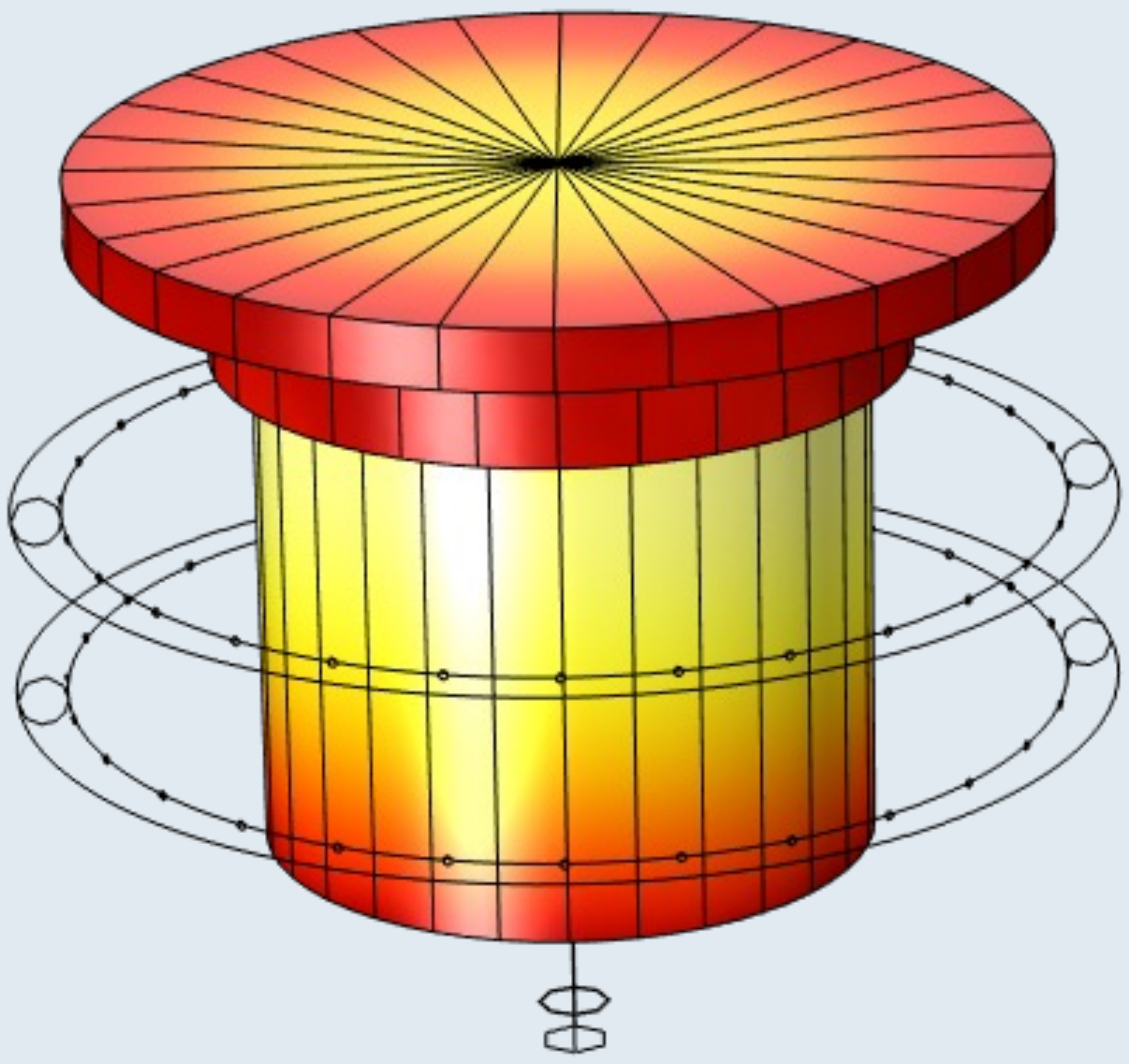

Simulation of a Bimetallic Alloy Cooling Process

Reduce shrinkage, porosity and cracks in bimetallic alloys by optimization of the cooling process

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Abstract

We present a 3D COMSOL Multiphysics® simulation model of a bimetallic Tokat-steel alloy cooling process. The phase change in the Tokat and the thermal radiation are considered. The residual stresses are computed with an elastoplastic material model. The level of shrinkage is estimated by the implementation of the Niyama criterion. The simulations allow to track the solid fraction and the solidification front, and to understand the cooling fluid flow distribution around the cooled part. The simulation results with COMSOL Multiphysics® are compared with experimental measurements of the temperature evolution at some points of the system.

