

AUTONOMOUS ENGINEERING

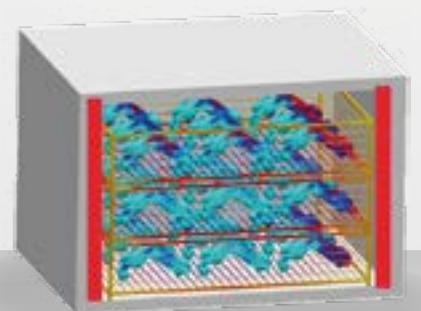


Heat Treatment

- Robust solutions for heat treatment processes
- Methodical rack layout and process design
- Ensure required microstructure and mechanical properties
- Minimize distortion and avoid high residual stresses and straightening processes
- Process knowledge through virtual experimentation
- Targeted solutions using automatic optimization

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MAGMASOFT®
autonomous engineering



Robust, economical, fast, **optimized**

Comprehensively optimize your heat treatment processes and find the best solution for your requirements - with MAGMASOFT® autonomous engineering

MAGMASOFT® is the comprehensive and powerful simulation software for all aspects of the lay-out and improvement of heat treatment processes, ensuring optimal part quality. 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 heat treatment process conditions based on the entire manufacturing process.

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 frame design and the continuous improvement of profitability in series production.

MAGMASOFT® autonomous engineering ...

- supports you in the comprehensive prediction of all process steps from casting through heat treatment
- offers you a virtual test bed to avoid quality issues
- 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



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 measures 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 manufacturing process, which is optimally designed for the desired objectives and that enables stable production conditions, taking into account all manufacturing steps from casting to heat treatment to final machining of the cast part.

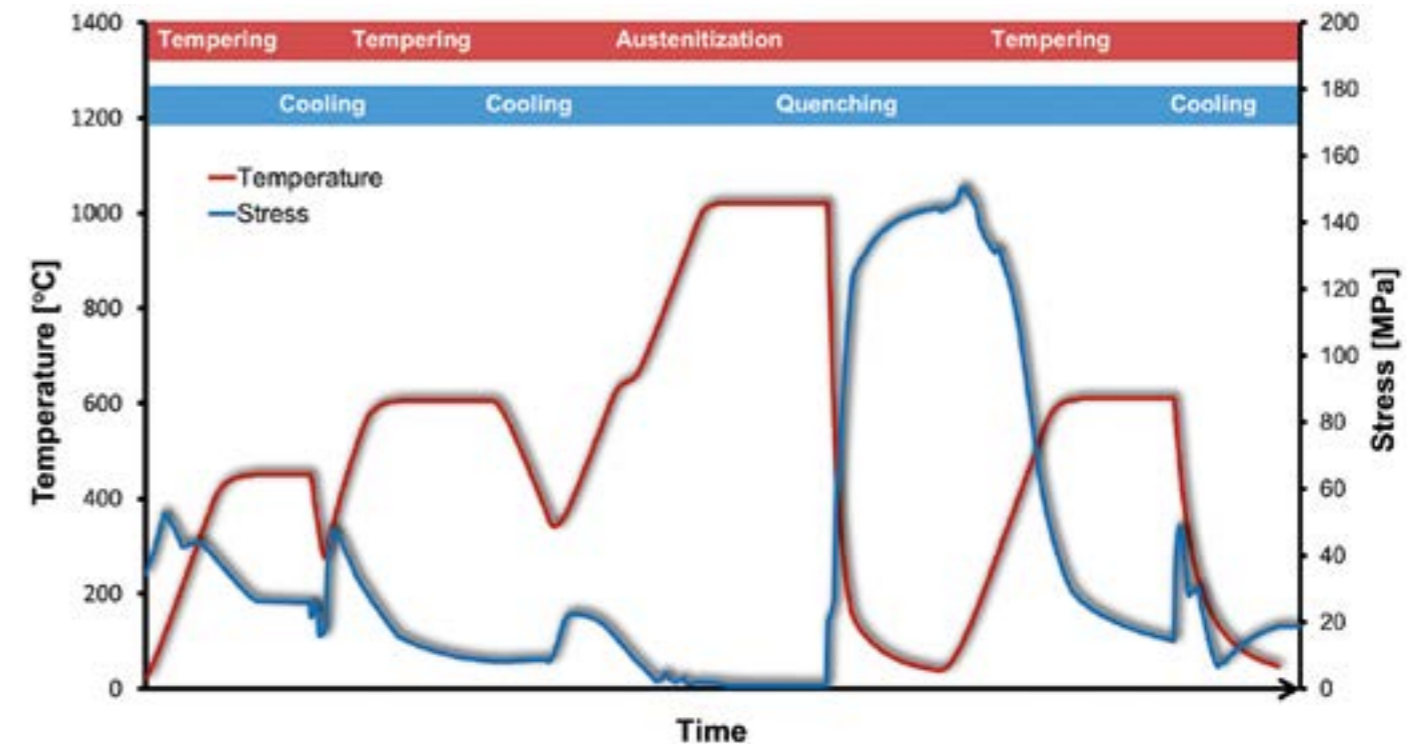
Set your **objectives**, define your **variables**, specify your **criteria**

