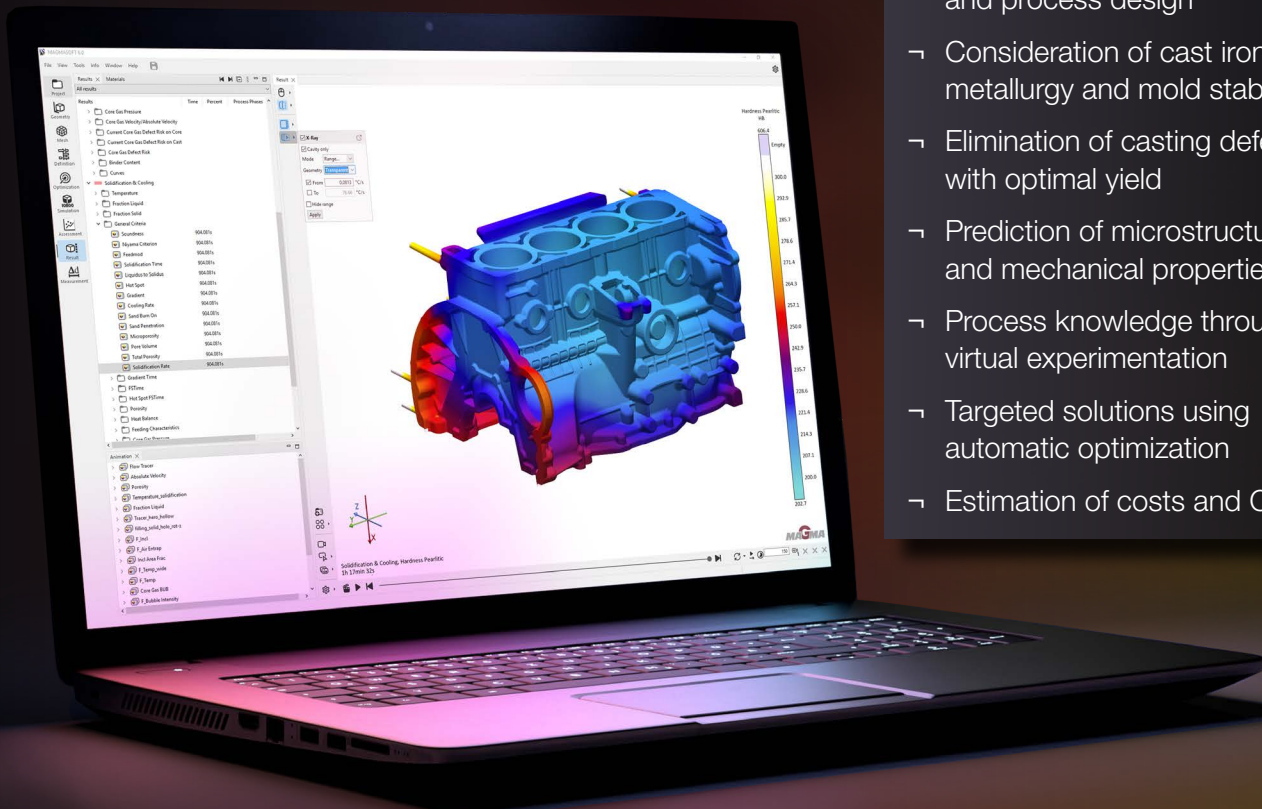


MAGMA Iron 6.1

Autonomous Engineering



Cast Iron



- Methodical casting layout and process design
- Consideration of cast iron chemistry, metallurgy and mold stability
- Elimination of casting defects with optimal yield
- Prediction of microstructure and mechanical properties
- Process knowledge through virtual experimentation
- Targeted solutions using automatic optimization
- Estimation of costs and CO₂ emissions

Robust, Economical, Fast, **Optimized**

Optimize all aspects of iron casting production and find the best solution for your requirements — with MAGMASOFT® autonomous engineering.

