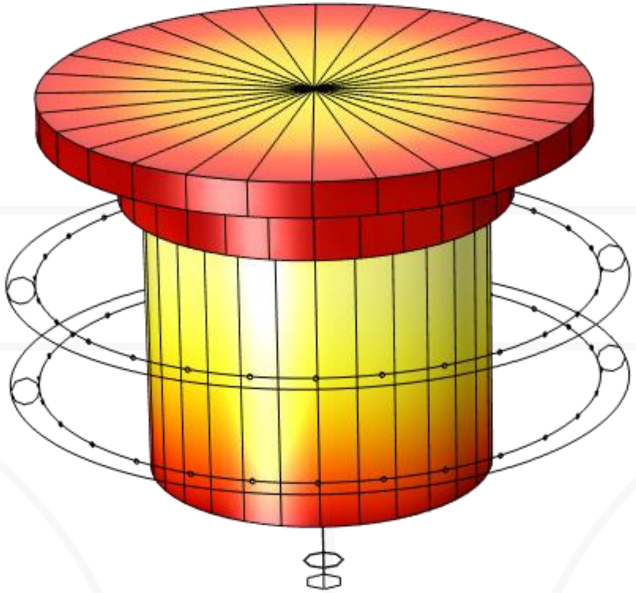

Simulation of a Bimetallic Alloy Cooling Process

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Introduction

- The Project

- Numerical Modelling of an Industrial Process for Bimetallic Alloy Casting (MIPBAC)

- Innosuisse Project (Swiss Innovation Agency, Bern-CH, ref. 102.365)

- Goals

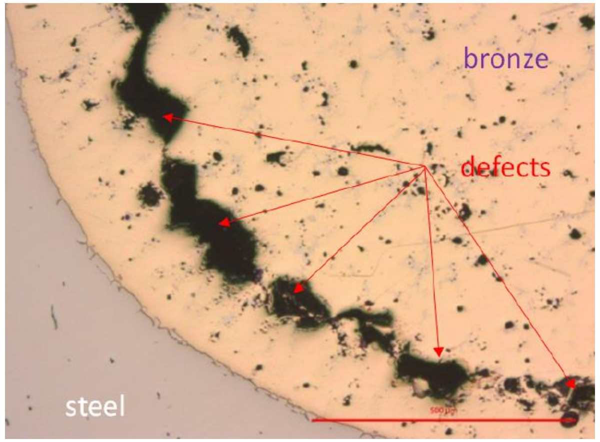
- Reduce shrinkage, porosity and cracks in bimetallic alloys (Steel-Tokat) by optimization of the cooling process