For many cast components, heat treatment after the casting process is a prerequisite to obtain the desired microstructure and mechanical properties or to reduce existing residual stresses and distortion.

COMPREHENSIVE PROCESS DESCRIPTION

The different heat treatment steps are specified according to the real process conditions to ensure accurate thermal results. Variations in furnace temperature, radiation and

quench conditions can be taken into account based on the orientation of the part.



Characteristic temperature profile and associated stress evolution during heat treatment

COMPLETE RACK DESCRIPTION

MAGMASOFT® enables modeling of the full support rack, to get accurate thermal and mechanical conditions for the part inside the furnace.

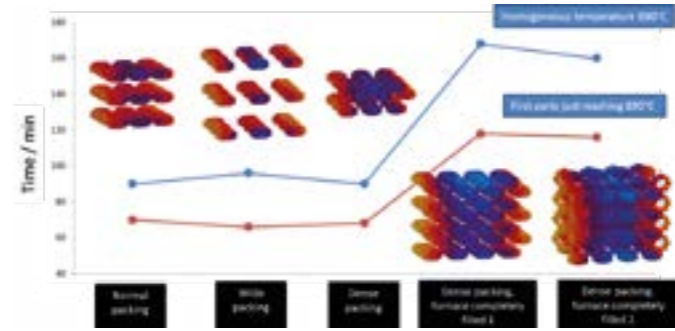
This allows the assessment of whether the design of the rack sufficiently supports the part at high temperatures, resulting in minimal deformations due to creep and thermal expansion.



Simulation of cast parts positioned in a heat treatment rack as in the real process

RADIATION AND THERMAL CONDITIONS

Use MAGMASOFT®'s fast and efficient algorithm for radiative heat exchange to determine process parameters dependent on different furnace configurations and the required material properties.