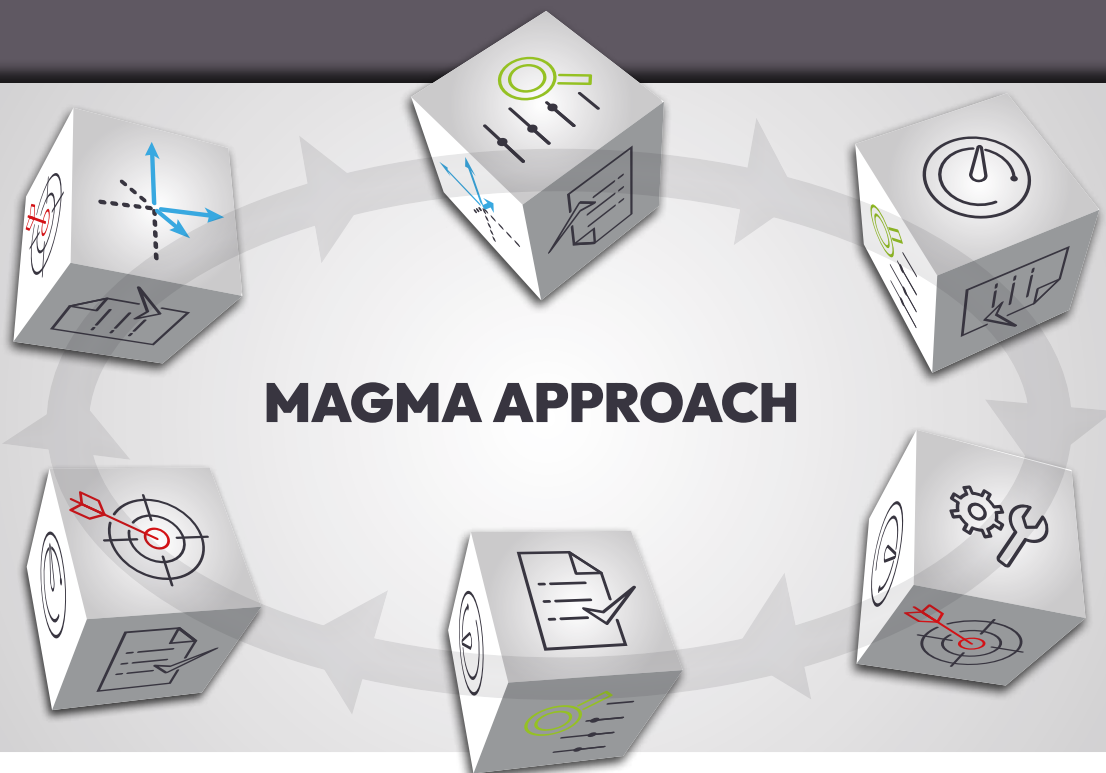
MAGMASOFT® is the comprehensive and powerful simulation software for all aspects around designing and improving iron casting quality, pattern design and robust process conditions while ensuring optimal profitability. The focus is on your resources, time and cost.

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 cast iron production conditions.

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

MAGMASOFT® autonomous engineering and MAGMA Iron:

- Support you in the comprehensive prediction of all process steps in the production of iron castings.
- Offer you a virtual test environment for the reduction of casting defects.
- Enable you to make quick decisions and save time for all parties involved.
- Allow proactive quality management by understanding process fluctuations.
- Improve communication and cooperation within your organization and with customers.

