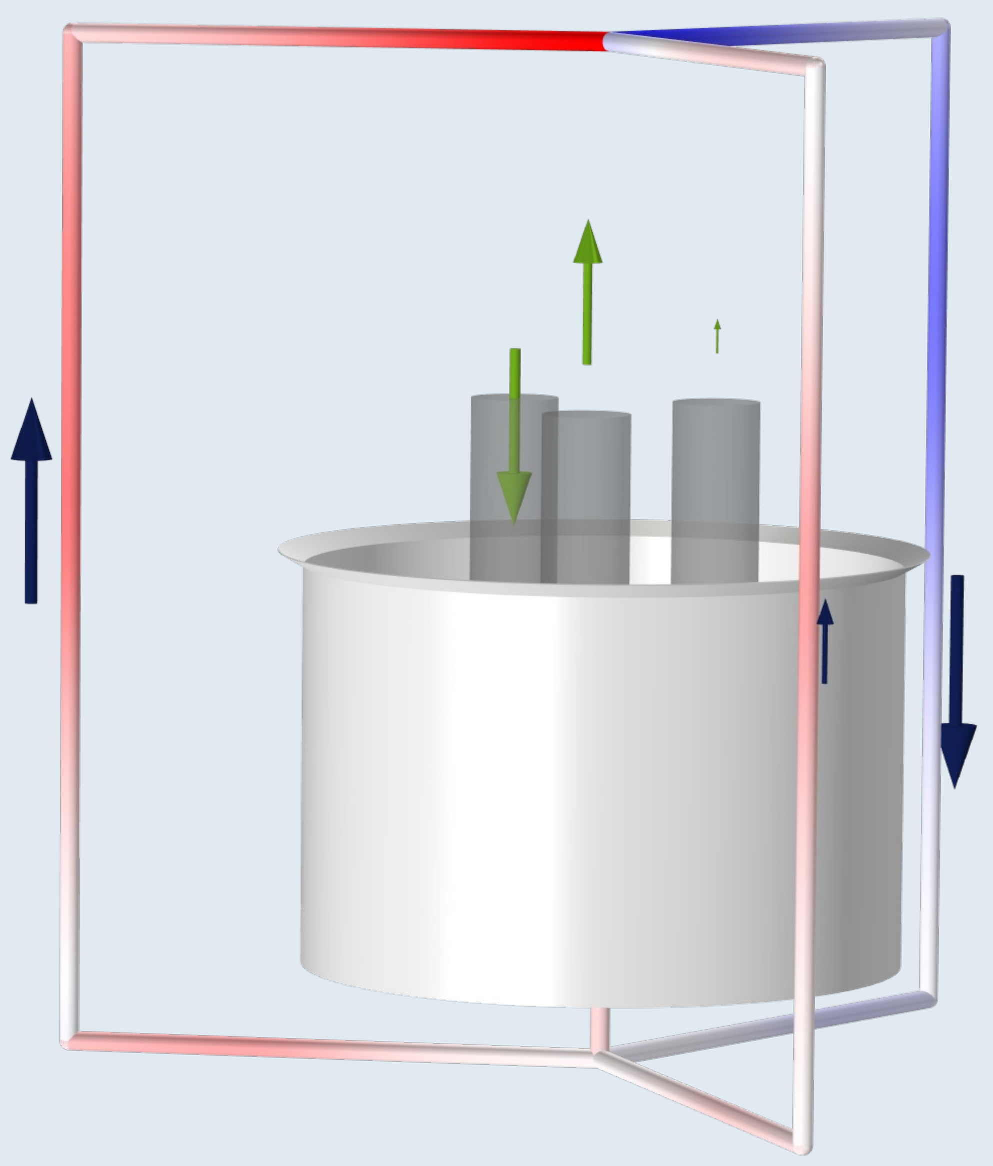

Modeling the Induction Error in Measuring Voltages in Metallurgical Submerged Arc Furnaces

Strong magnetic field around electric furnaces induces voltages in the measurement leads resulting in erroneous readings. Strategies to address this issue are evaluated.

