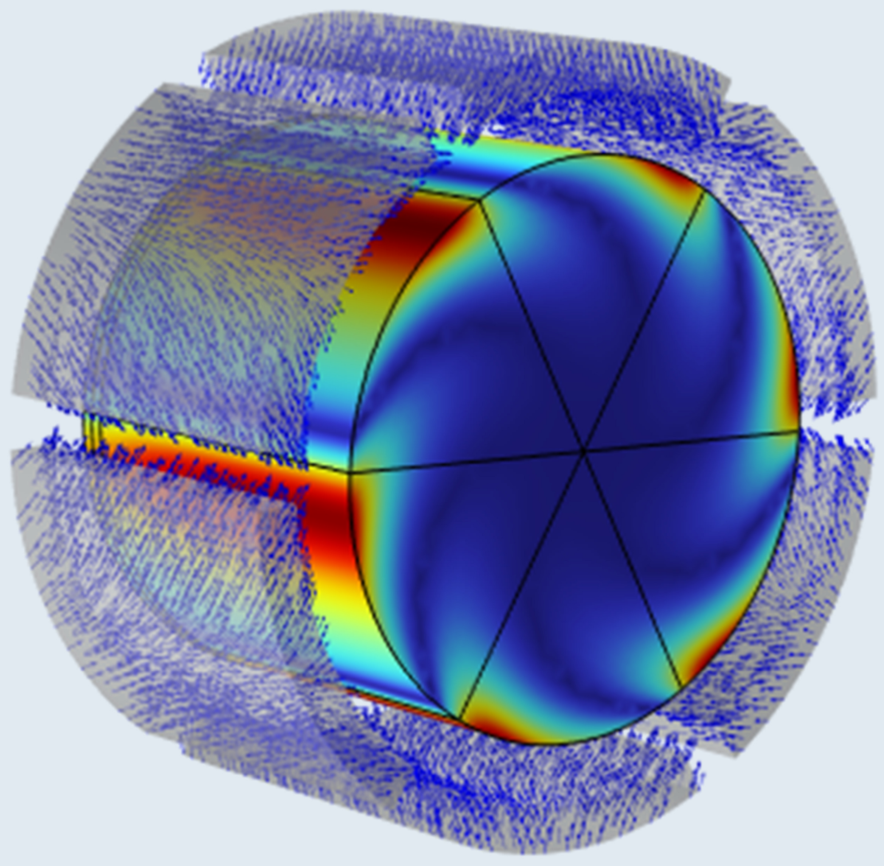

Rotating Permanent Magnet Heater for Aluminum Billet

How to model thermal transient in Aluminum billets with an automated form, combining electromagnetic and thermal simulations.

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Introduction & Goals

The rotating permanent magnet heater is a high efficient system for the electromagnetic heating of Aluminum billet before the extrusion process. The technology proposed by Inova Lab consists to clamp an Aluminum billet inside a rotating system of permanent magnets. This solution, in comparison with gas or induction heating technologies, allows to achieve an efficiency about 30% higher than traditional ones and a best temperature profile along the billet axis, splitting the rotor machine in several modules which rotate at different speed in opposite direction to reduce the braking electromagnetic torque generated in the Aluminum billet during the operations.

In this work modeling the system with COMSOL Multiphysics® from the electromagnetic and thermal point of view, is explained. The aim of work is to simulate the thermal transient in Aluminum billets for different rotation speed of permanent magnets.