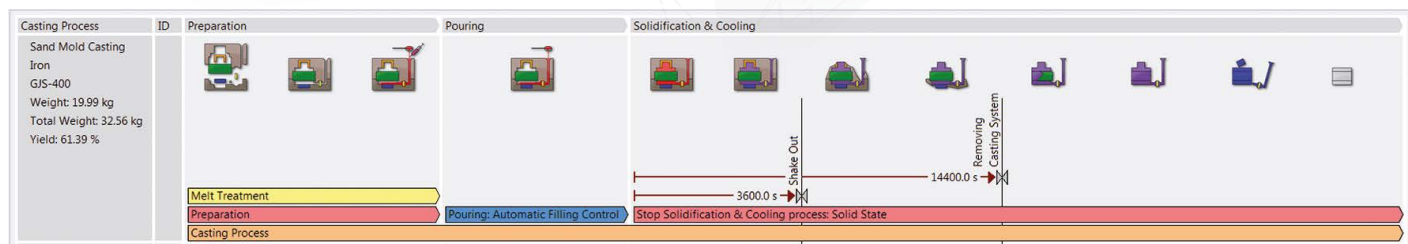


Targeted and Systematic Success

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 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 casting process that is optimally designed for the desired objectives and that enables stable production conditions taking into account alloy chemistry, melting practice and metallurgy.

Set Your **Objectives**, Define Your **Variables**, Specify Your **Criteria**



Cast iron specific process timeline

With MAGMASOFT®, you can freely and systematically vary your process to determine the influence of different production conditions on quality even before the first casting.

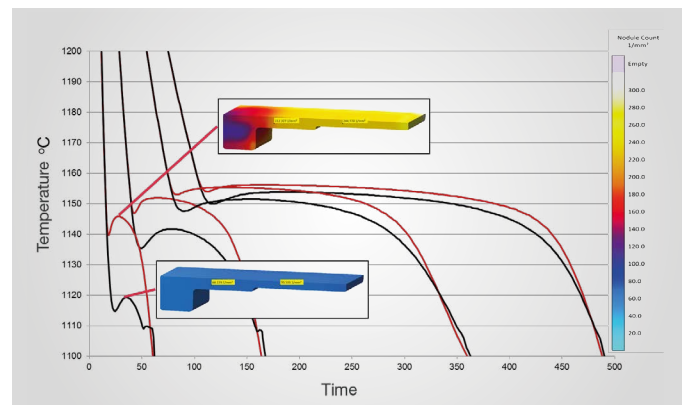
MAGMASOFT® effectively supports you in the:

- Reduction of required pattern plate changes to produce defect free castings
- Setting of robust production conditions to avoid scrap due to process fluctuations
- Target-oriented planning of your production process in terms of cost, quality and time

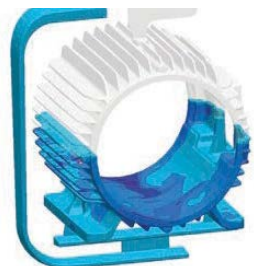
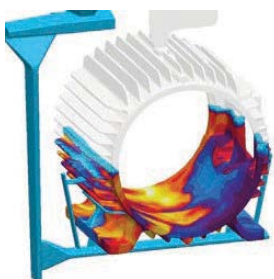
MAGMASOFT® uses kinetic growth models to calculate the solidification path of cast iron materials.

The software determines the type and quantity of precipitated austenite and graphite. The total shrinkage and the corresponding porosity are calculated based on the sum of the

shrinkage and the expansion of the present phases. On this basis, the distribution of the microstructure and the local mechanical properties are also predicted.



Calculated cooling curves and nodule count for two inoculants



Entrapped gas with the original (top) and optimized (bottom) gating system

Mold Filling

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

The systematic evaluation of the filling of the mold with MAGMASOFT® helps you to avoid flow-related defects, e.g.:

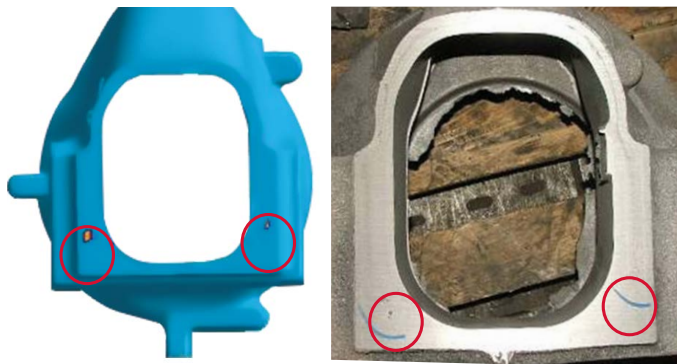
- Slag and sand inclusions
- Dross
- Entrapped air and gas bubbles
- Cold shuts, misruns and spray beads
- Mold erosion