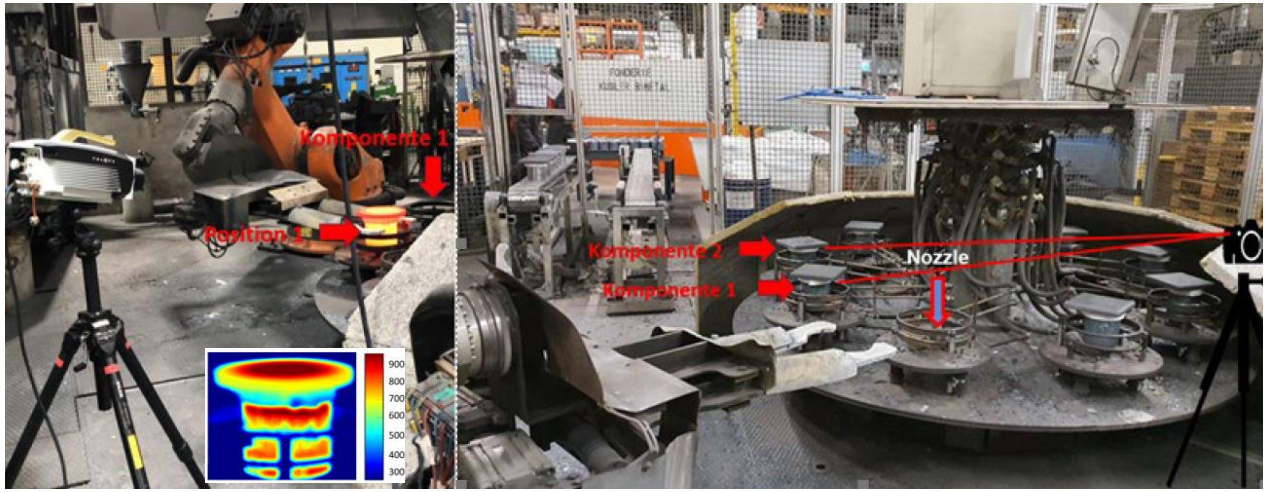
- Challenges

- Modeling the process with COMSOL Multiphysics

- Material characterization

- Experimental validations





Methods and Use of COMSOL Multiphysics

COMSOL

- Use of Modeling

- High temperature (1020°C), the complexity of the process and the factory environment make difficult fine-tuning

- Time and money costs

- Physical Parameters

- Tokat and Steel properties were characterized in laboratory

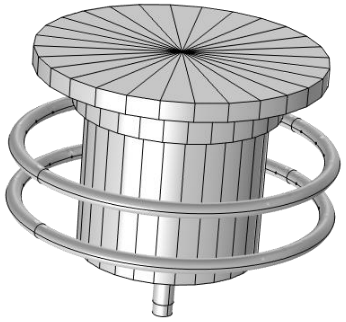
- Use of COMSOL Multiphysics

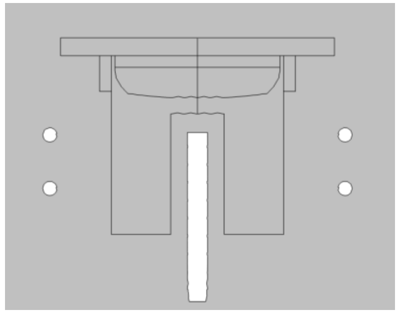
- Heat Transfer, CFD and Structural Mechanics modules were used

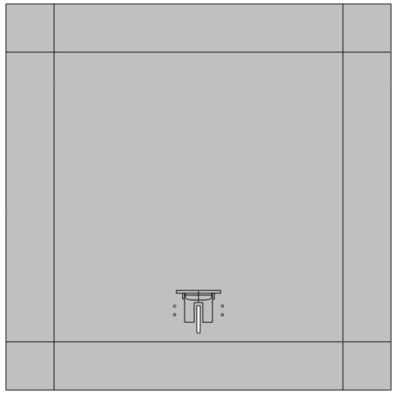
- Time dependent simulations

- Methodology

- Segregated Coupling







1. Natural Cooling – Phase Change (Air + Parts)

$$\rho C_p \frac{\partial T}{\partial t} + \rho C_p \boldsymbol{u} \cdot \nabla T - \nabla \cdot (-k \nabla T) = 0$$

2. Flow Field – Turbulent k-ε (Air)

$$\rho_a \frac{\partial \boldsymbol{u}}{\partial t} + \rho_a (\boldsymbol{u} \cdot \nabla)\boldsymbol{u} = -\nabla \cdot (p_a \boldsymbol{I} + \boldsymbol{K}) + \rho_a \boldsymbol{g}$$

3. Forced Cooling – Phase Change (Air + Parts)

$$\rho C_p \frac{\partial T}{\partial t} + \rho C_p \boldsymbol{u} \cdot \nabla T - \nabla \cdot (-k \nabla T) = 0$$

4. Thermomechanics – Thermal Expansion (Parts)

$$\rho \frac{\partial^2 \boldsymbol{u}}{\partial t^2} = \nabla \cdot (\boldsymbol{FS})^{\mathrm{T}} + \boldsymbol{F}_v, \boldsymbol{\varepsilon}_{th} = \alpha\left(T - T_{ref}\right)\boldsymbol{I}$$

