

The background of the slide is split into two main sections. The left section is a solid red triangle that points towards the top right corner. The right section is a curved, wavy pattern of horizontal lines in shades of blue, purple, and magenta, creating a sense of motion or a digital landscape.

[PiQ²]

Developing Expertise



AGENDA

- 1 **Company presentation**
- 2 Product overview
- 3 Product comparison



ABOUT US

We develop **cutting-edge simulation software** which blends the practical and theoretical knowledge gained from experience in the foundry.

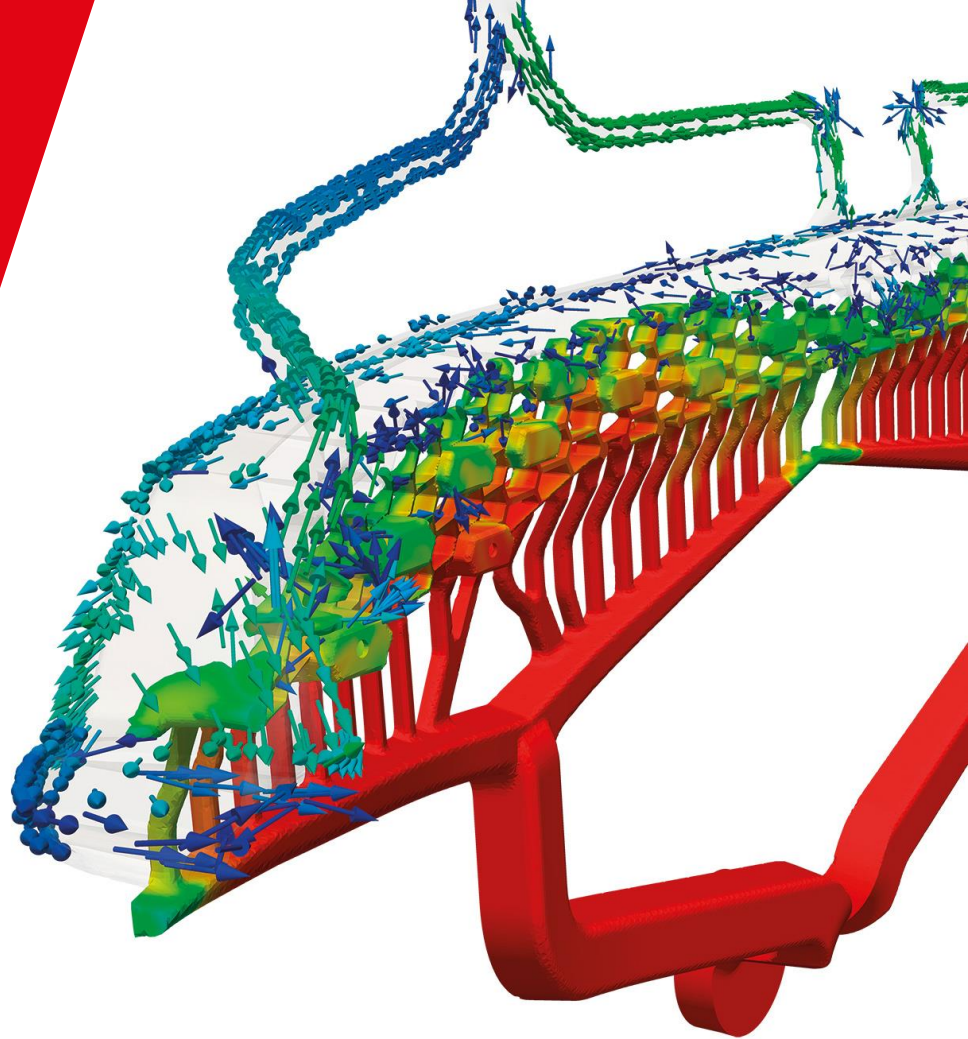


PiQ² facts

- Established in **2011**
- Head Offices in **Brescia** (IT)
- Part of Costamp Group since **2016**
- **Micro Enterprise**
- Innovative **Startup** Company
- Member of the Technological Hub of **CSMT**

OUR MISSION

The simulation phase is a key moment in the die manufacturing process



OUR MISSION

The simulation phase is a key moment in the die manufacturing process

Simulation software should be **easy to use**, making it **simple to share results** with key project personnel. It should simulate the process on a **detailed level**, **keeping all variables in check**, assisting the designer in each phase of the development of the die.

