Investigation of thin-sheet approaches to simulate beam tube losses*

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Introduction

The beam tube in acceleration facilities is often made of very thin metal. During the switch-on or switch-off process of the dipole-magnets, the fast change in the magnetic field lead to eddy currents in the conductive beam tube. Applying a standard finite-element method (FEM) in order to simulate the parasitic effects results often in inappropriate meshes and high computational effort. Thin sheet approaches improve the mesh quality and speed up the calculations, like shown in Fig. 1. In our report of 2013, existing thin-sheet approaches were studied and compared, and the approach of [1] and [2] were selected to be most efficient for the calculation of beam tube losses. In this report our new algorithm, which was already introduced in the report of 2012 for simple 1D test scenarios, is applied to higher spacial dimensions to be able to compare its performance to the competitive methods.

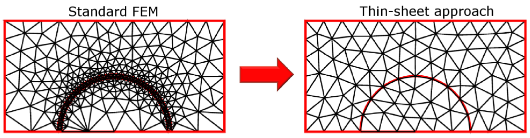

Figure 1: Mesh quality advantage of a thin-sheet approach.

Modified Bases in Higher Dimension

In taking the condition number of the system matrix into account, we developed in 2012 a new method [3] that outperforms the existing approaches according to this measure with respect to the accuracy. The basis functions of mesh elements that are directly connected to the interface are modified in order to account for the variation in thickness direction. But these modified bases are non-conform from one sheet adjacent element to the next. A penalization surface term has to be added to the weak formulation like also known from the discontinues Galerkin method or Raviart-Thomas elements.

A Two-dimensional Test Case

An electro-quasistationary test scenario was chosen to show the performance of our novel algorithm in higher spacial dimensions: A conductor excited by a harmonic voltage source of $U = 2\text{V}$ and $f = 50\text{Hz}$ and a small crack line with less conductivity in its center, see Fig. 2. The results

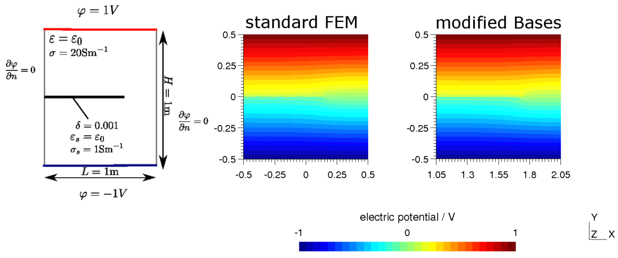

Figure 2: Geometry and result of test scenario.

of our thin-sheet approach are qualitatively comparable to standard FEM. Also the power loss is in good agreement with $P_{\text{el}} \approx 188.3\text{W}$. Fig. 3 shows the condition number of the final system matrix for different sheet thicknesses.

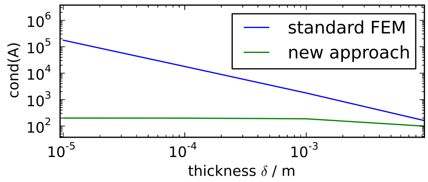

Figure 3: Conditioning with respect to sheet thickness.

Conclusion and Outlook

The promising approach of 2012 using modified bases is successfully applied to higher spacial dimensions, without loosing the advantageous properties. In a next step, the performance will be compared to the competitive methods of [1] and [2] in a beam tube simulation.

References

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