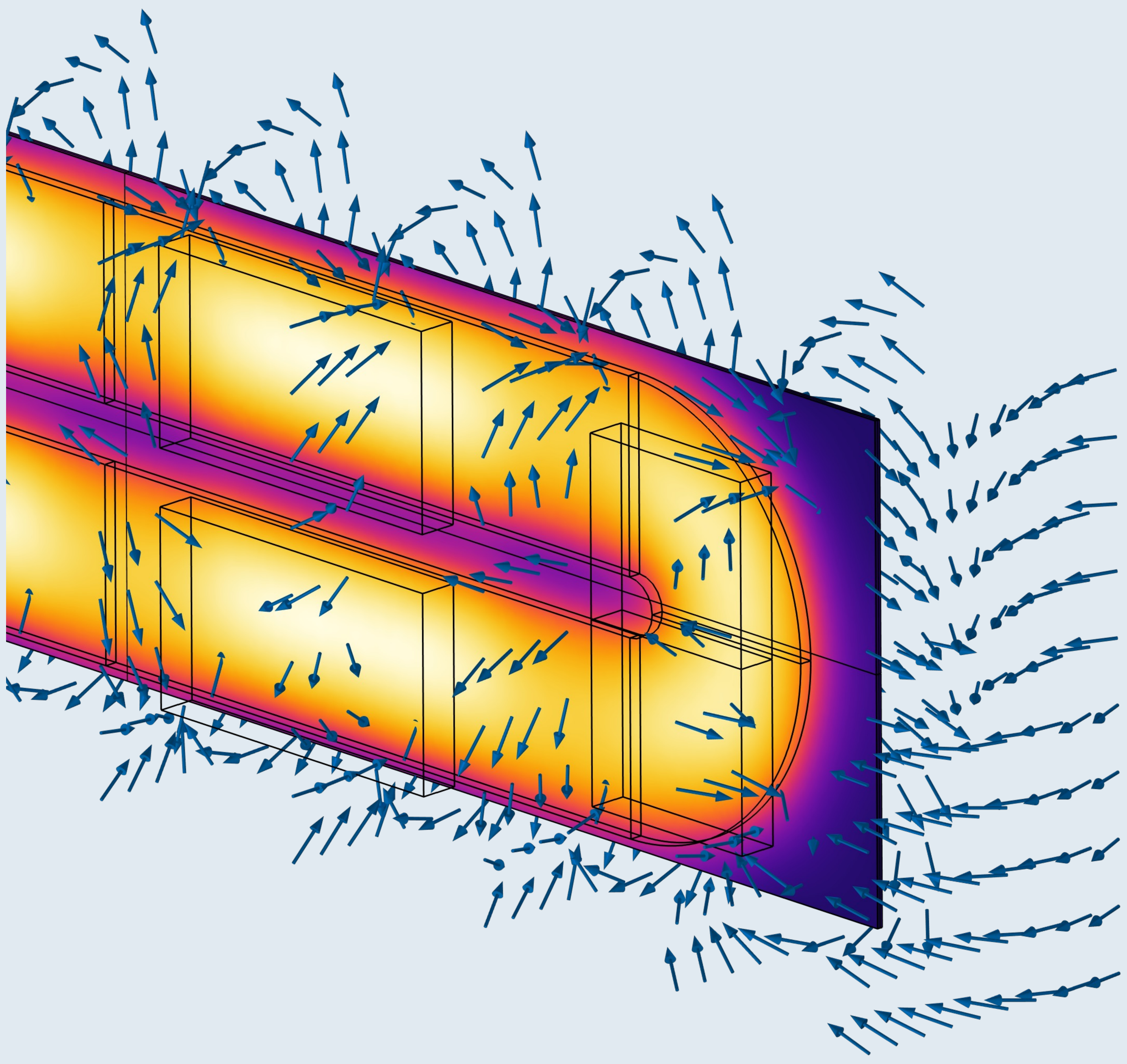

Electromagnetic and Thermal Simulation of an Induction Heating Process for a Moving Thin Layer Strip

This paper focuses on the transition from gas heating to induction heating in industrial packaging process.