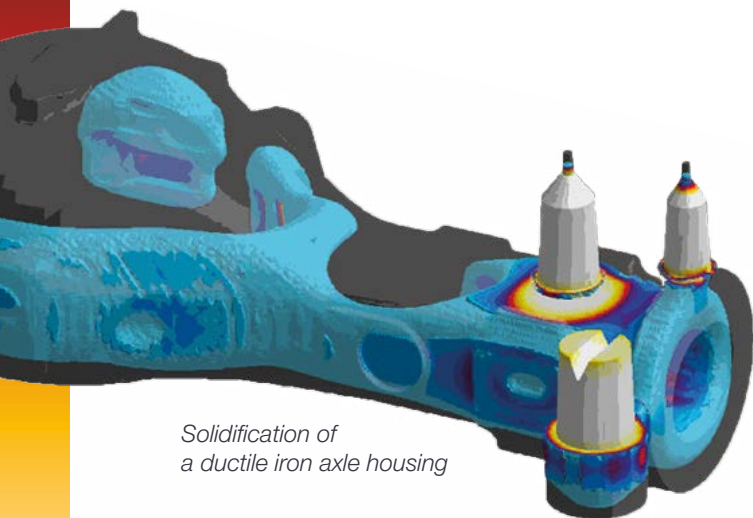
Mold filling of four gray iron brake discs

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

- Pattern plate layout
- Runner and gate dimensions
- Pouring rates and filling times



Porosity in a ductile iron housing



Solidification of a ductile iron axle housing

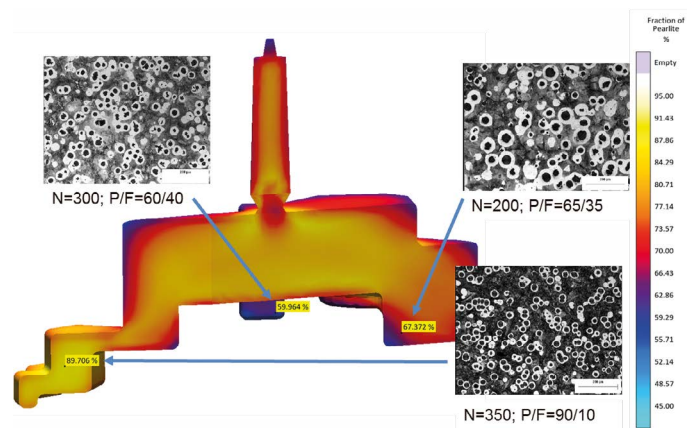
Solidification

During the solidification of cast iron, there are many process variables that influence the casting quality, such as the melt chemistry, trace elements, metal treatment and mold stability.

MAGMASOFT® takes these process variables into account when predicting casting defects such as:

- Shrinkage voids and porosity
- Core gas defects
- Burn-on and penetration

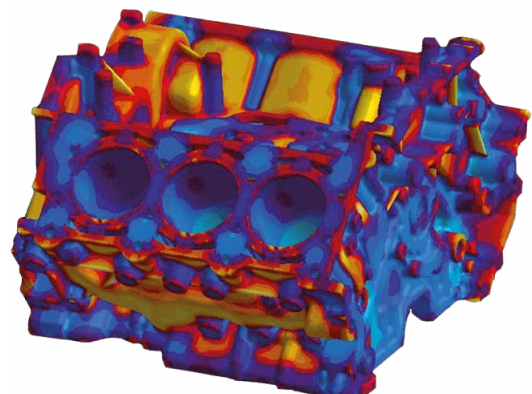
Microstructure and Mechanical Properties



