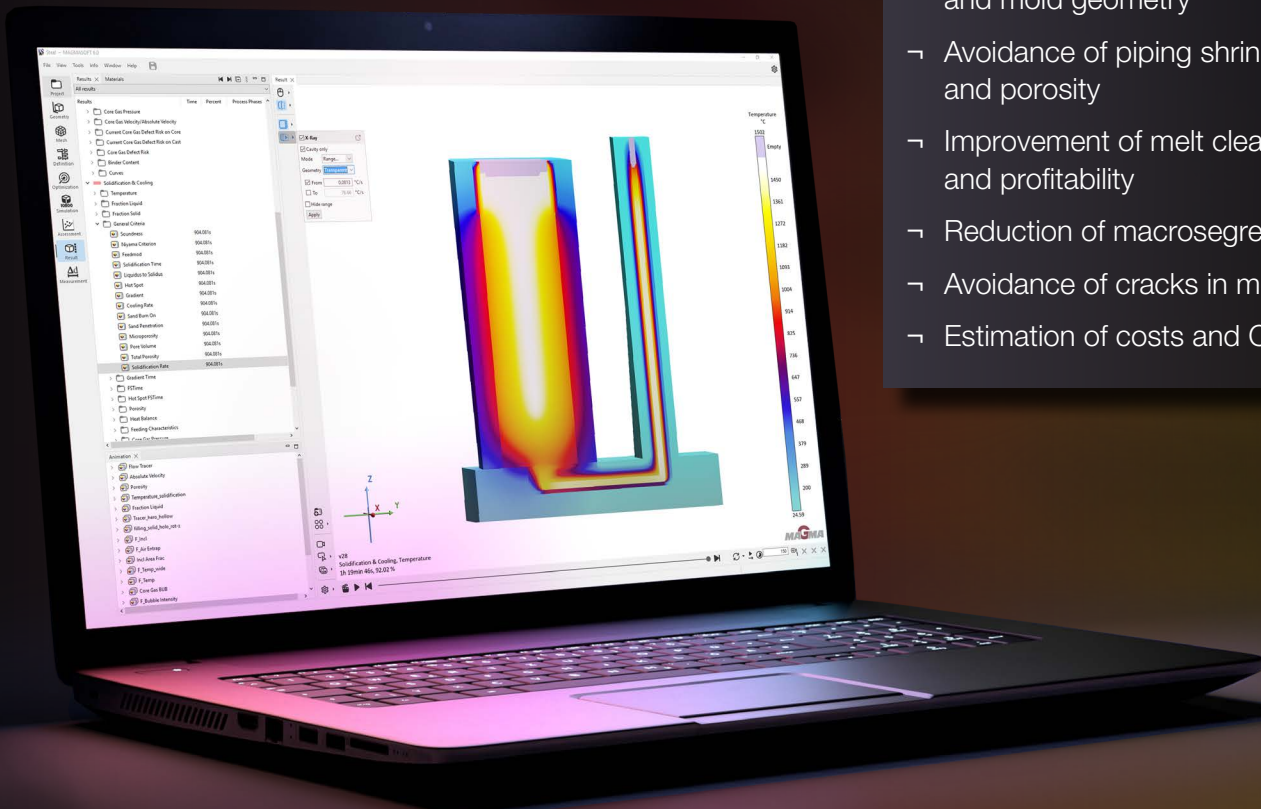


MAGMA Ingot Casting 6.1

Autonomous Engineering



Ingot Casting



- Optimization of ingot and mold geometry
- Avoidance of piping shrinkage and porosity
- Improvement of melt cleanliness and profitability
- Reduction of macrosegregation
- Avoidance of cracks in mold and ingot
- Estimation of costs and CO₂ emissions

