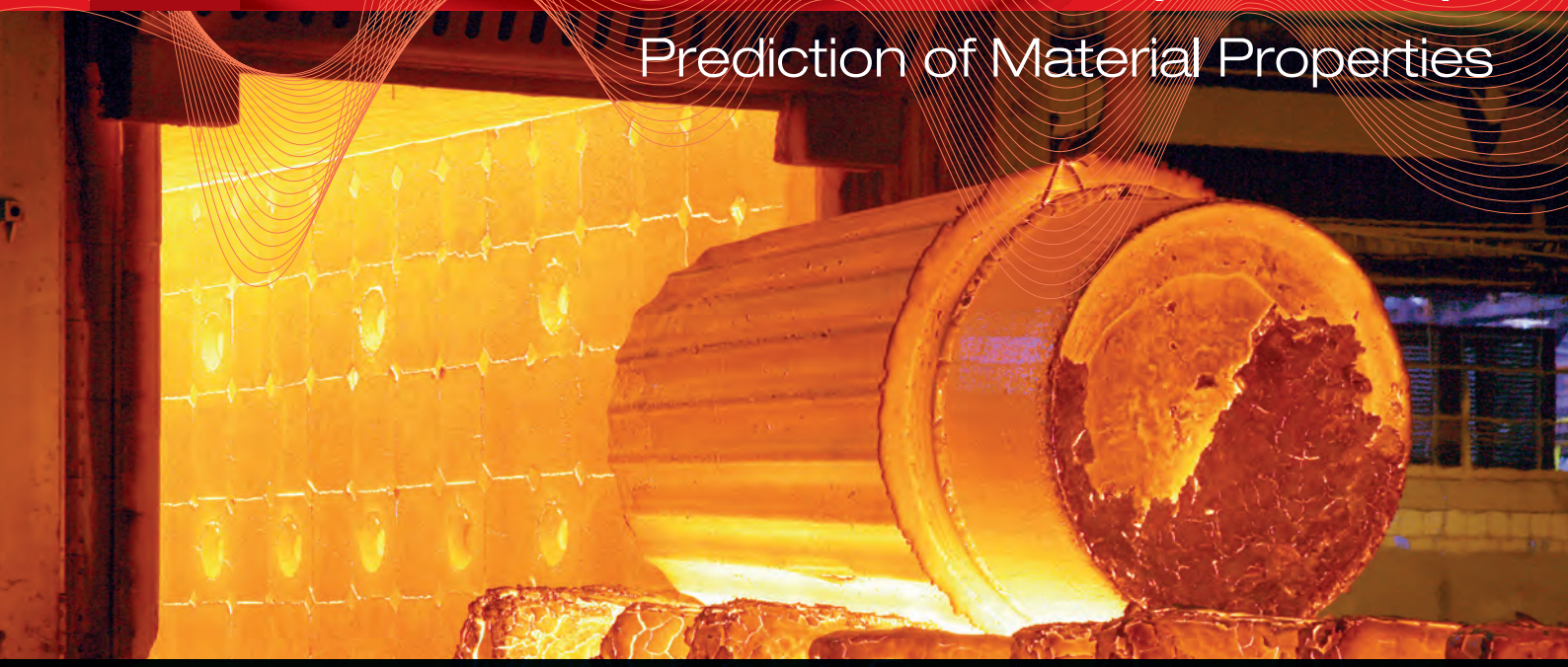
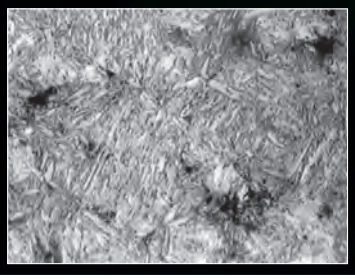
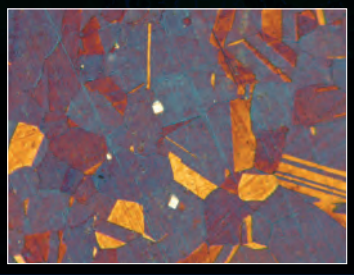
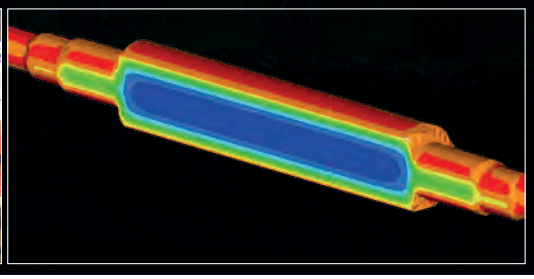
simufact.premap