Local pearlite fractions in a ductile iron lever component

The software predicts the local microstructure and resulting mechanical properties for gray, compacted graphite and ductile iron, and helps to predict and avoid:

- Undesirable microstructures such as carbides
- Local mechanical properties outside the specification
- Poor machinability



Graphite nodularity in a compacted graphite iron V6 crankcase

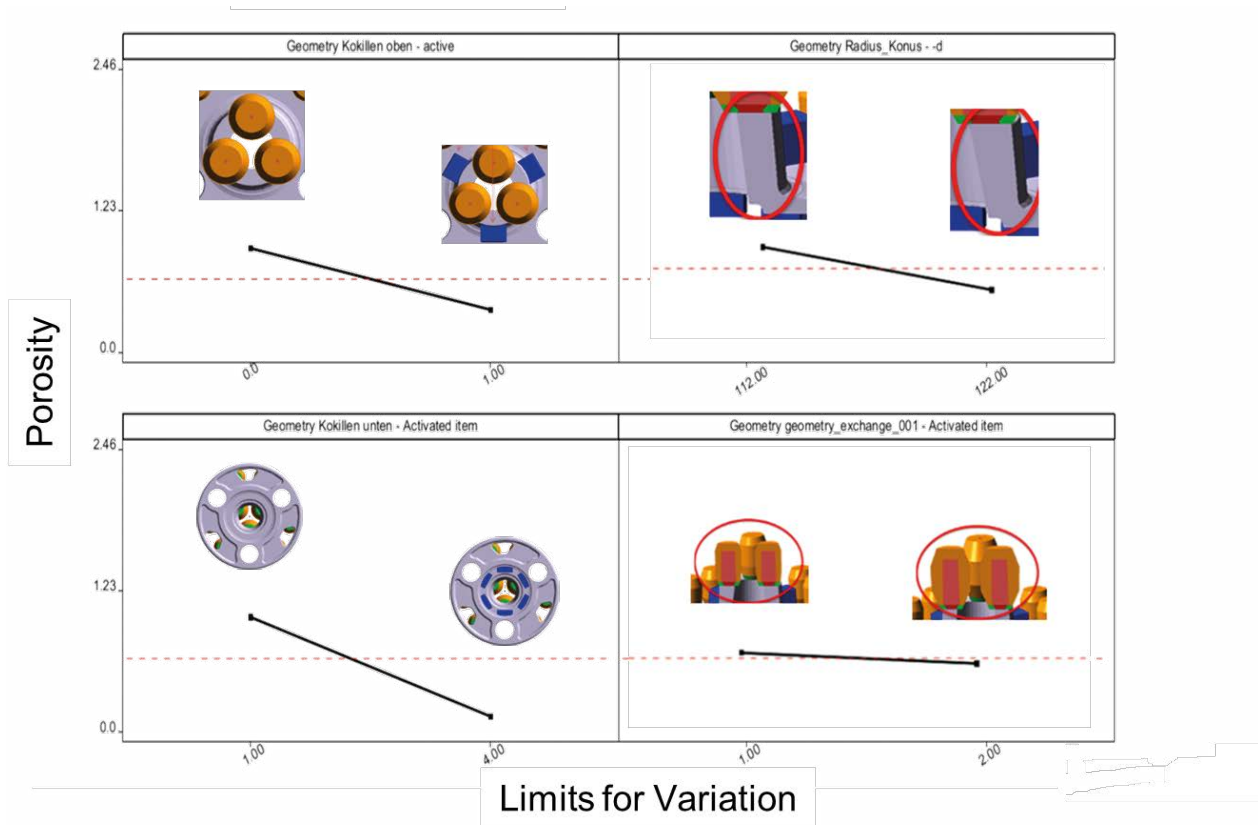
Design of Gating and Riser

Use different capabilities for automatic variation of geometries to:

- Exchange imported CAD geometries
- Use parametric geometries from the MAGMASOFT® database
- Move geometries on surfaces or along trajectories

Optimize:

- Local thermal modulus
- Solidification path and hot spots
- Feeding patterns
- Macro- and microporosity