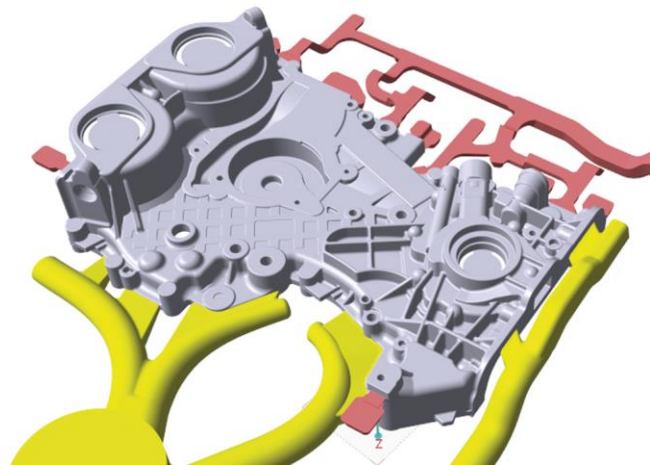
OUR CORE BUSINESS

Castle meets these needs via 4 independent modules

Castle is a software application created by PiQ² for the aluminium, zinc and magnesium alloy die casting process.



Simulates the production scenario which the die will operate in, providing crucial information to ensure it is developed correctly.



[castle] RUN

Allows the user to carry out a **simulation of a single runner**, in order to optimise a section or quickly assess alternative solutions.

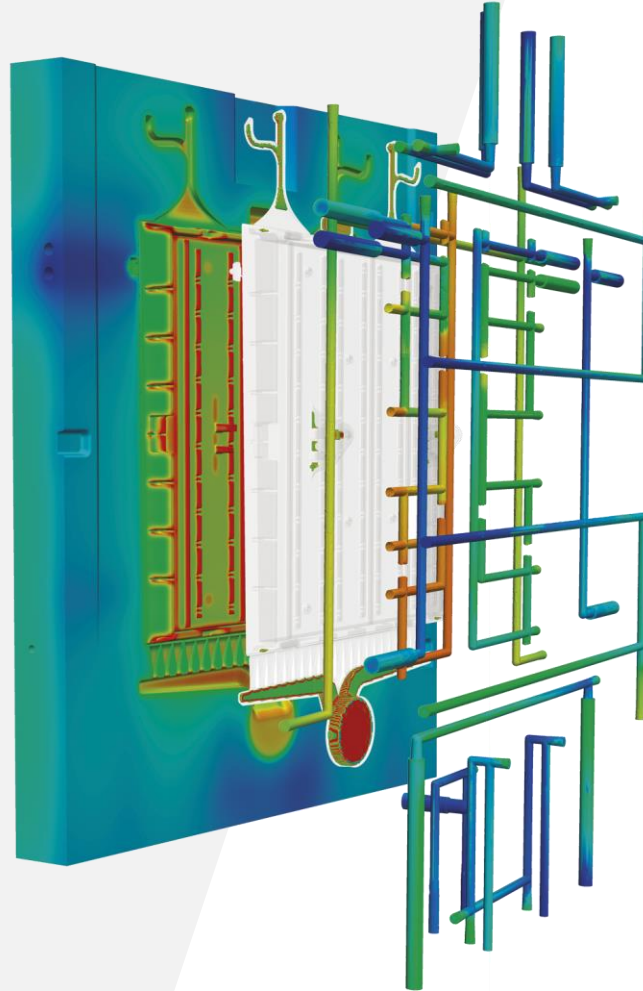


[castle] BODY

Simulates filling and solidification phases whilst taking air flow into consideration.



This module **simulates**
the thermal behaviour
of the entire die.



The 4 Castle
independent modules
allow for **accurate**
simulation of die
performance in all
its operational
phases, providing
comprehensible results
that can be used to
optimise output.

WHY CHOOSE CASTLE?