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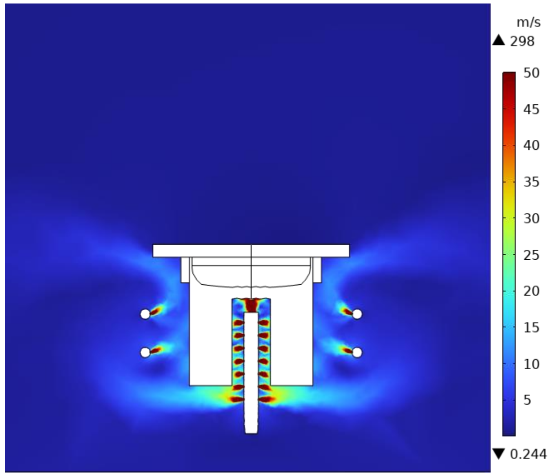
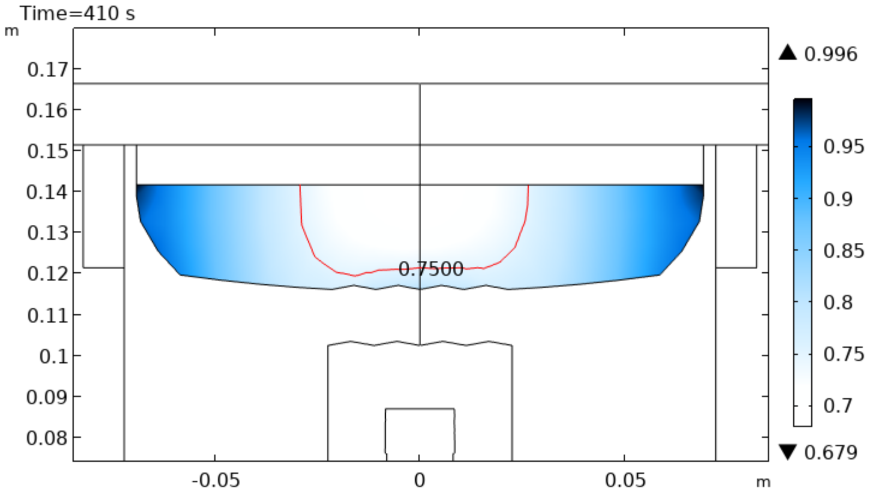
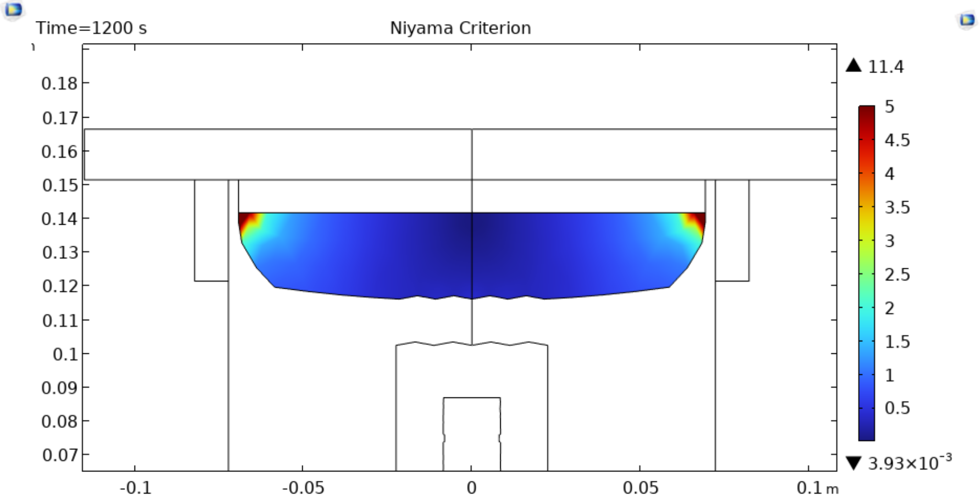
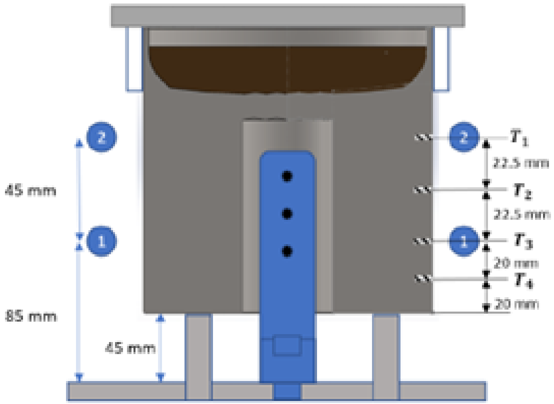
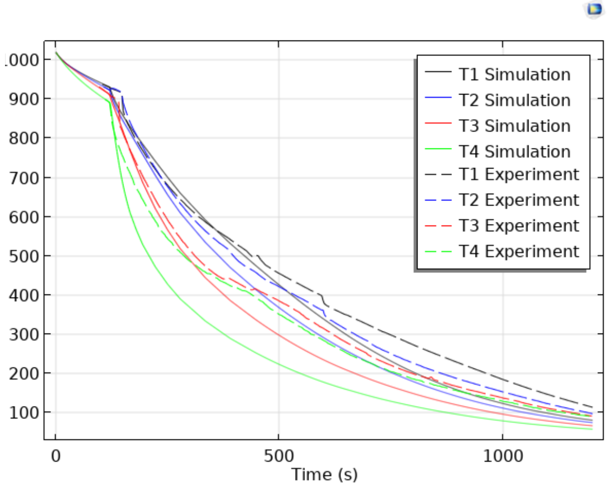
Results

