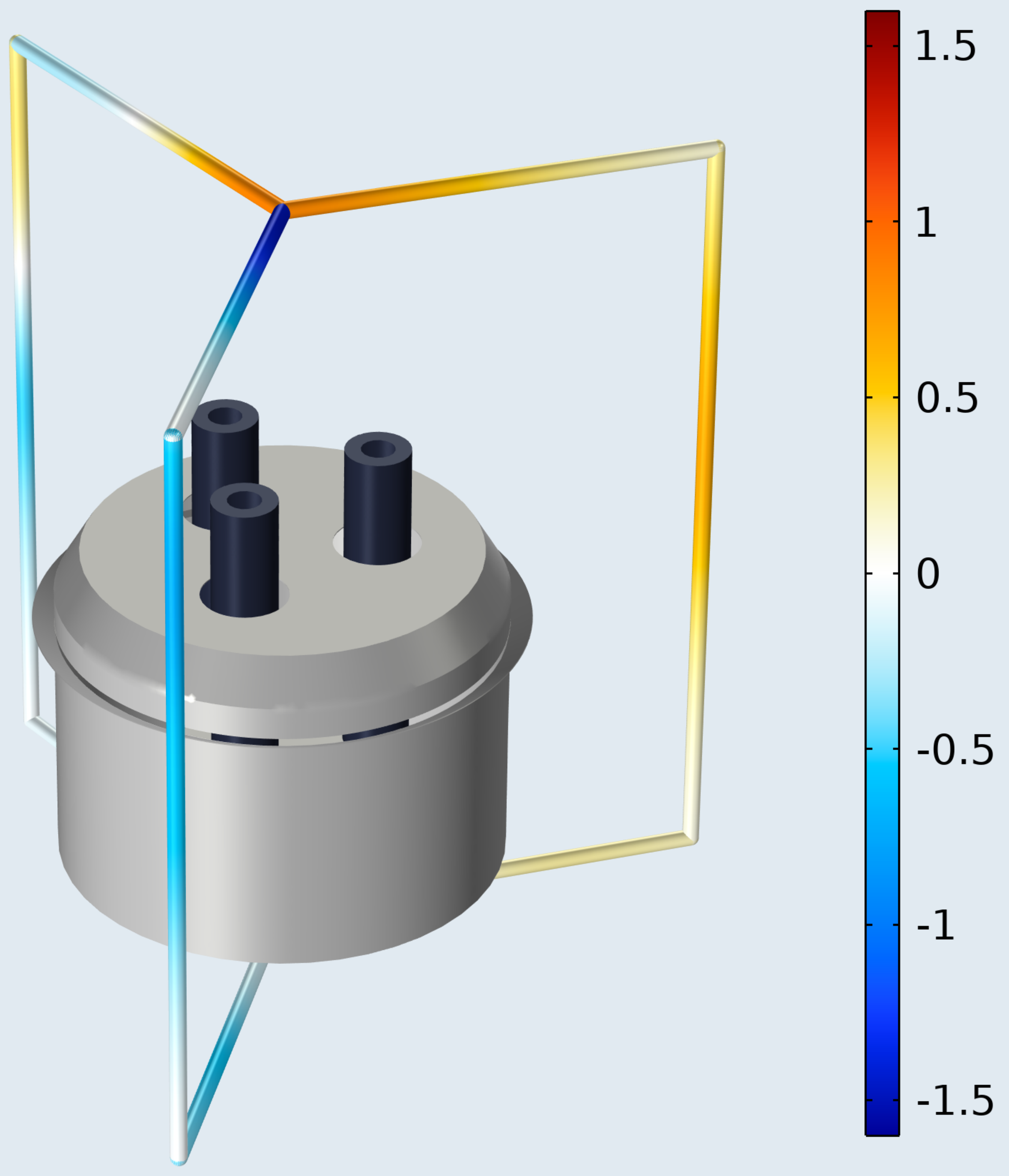

Utilization of Models for the Electrical Conditions in Submerged Arc Furnaces.

Due to extreme internal conditions, numerical modeling using the Finite Element Method (FEM) is a crucial tool for optimizing the performance of three-phase electric smelting furnaces.

