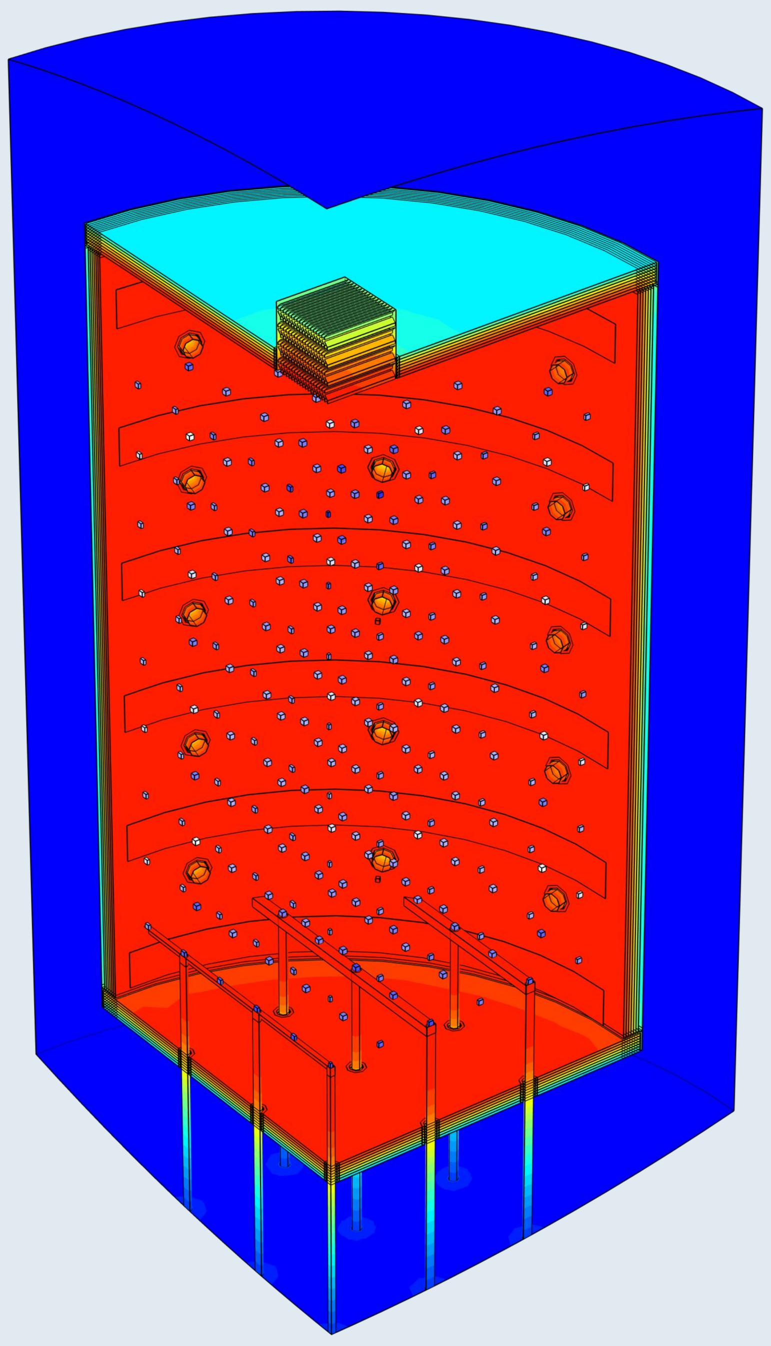

Multi-Physical Simulation Based Analysis of Temperature Homogeneity in Vertical High Temperature Vacuum Furnaces

Multi-physical thermo-electric models are a valuable tool for the optimization of high temperature vacuum furnaces and the evaluation of new design concepts.

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Abstract

In the development of refractory metal **hot zones for high temperature vacuum furnaces** at PLANSEE SE a multi-physical model was developed for a detailed analysis of the influence of different **heater configurations** and gas system concepts on achievable **temperature homogeneity** and **power consumption**. The thermo-electric model allows a more accurate evaluation of temperature homogeneity than the current standard measurement procedure. The simulation results show that temperature homogeneity of vertical high temperature vacuum furnaces can be significantly improved by additional top and bottom heaters. However, comparable temperature homogeneity can be achieved with the so-called **“FlowBox”-concept** developed at PLANSEE SE, without additional heaters at a significantly reduced power consumption.

