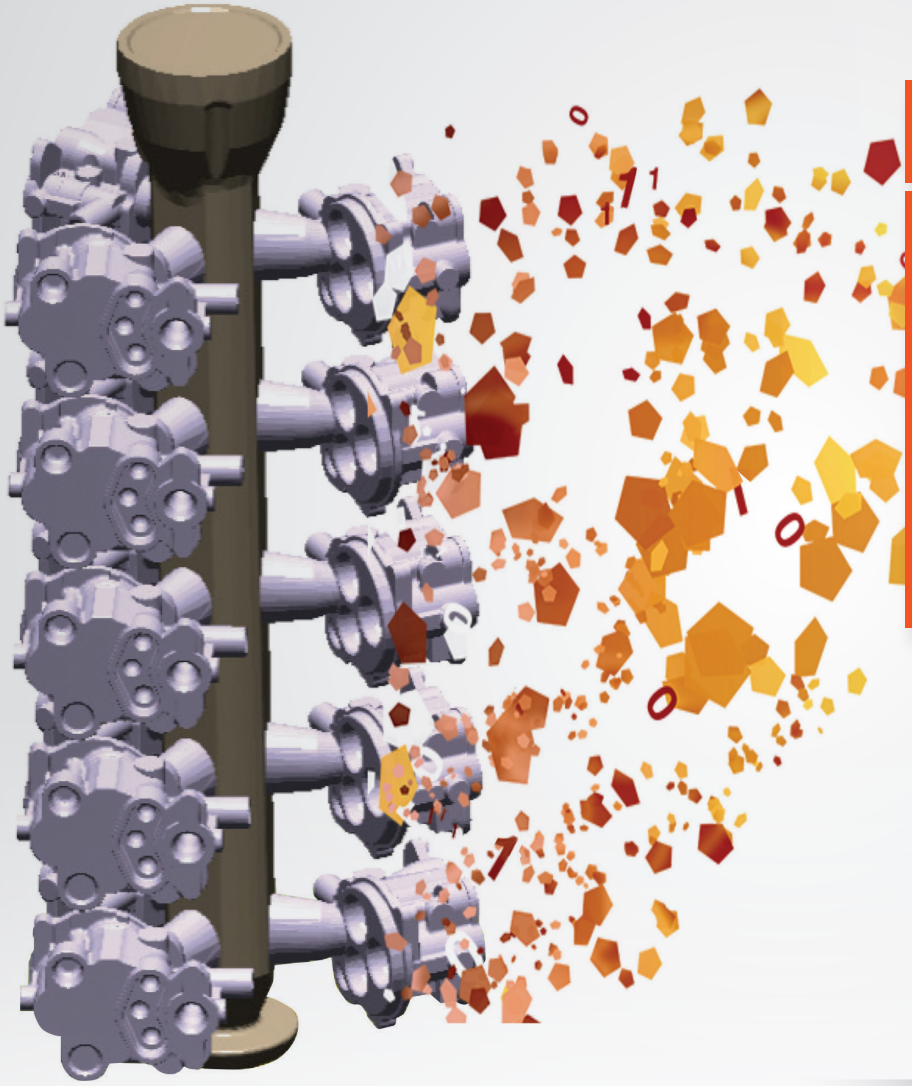
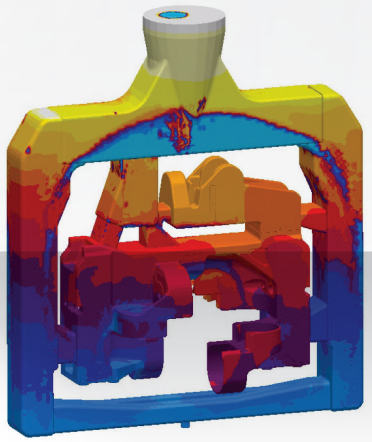
AUTONOMOUS ENGINEERING™



INVESTMENT CASTING

- 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
- Automatic generation of investment shells
- Precise modeling of radiation



MAGMA

Committed to Casting Excellence

THE MAGMA APPROACH

Targeted, Systematic Path to Success

Successfully navigating the highly complex investment 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 engineering, 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

