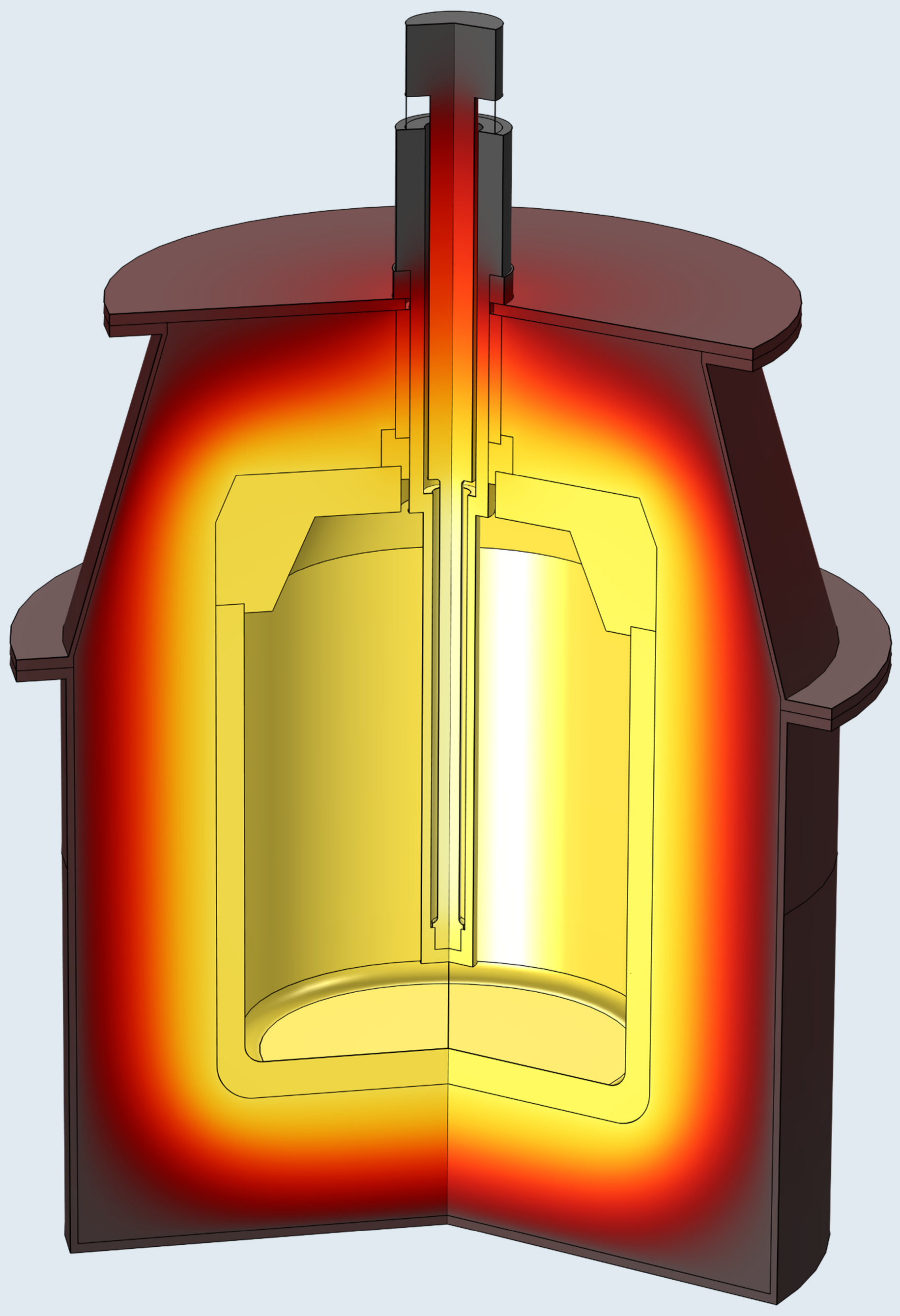

# Modelling of the Ladle Furnace Preheating with a Graphite Heating Rod

Simulation of the ladle furnace preheating in the framework of the SisAl Pilot EU project. The goal of the work is to tune unknown material properties by fitting experimental temperature curves.

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## Introduction & Goals

This work is done in the framework of the SisAl Pilot EU project, which is focused on demonstrating the possibility of metallurgical grade silicon production at pilot scale based on aluminothermic reduction of silica. In comparison with the traditional carbothermic reduction of silica, the advantage of the proposed technology is in its low CO2 emission. As part of the project, the numerical modelling support of experimental works is stipulated. Development of a numerical model of ladle furnace preheating and its validation against experimental data makes possible predictive simulations and an efficient development and testing of new furnace designs. The present work is focused on modelling of preheating of an existing ladle furnace with a graphite heating rod used as a resistive element powered by a DC electric current. The aim is to tune unknown model parameters, especially properties of the porous graphite (ref. 1-3), to improve the model's predictive ability.

