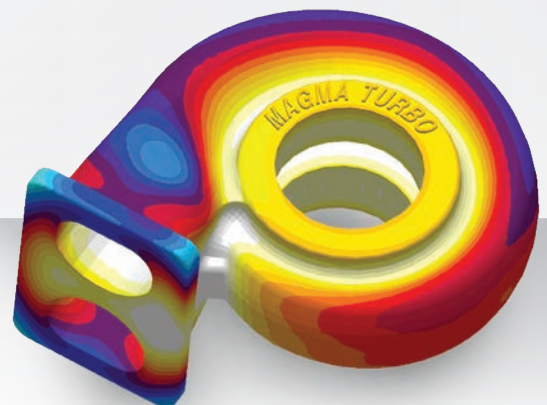


AUTONOMOUS **ENGINEERING™**



IRON

- Eliminate defects before they become a reality
- Identify significant process and design variables
- Consider process variability
- Balance production costs with quality
- Predict microstructure and mechanical properties
- Consider iron quality, chemistry and mold strength



THE **MAGMA** APPROACH



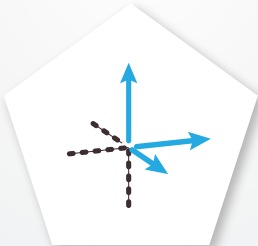
Targeted, Systematic Path to Success

Successfully navigating the highly complex iron casting process doesn't just happen by chance... it requires a game plan that will get you to your final goals.

The MAGMA APPROACH is that game plan. Simply put, this systematic problem solving method is not only integrated into MAGMASOFT® autonomous optimization, it is the foundation of everything we do as an organization.



**SET UP YOUR
OBJECTIVES**



**DEFINE YOUR
VARIABLES**



**SPECIFY YOUR
CRITERIA**



**KEEP THE TASK
EFFICIENT**



**CHOOSE YOUR
METHOD**



**ACT & CHECK YOUR
IMPROVEMENTS**

SET UP YOUR

objectives

We know that foundry engineers work hard to produce quality castings, meet deadlines and reduce costs. Your job is complex and keeping all of the moving pieces together can be a challenge. We understand this and so does our software.

IMPROVED QUALITY

Every time a mold is poured the potential to create casting defects exists. With every casting defect comes the threat of increased scrap rates, lower production rates, increased costs, increased lead times and unhappy customers.

ON TIME DELIVERY

Your customers are counting on the castings you provide for their finished products. To meet their goals, they need their castings on time. Late castings mean lost business for your customer and your foundry.

REDUCED COSTS

Your foundry is one of many in a global industry where your customers are seeking to lower their costs and maximize their profits. To be competitive your foundry must consider the impact that material costs, labor, production and defects have on your bottom line.



At Griffin Industries we use MAGMASOFT® autonomous engineering to obtain sound castings quickly for our customer's prototype needs. We're able to use MAGMASOFT® in our discussions with customers to justify the need for feed pads and minor design changes to ensure we can supply the castings within the defined timeframe and at the defined quality. In the world of prototype castings there's no time for trial and error, we need trial and success.

*– Jon Krouth, President, Griffin Industries
Green Bay, Wisconsin*



MAGMASOFT®
autonomous engineering



DEFINE YOUR

variables

To do your job successfully, you have to understand the effects that many different variables have on the casting process. From tooling and casting design to chemistry and melt treatment, to material properties, mold strength, and machine parameters.

We understand and consider these variables and how they impact your casting quality, production rate and costs.

MAGMASOFT® autonomous engineering can evaluate multiple variables at the same time. These variables can include the variation of any casting or tool dimensions, process parameters or materials. The software can consider all of these variables while working to achieve the objectives you have set.