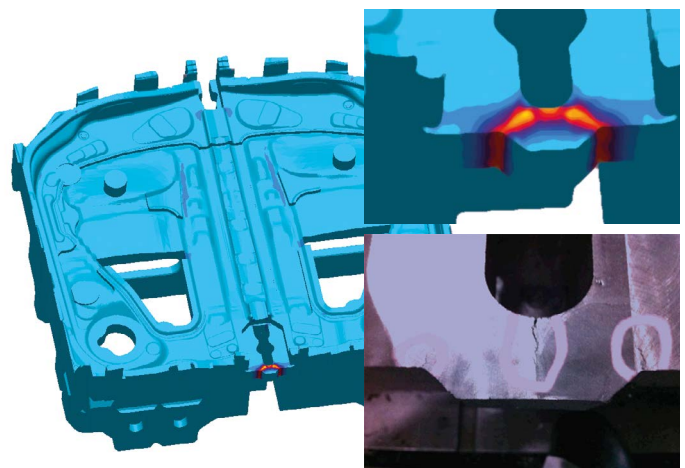
Quantitative determination of main influencing variables on porosity in a casting (feeder sizes, chills, padding)

Residual Stresses and Distortion

The casting shrinks during cooling. Depending on the component geometry and the mold stiffness, residual stresses build up in the casting.

The detailed prediction of casting residual stresses and component distortion is seamlessly integrated into the virtual process chain.

Examine important variables such as the shakeout time, the removal of the gating and feeders or machining on possible cracks and the dimensional accuracy of the casting.

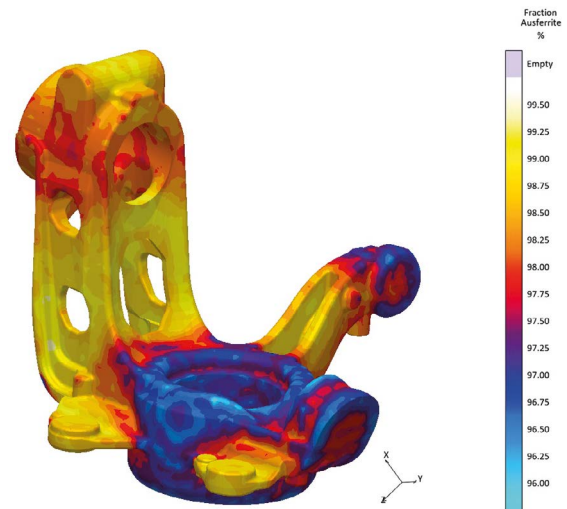


Risk for cold cracking in the cast component

Heat Treatment

Heat treatment is required for special cast iron materials or components. MAGMASOFT® takes into account all process steps in heat treatment, from heating and austenitization to quenching, ageing and further cooling to room temperature. The program calculates the heat treatment of austempered ductile iron (ADI) as well as the ferritization and pearlitization of ductile iron. Improve your heat treatment by optimizing:

- Austenitization times and temperatures
- Ausferritization times and temperatures
- Microstructure after heat treatment