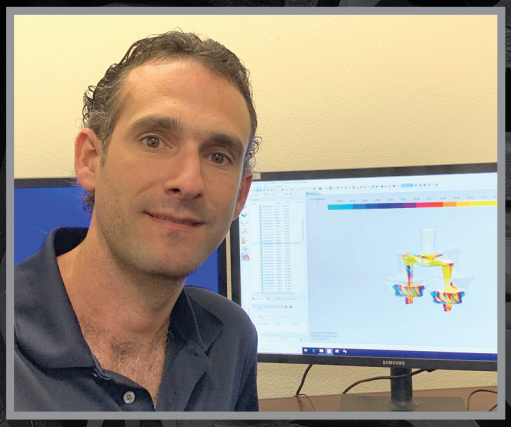
Every time an investment shell is poured the potential to create casting defects exists. With every casting defect comes the threat of increased scrap rates, lower production rates, increased costs, increased lead times and unhappy customers.

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 FS Precision Tech we invest significant amounts of engineering time to analyze how material will flow and solidify. The use of MAGMASOFT® autonomous engineering ensures that we achieve production readiness for new programs in the shortest possible time. As a program proceeds through its production life cycle, casting process simulation and optimization is also used to improve efficiency, yields, and overall program costs, ensuring that our customers always receive the greatest value for their casting investment.

– Issa Nassar, Engineering Manager, FS Precision Tech, Compton, California

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 melt chemistry, to material properties, and process 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

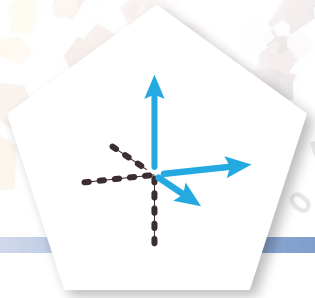
- Alloy chemistry
- Shell material
- Shell thickness
- Kaowool

GEOMETRY

- Casting
- Rigging

PROCESS

- Pouring temperature and rate
- Shell temperature
- Shakeout time
- Rigging removal and machining



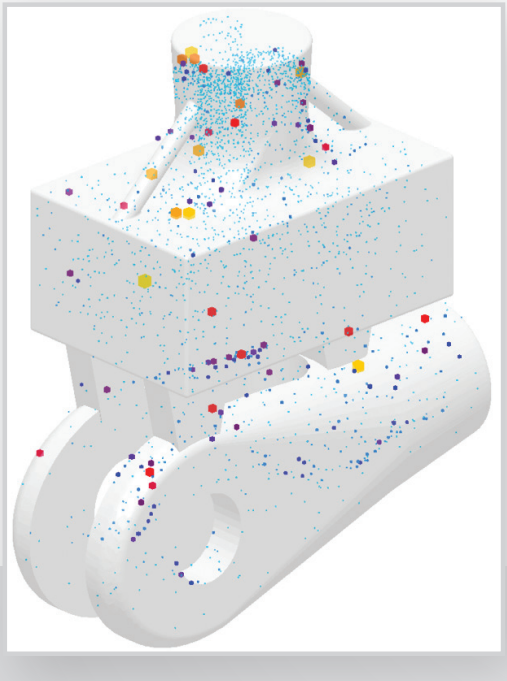
SPECIFY YOUR criteria

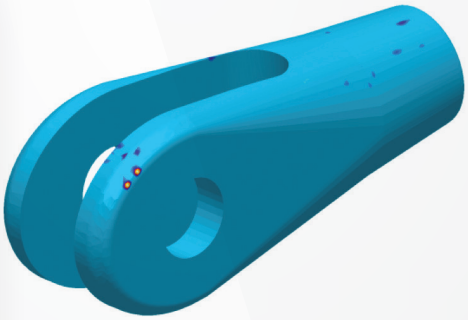
Before a problem can be solved, it must first be quantified and properly understood. MAGMASOFT® considers your entire process and provides quantitative results that measure progress.