MATERIAL

- Alloy type and exact alloy chemistry
- Mold and core sand
- Mold stability and mold wall movement
- Riser sleeves
- Filters
- Chills

MOLDING METHOD

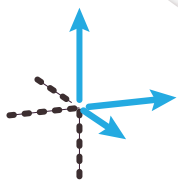
- Horizontal
- Vertical

GEOMETRY

- Casting
- Rigging

PROCESS

- Pouring temperature and rate
- Sand conditions
- Inoculation and melt treatment
- Shakeout
- Rigging removal and machining



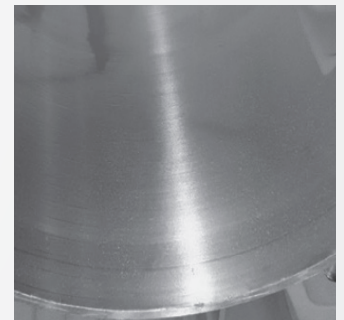
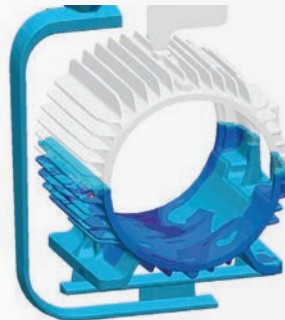
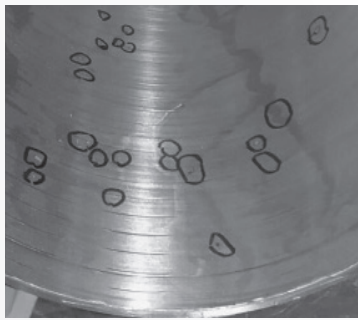
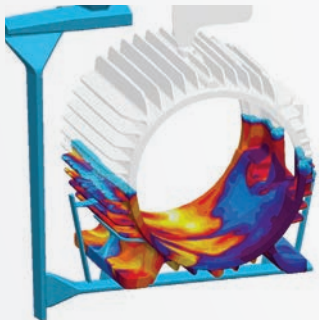
SPECIFY YOUR criteria

Before a problem can be solved, it must first be quantified and properly understood. MAGMASOFT® considers your entire process and provides quantitative results that measure progress.

MOLD FILLING

When liquid iron is poured into a mold, there are many opportunities for defects to occur. Analyzing the filling using MAGMASOFT® allows you to avoid defects such as:

- Inclusions
- Entrapped air or core gases
- Misruns
- Cold lap



Air entrapment during filling for baseline gating system (left), reduced air entrapment during filling for optimized gating system (right)



SPECIFY YOUR criteria

SOLIDIFICATION & COOLING

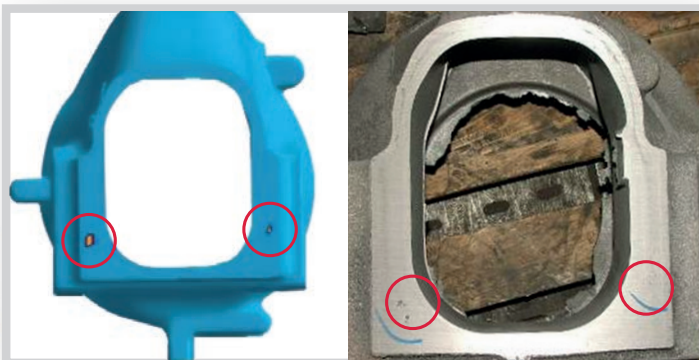
During solidification there are many factors that influence defect formation, such as: the chemistry of the melt, the metal treatment practice used, the mold wall stability and the heat transfer in the casting system and mold.

MAGMASOFT® considers each of these variables when predicting defects that occur during solidification such as:

- Shrinkage porosity
- Binder gas defects
- Burn on sand and penetration



PREDICT



Porosity in a ductile iron casting



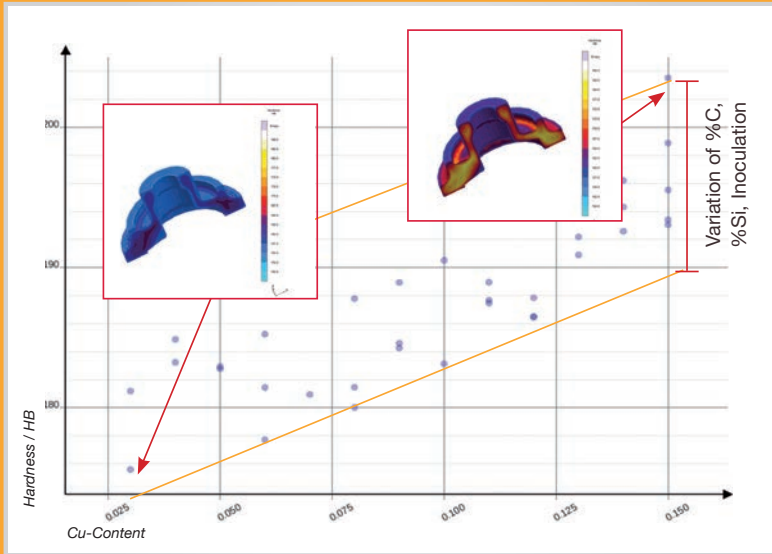
Solidification path for a ductile iron axle housing during cooling



