

## **Numerical Simulation Tools and Methods used at the Institute of Electrotechnology**

**B. Nacke<sup>1</sup>, E. Baake<sup>1</sup>**

Numerical simulation methods are the tools necessary for analysis, design and optimization of the mostly complex Electrotechnology processes. The Institute of Electrotechnology (ETP) at Leibniz University of Hannover have been developing and using these numerical tools for many years. The presentation gives an overview of the different fields of application and the main features of numerical simulation tools used at ETP. It also shows the challenges of numerical simulations in the future.

An important field of applications is the simulation of fluid flows in liquid metals. Modern LES simulation methods in combination with electromagnetic field codes are used in order to realize the simulation of three-dimensional turbulent liquid metal flows for industrial size melting or holding installations. These methods have lately been adapted and developed also for non-metallic melts like melts of oxides and glasses.

The second large field of application is the simulation of the coupled nonlinear electromagnetic-thermal field for induction or conduction heating applications. The typical application areas are the induction heating for forging, strip heating for direct casting or coating lines and induction surface hardening. Just in the last area, the strong non-linear behaviour of magnetic steel properties requires a very accurate time dependent thermal simulation. The three-dimensional models increasingly are used due to the increasing complexity of the work-pieces.

During the last years special methods and tools have been developed at ETP for the optimal design of Electrotechnology processes and systems. These tools rely on using the method of mathematical optimization in combination with numerical simulation tools in order to find the optimal design and process parameters for complex systems. The presentation shows different applications of mathematical optimization.

The future challenges for numerical simulation at ETP are faster simulation of complex turbulent electromagnetic flow fields, coupled electromagnetic and flow calculation taking into account the melt free surface, simulation of melt flows including the crystallization or solidification processes at the solid-liquid interfaces, simulation of three-dimensional coupled electromagnetic-thermal processes with consideration of the field and temperature-dependent permeability and mechanical stress calculation during and after cooling of work-pieces, for example, in cases of surface hardening.

<sup>1</sup>Institute for Electrothermal Processes, Leibniz University of Hannover, Wilhem-Busch-Str.4, D-30167 Hannover, Germany