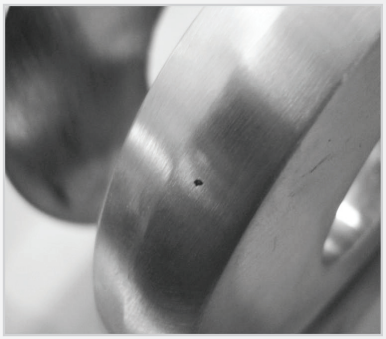
INVESTMENT SHELL FILLING

When liquid metal is poured into an investment shell, there are many opportunities for defects to occur. Analyzing the filling using MAGMASOFT® allows you to avoid defects such as:

- Inclusions
- Entrapped air
- Misruns
- Cold lap







Predicted reoxidation inclusion and corresponding casting defect found in production

SPECIFY YOUR criteria

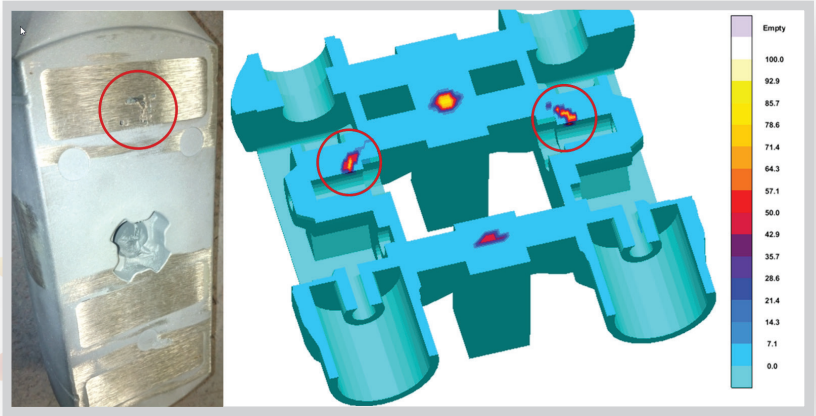
SOLIDIFICATION & COOLING

During solidification there are many factors that influence defect formation, such as: the chemistry of the alloy, the shell material being used and the heat transfer in the casting system and shell.

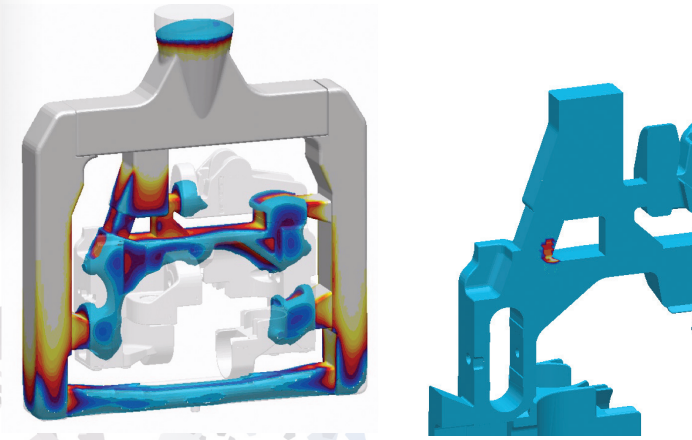
MAGMASOFT® considers each of these variables when predicting defects that occur during solidification such as:

- Macro shrinkage porosity
- Micro shrinkage porosity

PREDICT



Porosity in investment casting

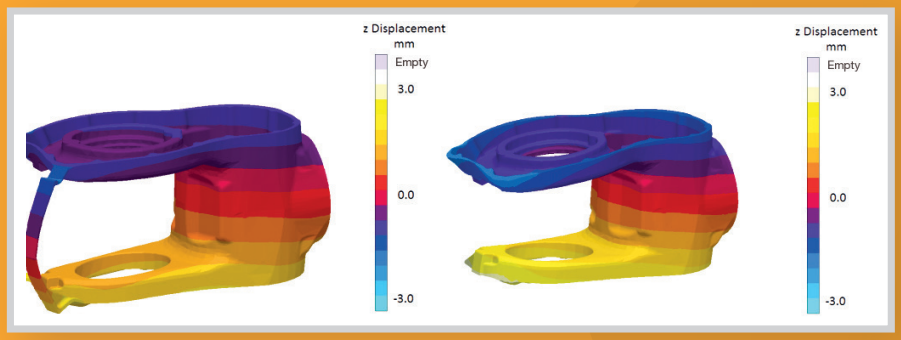


Fraction liquid during solidification (left) Shrinkage porosity (right)