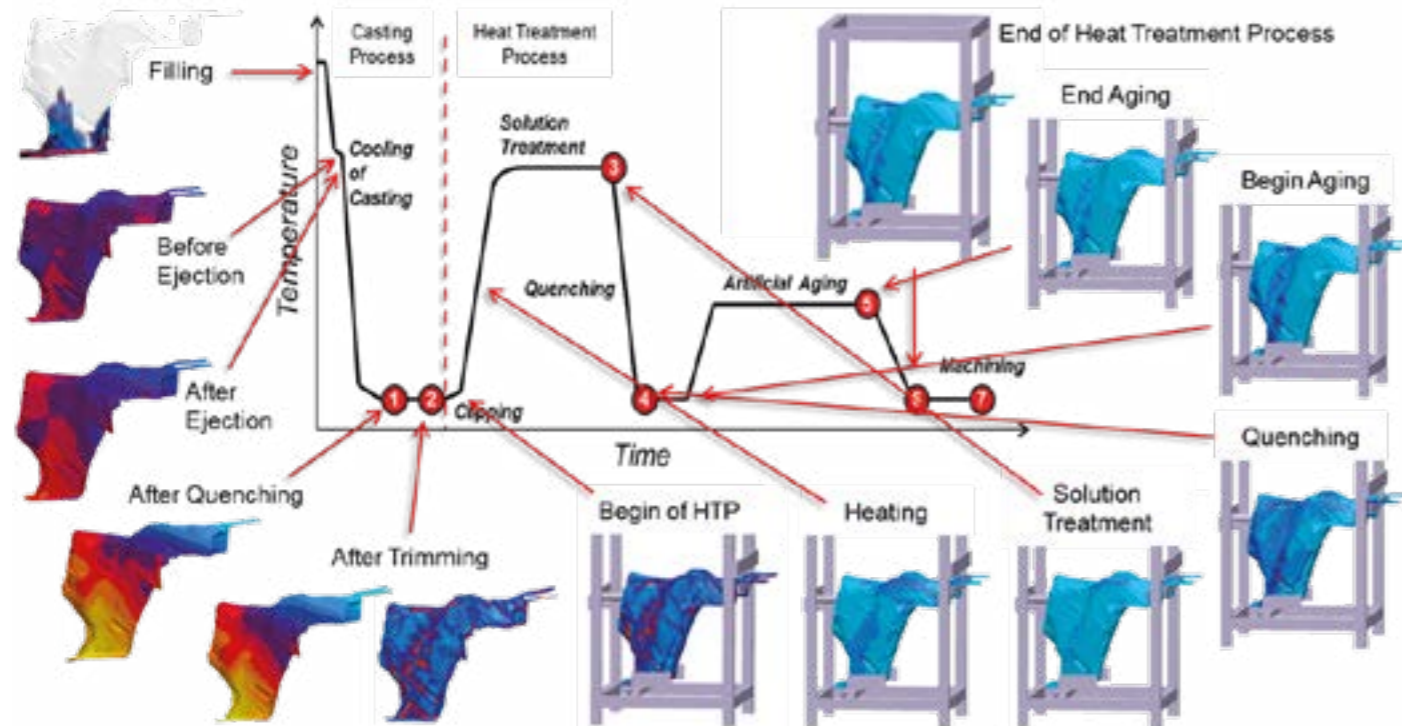


Austenitization times for different charges

FROM CASTING TO HEAT TREATMENT

The simulation of the heat treatment process is seamlessly integrated into the virtual process sequence for casting production. All process steps from casting, trimming, heating, solution treatment, quenching, tempering or ageing and finally cooling to room temperature can be considered.

This ensures a comprehensive evaluation of thermal fields, stress states and component distortion.



Integrated modeling of the casting and heat treatment processes

VIRTUAL EXPERIMENTATION AND PROCESS OPTIMIZATION

MAGMASOFT® offers extensive possibilities for virtual designs of experiments and optimization. This enables detailed analysis of the process window without economic risks or delays in production. Numerous process variables can be analyzed to set robust manufacturing conditions.

Comprehensive statistical evaluation methods enable you to determine optimal heat treatment conditions for:

- Process times, temperatures and material composition
- Temperature control in the furnace
- Microstructure and material properties
- Reduction of residual stresses, cold cracking risk and distortion of the cast component

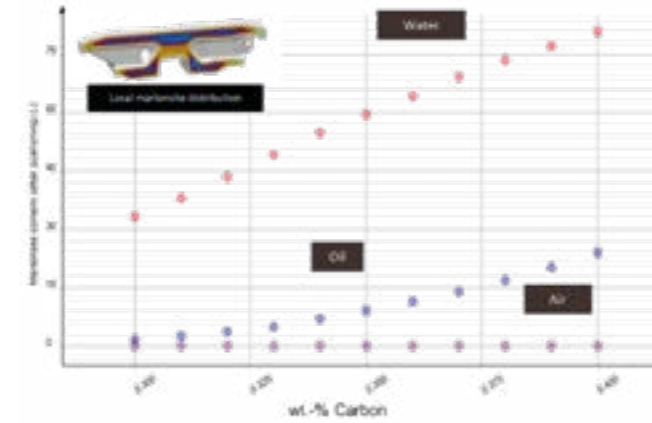
ROBUST PROCESSES

Determine the influence of process fluctuations on casting quality after heat treatment through systematic Designs of Experiments. With MAGMASOFT® autonomous engineering you can quantitatively evaluate main effects and correlations, and determine concrete actions for your production even before the first trial has been carried out.