PARTNER IN DESIGN

Supporting
the designer
in making
key choices



COMPATIBLE

Import, modify and
export all leading
3D formats
(*Step, Parasolid, IGES,
SolidWorksTM, CatiaTM
SolidEdgeTM, and many
others*)



USER FRIENDLY

Intuitive interface,
easy to use



DUAL PHASE

Can accurately
simulate air
behaviour, showing
both the flow and
any air entrapment



INVESTMENT

Immediate results,
guaranteeing
a rapid return
on investment

OUR SIDE BUSINESS

- **CONSULTANCY** in metallurgy and manufacturing processes of light alloys
- **TRAINING** in metallurgy and manufacturing processes
- **PRODUCT DESIGN** development and optimization
- **CUSTOM SOFTWARE DEVELOPMENT** upon specific request
- **COMMISSIONED R&D** on foundry-related technologies

OUR MARKET

CUSTOMERS Italy, Austria, UK,
Singapore, China, Japan, India,
Romania, Brazil, Turkey, Germany

DEALERS Italy, USA, India,
Turkey, China, Hong Kong,
Japan, Czech Rep.

81 software customers
(June 2019)

92 licenses
(June 2019)



OUR CUSTOMERS

AL foundries



ENDURANCE OVERSEAS

FONDAREX®

SWISS VACUUM TECHNOLOGY

+GF+

EUCASTING



METALPRES
DONATI



BOSCH

autoheinen



COSTAMP
= GROUP =



OUR CUSTOMERS

AL foundries



Tecnomeccanica SpA



OUR CUSTOMERS

AL foundries



宁波泛德压铸有限公司
NINGBO FOUNDERS DIE-CASTING CO.LTD.



OUR CUSTOMERS

AL foundries



OUR CUSTOMERS

Diemakers



OUR CUSTOMERS

Diemakers



OUR CUSTOMERS

Zamak



OUR CUSTOMERS

Zamak



Euro Stampaggi spa

MICROCAST





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SIMULATION

According to PiQ²
vision, simulation is:



