROM is of sufficient accuracy compared to typical errors of the underlying discretization methods. Online computational speed of the proposed method is more than 4000 times faster than with the conventional approach.

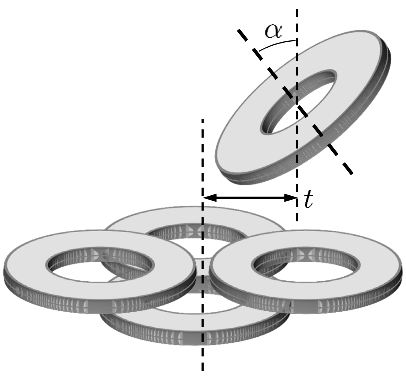

Figure 1: Geometric parameters.

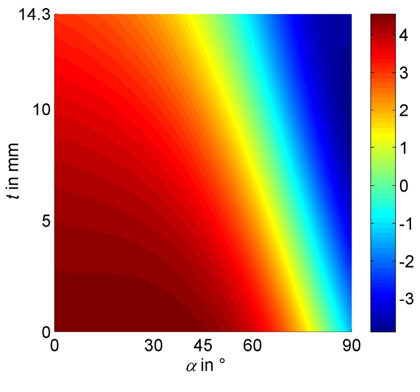

Figure 2: Coupling factor.

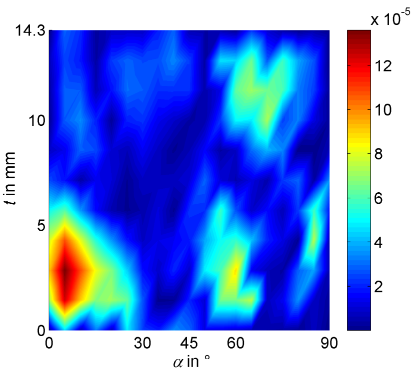

Figure 3: Absolute error.

References

[1] M. Barrault, Y. Maday, N. C. Nguyen, and A. T. Patera. An 'empirical interpolation' method: application to efficient reduced-basis discretization of partial differential equations. *Comptes Rendus Mathematique*, 339(9):667–672, 2004.

[2] R. Hiptmair and J. Ostrowski. Coupled boundary-element scheme for eddy-current computation. *Journal of Engineering Mathematics*, 51(3):231–250, 2005.