Prediction of Material Properties









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Prediction of Material Properties

Correct material selection is essential to create high quality products of sophisticated complexity. The material by itself will however rarely be able to provide the component properties required by the customer. The suitable manufacturing strategy and a high-level modern heat treatment are necessary as well. Only with this combination the requested quality can be reached, while guaranteeing resource protection within the shortest possible development time.
Nowadays, these requirements cannot be met without the use of modern simulation tools for process design and optimization. Simufact.premap is a tool at hand for all practitioners and scientists involved in comprehensive heat treatment and microstructure simulations. Being the complementary solution to Simufact.forming and Simufact.welding, it completes the product range for continuous process chain simulations in the manufacturing surroundings of Simufact Engineering GmbH.

Comprehensive process realization – a matter of course

Simufact.premap enables you to simulate all stages of a heat treatment process, including heating, holding, quenching, but also targeted cooling and tempering. During the heating process, grain growth and grain size can already be predicted. Then, austenization can be determined by calculating the phase transformation during the holding stage. In the cooling phase, all technically relevant processes can be represented virtually. A wide range of cooling rates can be analyzed up to quenching resulting in Martensite structures. After a final tempering, the properties of the stress relieved Martensite structures are available as a simulation result.

Very different heating and cooling processes can be modeled:

- conductive heating in furnace
- interface for heating simulation of furnace vendors (e. g. Thermprof developed by ABP Induction)
- inductive heating
- cooling in static air or in jet stream
- cooling in water bath or oil bath, but also in water jet
- a combination of the above, e.g. by plunging a product from the air into a medium
- global as well as partial product heating and cooling can be simulated

simufact Simulating Manufacturing

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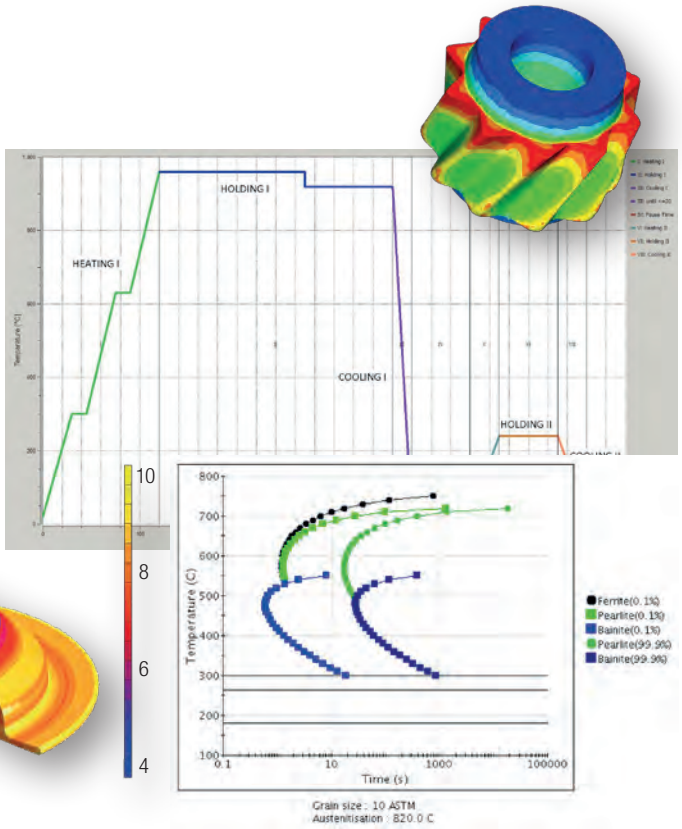


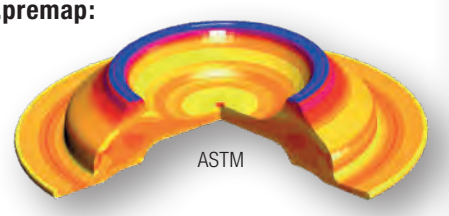
All currently well-established hardening mechanisms are supported: Martensitic hardening of steel, but also precipitation hardening for Aluminium or AFP-steels. Case hardening based on diffusion, such as carbonizing, nitrating and carbo-nitrating, is also supported. Simufact.premap`s scope of work is rounded off by representing normalization and homogenization as well as by simulating the Jominy Test.

