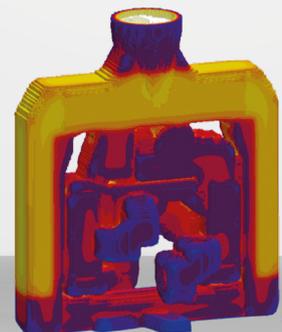# AUTONOMOUS
ENGINEERING

Investment Casting

¬ Robust solutions for all investment casting processes

¬ Methodical design of casting layouts and processes

¬ Robust production through virtual experimentation

¬ Profitable solutions using automatic optimization

5

MAGMASOFT®
autonomous engineering

Robust, economical, fast, **optimized**

Optimize all aspects of the production of investment castings and find the best solution for your requirements - with MAGMASOFT® autonomous engineering.

MAGMASOFT® is a comprehensive and powerful simulation software for all aspects of the design and improvement of investment casting quality, pattern design and robust process conditions, ensuring optimal profitability. The focus is on your resources, time and costs.

With MAGMASOFT® you use simulations in an automated virtual Design of Experiments or genetic optimization. The result is Autonomous Engineering - systematic and fully automated decision making for pattern layouts and investment casting production conditions

With Autonomous Engineering you can simultaneously pursue different quality and cost objectives. From securing part quality and process fitness at the concept stage, through final pattern design and the continuous improvement of profitability in series production.

MAGMASOFT® autonomous engineering …

¬ supports you in the comprehensive prediction of all process steps in the production of investment castings

¬ offers you a virtual test bed for the reduction of casting defects

¬ enables you to make quick decisions and saves time for all parties involved

¬ allows proactive quality management by understanding process fluctuations

¬ improves communication and cooperation within your organization and with customers

OBJECTIVES VARIABLES QUALITY EFFICIENCY METHOD ACTION

Targeted and systematic success

The MAGMA APPROACH, which is fully integrated in MAGMASOFT®, is a systematic methodology for achieving your objectives using virtual experiments. In combination with MAGMASOFT® autonomous engineering, secured actions can be identified and implemented to achieve continuous improvements, without economic risks.

The MAGMA APPROACH supports you at every stage of the product development or improvement process, through a systematic methodology. The result is a robust investment casting process, which is optimally designed for the desired objectives to realize a stable production.

Set your **objectives**, define your **variables**, specify your **criteria**

RELIABLE CONTROL OF THE PROCESS

Robust and reproducible quality in investment casting is not achieved by chance. The management of the diverse and often individual process steps to achieve a successfully poured investment casting requires a high level of specialist knowledge and experience. With MAGMASOFT® you can quantify your process knowledge and methodically and sustainably improve profitability.

THERMAL PROCESS CONDITIONS IN INVESTMENT CASTING

MAGMASOFT® takes the special thermal conditions in investment casting during pouring, solidification and cooling of the metal into account. This includes:

¬ Exact consideration of thermal radiation from the hot shell

¬ Consideration of shading between adjacent surfaces and heat accumulation in pockets

¬ Cooling of the shell before casting

¬ Local thickening of the shell

¬ Consideration of insulating materials or chills

¬ Controlled cooling/immersion of the casting including the shell
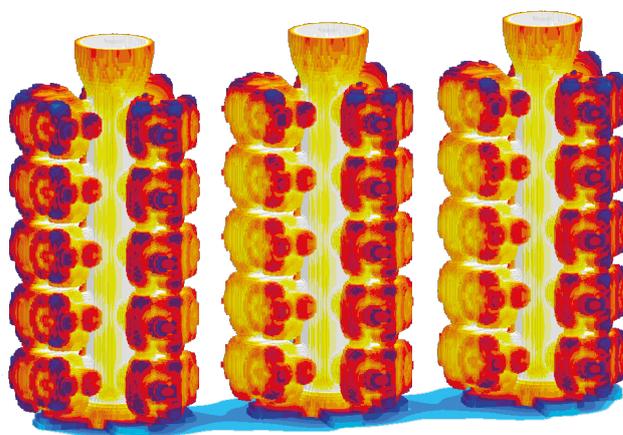
*Radiation between heated shell molds and with the environment*

FILLING

A reproducible filling of the mold is an important prerequisite for avoiding casting defects. The layout of the casting gating with MAGMASOFT® allows you to identify the root causes of possible defects, to understand them and eliminate them by systematically examining the relevant process variables.