MICROSTRUCTURE & MECHANICAL PROPERTIES

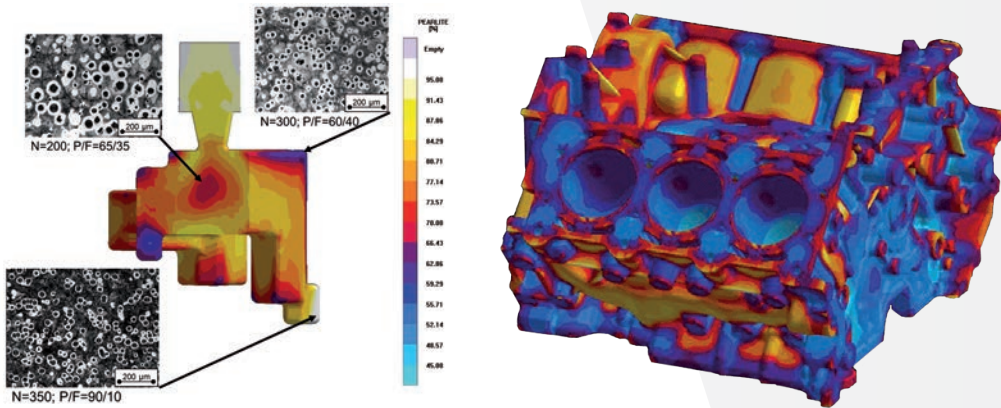
The MAGMASOFT® Iron micromodel helps you avoid:

- Undesirable microstructures
- Out-of-spec mechanical properties
- Poor machinability



Influence of alloy chemistry on mechanical properties

ANALYZE



Local pearlite fractions in a ductile iron casting (left), nodularity distribution in a CGI V6 crankcase (right)



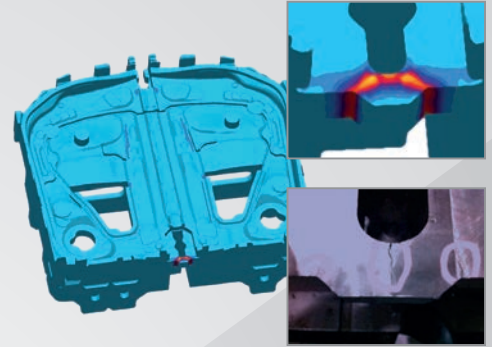
SPECIFY YOUR

criteria

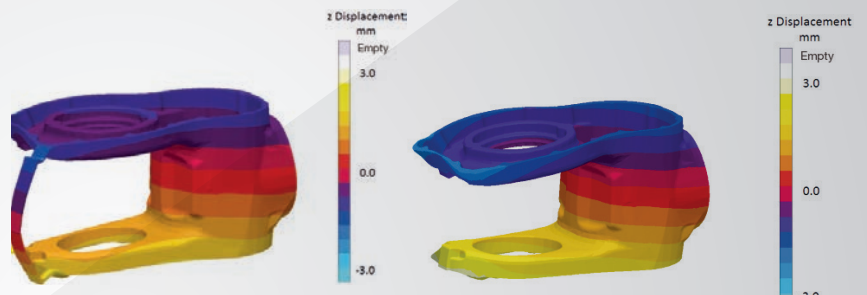
STRESS & DISTORTION

The expansion and contraction of iron castings during the casting and heat treatment process, along with the influence of constraints from the core and mold sections can result in:

- High residual stresses
- Cold cracking
- Excessive distortion



Cold cracking in an iron casting

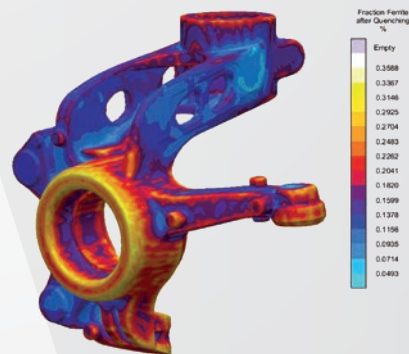


Distortion after shake-out: The two "ears" move towards each other (left), Distortion after machining: The two "ears" move further towards each other (right)