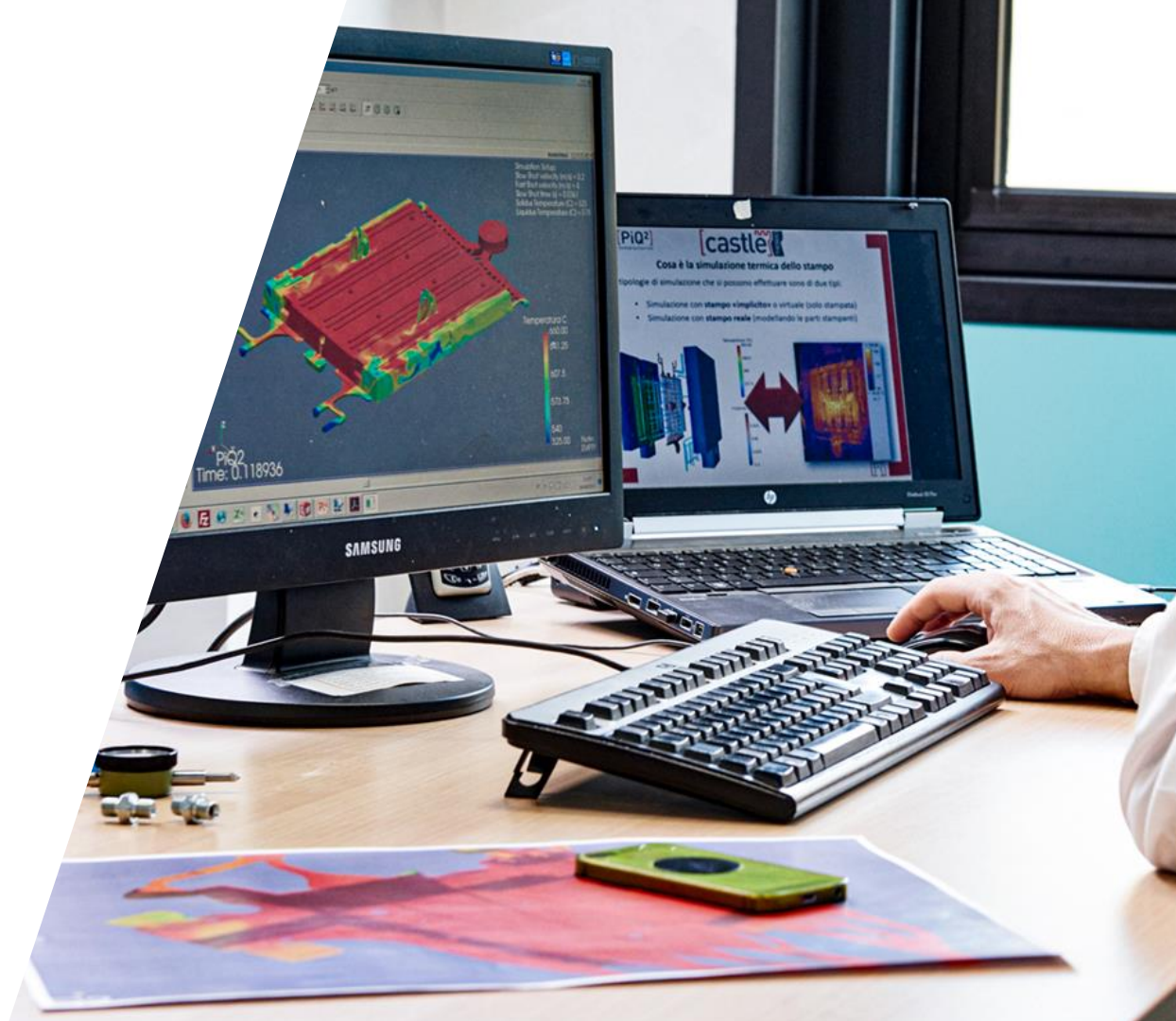
a design tool



a working method



a verification tool



SIMULATION

Critical points

Castle software was purposely developed to overcome typical critical points of simulation software.



CRITICAL POINTS

- **High purchase and maintenance costs**
- **High usage costs**
(skillness & complexity):
bottleneck in the engineering department workflow
- **Analysis timing**
typically, the simulation can be performed only once the runner design is completed
- **Simulation results**
the simulation does not take into account some well known phenomena that occur during the process