Take advantage of specific investment casting capabilities such as automatic control of the fill level in the pouring basin, pouring rate control through automated pouring or the influence of a vacuum. You can tilt the shell, rotate it or use a low-pressure process to fill it.

Evaluate quality criteria such as: inclusions (oxides, shell erosion), entrapped air, misruns, incomplete filling or cold shuts, as well as the uniformity of filling for all parts.

Investigate impacts on the quality of filling through the systematic variation of:

¬ Pouring rates and filling times

¬ Runner and gate cross-sections
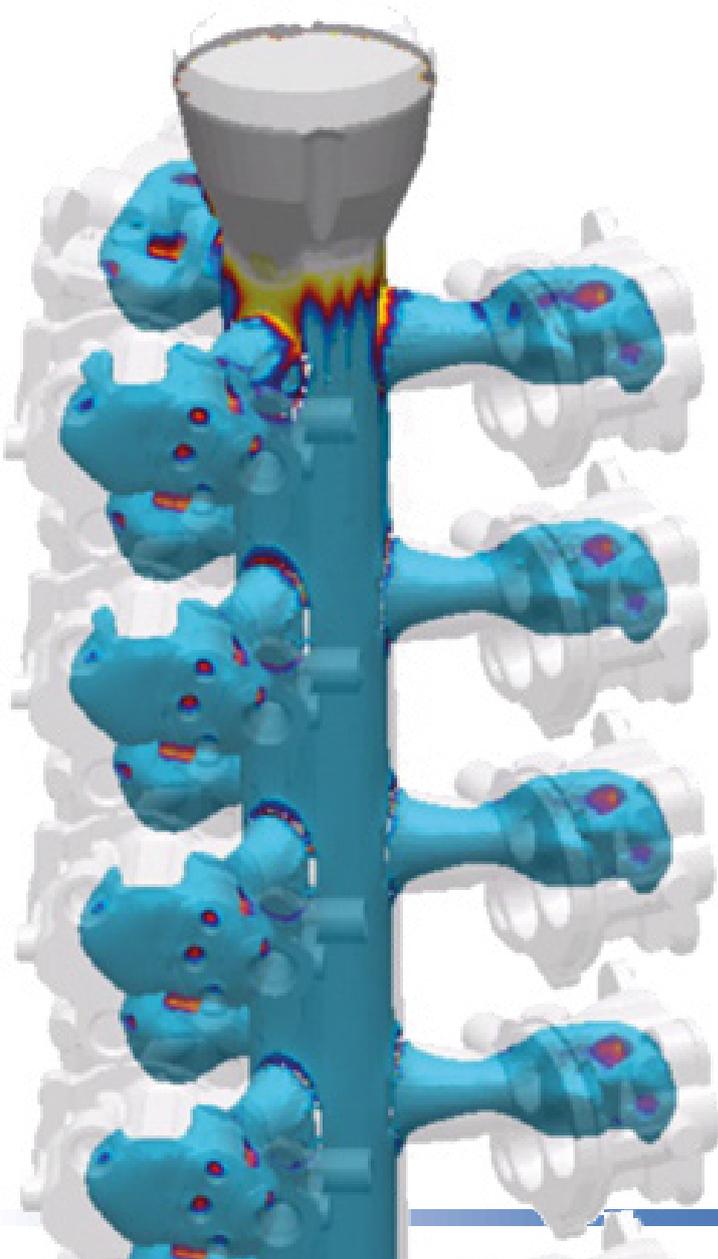
¬ Number of mold cavities
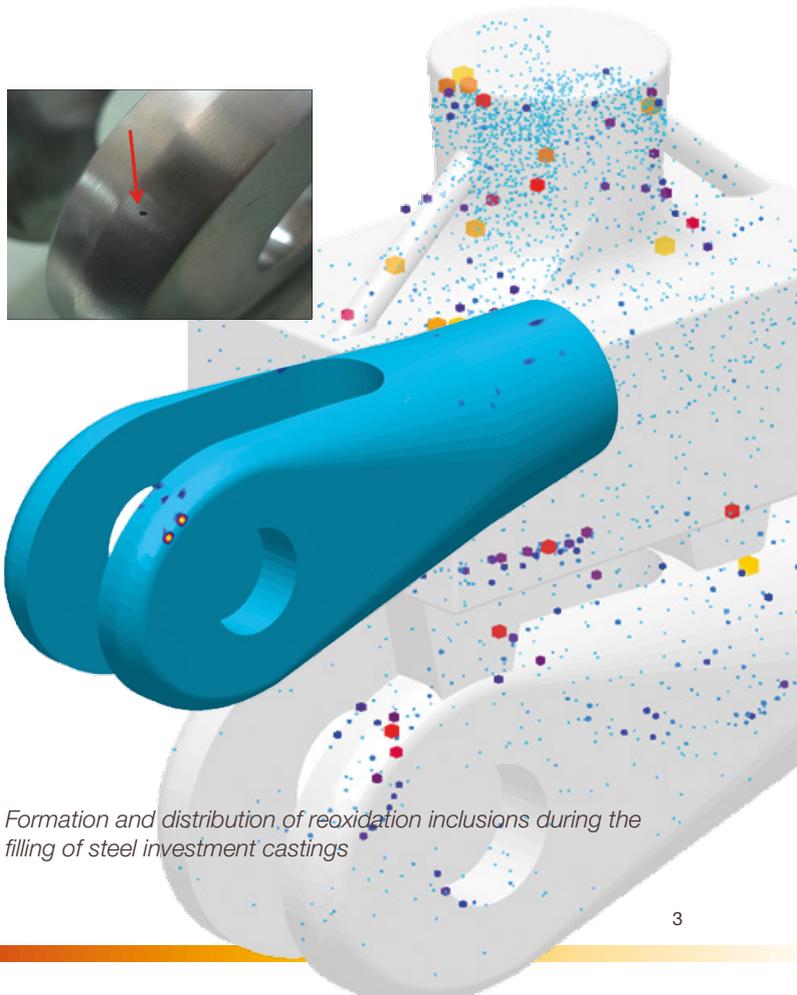
Formation and distribution of reoxidation inclusions during the filling of steel investment castings
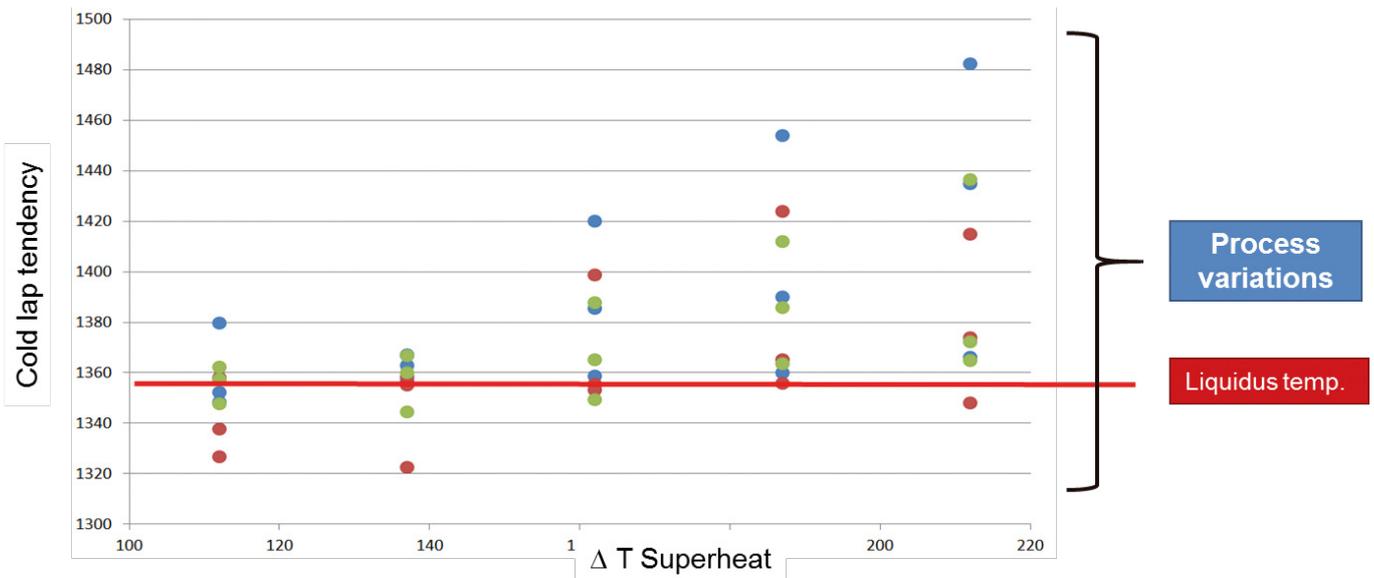
Determination of the risk for cold shuts as a function of process variables and fluctuations