Robust, Economical, Fast, **Optimized**

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

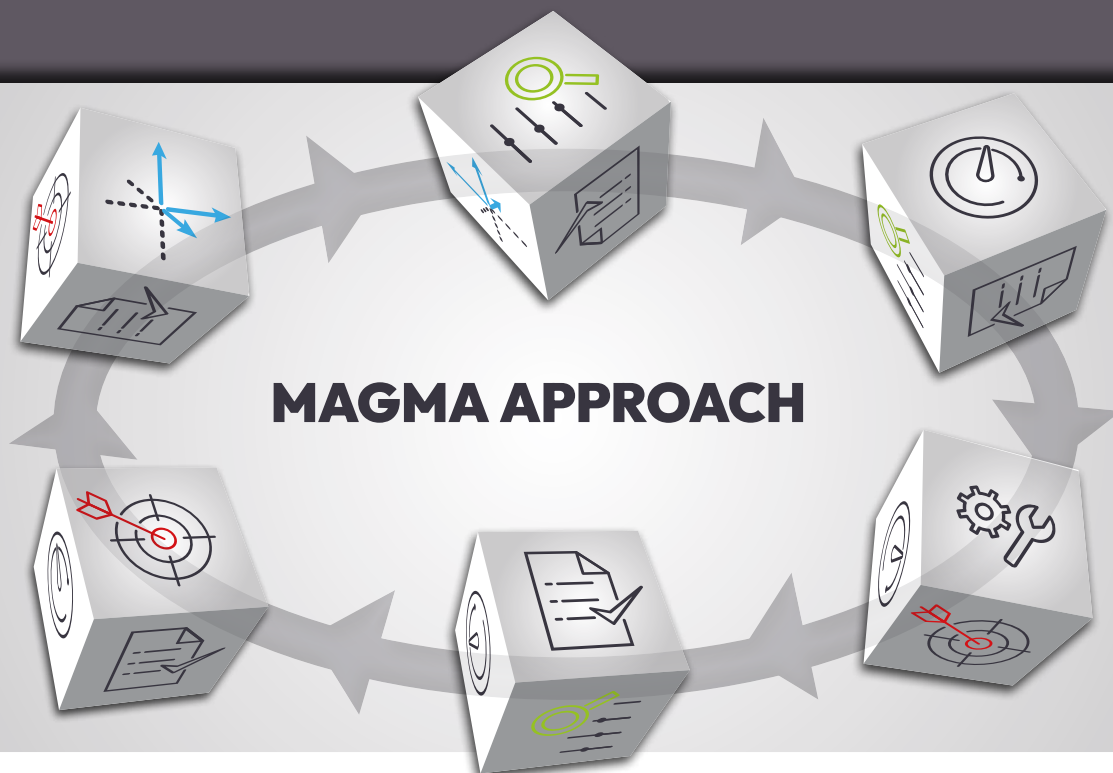
MAGMASOFT® is the comprehensive and powerful simulation software for all aspects around designing and improving ingot casting quality, mold design and process robustness while ensuring optimal profitability. The focus is on your resources, time and costs.

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 your production conditions.

With Autonomous Engineering, you can simultaneously pursue different quality and cost objectives. From securing product quality for new alloys, to the final design of the mold and the continuous improvement of profitability in your production.

MAGMASOFT® autonomous engineering:

- Supports you in the comprehensive prediction of product quality and a robust process layout.
- Offers you a virtual test environment for the optimization of your productivity.
- 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 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 process that is optimally designed for the desired objectives and prevents casting defects.

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

Layout of the Complete Process

MAGMASOFT® is the fully integrated solution for virtual design and optimization of the ingot casting process. Parametric geometry modeling, automatic meshing, an extensive database and comprehensive tools for evaluating and statistically assessing results are integrated into the software.

MAGMASOFT® offers a comprehensive simulation of the ingot casting production process, from the design of the mold, the layout of the head and gating system, to the provision of all necessary information on the quality of the cast ingot. The planning of casting layout and production is reliably supported by:

- Calculation of the flow from one or more ladles and determination of the teeming time as a function of the ladle geometry
- Prediction of the thermal behavior of all materials (heat conduction of the mold, influence of anti-piping powder)
- Calculation of heat radiation between groups of molds
- Prediction of piping, centerline shrinkage, microporosity, hot spots, solidification times and temperature gradients
- Determination of volume and weight of the casting, the head, the gating system and the mold