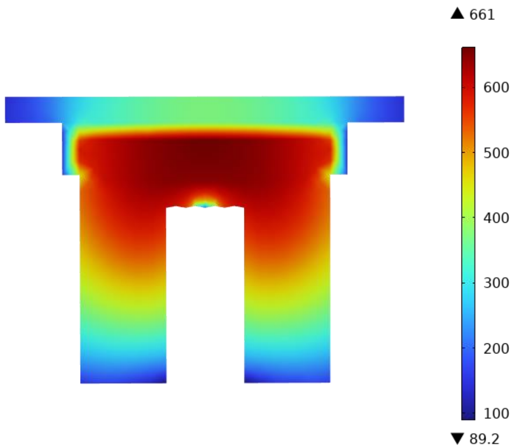


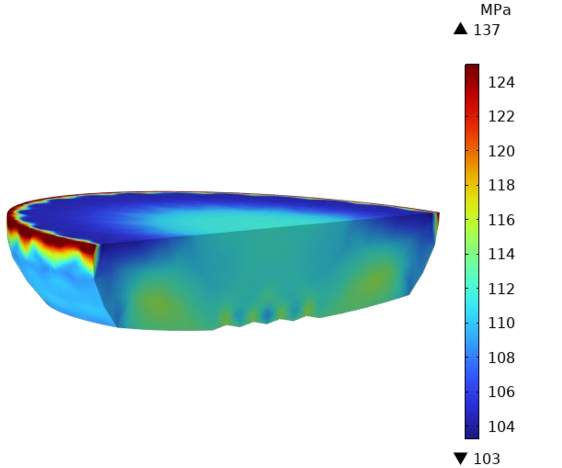












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Conclusions

- COMSOL Multiphysics

Right tool for the simulation of the cooling process :

- Easy setup of the material user data
- Easy setup to couple physics
- Efficient postprocessing tools

- Simulation Results

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.

- Impact of Simulation Results

- Validation of the current process
- Sensitivity on cooling air flow (stability)
- Effect of the oxydation of the steel
- Potential effect of steel plastic residual déformations
- Design of an improved cooling system