DESIGN OF THE RIGGING

During the solidification MAGMASOFT® considers important process variables that influence the casting quality. Use different capabilities for automatic variation of geometry to:
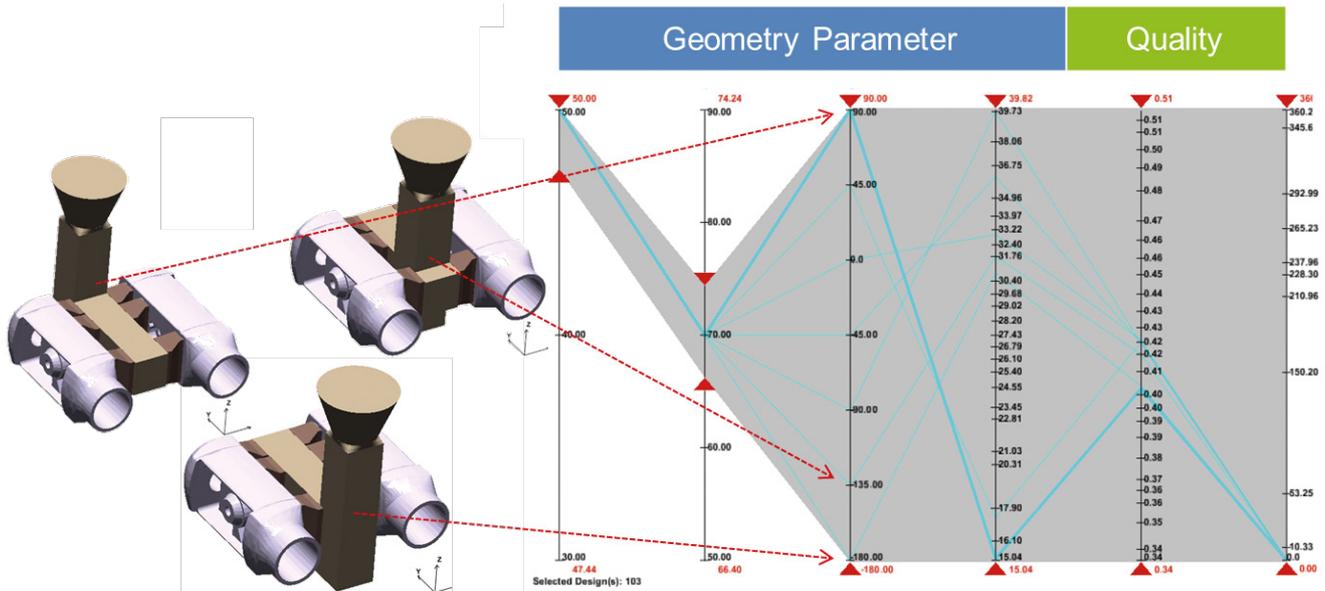
¬ Exchange imported CAD geometries

¬ Use parametric geometries from the MAGMASOFT® database

¬ Move geometries on surfaces or along trajectories

Optimize

¬ Local thermal modulus

¬ Solidification pattern and hot spots

¬ Feeding behavior of the casting

¬ Macro- and microporosity
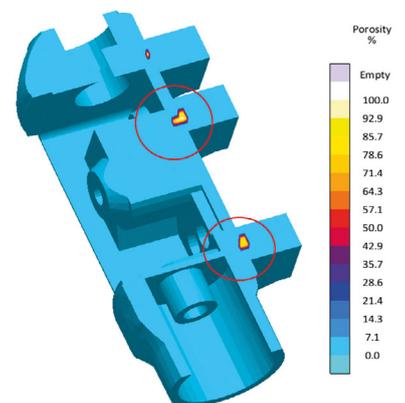
Different holding times lead to scrap

Geometry Parameter	Quality

Parallel Coordinates Diagram: Evaluation of different geometries on the selected quality criterion (porosity) in a Design of Experiments

# SECURE PROCESSES WITH VIRTUAL DESIGNS OF EXPERIMENTS

In MAGMASOFT®, you can freely vary your process systematically, to understand the influence of different production conditions on quality before you even start manufacturing.