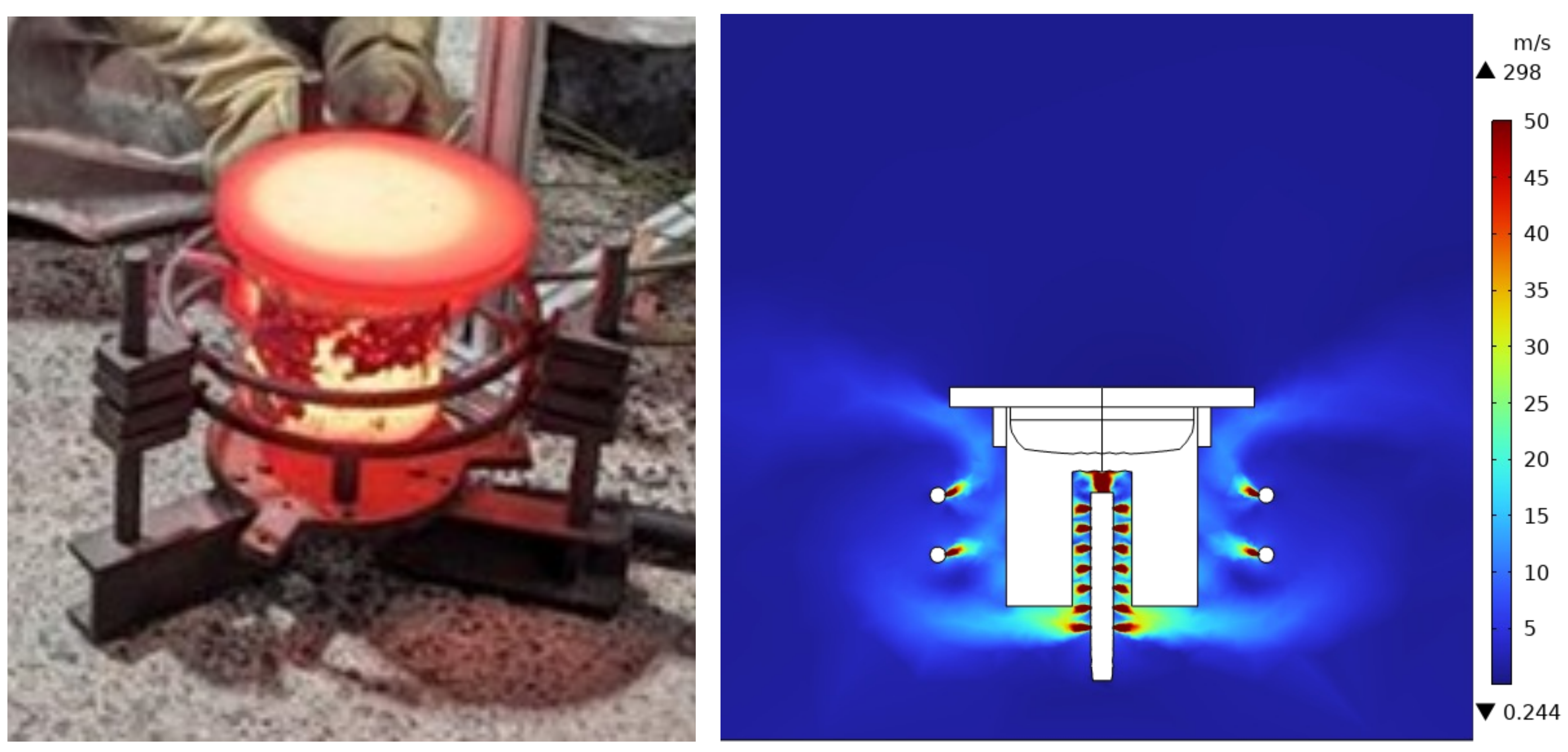

FIGURE 1. Left: The system to be cooled on the cooling station having two cooling rings and one central cooling tube with holes. Right: Distribution of the cooling air flow around the cooled system computed with Comsol Multiphysics.

Methodology

1. Natural Cooling: computation of the temperature field everywhere while the part is moved from the furnace to the cooling station.
2. Flow Field: computation of the quasi-stationary cooling air velocity distribution under the temperature field calculated at the end of natural cooling.
3. Forced Cooling: computation of the temperature field everywhere under the convective flow field.
4. Thermomechanics: computation of the residual stresses using the calculated temperature distribution.