HEAT TREATMENT

Austempered Ductile Iron (ADI) requires precise process control throughout austinitization, quenching and ausferritization in order to provide the desired microstructure and resulting mechanical properties. MAGMASOFT® accounts for each of these process steps and their specific conditions so that the following can be understood:

- Austinitization time
- Ausferritization time
- Phase distributions



Calculated microstructure distribution in the ausferrite after ADI heat treatment



KEEP THE TASK

efficient

Time and engineering resources are at a premium in the iron foundry. You need tools that allow your entire organization to be as productive as possible.

MAGMASOFT® DESIGN TOOLBOX

MAGMASOFT® gives you tools that will save you time and help you to work as efficiently as possible, including:

Tools that save set-up time

- A library of premade and easily editable rigging components, including risers, runners, and sprues
- Quick and easy meshing of any geometry
- Automated geometry changes when testing different designs variables

Tools that save calculation time

- A queuing system for prioritizing and scheduling multiple simulations or virtual experiments
- Ability to run multiple designs in parallel to reduce processing time
- Scalable multi-core performance for faster runtimes

Tools that save time analyzing results

- Data analysis tools for quickly identifying significant variables in virtual experiments
- Comparison of results from multiple designs in multiple views simultaneously
- Automated image and movie generation



At Poitras we use MAGMASOFT® autonomous engineering to optimize our tooling designs and production processes, for both the castings and cores we produce. MAGMASOFT® enables us to quickly identify the geometries and/or process conditions that are inhibiting the quality and production goals we've defined. By identifying those root causes we are able to optimize our tooling and processes to meet our production and quality goals. Our use of MAGMASOFT® has directly improved our efficiency.

– Jason Robitaille, President, Poitras Foundry, L'Islet, Quebec City, Canada



CHOOSE YOUR

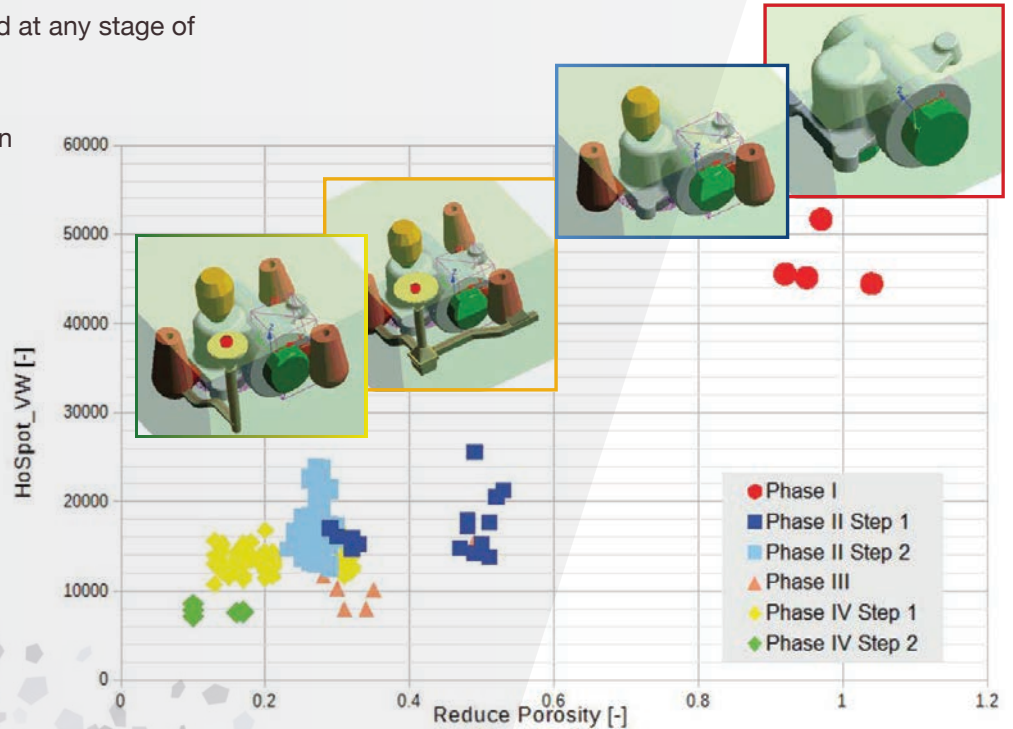
method

Every project presents unique challenges and requires different strategies to reach your goals. MAGMASOFT® autonomous engineering provides different strategic approaches for each unique project.