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Introduction

Accurate measurement of electrode loads is essential for optimal operation of large 3-phase electric melting furnaces. Typically, this involves combining electrode current and voltage drop between the electrode tops and the furnace core, requiring the core to be electrically connected to a control room measurement device. However, induced voltages from the furnace's strong magnetic field cause erroneous readings. To solve this, three measuring leads are placed symmetrically around the furnace to provide destructive interference of induced voltages and reduce inductive error. Although this method is believed to be accurate, it faces challenges in industrial settings and may not perform well under asymmetrical electrical conditions.[1]

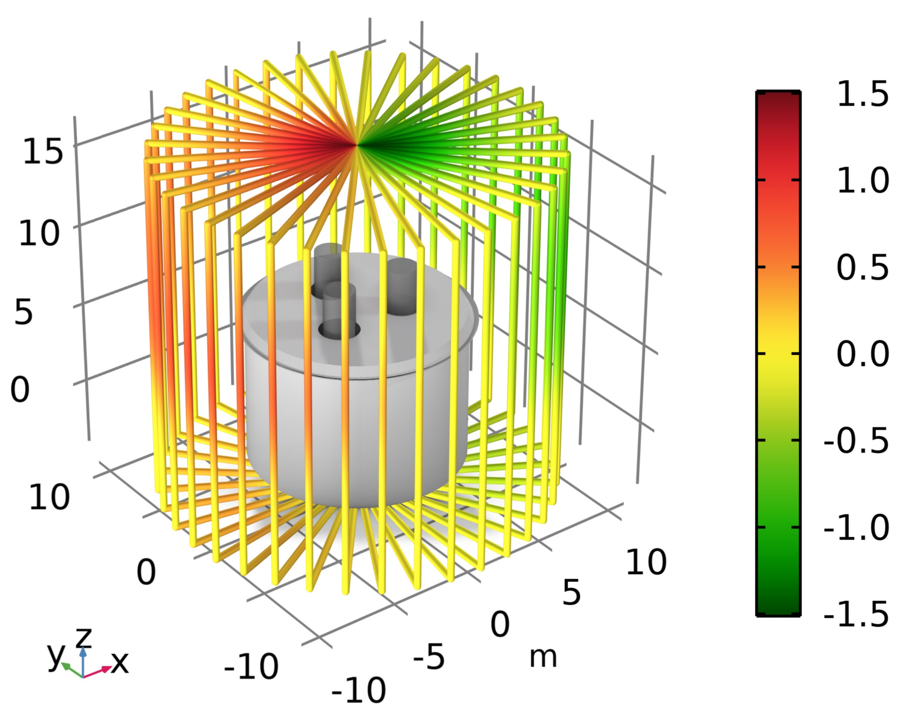

FIGURE 1. Leads color coded with the local instantaneous amplitude of the tangential electric field (V/m).

Methodology

Our model employs an idealized yet realistic 3D representation of a submerged arc metallurgical furnace, detailing the distribution of materials and structural elements. In this system, power is delivered via three large graphite electrodes arranged in an equilateral triangle. The 3-phase electrical system provides up to 42 MW, with currents exceeding 100,000 A. We investigate the electrical conditions using the AC/DC Module (magnetic and electric field - mef) while an electrical circuit (cir) model tracks the true power for each phase.[2] The model includes 36 unique leads represented as open curve polygons. For each lead path, integration along the defining edges of the tangential component of the electric field gives the induced voltage.[3]

Results

By examining the residual inductive errors of different lead arrangements under various conditions and investigating the impact of the furnace's electrical status on measurement accuracy, we demonstrate that: a) symmetrical lead placement results in complete destructive interference of induced voltage when the furnace's electrical state is balanced; b) material imbalances cause signal cancellation to be only partial, resulting in an induction error in phase with the core voltage; c) adjusting the electrode positions to restore electrical balance also reduces the residual induction error; and d) disrupting the symmetry of the leads requires compensation by scaling and/or shifting the induced voltages, which involves optimizing at least two resistance or one impedance.[3]