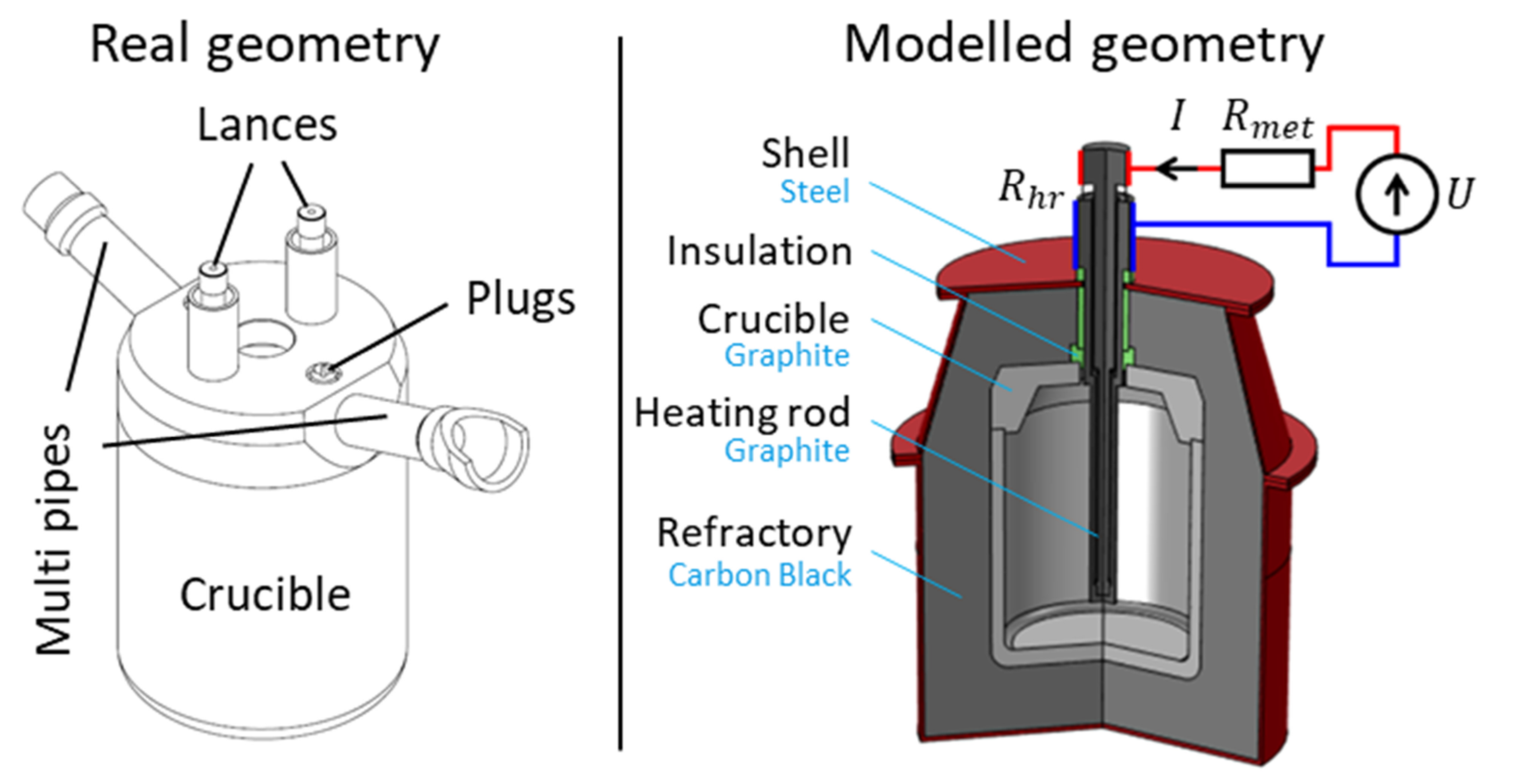


FIGURE 1. Real and modelled furnace geometry. $R_{met}$ is the metal wires resistance, $R_{hr}$ is the heating rod resistance, $U$ is the measured voltage.