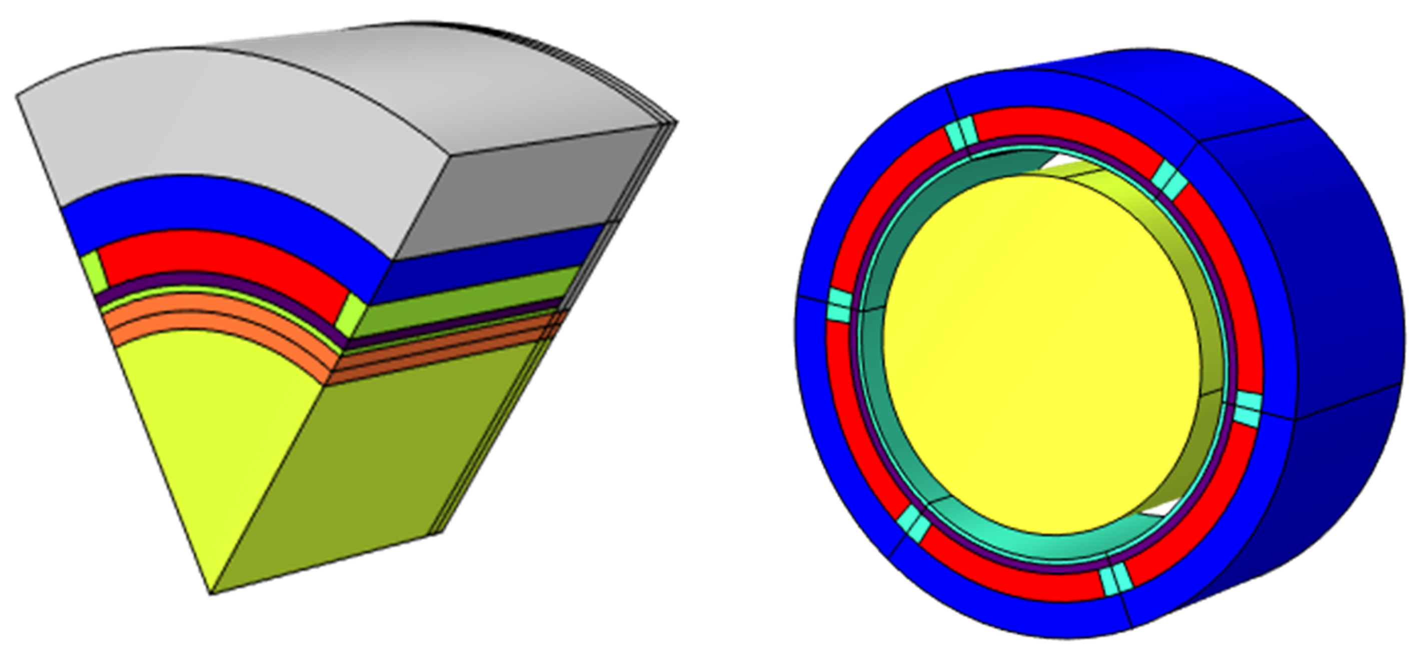

FIGURE 1 Left: geometry of magnetic pole, red magnet, blue back iron, yellow billet, orange airgap, black thermal insulator. Right: complete geometry of a magnetic rotor

Methodology

One magnetic pole of rotor is modeled in 3D to consider the end effect of machine. To calculate the electromagnetic losses in the billet a study with magnetic time depend solution is done in function of rotation speed. At the end of EM time-dependent solution, time-to frequency-losses are calculated to carry out the average losses in an electrical period which are the input of time-dependent thermal analysis.

The complete solution of thermal transient is carried out through an automatic form realized by the Application Builder composed by 5 concatenated study: 2 electromagnetic and 3 thermal.

Results

The automated method to simulate the complete heating thermal transient of Aluminum billets is done with a custom-made form. Figure 2 shows: the result of the electromagnetic problem: the instantaneous electromagnetic losses due to the rotation of permanent magnets and the average losses calculated in an electrical period. Figure2 also shows thermal analysis result: the final temperature inside the Aluminum billet at the end of thermal transient, and the temperature evolution in the axis of the billet and in the external surface of the billet. The transient is divided in three parts: the first one with high rotation speed (high power) a second one with lower rotation speed (low power) and the third one with no rotation of PM (no power, free evolution of temperature).