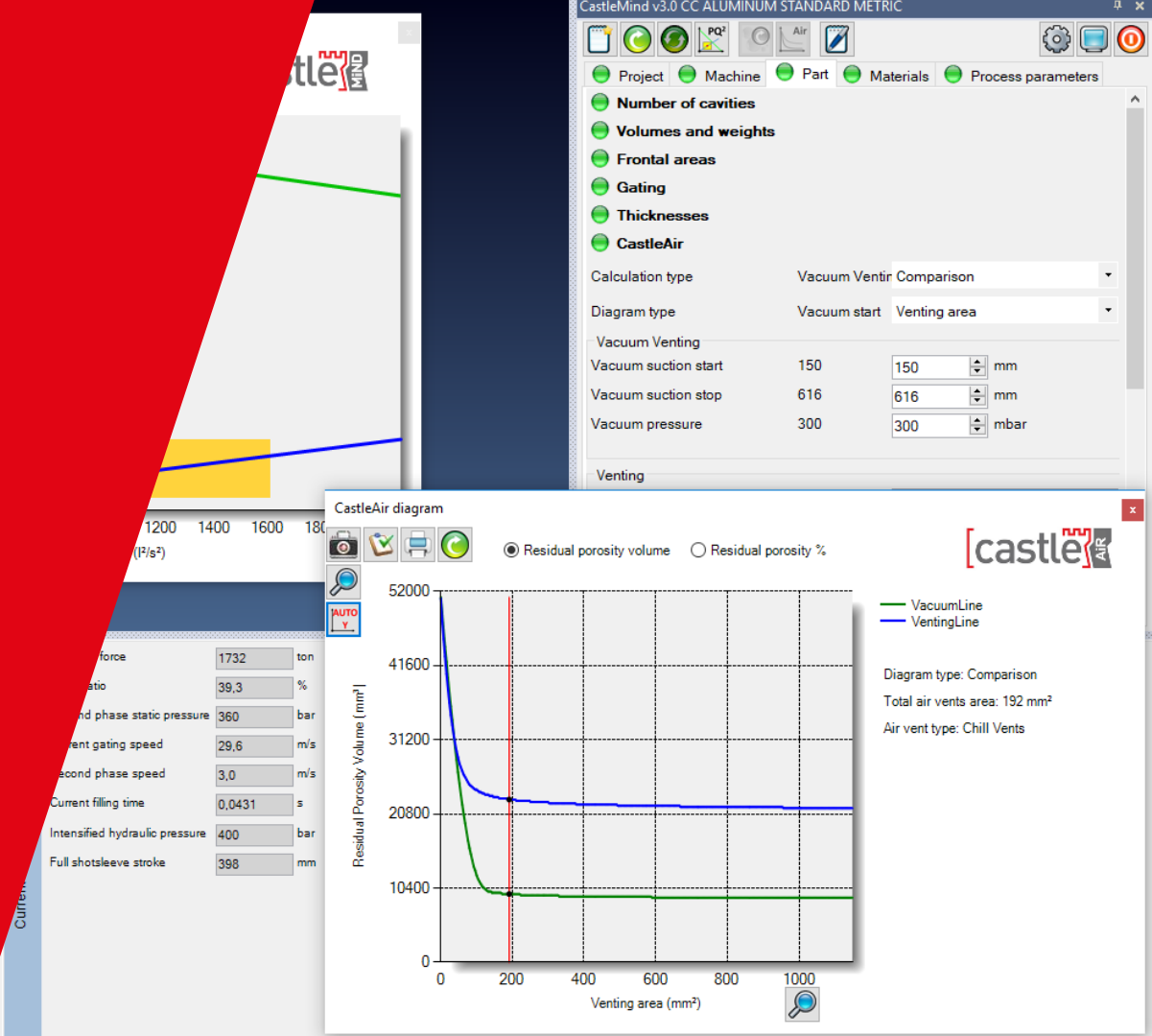


1st step: think before designing...

- Make a **global setting evaluation** before die design
- Accurately **calculate and predict** the effective die performance on the machine
- **Evaluate** the casting geometry, **define** the quality requirements and **optimize** the mold-machine system

[castle]²MIND

Innovative software solution
that combines mathematical
concepts from fluid dynamic
principles with experience
gained in die manufacturing
and the foundry.



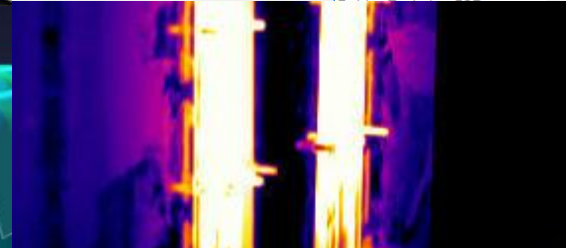


Analysis and definition of casting and process

- Geometry (3D or virtual)
- Machine, plunger, shot sleeve
- Die and casting alloy grades
- Process parameters.
- Quality goals (porosity/surface quality)



Model		
Name	LK DC630	LK DC630
Suggested line press.	140	MAICO GK650
Dry shot speed	8,5	MAICO GKL1000
Max injection force	610	MAICO GK1100
Max injection pressure	458	MAICO TEK1500
Locking Force	630	MAICO GKS2000
Suggest. sec. phase speed	3	METALPRES MP200
		METALPRES MP300
		METALPRES MP400
		METALPRES MP550
		METALPRES MP750
		METALPRES MP900
		METALPRES MP1100
		COLOSIO PF320
		COLOSIO PFO400
		COLOSIO PFO500
		COLOSIO PFO600
		COLOSIO PFO750
		COLOSIO PFO 1100
		COLOSIO PFO 1200
		Buhler Evolution 26C



Part material		
Alloy grade		EN AC46000 AlSi9Cu3Fe
Solid state density	2,74	NODEF
Solid state temperature	525	AA100 Al99,0
Liquid state density	2,43	AA170 Al99,7
Liquid state temperature	590	EN AC43400 AlSi10MgFe
Suggested furnace temperature	670	EN AC43500 AlSi10MnMg
Suggested die temperature	280	EN AC44100 AlSi12
		EN AC44300 AlSi12Fe
		EN AC44400 AlSi9Mg
		EN AC44500 AlSi12Fe
		EN AC46000 AlSi9Cu3Fe