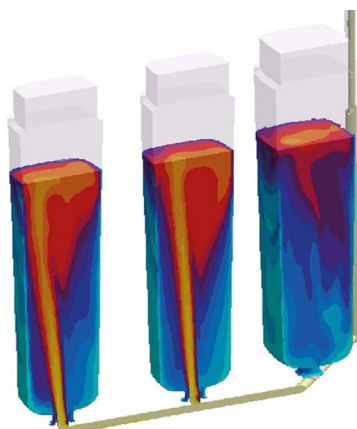
Casting in a cluster: ensuring a uniform solidification



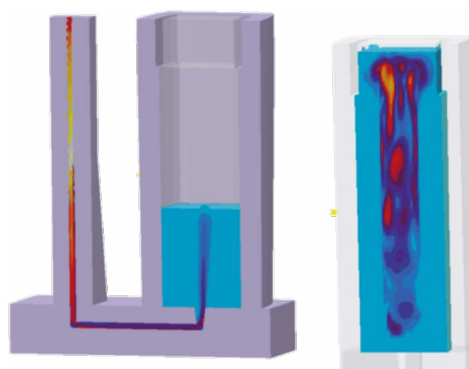
Mold Filling

A robust and reproducible teeming of the ingot is an important prerequisite for avoiding defects. The layout of a gating system with MAGMASOFT® allows you to identify the root causes

of possible defects, to understand and to eliminate them by systematically investigating the relevant process variables.



Casting in a cluster: simulation of teeming



Flow velocity during teeming

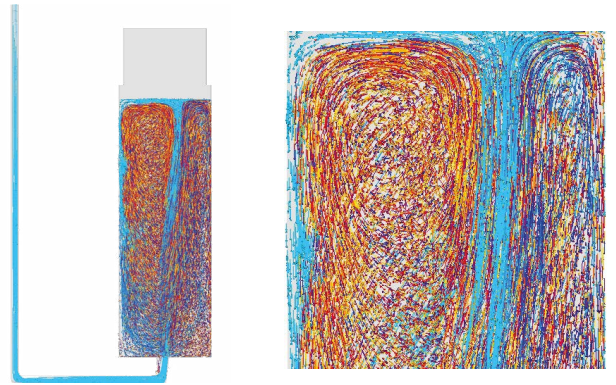
Degree of Cleanliness and Surface Quality

MAGMASOFT® predicts the formation, movement and agglomeration of reoxidation inclusions in the gating and in the ingot. Places where inclusions are likely to accumulate are identified.

Areas of the casting surface with a high tendency towards erosion are predicted.

Investigate impacts on the quality flow during teeming through the systematic variation of:

- Gating, mold and head layout
- Pipe and centerblock dimensions
- Pouring rates and teeming times

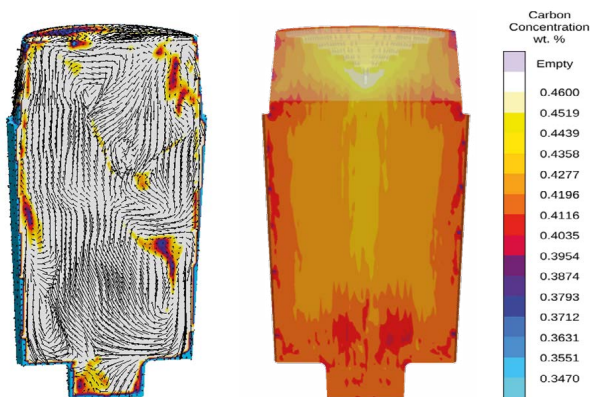


Evaluation of the metal cleanliness through prediction of reoxidation inclusions

Convection and Segregation

MAGMASOFT® considers the flow behavior and the temperature distribution in the solidifying ingot due to thermal and solutal convection.

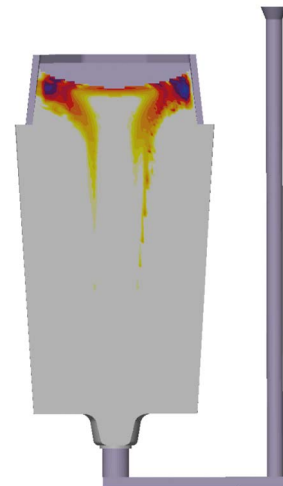
Through coupling with a segregation model, the redistribution of alloying elements and macrosegregation in the ingot can be predicted.