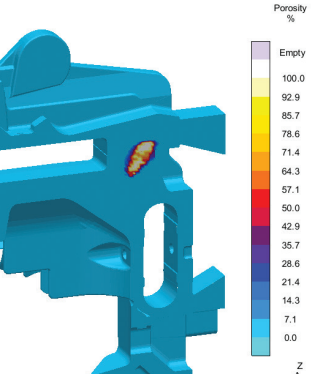
STRESS & DISTORTION

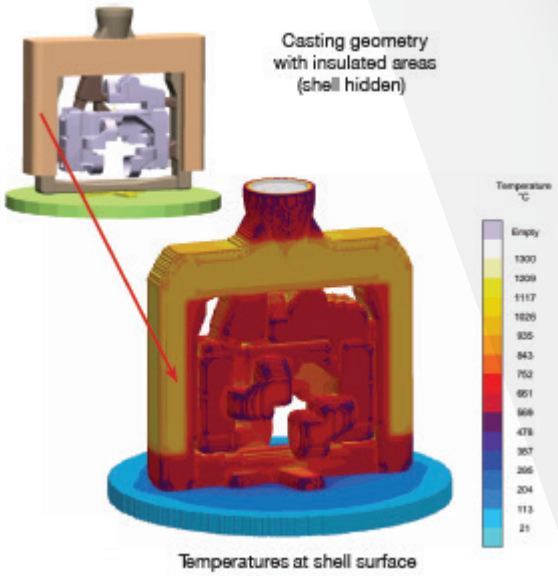
The expansion and contraction of investment castings during the casting and heat treatment process can result in:

- High residual stresses
- Cold cracking
- Hot tearing
- Out-of-spec dimensions

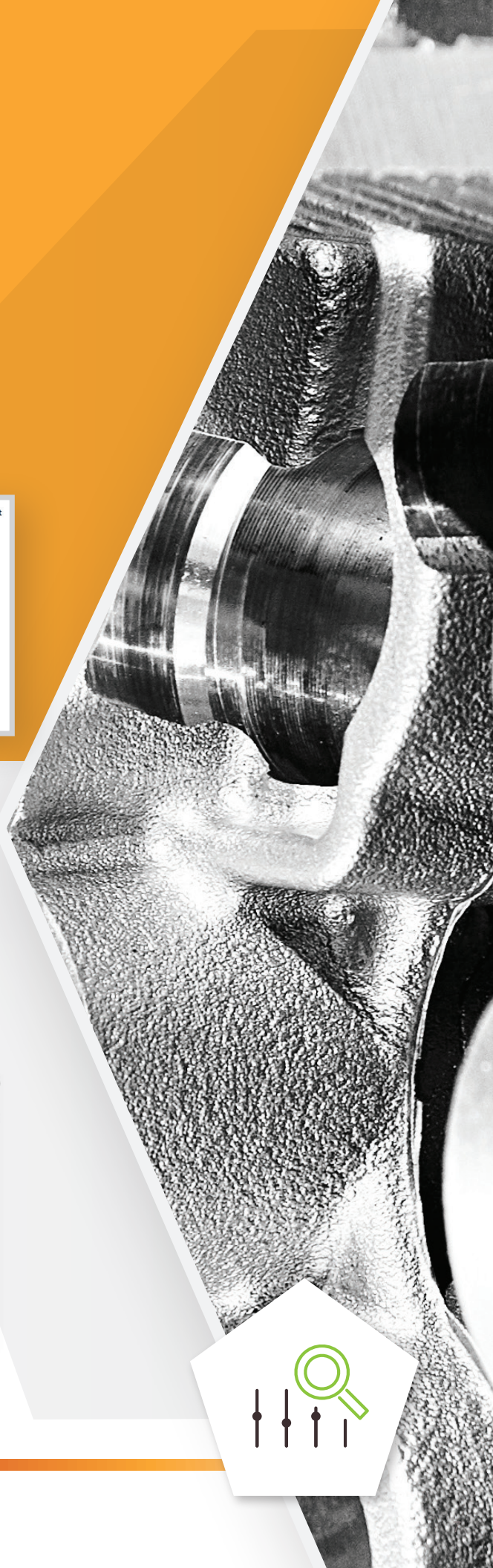


Distortion after knock-out: The two "ears" move towards each other (left), Distortion after machining: The two "ears" move further towards each other (right)