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Abstract

Optimizing three-phase electric smelting furnaces (SAFs) is difficult due to the extreme conditions that make direct observations challenging. This work presents examples of computational studies using a detailed FEM models of an industrial-scale SAF, developed in COMSOL®. The base model is used to analyze the furnace's electromagnetic behavior, including the distribution of active and reactive power, electric and magnetic fields, to derive key operational parameters. Building on this foundation, derived models have been applied to investigate, for example, the optimal use of virtual magnetometers, assess multi-lead measurement techniques. This research provides valuable insights into the complex electrical and electromagnetic phenomena within SAFs, ultimately contributing to improved operational control, enhanced measurement accuracy, and the development of more sustainable production processes. This work is as part of the SAFECI project "Electrical Conditions in Submerged Arc Furnaces – Identification and Improvement", with financial support from The Research Council of Norway (Pr. Nr. 326802) and industrial partners.

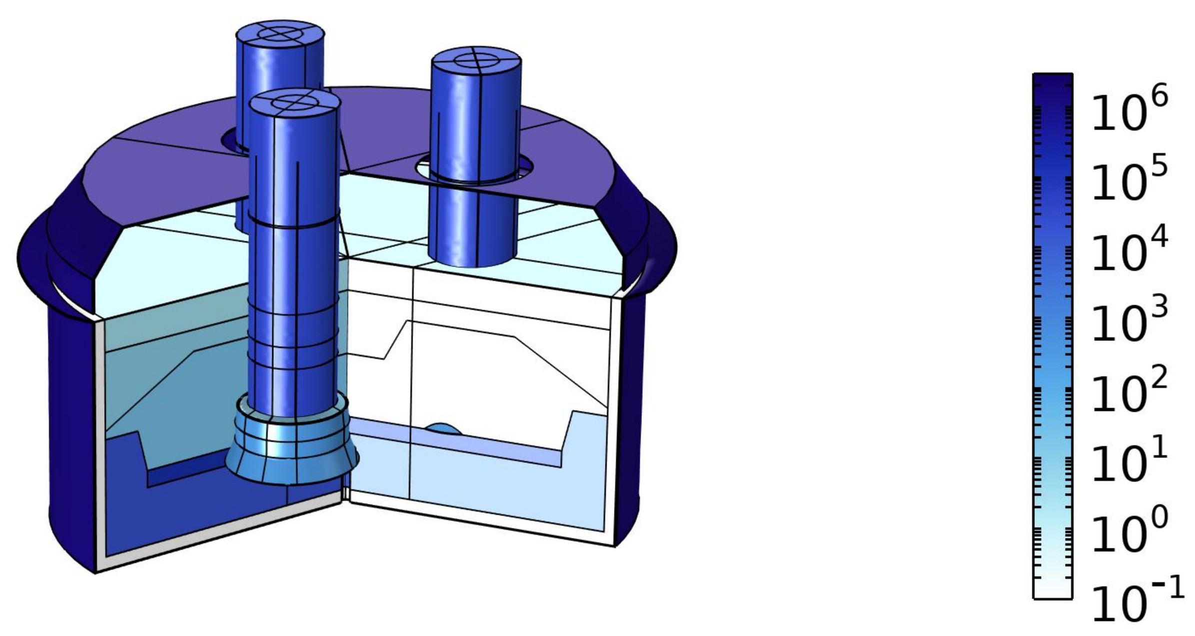

Figure 1. The base model, with the electrical conductivity of the materials displayed on a logarithmic color scale in S/m.

Methodology

The geometrical model is an accurate representation of an industrial three-phase electric smelting furnace. It incorporates three electrodes in an equilateral triangle within an inclosing steel shell. It includes layers of non-conductive insulation and a conductive carbon lining. The internal domains include charge banks with varying resistivity. Depending on the process, the model features either coke beds with adjustable diameters and resistivity or craters with non-conductive gas and resistive arcs. The AC/DC - Magnetic and Electric Fields (mef) interface, was used to set up the electrical conditions. An Electrical Circuit (cir) model was integrated to track the true power for each phase, providing a comprehensive understanding of power flow.

Results

Based on a foundational model that analyzes the furnace's power distribution and electromagnetic fields, we developed specialized models to address key operational challenges.