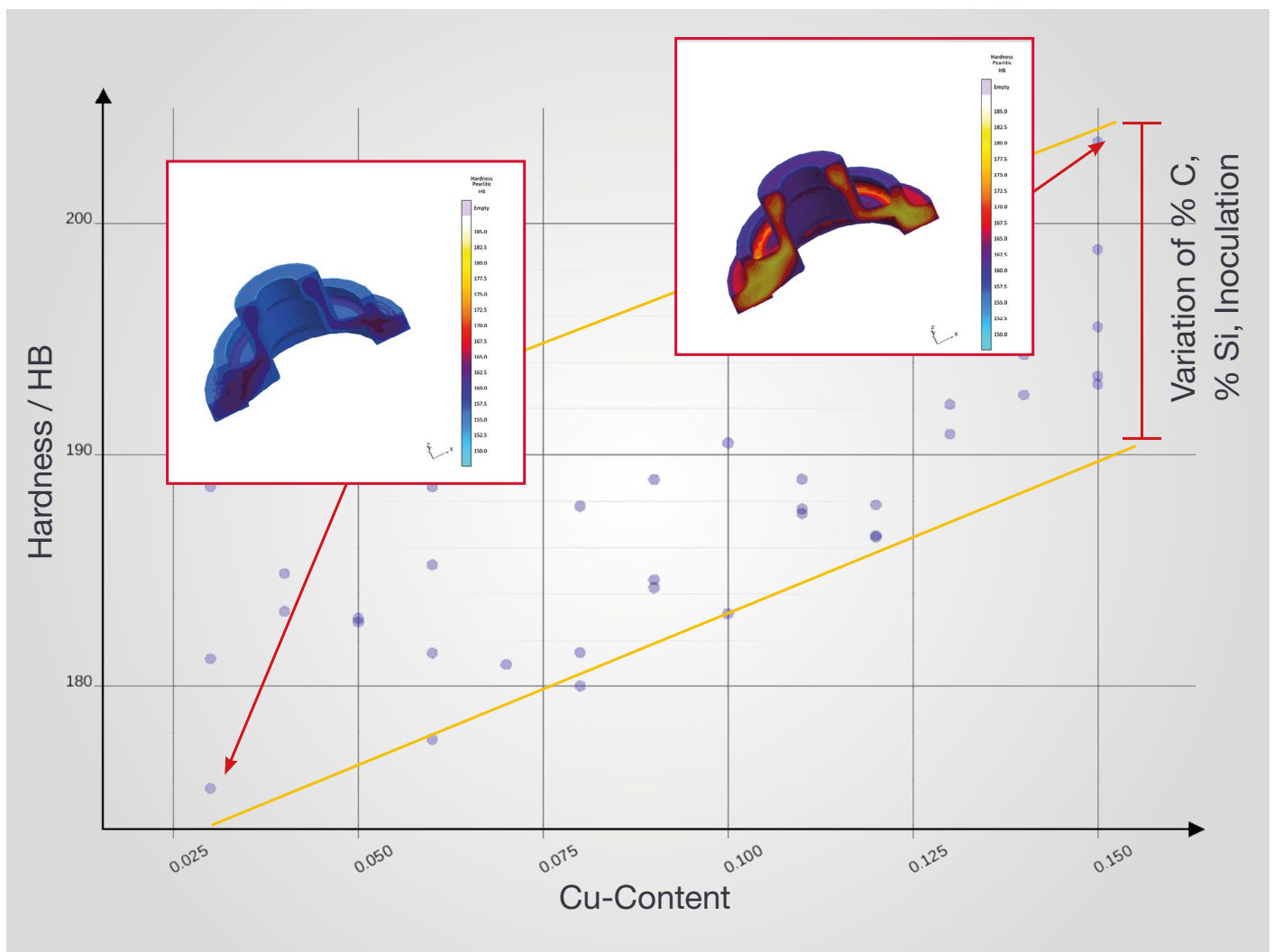


Microstructure distribution in ADI after heat treatment

Robust Processes

Determine the influence of process fluctuations on the solidification behavior of your castings 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 casting has been made.



Influence of alloy chemistry on mechanical properties

Work **Efficiently** and **Systematically**

Your time is limited! To achieve your goals, it is crucial to systematically and efficiently utilize all the available possibilities in MAGMASOFT®'s comprehensive toolbox.



Assisted Modeling

Convenient CAD capabilities support you in a targeted and effective model preparation and enable a short time to answer with minimum effort. Use the practice-oriented visualization of all relevant process steps for optimization of the entire process.