Convective flow and evaluation of product quality using carbon segregation as an example

Local alloy concentrations can thus be determined quantitatively for different elements.

The prediction of A-segregates is possible by applying thermal criteria.



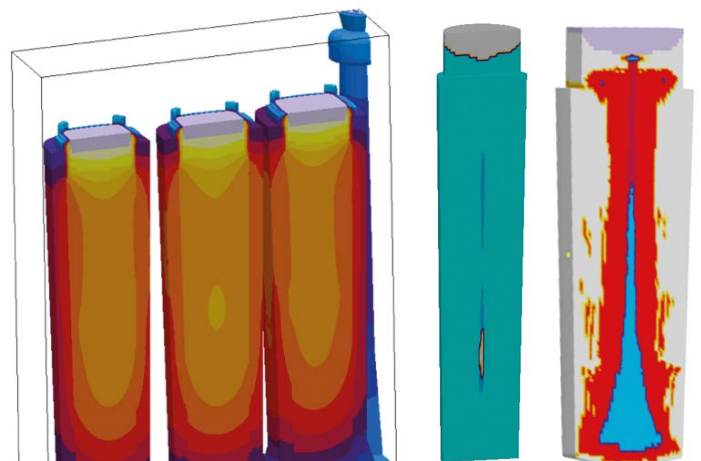
Risk for A-segregates

Solidification

During the solidification of the metal in an ingot, there are many process variables that influence the product quality, such as the melt chemistry, including trace elements.

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

- Shrinkage pipe and porosity
- Surface quality



Ingot and mold temperatures in the cluster (left); porosity indications, CET zone (right)

Residual Stresses and Cracks

MAGMASOFT® predicts the residual stresses that develop during teeming, solidification and cooling of the ingot, and shows the risk of cracks occurring in the ingot and mold.

Heat Treatment

Heat treatment is typically a requirement for all steel grades. MAGMASOFT® takes into account all the process steps in heat treatment, from heating and austenitization to quenching, tempering and further cooling to room temperature. Improve your heat treatment by optimizing:

- Austenitization times and temperatures
- Conditions for quenching and tempering
- Microstructure and mechanical properties after heat treatment