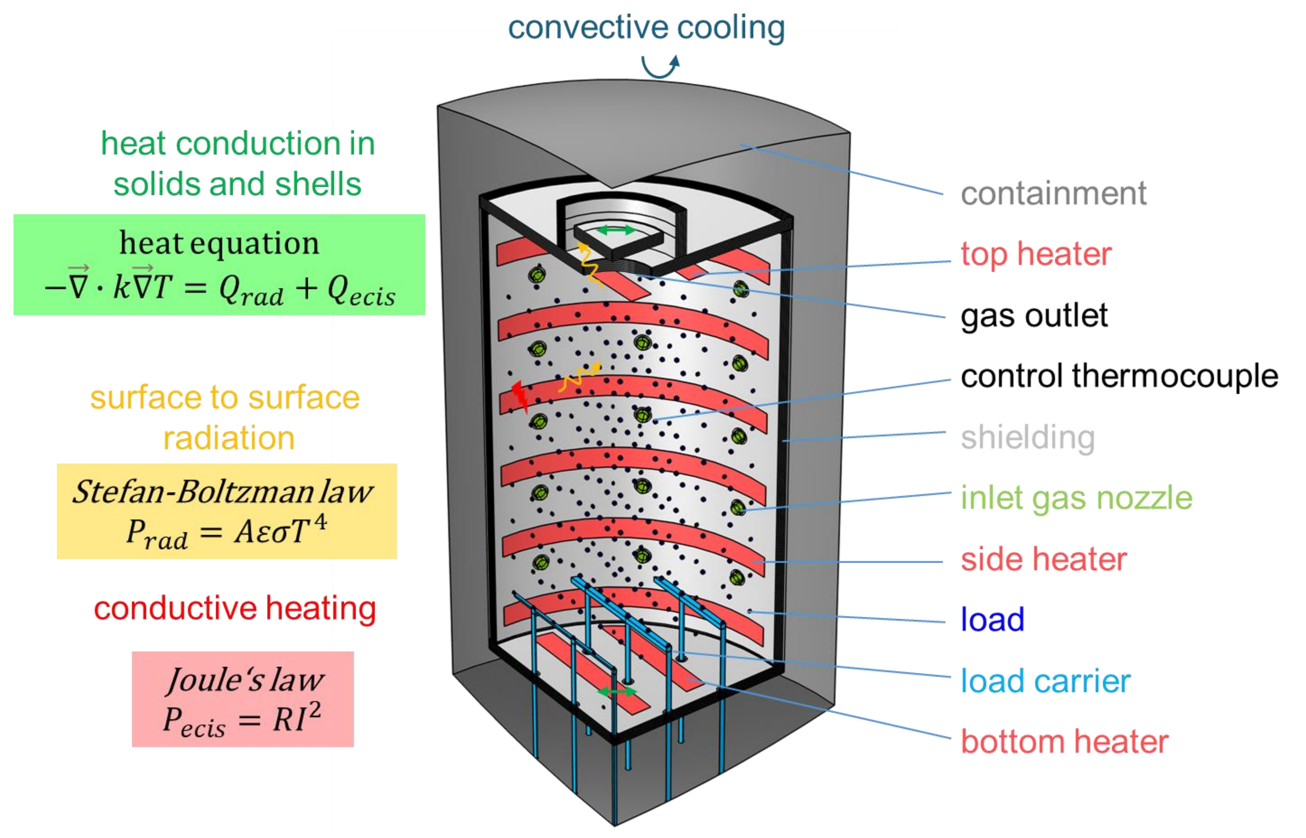

FIGURE 1. Multi-physical thermo-electric model of vertical high temperature vacuum furnace: geometry and included physics.

Numerical Model

The 3D stationary thermo-electric model uses the heat transfer and AC/DC module of Comsol Multiphysics. It considers electric heating, heat transfer and surface to surface radiation. Thin sheet structures are modelled as shells. The geometry of the furnace (FIGURE 1) is built of fully parametrized parts. Symmetry in two orthogonal vertical planes is taken into account. Physics and mesh are controlled by selections. A Java-method is used to activate physics for optional components in a parameter sweep. The electric current in the heaters of each heating zone is controlled by the temperature of an associated control thermocouple using global equations.