Using a correlation matrix you can reveal physical relationships and make your process easier to control.

MICROSTRUCTURE AND MECHANICAL PROPERTIES

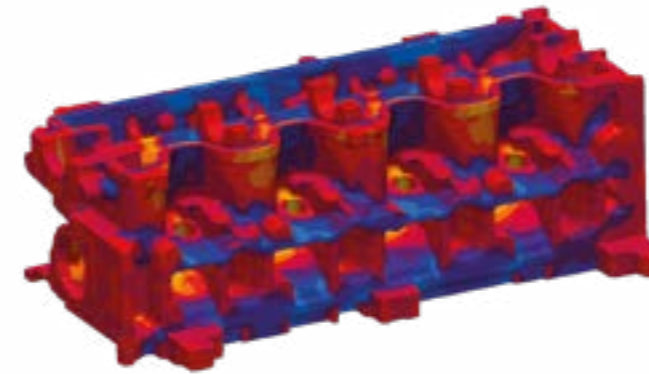
For many materials, MAGMASOFT® predicts local microstructures and mechanical properties in the component.



% Martensite as function of carbon content and quench medium

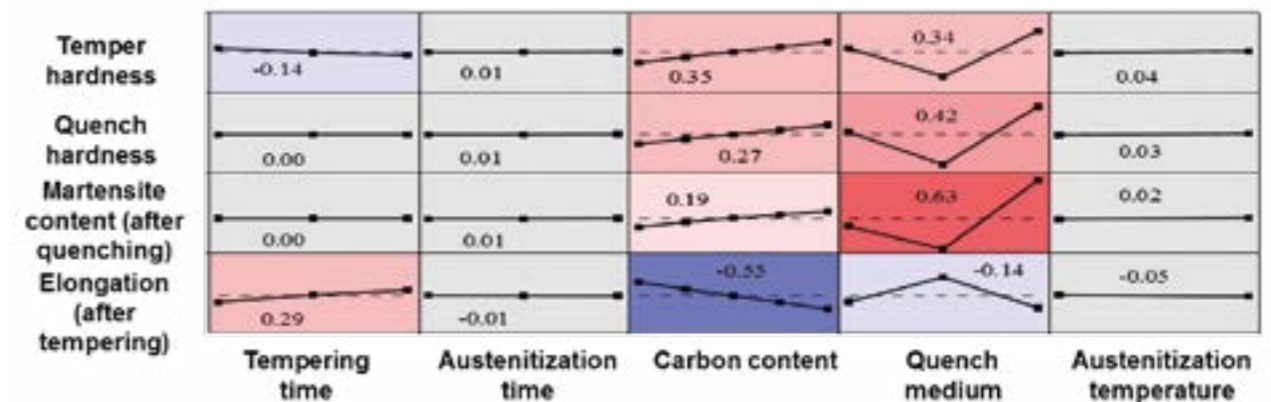
Microstructure and material properties are predicted for low-alloy steel grades. Both the chemical composition and the temperature history during heat treatment are taken into account.

The program calculates the heat treatment of austempered ductile iron (ADI) as well as the ferritization and pearlitization of ductile iron.