Temperatures at shell surface

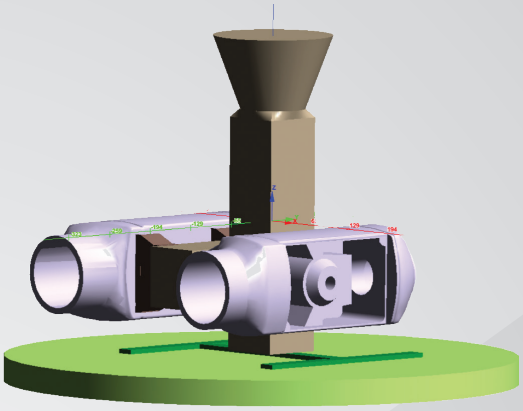


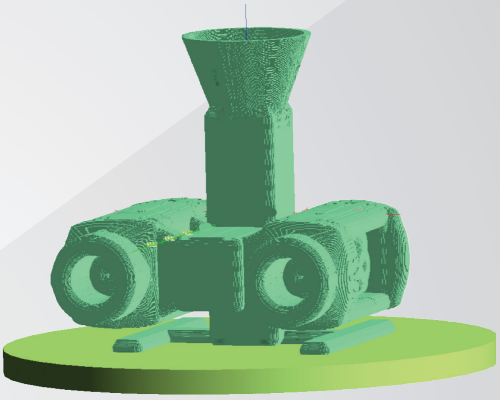
SPECIFY YOUR

criteria

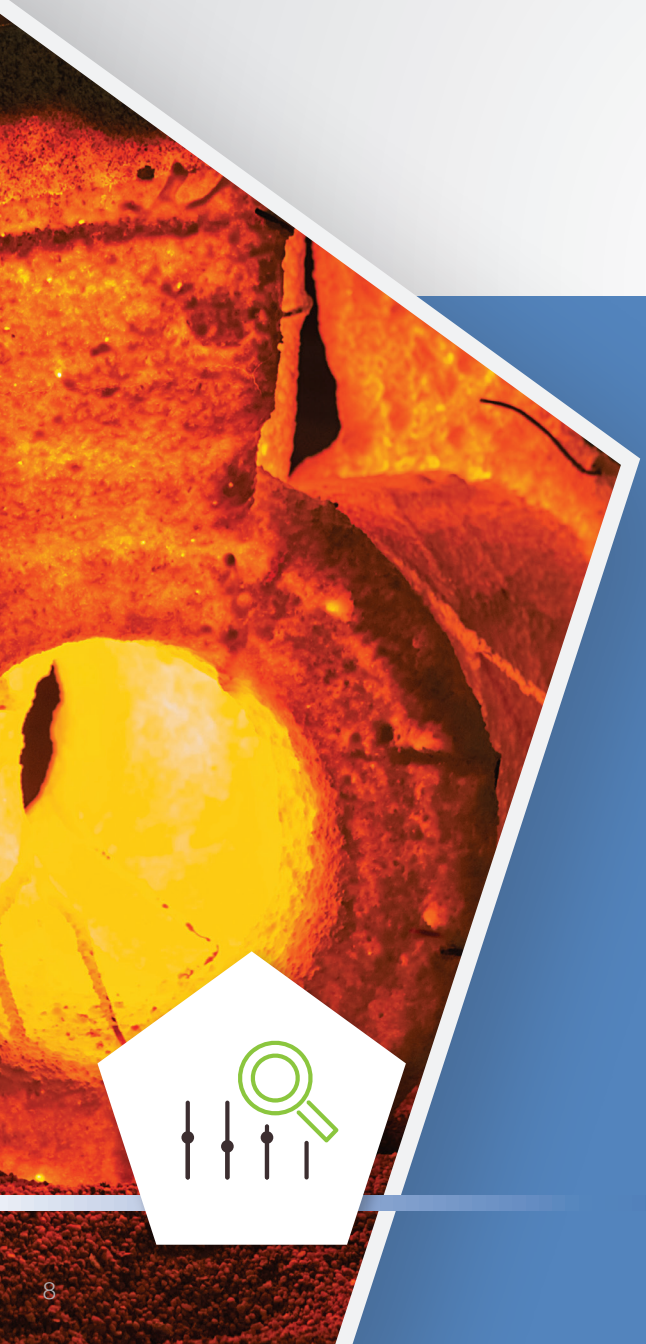
AUTOMATIC SHELL GENERATION & CONSIDERATION OF RADIANT HEAT