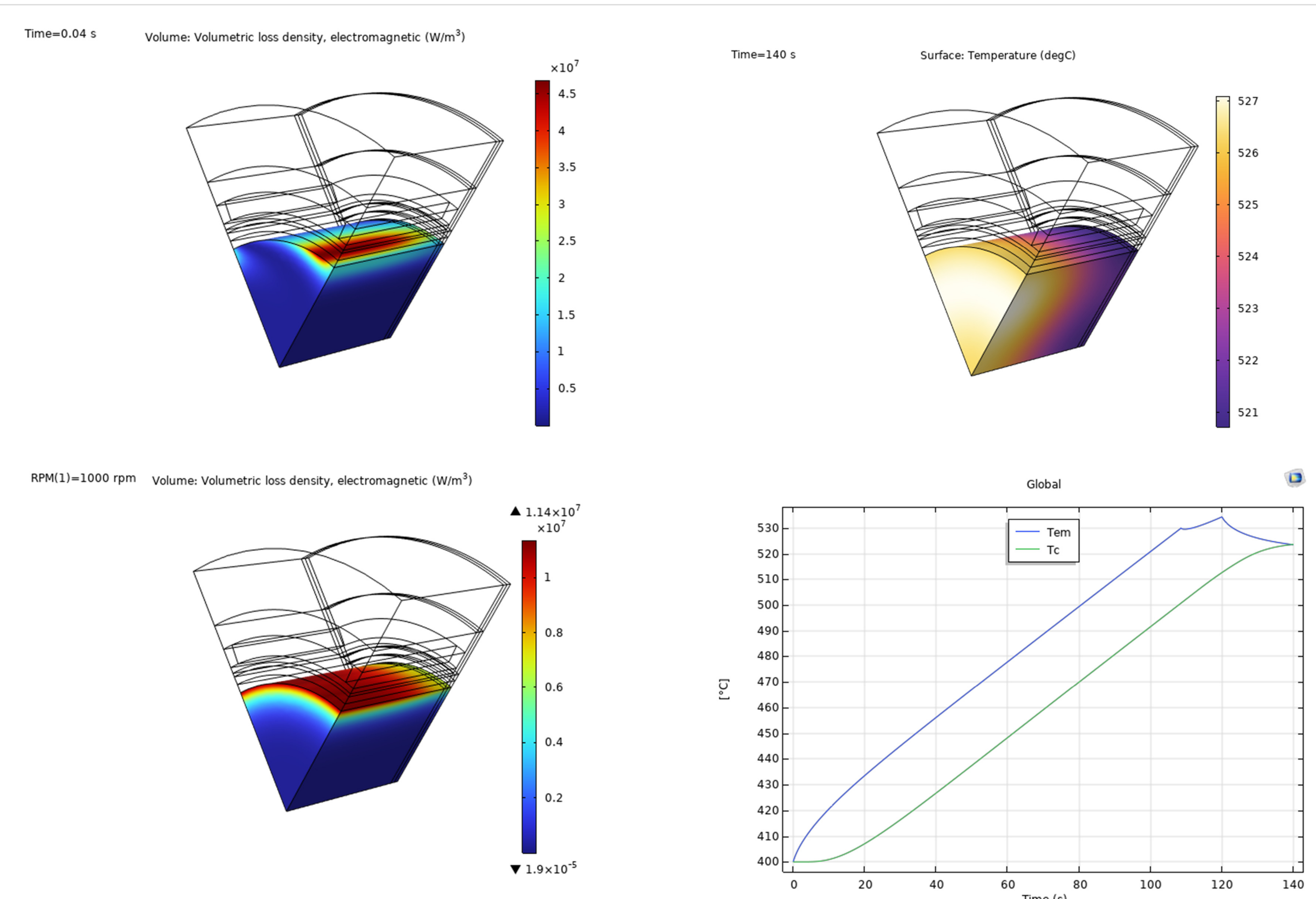

FIGURE 2 Left instantaneous EM losses and average EM losses. Right: final temperature distribution and total transient thermal result evolution.

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