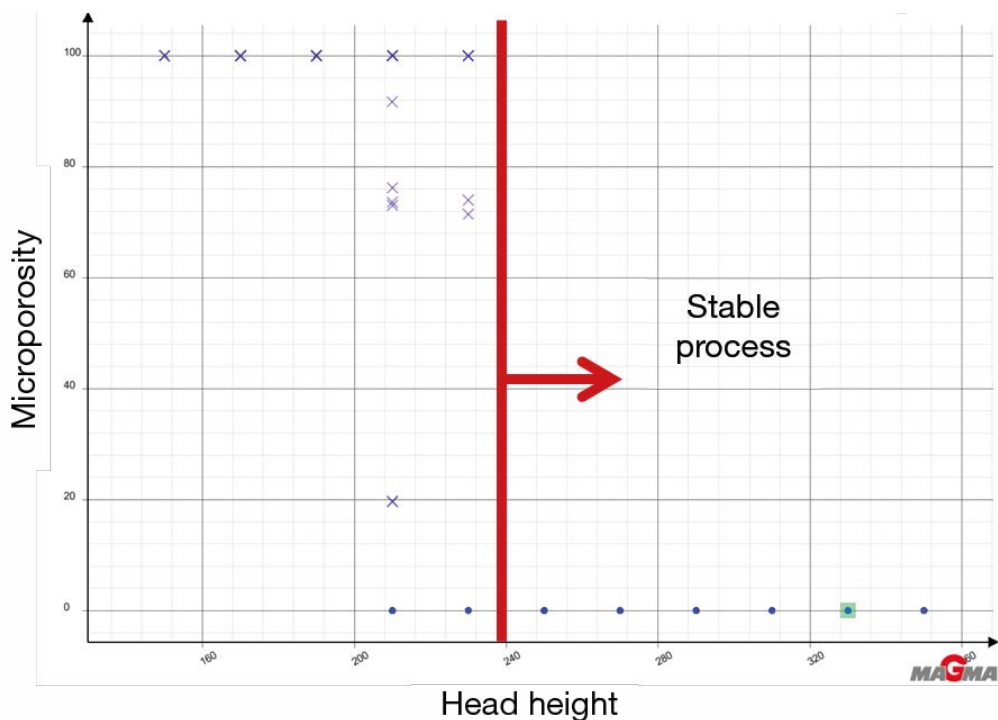
Optimization and Robust Processes

In order to ensure profitability and highest quality, the ingot casting process today demands a maximum of robustness and an optimum design of the process sequence. With MAGMASOFT®, you can automate and optimize using virtual experiments to achieve important quality and cost targets. This ensures a high productivity and excellent product quality.

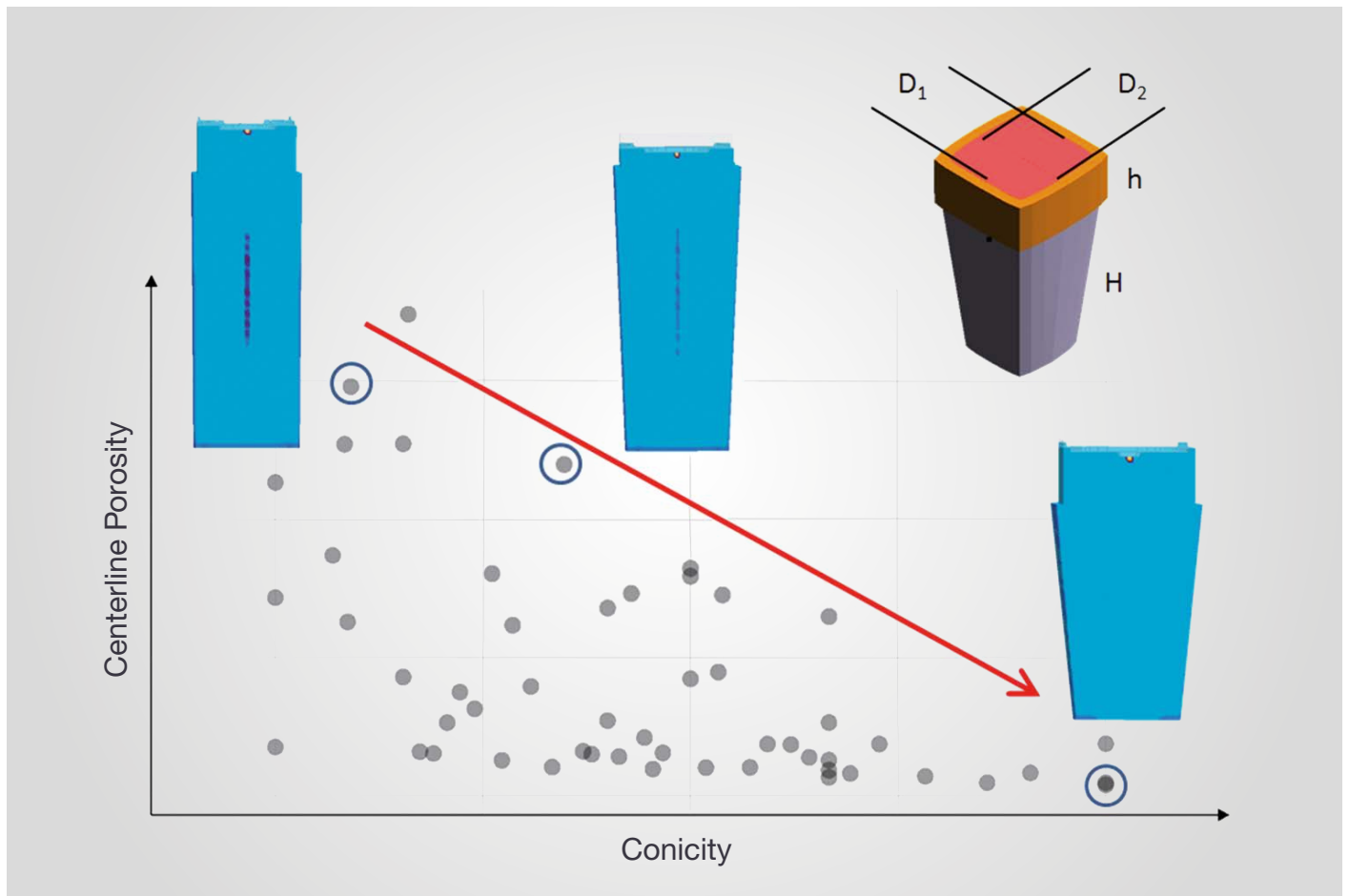
MAGMASOFT® offers extensive capabilities for virtual designs of experiments and optimization. This enables the analysis of process windows without economical or production risks. In addition to optimizing the casting layout, numerous process variables can be analyzed for setting robust manufacturing conditions.

