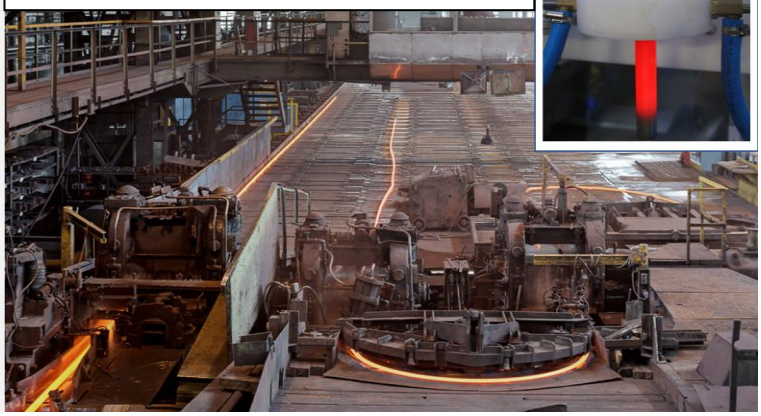
SUCCESS STORY

IC-MPPE / Integrated Computational Materials Process and Product Engineering

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Centre (K2)

Project P3.7
"InductionHeatTreatment"
Multi-firm project
(2017-2021)



Bottom: Steel rolling at Stahl Judenburg; (by Viktor Mácha / viktormacha.com)
Top right: induction hardening test setup at MCL, image: MCL

IMPROVING THE PROCESS CONTROL OF INDUCTION HARDENING

EXPERIMENTAL AND NUMERICAL MODELLING OF THE INDUCTION HARDENING PROCESS SHALL ENABLE A BETTER CONTROL OF THE FINAL PRODUCT QUALITY

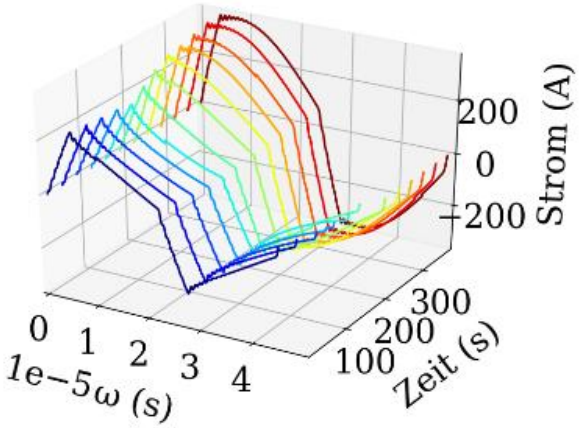
Induction heating is commonly applied for industrial heat treatments, mainly for surface but in some cases also for through volume hardening of steel products. While existing processes are to a certain degree repeatable, cost efficient and quick, difficulties arise with varying material chemistries and new geometries.

Computer based modelling of the process provides means to tackle these problems and to broaden the understanding of the complex interactions between process data, material properties and temperature evolution in this multi-physical process. However, the computer models themselves rely on measurements that on the one hand provide input data (like process conditions and physical properties) for the models and on the other hand means to validate the simulation results (like the achieved hardness and stress distribution).

To deliver the necessary process data, an induction test rig has been set up at the Materials Center Leoben Forschung GmbH (MCL) (small picture above) that mimics the process control of a real production setup and enables the variation of the production parameters on a small piece in the laboratory. In collaboration with the industrial partner Stahl Judenburg, the process control and the resulting outputs were analyzed both in the lab and in the real production setup.

The data from the various induction furnaces show that the signal shape of inductor current commonly deviates from a simple sinusoidal signal. The

deviation has been described mathematically and can and be now used in multi-physics simulations of induction hardening, where simplifications of the reality are made to ensure feasibly model sizes. The decision on which simplifications are admissible are based on the actual process data of the simulated induction furnace. Furnaces with inductor currents following closely a sinusoidal signal can be described with a simple time harmonic representation of the induction process transferring energy from the current bearing inductor to the heated component within the inductor.



Change of signal shape of inductor current with time, i.e. sample temperature. Image: MCL

More complex signals entail computationally more expensive mathematical representations. Having proper measurement techniques at hand the simulations can be used to investigate correlations of other quantities in the multi-physical system that cannot be measured directly. An example is the interrelation between chemistry dependent electromagnetic properties and heat generation within the component. This knowledge can be used to adapt and optimize industrial processes leading to more efficient processes as well as shorter ramp-up times for new materials and geometries

Impact and effects

The measurement technique along with simulation models are the basis for advanced characterization techniques of temperature dependent material properties such as magnetic properties.

The developed numerical and experimental techniques open the door for online materials characterization in industrial context. Consequently, the improved models will be used to improve the on-line control of the production process.

Project coordination (Story)
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- Robert Bosch GmbH, Germany
- Engineering Center Steyr GmbH & Co KG, Austria
- BMW Motoren GmbH, Austria
- Technical University Vienna, Austria
- Montanuniversität Leoben, Austria
- Materials Center Leoben Forschung GmbH, Austria

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