Die/process output & optimization

- Optimized process parameters
- PiQ² DIAGRAM analysis
- Gating dimensioning
- Suggestions in spoken language

Calculated injection parameters

Theoretical second phase start	388	mm
Optimized second phase start	366	mm
Theoretical third phase start	473	mm
Optimized third phase start	465	mm
Third phase stroke	17	mm
Maximum first phase plunger speed	0,35	m/s
Optimal second phase plunger speed	2,2	m/s
Optimal gating speed	40,9	m/s

Current working parameters

Opening force	482	ton
Filling ratio	32,3	%
Sec.phase static press.	371	bar
Current gating speed	55,0	m/s
Second phase speed	3,0	m/s
Current filling time	0,028	s

The machine clamping force is **optimal**.

The filling ratio is **good** if necessary, try to reduce the [plunger diameter](#), increase the [counterbushing length](#).

The gating size is **optimal**

The plunger size **is quite good**.

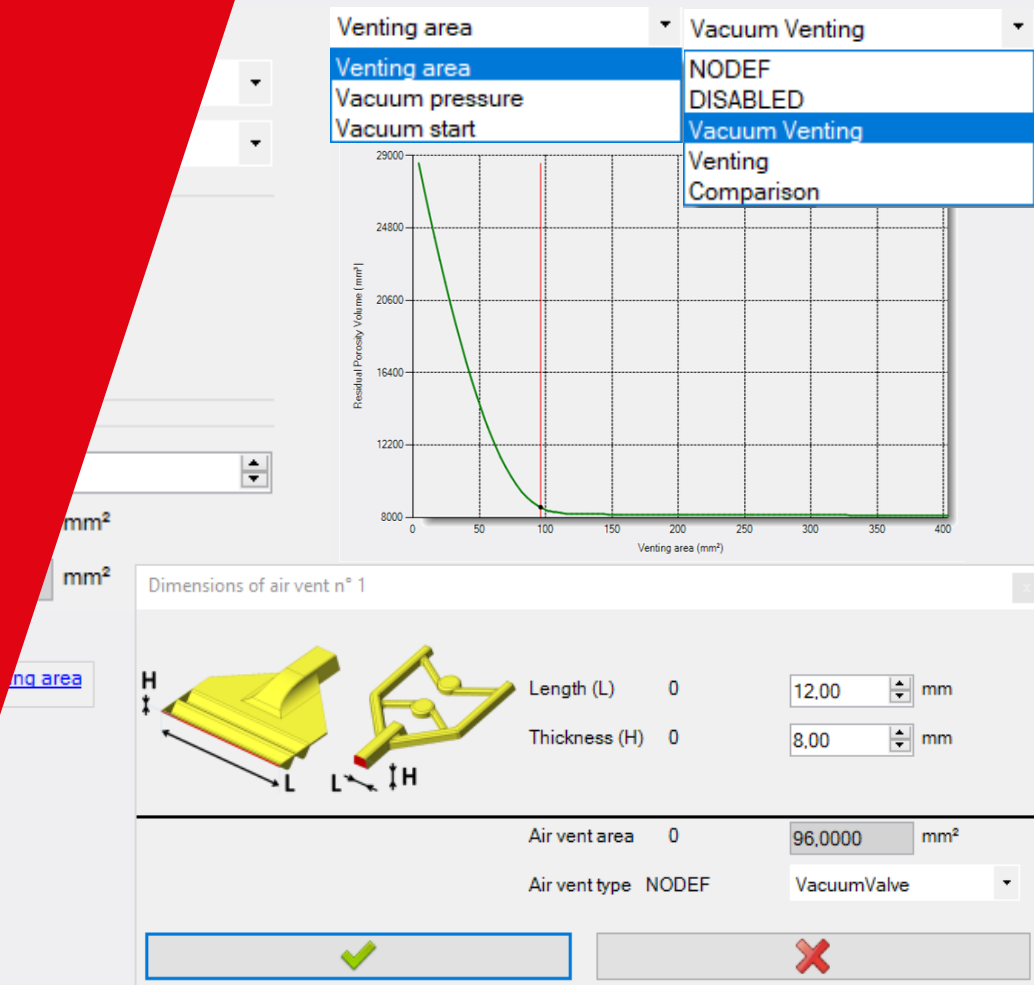
The second phase static pressure is **too low** to ensure the required porosity level: decrease [plunger diameter](#).