Answer questions such as:

- ¬ Which casting parameters are optimal for the selected casting layout?
- ¬ How does a different temperature of the shell before pouring affect the mold filling behavior?
- ¬ Do fluctuations in the following production parameters have an influence?
  - ¬ Shell thickness and properties
  - ¬ Alloy composition
  - ¬ Pouring rate
  - ¬ Shake-out time
 - ¬ Removal of the rigging

ROBUST PROCESSES

Determine the influence of process fluctuations on the solidification behavior of your casting through systematic virtual experimentation. With MAGMASOFT® you can quantitatively identify main effects and correlations, and determine concrete actions for your production before the first casting has been made.
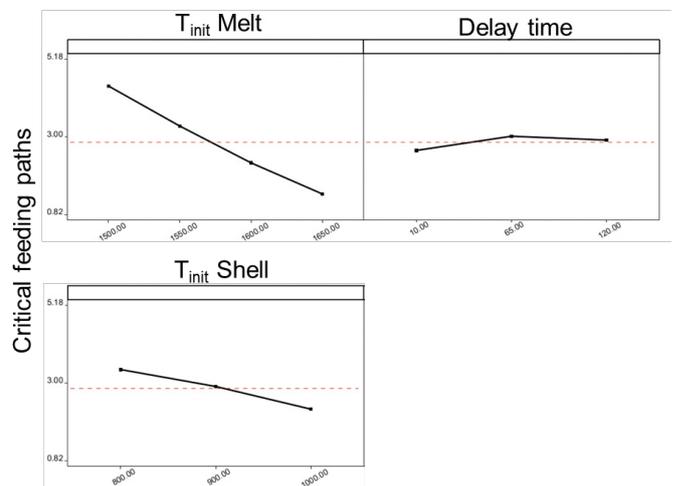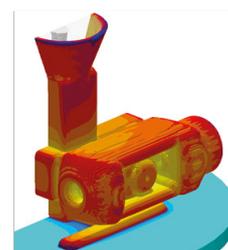

Main Effects Diagram: Influence of process parameters on the feeding behavior in the component
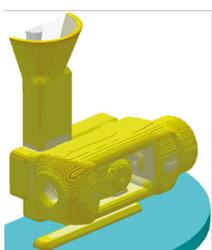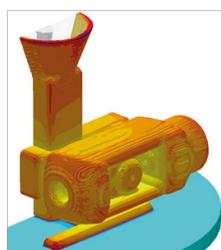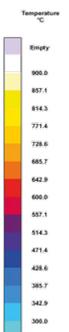

Cooling of the shell mold for different holding times

STRESSES, CRACKS AND DISTORTION

The casting shrinks during cooling. Depending on the component geometry and the resistance of the shell, residual stresses may build up in the casting.

Examine the influence of parameters such as the shake-out time, the removal of the rigging or machining on crack tendencies and the dimensional accuracy of the casting.
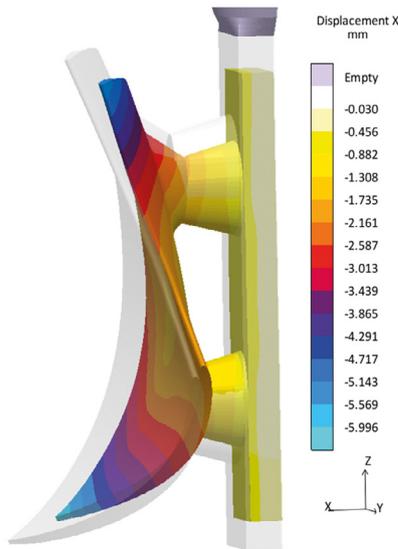
Distortion of the component after shake-out and cooling (magnified representation)