Residual stresses in a cylinder head after heat treatment

RESIDUAL STRESSES AND CRACKS



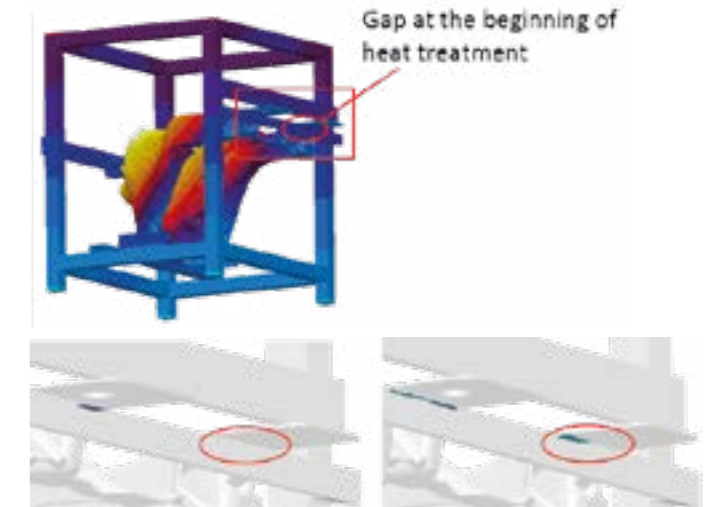
Correlation matrix - statistical assessment of results

During heat treatment, the stress state changes in the cast material. While stresses are relieved during solution treatment and tempering/aging as a function of the temperature level and process time, stresses typically build-up during quenching due to the thermal gradients and decreasing temperatures.

MAGMASOFT® allows the prediction of local stresses, deformation and the risk for crack formation in the component.

SUPPORT RACK DESIGN

Calculate the distortion of your component during heat treatment with a state-of-the-art contact algorithm.

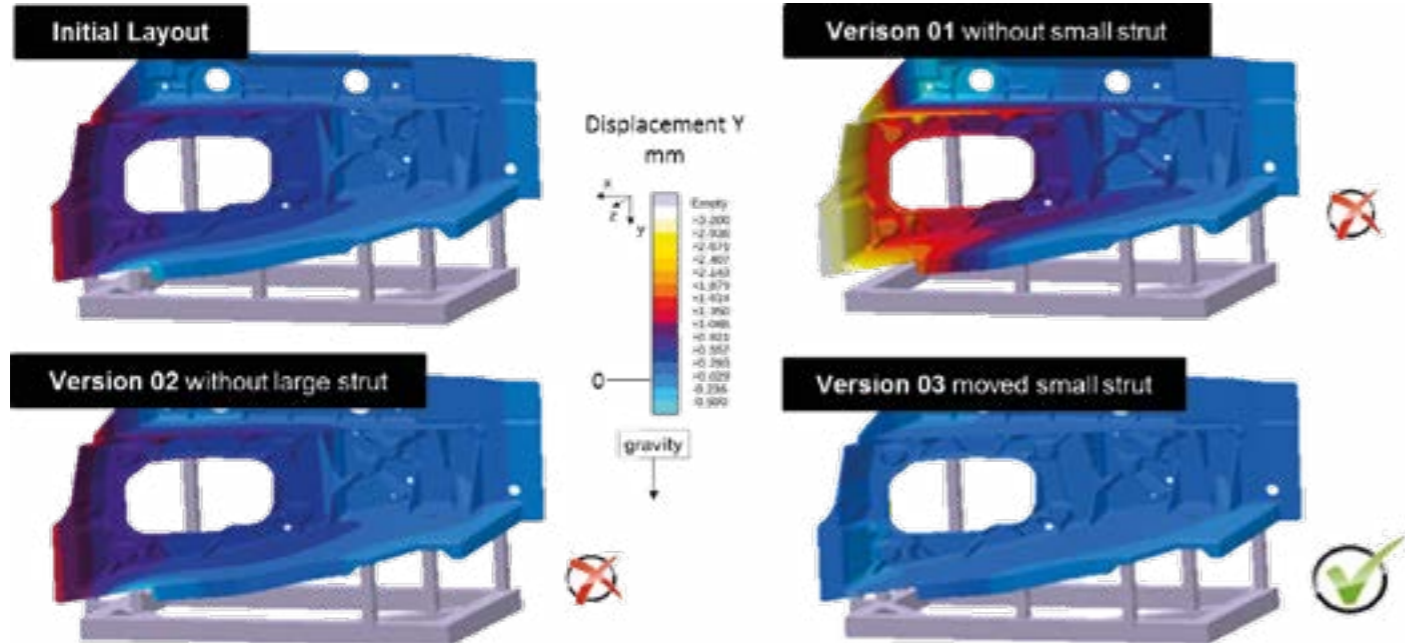


Automatically identified and continuously updated contact points

All contact pairings are automatically detected and updated at each calculation step, without the need for cumbersome contact definitions. Realistic contact conditions ensure that distortion results correspond with reality.