We investigated virtual magnetometers for potential real-time monitoring and assessed traditional multi-lead measurement techniques to understand their effectiveness in reducing magnetically induced errors. We also created highly parameterized models to generate extensive datasets for training surrogate models, which can provide fast and efficient predictions of furnace behavior, bypassing the need for time-consuming simulations.

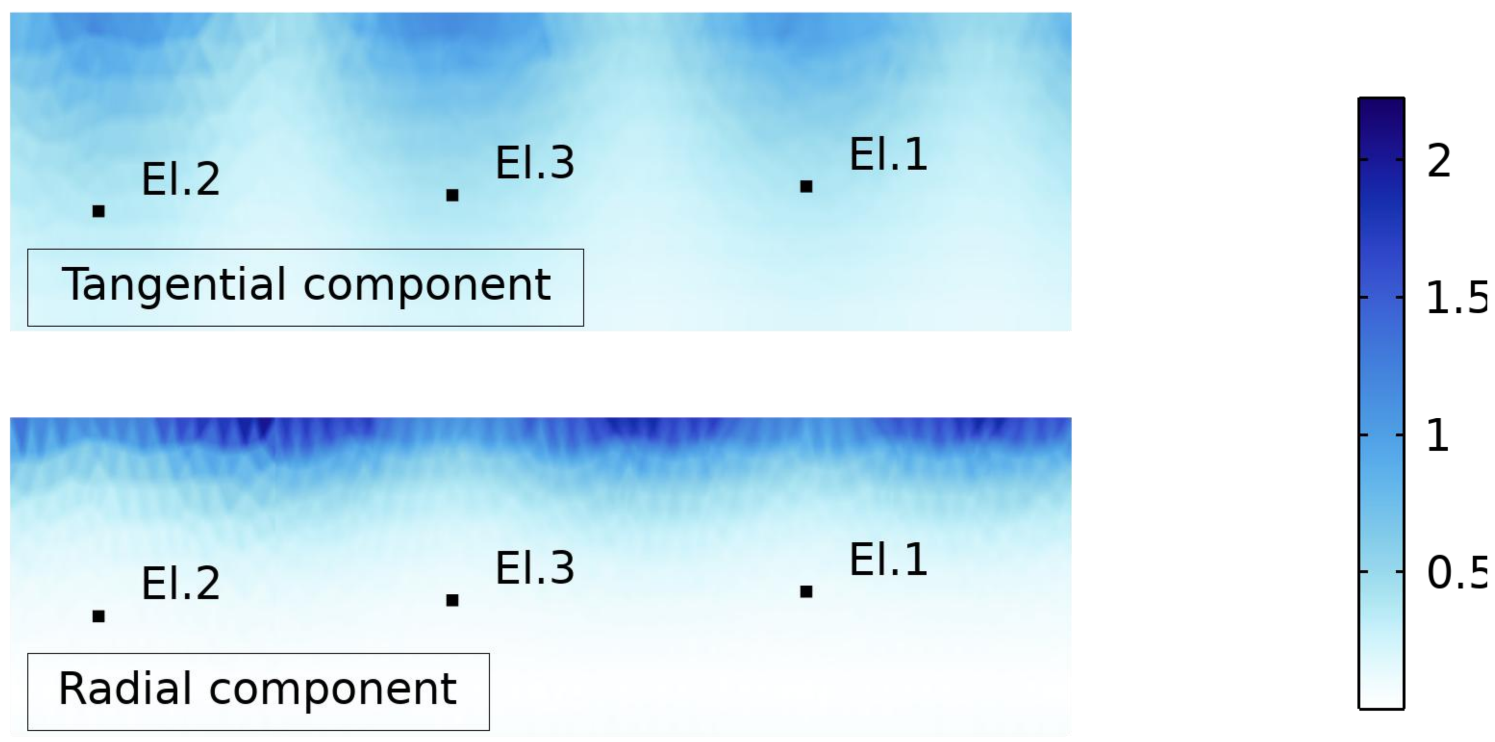

Figure 2. Projection of a cylindrical probe surface into a 2D map of the tangential and radial components of the magnetic field (mT). The marks show the closer point to the tip of the electrodes.

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