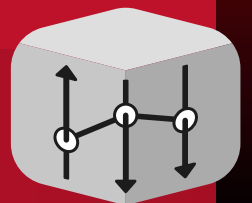
Easy-to-use wizards support you in entering or optimizing process-relevant variables such as:

- Iron chemistry
- Inoculation and metal treatment
- Automatic pouring control
- Mold permeability



Design Variable	Lower Limit (%)	Upper Limit (%)	Step (%)
Cast Alloy Class - C (Carbon)	3.2	3.4	0.2
Cast Alloy Class - Si (Silicon)	1.9	2.1	0.2
Design Variable	Lower Limit (°C)	Upper Limit (°C)	Step (°C)
Cast Alloy Class - Initial Temperature	1370.0	1390.0	20.0
Design Variable	Lower Limit	Upper Limit	Step
Melt Treatment - Graphite Precipitation	6	8	2
Design Variable	Lower Limit (%)	Upper Limit (%)	Step (%)

MAGMA ECONOMICS Technology & Profitability



MAGMA ECONOMICS expands technical optimization with MAGMASOFT® to include economic decision-making criteria. This allows identifying savings potentials that are often overlooked in purely technical simulations. The information provided by MAGMASOFT® thus creates additional opportunities as a management within the company.

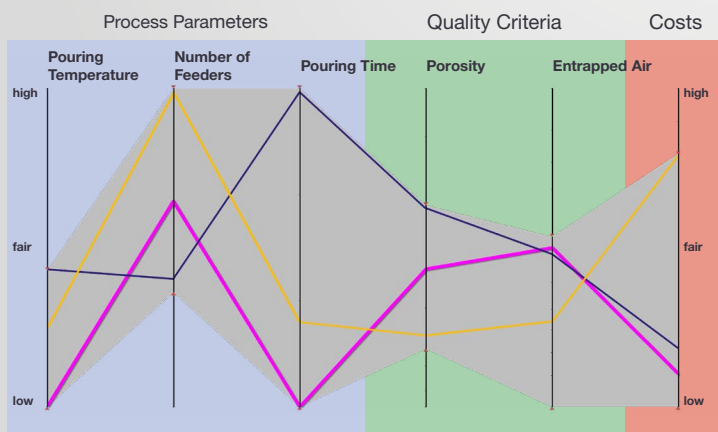
Optimize Your Casting Quality, Cost & Carbon Footprint

MAGMA ECONOMICS calculates and compares costs, energy consumption and CO₂ emissions of different scenarios. The perspective draws on existing geometry, material and process data as well as simulation results.

Customizable templates for common materials and processes contain specific cost and emission factors, enabling a detailed analysis of resource consumption and production costs along the entire casting process – from tooling preparation to actual casting and possible machining steps.

Key Features

- **New perspective:** comprehensive quantitative analysis of costs, energy and resource consumption, and CO₂ emissions, coupled with quality criteria in MAGMASOFT®
Intuitive evaluation of quality, productivity, project costs, and sustainability as key tool for your competitiveness
- **Database:** evaluation based on existing geometries, materials, processes, and simulation results
- **Customizable templates:** templates for materials and processes with specific cost and emission factors
- **Scenario comparison:** individual variation of process parameters and comparison of different scenarios – thanks to intuitive control – without additional simulation time
- **Autonomous Engineering:** seamless integration with optimization and virtual design of experiments



With MAGMA ECONOMICS, the parallel coordinate diagram as established, interactive tool for analyzing process variations and quality criteria is complemented by corporate criteria such as costs, energy/resource consumption and sustainability.

Systematically and quickly find the best compromise between quality and costs (violet line) and the limits of your robust manufacturing process (process window, marked in gray).

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!

MAGMASupport

MAGMASupport 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.

MAGMAacademy

The MAGMAacademy systematically supports you in the implementation of both casting process and virtual optimization, from the initial rollout 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.

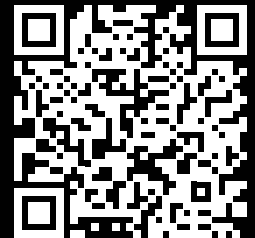
MAGMAengineering

As an independent and competent partner, MAGMAengineering 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.



More Information:



6.1

 **MAGMASOFT®**