Results

COMSOL Multiphysics® allowed to model the Kugler Bimetal process of cooling of bimetallic alloys. It was possible to couple three physics where we included user definitions of materials coming from laboratory characterization. The model we made gives coherent results in comparison with experiments. However, experiments were made in situ in the factory under real production conditions. This makes the comparisons more difficult because the factory environment cannot be fully controlled.

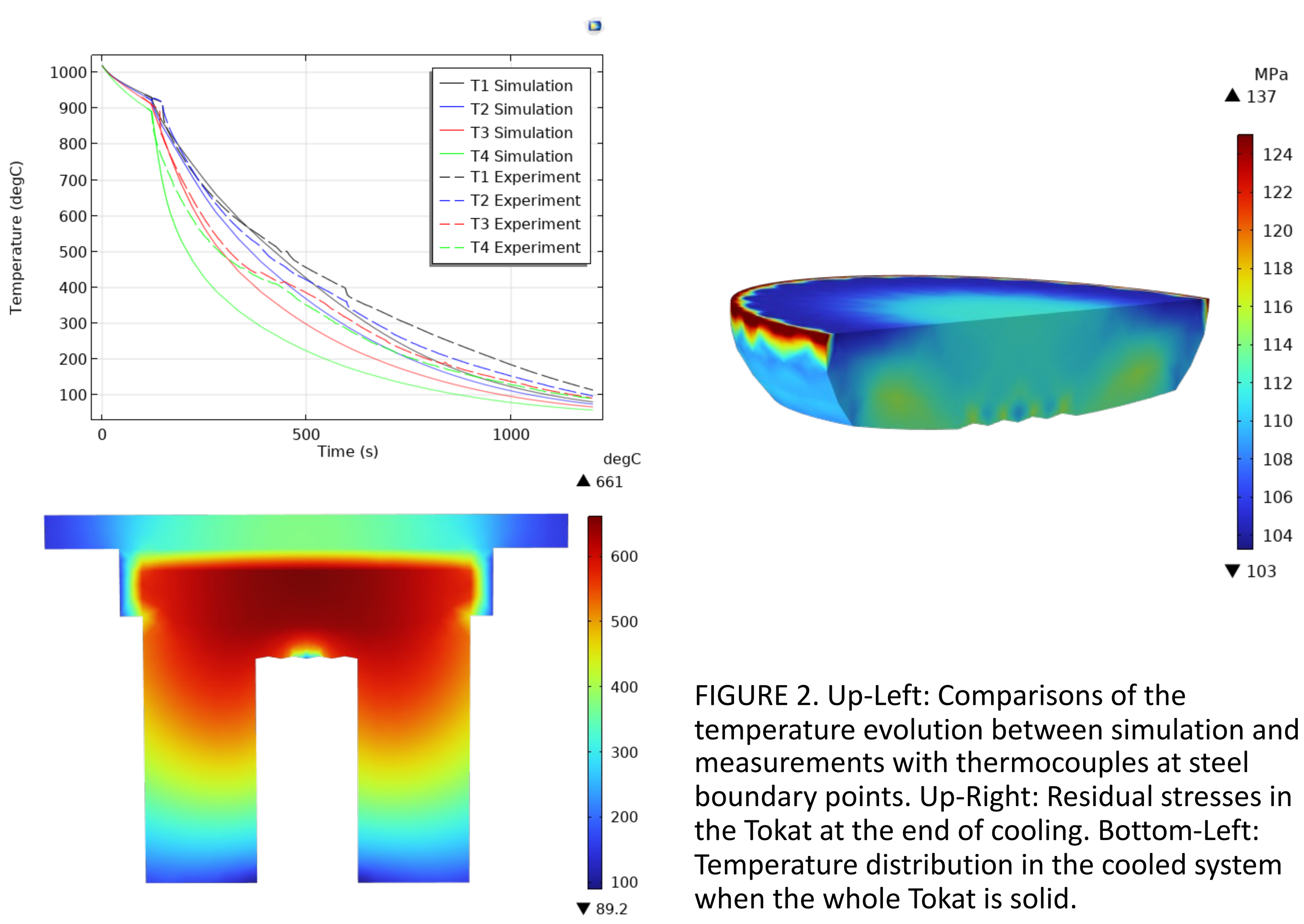

FIGURE 2. Up-Left: Comparisons of the temperature evolution between simulation and measurements with thermocouples at steel boundary points. Up-Right: Residual stresses in the Tokat at the end of cooling. Bottom-Left: Temperature distribution in the cooled system when the whole Tokat is solid.

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