*Cracks in the component due to excessive stresses during cooling*
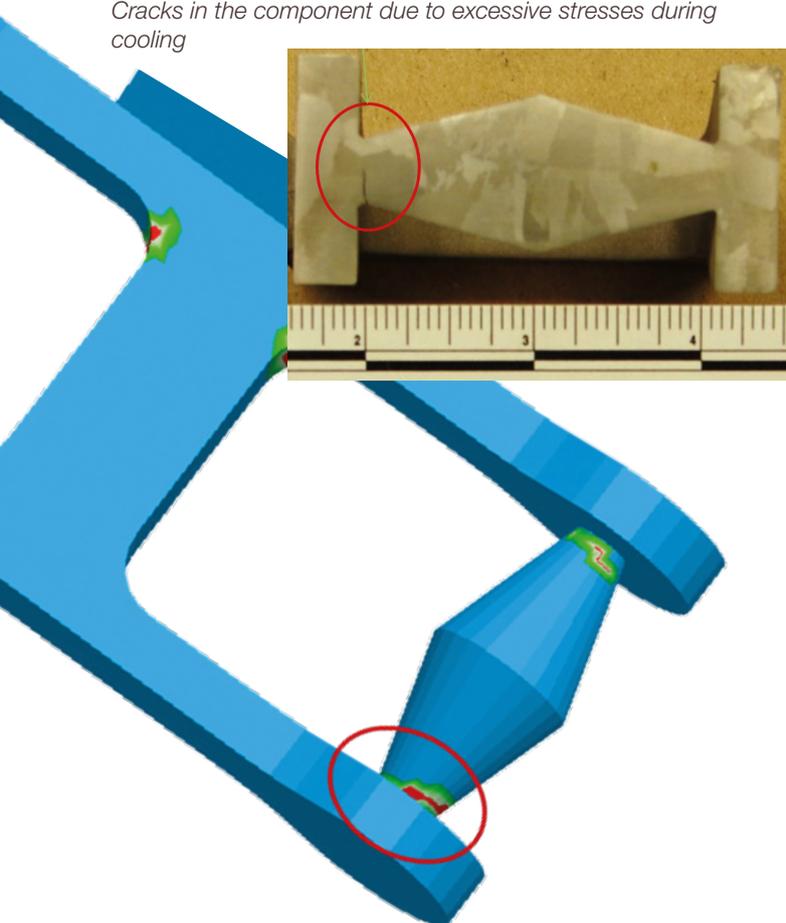
HEAT TREATMENT AND MICROSTRUCTURE

The simulation of heat treatment is seamlessly integrated into the virtual process chain for investment castings. Use pre-defined process conditions and common quenching media to optimize the heating sequence, solution treatment times and temperatures, quenching behavior as well as tempering and cooling to room temperature.

For cast steel and non-ferrous alloys, local microstructures and mechanical properties can be predicted.

During solution treatment and ageing, the reduction in residual stresses due to creep as well as component distortion due to gravity are accounted for.

Evaluate local residual stresses and component distortion after heat treatment for pre-compensation of your pattern geometry.
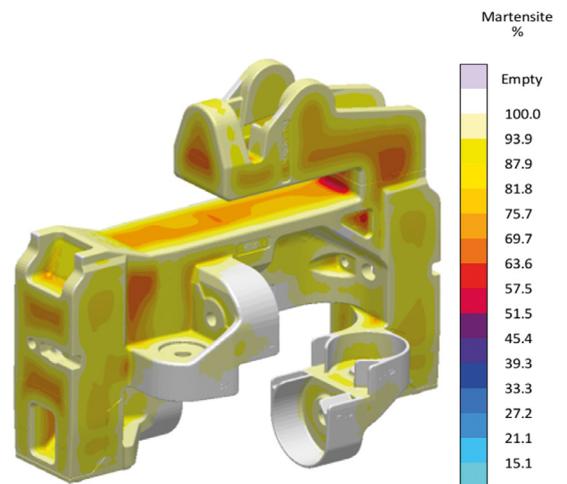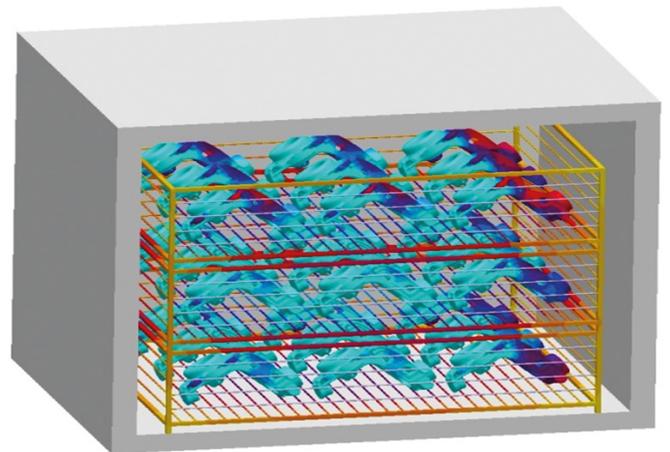