## Methodology

An assumption of axial symmetry reduces the problem dimensionality: graphite lances, plugs and multi pipes are not modelled. The following physics interfaces are employed: Heat Transfer in Solids and Fluids with convectively enhanced gas conductivity, Surface-to-Surface Radiation, and Electric Currents to simulate the Joule effect in electrically conducting materials. All interfaces are coupled via temperature-dependent material properties. To simplify the adjustment of graphite properties, they are assumed to be functions of only temperature and material's porosity. The heat losses towards outside include the thermal radiation, the external natural convection, water cooled terminals of the heating rod, and the heat loss due to inert gas purging through an empty crucible.

## Results

The proposed numerical model has successfully simulated the ladle furnace preheating. The work is validated against experimental data: the tuning of model and material parameters has resulted in a satisfactory fitting of experimental curves. The following values of adjustable parameters are found to be optimal: porosity of the heating rod graphite is 8%, porosity of the crucible graphite is 0%, and the heat transfer coefficient on the heating rod terminals is infinite, i.e. ambient temperature is imposed on the terminals. The adjusted graphite properties are ready to be exploited in the next stage of the SisAl Pilot project, which is focused on the numerical analysis of new furnace designs.

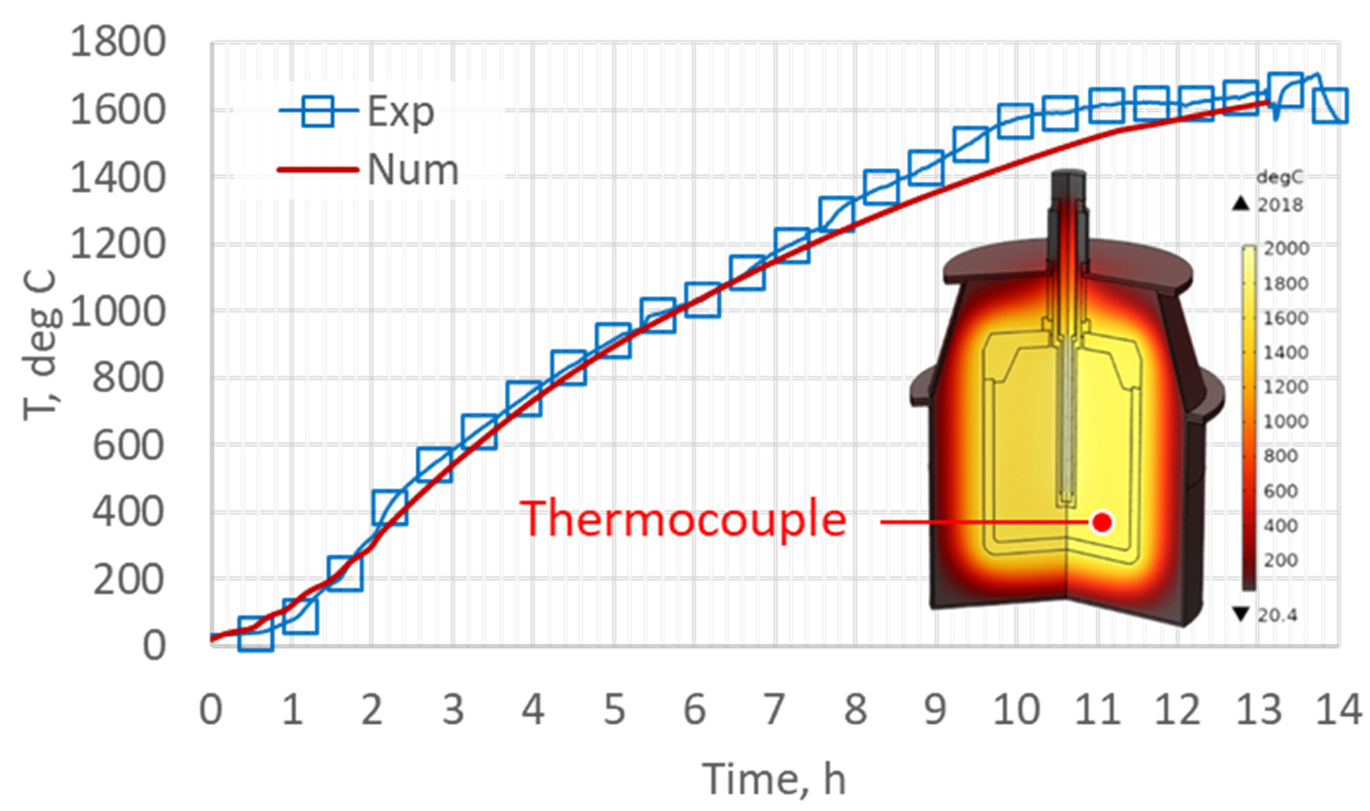


FIGURE 2. Numerical and experimental temperatures at the position of a thermocouple.

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