- Automatic enmeshment of the investment shell based on the desired shell thickness
- Shells can be locally thickened and pockets can be filled in with additional shell material as needed
- The modeling of insulated areas and mold backing is easily considered





Automatically generated shell



ADVANCED RADIATION MODEL

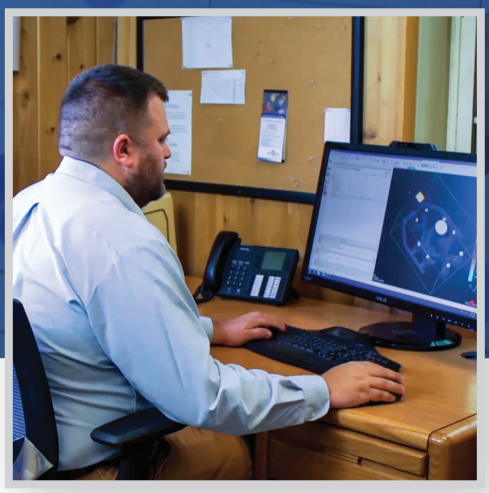
Advanced radiation model accurately considers:

- Radiant heat exchange between different surfaces of a heated shell including neighboring cavities and tight pockets in the shell
- Heat transfer to and from surfaces surrounding the shell such as a sand bed or other material that the shell is sitting on
- Heat transfer from the shell to the surrounding environment

Illustration demonstrating how shadowing effects are considered in the advanced radiation model

KEEP THE TASK efficient

Time and engineering resources are at a premium in the investment 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

While using MAGMASOFT® autonomous engineering I am able to take advantage of many different tools that help me to quickly and easily get to the results that I need to produce castings that meet our customer's requirements. Being able to run simulations on multiple cores provides results fast and being able to analyze multiple designs at the same time helps me get to a good solution quickly.

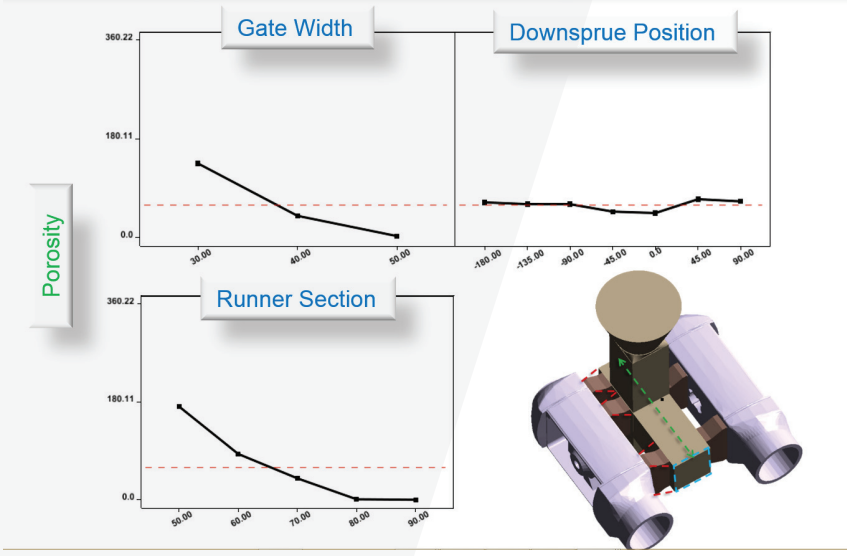
– Erik Johnson, Engineering Manager, Northern Stainless Corporation, Pewaukee, Wisconsin

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



Main effects plot that highlights the impact of different variables considered in a virtual design of experiment (DoE)

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.

MAGMASOFT®
autonomous engineering

MAGMA
Committed to Casting Excellence

MAGMA Foundry Technologies, Inc.
10 N. Martingale Road, Suite 425, Schaumburg, IL. 60173
847-969-1001 | info@magmasoft.com | magmasoft.com