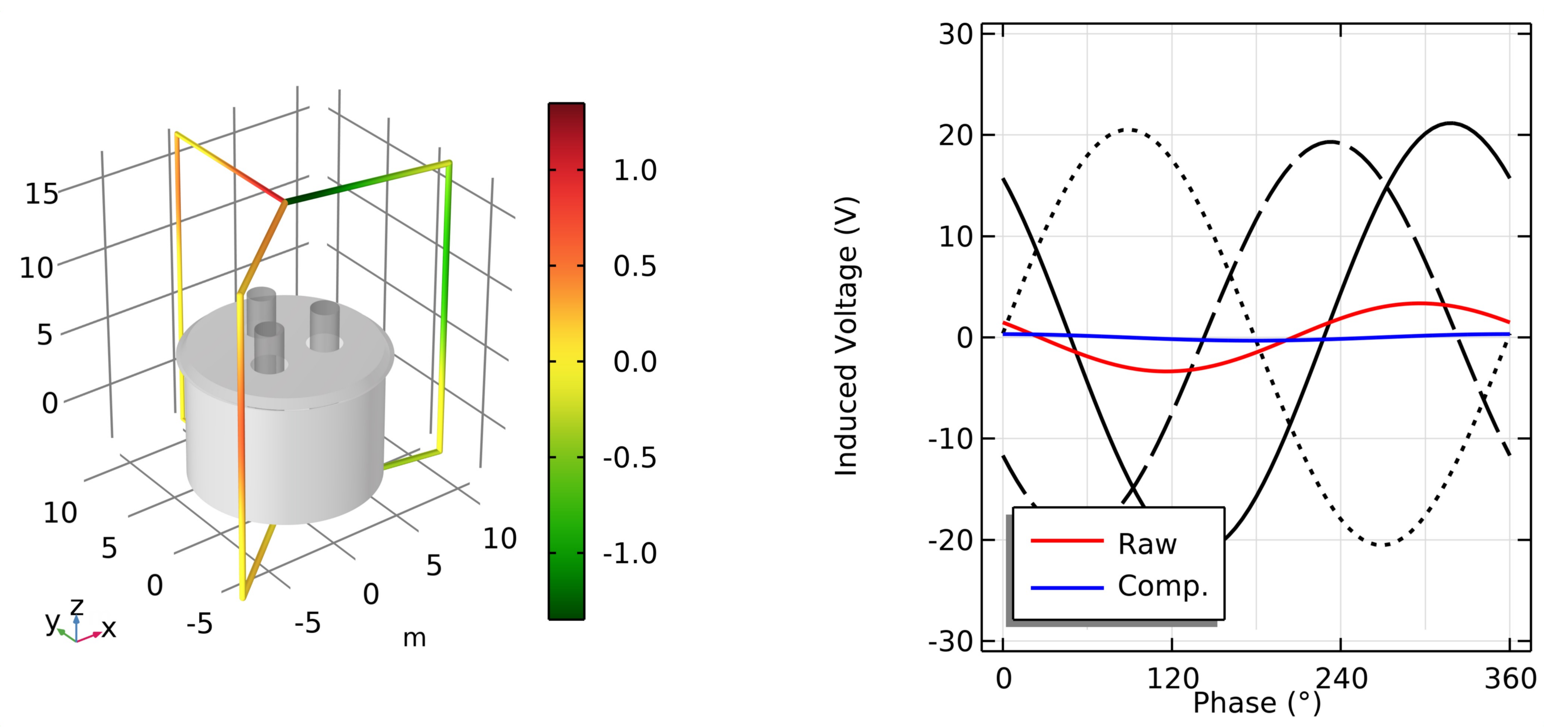

FIGURE 2. Asymmetry in the placement of the leads. Effect on the partial destructive interference (red) and compensation (blue).

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