MAGMASOFT® gives you the ability to evaluate different process conditions at an early stage to minimize distortion during heat treatment. Alternatively, you can test different support rack designs to bring the component into the required dimensional tolerances.

Reduce or avoid costly straightening operations for your component. Show your customers the advantage of an almost stress-free component with a straightening-free production method.



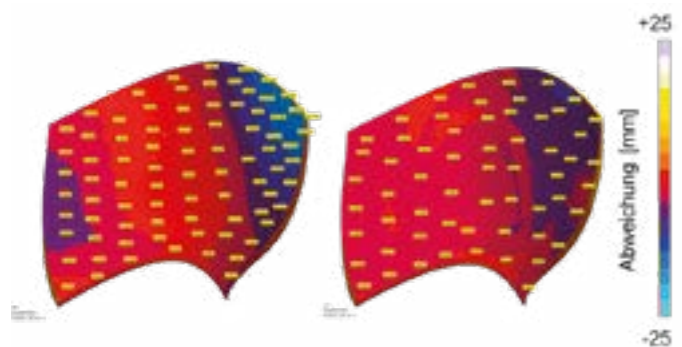
Evaluation of different rack designs

PRE-SHAPING THE MOLD

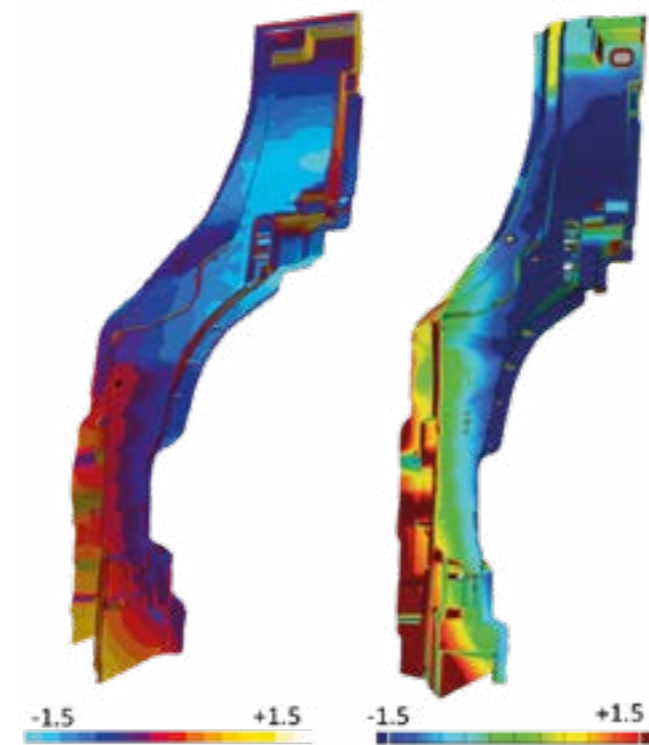
Throughout the entire casting and heat treatment process chain, it is possible to check compliance with the required manufacturing tolerances. MAGMASOFT® simulations are used to pre-shape the tooling so that expensive machining or repair of the part can be avoided.

EVALUATION OF DIMENSIONAL TOLERANCES

Evaluate the distortion of the component after each process step directly in MAGMASOFT® (3-point, 6-point or Best Fit methods) and evaluate the most critical phases of your process in terms of distortion.



Reduction of distortion after the complete process using pre-compensation in the tooling in comparison with the original shape (left)



Evaluation of the predicted distortion using the 6-point method

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.

INTUITIVE PROCESS CONTROL

Use MAGMASOFT® to optimize all relevant process steps. From furnace design and rack construction to treatment times and temperatures, virtual experiments can lead you to a robust optimum.



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.