Simulation Results

The simulation results demonstrate the limitations of the Temperature Uniformity Survey (TUS) measurement procedure (Ref. 1) with a generally limited number of thermocouples for an objective evaluation of temperature homogeneity of high temperature furnaces. I.e. cold and hot spots in the load volume cannot be reliably detected with the limited amount of measurement points. Additional top and bottom heaters can help to reduce the cold spots induced by load carrier and top gas outlet, however at the price of an increased power consumption. Comparable temperature homogeneity can be achieved with the “FlowBox”-concept (Ref. 2), a gas permeable multi-layer structure shielding thermal radiation developed at PLANSEE SE, without additional heaters at a significantly reduced power consumption (see FIGURE 2).

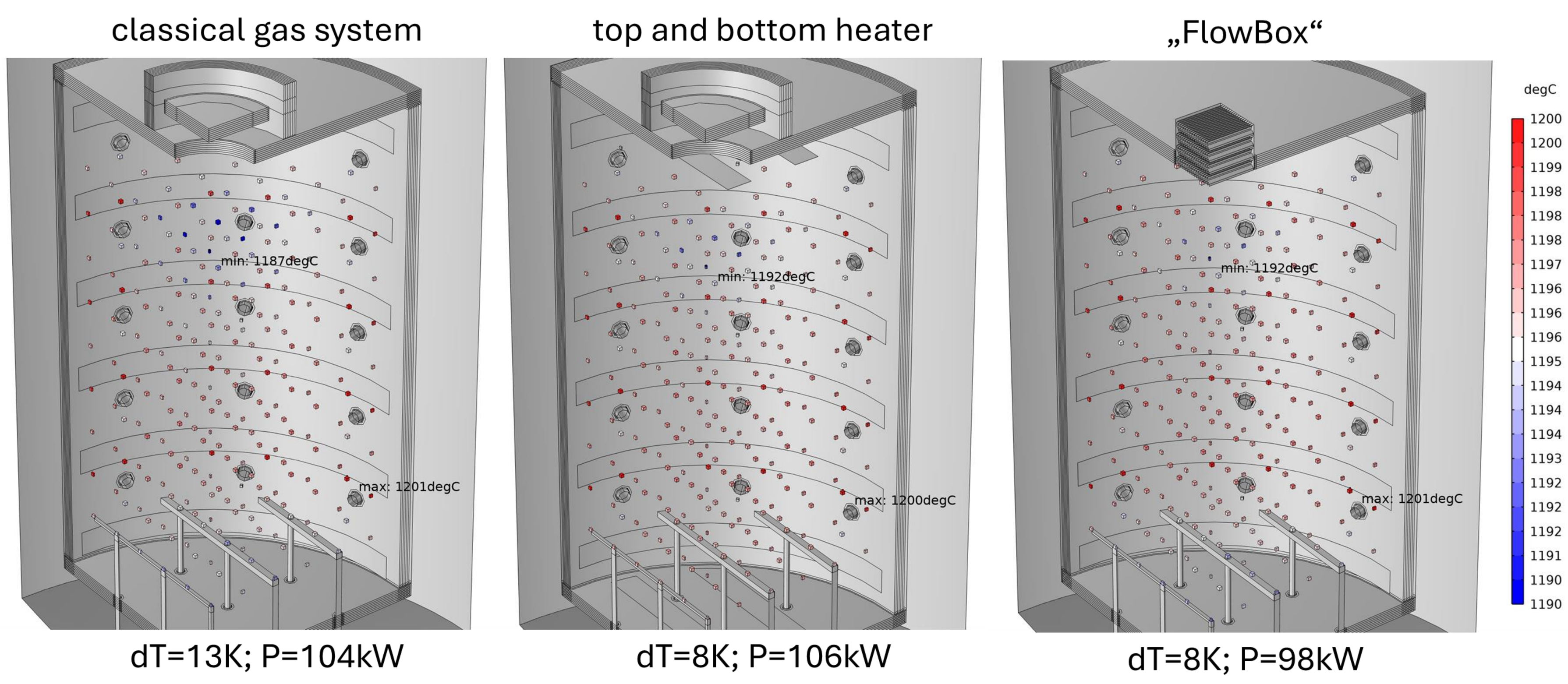

FIGURE 2. Temperature homogeneity dT and power consumption P of a high temperature vacuum furnace for different heating and gas system configurations.

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