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Abstract

The aim of the study is to simulate and size the induction heating system of a thin aluminum strip for industrial welding of packages using COMSOL Multiphysics®. The strip that will be heated is set in motion by wheels and pulleys, and the induction system consists of a couple of pancake-type coils facing the strip. Since the model is time consuming, efforts were made to simplify and decouple it to find a fast and reliable solution. The first step consists in decoupling the problem in a thermal and an electromagnetic ones. The thermal problem is solved using the Heat Transfer Module and its features to simulate the strip movement, considering the system losses. Once the necessary power is determined, two inductors are sized to transfer that target power to the strip. The second step is performed using the AC/DC Module, conducting frequency studies (Frequency Domain). Also, the Electrical Circuit (CIR) interface is used to model the correct resonant circuit and feed the inductors from a circuit perspective. This approach exponentially reduced the simulation time while obtaining reliable results.

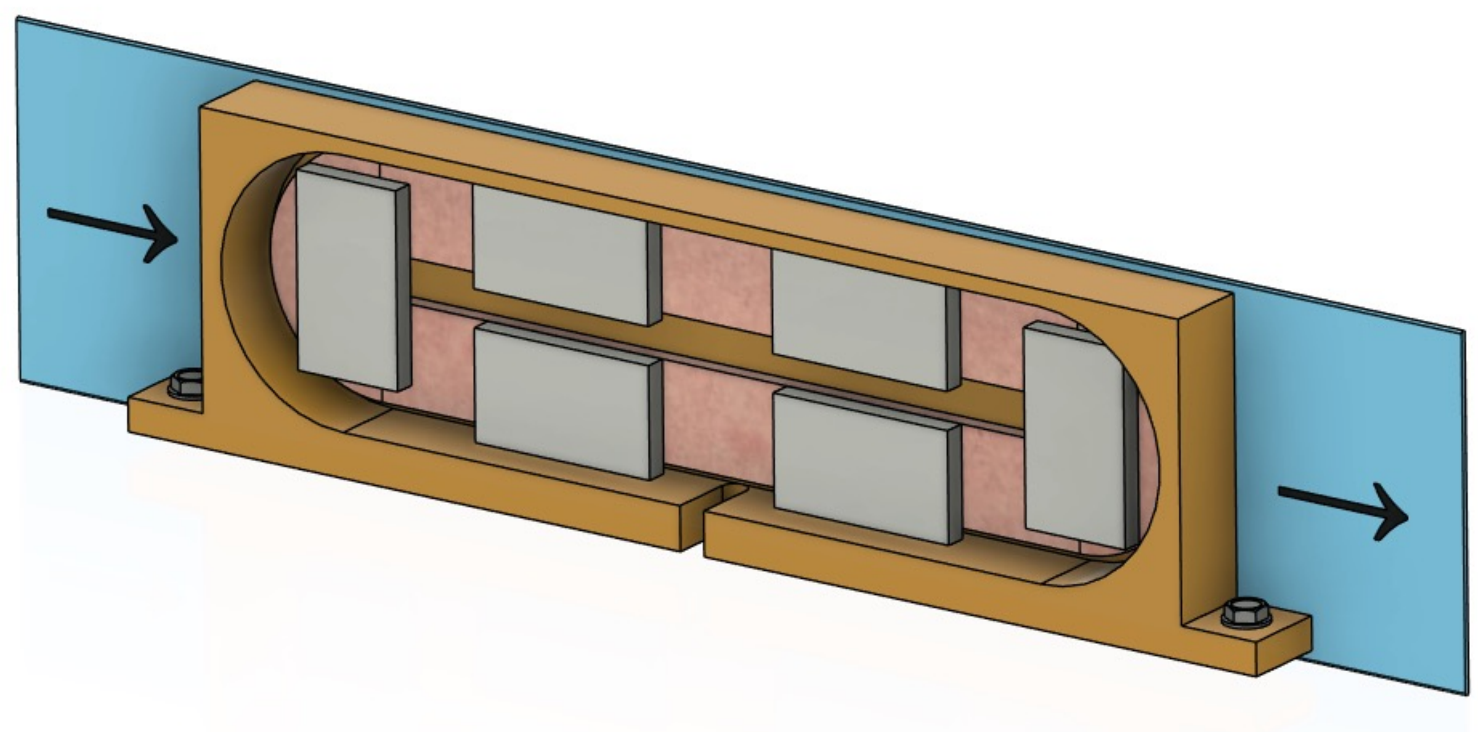

FIGURE 1. 3D representation of the induction system (blue: moving tape, pink: inductor, gray: ferrites, yellow: inductor fiberglass support).