Comprehensive statistical evaluation methods support you in determining optimal conditions for:

- H/D ratio, conicity, head height and geometry
- Mold wall thickness
- Teeming conditions, e.g., pouring temperature
- Shakeout temperature and time
- Pipe and centerblock geometry and the configuration of multiple molds
- Inverse determination of local heat transfer coefficients



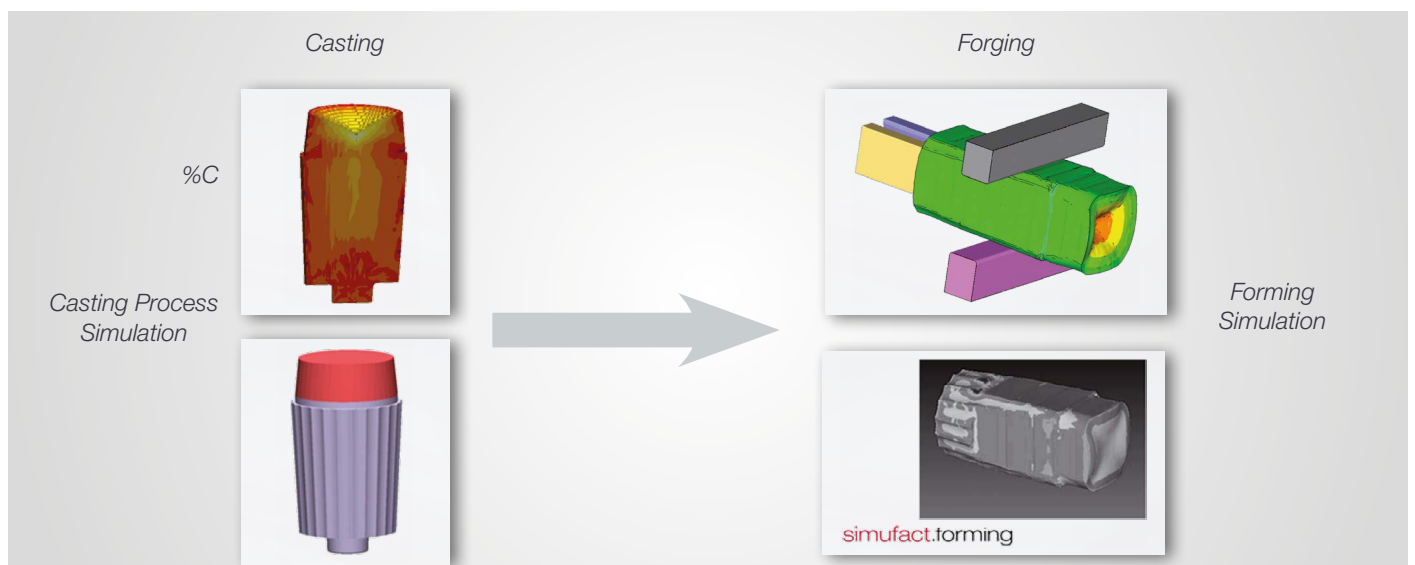
Ensuring robust processes



Optimization of the ingot geometry to avoid centerline porosity

The Whole Process Chain

MAGMASOFT® provides realistic starting conditions for forming simulations by predicting various local properties or damage in the casting or ingot. With the transfer of this information, a robust forming process can be designed. Potential risks from segregation or shrinkage porosity in the workpiece can thus be identified at an early stage.