Material parameters – the key to a realistic heat treatment simulation

Material data depend on many parameters. In Simufact.premap, material data are used depending on many physical state variables. For example, the material characteristics are dependent on chemical composition, phase composition, grain size and temperature. Moreover, the yield stress depends on the true strain and the strain rate.

Available material data in Simufact.premap:

- young´s modulus
- thermal expansion (coefficient)
- thermal conductivity
- posson´s ratio
- density
- yield stress



In case of multiple phase structures the material parameters are calculated using the fractions of the individual phases. The calculation is based on isothermal transformation diagrams (TTT-diagrams) and continuous cooling diagrams (CCT). The detected phases are Austenite, Martensite, Bainite, Pearlite and Ferrite.
The correct determination of a parameter requires a precise, process-dependent temperature representation. In this sense, the external heat transfer to the environment or to the tools is calculated as well as the internal temperature evolution which results from conductivity, plastic deformation, specific heat capacity and the latent heat.
A realistic mechanical material characterization is ensured by considering the changes in volume. This may result from thermal expansion (whereby Simufact.premap also considers latent heat) but also from grid conversion of e.g. a face-centered cubic grid into a body-centered cubic grid.
In the context of simulating a process chain, the material parameters are continuously adjusting to the evolving material properties. To undertake a sensitivity analysis of the parameters it is possible to create data sets using the upper and lower bound of the chemical composition.

Simulation results can evaluate the quality of a process

To review a product and the corresponding manufacturing processes, the developer can use a variety of results.
In order to describe the microstructure, phases and phase composition of Martensite, Bainite, Pearlite, Ferrite and residual Austenite are displayed. Grain size can be displayed as a result of grain growth in micrometers or ASTM, with or without dynamic and static recrystallization. In case hardening, penetration depth of carbon and nitrite can be analyzed.

After a simulation, many relevant mechanical process parameters are available: hardness, yield strength, tensile stress, proof stress. Further physical quantities important to evaluate the performance characteristics of a structure will gradually be integrated into Simufact.premap.
Of course, all results can be displayed and evaluated at any time of the process and in any location of the component.
A very important result of simulating material behavior is the geometrical distortion and thus the possible representation of the real geometry of a component undergoing process-related residual stress.

Powerful simulation approaches for correct material analysis

Guarantor for a first-class, precise process simulation – also in case of heat treatment – is the use of powerful non-linear solvers. Simufact.premap is based on the approved technology of MSC.Marc of the global market leader MSC.Software, which has been established for decades.
A fully thermal-mechanical, elastic-plastic coupled analysis which also supports the so-called multi-physics approach of complex material kinetics is facilitated.
The Finite-Element Solver by MSC.Software are fast and well-engineered and allow of course a parallel computing on modern high performance work stations and clusters using Windows and Linux operating systems.
For modeling structures and components, all relevant 2D and 3D meshing technologies are available. Apart from the wide-spread tetrahedral meshing, innovative quad- and hex-element meshing technology is implemented within Simufact.premap and guarantees the highest possible result quality.
Inverse calculation of heat transfer coefficient based on automated optimization leads to maximum precision in material simulation.

Simufact.premap is a software solution which can be used as a stand-alone system for the simulation of heat treatment processes and the calculation of material properties. Moreover, the process designer also owns a powerful tool for analysis of microstructure evolution and for calculation of material properties within the software environment of Simufact. forming and Simufact.welding.
Thus Simufact.premap becomes an essential part of an innovative process chain simulation.
Scenarios as e.g. a forming simulation which incorporates results from a previous casting simulation of the semi-finished product, then followed by a joining simulation and finally a virtual heat treatment analysis will soon become the state of the art of innovative engineering and will be providing the starting point for the final component structural FEA.

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