Methodology

The analyzed system consists of an inductor with ferrite cores, and the metallic tape to be heated. The problem was decoupled by first applying thermal power to the inner aluminum layer to achieve a steady state temperature of 180 °C. Then, the inductor was designed to transfer this power to the tape.

Given the reduced thickness of the thin aluminum layer (50 µm), the Thin layer characterization was used in the AC/DC Module. This approach allows Maxwell's equations to be solved analytically without needing to create a mesh for the layer.

$$T_{target} \rightarrow P_{thermal} \rightarrow P_{electromagnetic} \rightarrow I_{coil}$$

Results

In the image on the right, the results of the simulations are shown.

On the right side, the thermal tests performed in the preliminary thermal analysis highlight the different temperatures on the surface of the tape at various power levels applied to the inner aluminum layer.

On the left side, the induced current density obtained in the thin aluminum layer and the direction of the current vector can be seen.

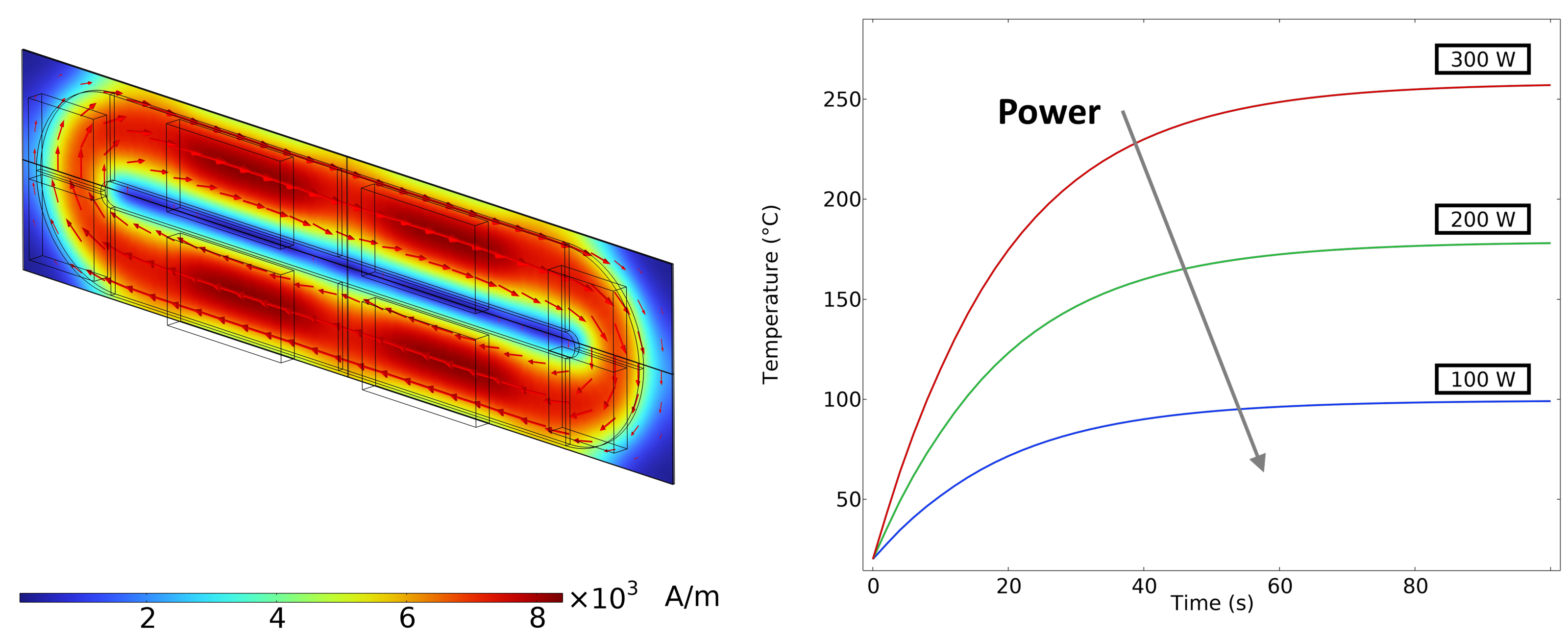

FIGURE 2. Left: EM analysis: eddy currents density on the tape surface. Right: thermal analysis: maximum temperature on tape surface with different power applied.

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