Heat treatment of cast steel: Martensite distribution after quenching and tempering

Work **efficiently** and **systematically**

Your time is limited! That makes it all the more important to methodically and efficiently use all the possibilities in the comprehensive toolbox MAGMASOFT® offers to achieve your goals.

ASSISTED MODELLING

Versatile wizards and convenient CAD capabilities support you in targeted and effective model preparation and enable short response times with minimum effort. For investment casting, you benefit from an automatic, user-defined generation of the shell. Use parametric geometries from the extensive geometry database or take advantage of the simple preparation of complex CAD models.
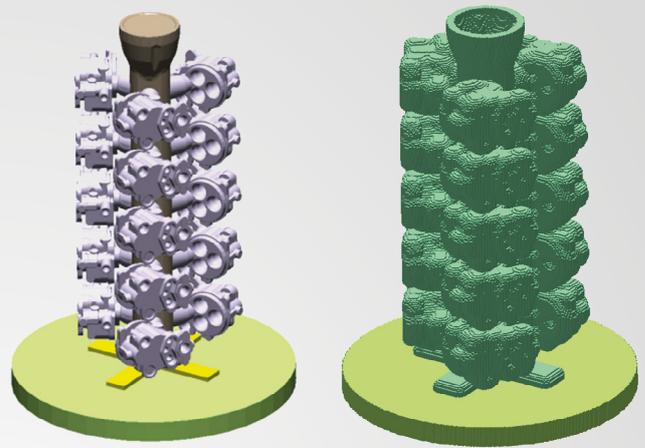
Complete wax model and automatically generated shell mold

Act & Check your **improvements**

Success is more than software and hardware. MAGMA's professional team is ready to comprehensively support you in realizing your goals. You can take advantage of the services of our MAGMAacademy, engineering and support teams, when and how it suits you and all from a single source.

IMPLEMENTATION

All MAGMASOFT® programs are more than just software. They offer a methodology for optimizing engineering, communication and profitability in your organization.

Even before starting with our software, we will take the time to discuss with you the most important factors to ensure an effective and secured use of our tools based on your situation: from the required computer hardware through the qualification and training of users, to jointly defining objectives regarding where you want to be in the next year.

Whether you are a new customer or a long-time user of our software - we have plans with you!

MAGMA SUPPORT

MAGMA Support stands for the competent, methodical and fast support of our customers worldwide regarding all questions in the application of and problem solving with our products. With the MAGMA APPROACH, our qualified support staff will help you to make better use of our software every day.

MAGMA ACADEMY

The MAGMAacademy systematically supports you in the implementation of casting process and virtual optimization, from the initial roll-out to the comprehensive application of Autonomous Engineering throughout the entire organization.

In our training courses, workshops and seminars, we convey interdisciplinary understanding across all processes and departments for the best possible use of MAGMASOFT® - conducted at our offices or through a customized solution on-site.

MAGMA ENGINEERING

As an independent and competent partner, MAGMA Engineering supports a successful virtual product development, tooling design and optimization of your robust foundry processes within the framework of engineering projects.

An interdisciplinary and international team of experts, with numerous years of casting expertise, is available to work with you using MAGMASOFT® autonomous engineering to address your challenges.

FAST
~~OR~~ GOOD

MAGMA stands worldwide for innovative solutions for castings and for reliable partnerships with the metal casting industry, including casting designers and consumers.

MAGMASOFT® autonomous engineering supports you in the design of optimized, robust and profitable solutions in product planning, tooling design and series production.

With the MAGMA APPROACH and our customer support, engineering and MAGMAacademy services, we offer a comprehensive methodology for the implementation and effective use of MAGMASOFT® in your company.

That is how we ensure you achieve clear cost and competitive advantages for your objectives.

MAGMA