Simulation of the complete process chain – transfer of as-cast properties to forging simulation

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

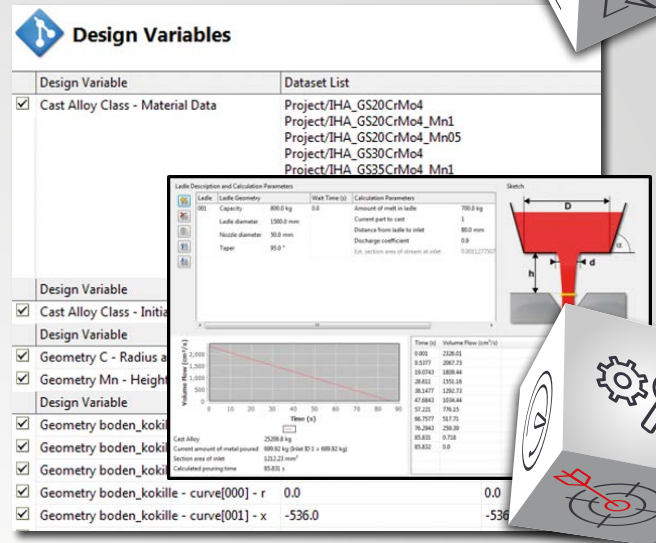
Your time is limited! To achieve your goals, it is crucial to systematically and efficiently utilize all the available possibilities in MAGMASOFT®'s comprehensive toolbox.



Assisted Modeling

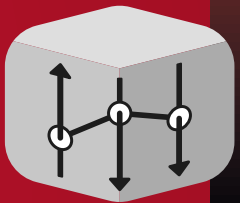
Versatile wizards and convenient CAD functions support you in a targeted and effective model preparation and enable a short time to answer with minimum effort.

Use the practice-oriented visualization of all relevant process steps for optimization of the entire process. Is your focus on teeming or would you like to avoid cracks in your mold? Consider the process steps separately or combine them as needed.



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.



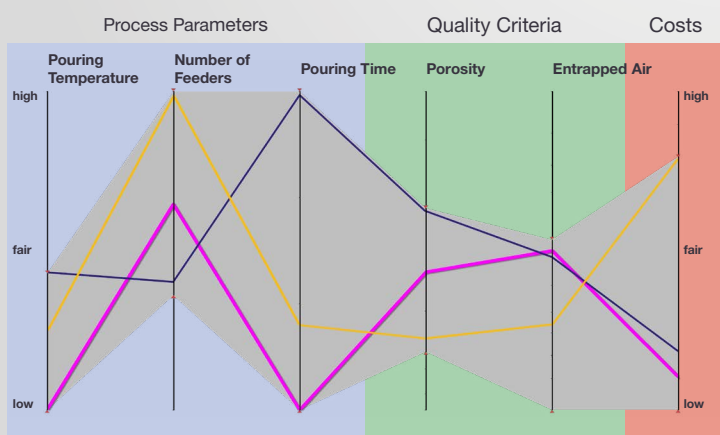
Optimize Your Casting Quality, Cost & Carbon Footprint

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

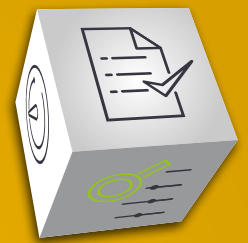


With MAGMA ECONOMICS, the parallel coordinate diagram as established, interactive tool for analyzing process variations and quality criteria is complemented by corporate criteria such as costs, energy/resource consumption and sustainability.

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.

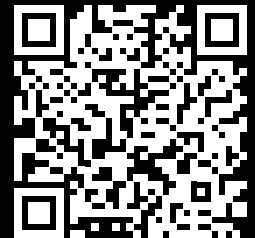
MAGMAengineering

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®**