Measurement and Modeling of EMF Induced by an Electromagnet with a Large, High-Reluctance Air Gap

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Introduction

Transportation Technology Center, Inc. (TTCI) is testing a prototype system for use in the railroad industry. The system utilizes a small electromagnet for inducing an alternating current electromotive force (EMF) in railroad track, which is separated from the electromagnet by a substantial, high-reluctance air gap. Maximizing the induced EMF in the circuit with the presence of the large air gap requires careful optimization of the electromagnet. Experiments and simulations were carried out at the Pulsed Field Facility to validate the model, improve the design, understand how magnetic flux from the electromagnet interacts with the rail, and optimize design parameters.

Experimental

Experimental work was carried out at the Pulsed Field Facility at Los Alamos National Laboratory in New Mexico. A prototype electromagnet was characterized in the laboratory. Magnetic flux at several points around the electromagnet was measured under various conditions of voltage, current, and frequency. The number, density, and position of windings on the electromagnet were varied. The EMF induced in a small section of railroad rail was measured. An ANSYS model was developed and simulations were carried out to evaluate the effects of additional parameters, including the cross-sectional area of the magnetic core, separation of the poles of the magnetic core, and distribution of the coil turns along the magnetic core.

Results and Discussion

Experimental measurements were compared to ANSYS simulation results and found to be in close agreement. Results of the testing and modeling were used to identify the critical parameters for optimization, and were used in constructing an improved prototype electromagnet.

Conclusions

Experimental data and simulation results obtained from work done at the Pulsed Field Facility were extremely useful in optimizing the design of an industrial electromagnet.

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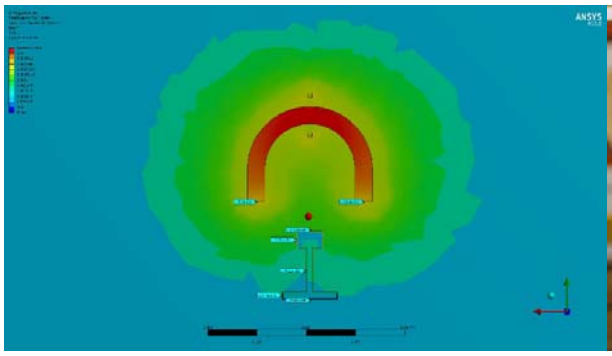
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