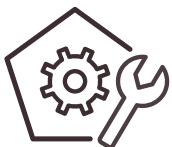


CUSTOMIZE YOUR STRATEGY

- Using MAGMASOFT® you can easily define goals using single simulations, design of experiments and optimizations that consider multiple designs at once.
- The influence of many variables can be quickly analyzed when running design of experiments or optimizations.
- Numerical objectives and automated setup help to quickly identify designs that meet competing objectives (i.e. quality and yield).
- Each strategic approach can be used at any stage of product life cycle including:
 - New part development
 - Trouble shooting current production
 - Continuous improvement



Scatter chart illustrating quality improvements during different phases of new tooling development



ACT & CHECK

improvements

Success requires more than just Autonomous Engineering™... it requires a team of professionals to help you reach your goals.

MAGMA provides this team. With our implementation plan, **MAGMASupport**, engineering services and the **MAGMAacademy**, we are here to support you every step of the way.

IMPLEMENTATION PLAN

The implementation of MAGMASOFT® autonomous engineering begins with a customized plan that your dedicated Account Manager will review with you on day one.

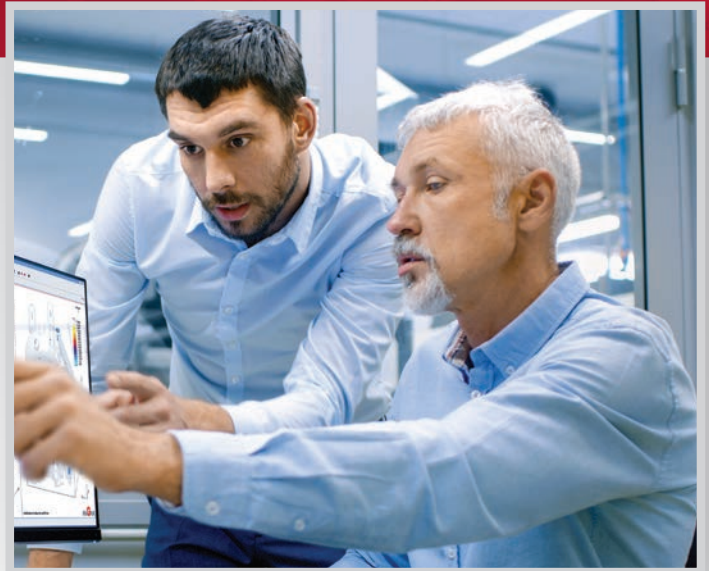
This plan covers all pertinent information for successfully launching MAGMASOFT® within your organization, including:

- Appropriate software modules
- Hardware requirements and configuration
- Installation & assistance
- Formal training

ONGOING SUPPORT

Once MAGMASOFT® has been successfully launched at your organization, we will transition into an ongoing development plan to identify how best to support you. Our goal is to establish a long-lasting partnership between MAGMA and your organization.

Our support staff is made up of metal casting experts with over 230 years of industry experience. Dedicated support engineers will work each day to make sure your organization is consistently meeting its goals, day after day, year after year.



ENGINEERING SERVICES

MAGMA project engineers are here to help you with any casting project assistance you need. You do not need to be a MAGMA customer to benefit from our Engineering Services. Each of our engineers will bring their years of experience in the metal casting industry to your project to help ensure a successful partnership between your company and ours.



MAGMAacademy

MAGMAacademy is a training and continuing education program at MAGMA. All training and ongoing learning relating to MAGMASOFT®, seminars and workshops are done through MAGMAacademy.

TRAINING

Users learn to efficiently and systematically use MAGMASOFT®.



ONLINE RESOURCES

- Webinars
- Tips & Tricks
- Video Tutorials

WORKSHOPS

Learn and practice more advanced skills, techniques and applications.



ANNUAL USER MEETING

Users learning from other users.

SEMINARS

Users and non-users gain deeper insight to organization-wide improvement strategies.



The MAGMAacademy invites non-customers to most of our workshops and seminars, please check out the MAGMAacademy section of our website for more information and to register for the MAGMAacademy events.

5

MAGMASOFT®
autonomous engineering