The allowed plunger speed is good enough.

Fast shot speed is **optimal**.



CastleMIND can analyze and optimize the behavior of the air extraction system either through simple air vents, chill-vents or valves, to optimize venting sections, pressures and strokes.



MAIN FEATURES



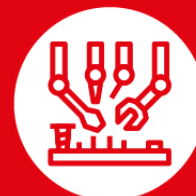
ASSISTS THE DESIGNER

Assists and optimizes the dimension and shape of the gates and vents. **Suggests** the optimum piston diameter and automatically fills out the machine parameters datasheet.



PERSONALISED MACHINE DATABASES

Provides a **complete modelling service** of a machine's equipment.



ASSISTS THE FOUNDRY

Enables any **defect** verified in production to be **identified** as a result of the die, the machinery or the process. **Helps to maintain casting quality**. **Assists in reducing die wear** and metallization phenomena.



2nd step: optimize the runners,
before simulating...

- **Optimize** the geometry upstream of the gatings to avoid problems in the casting
- **Evaluate** the effective behaviour of the channels
- **Compare** different runner/gatings solutions in a few minutes

[castle]^{3D}_{RUN}

Innovative tool for the simulation
of the flow in the runners.

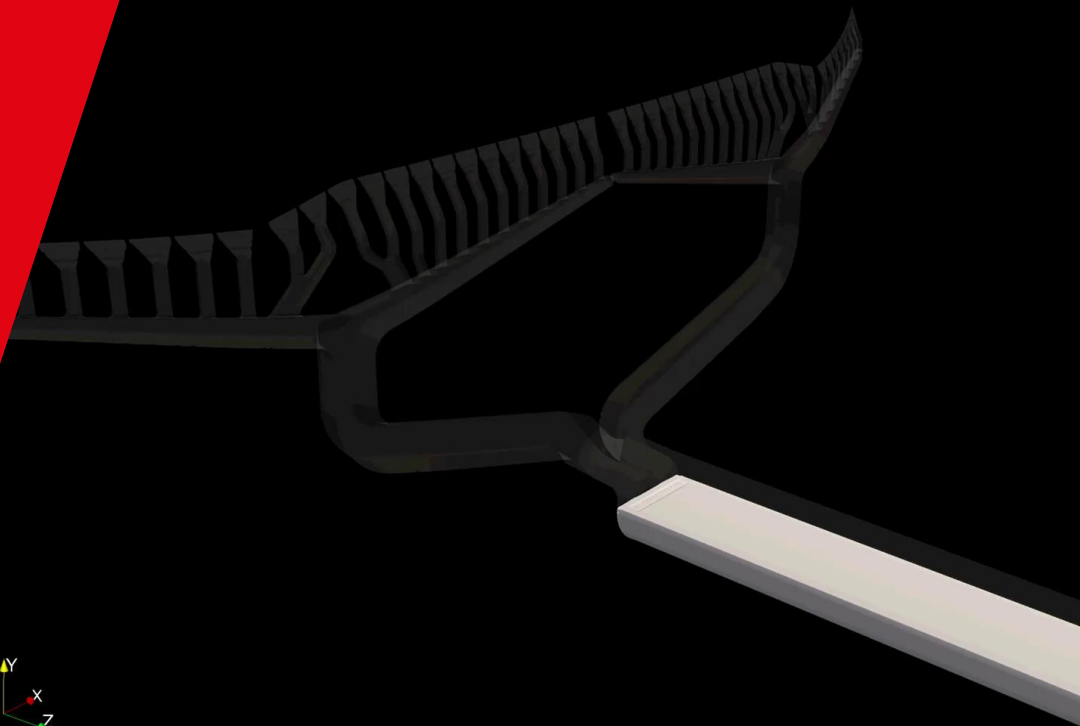
Allows the die maker to ensure
the optimum geometry for the channel
without carrying out the entire
simulation of the model.

Allows for the effective testing
of various solutions to achieve
the desired results.





- Run slow shot only simulation to check alloy behaviour or optimize slow shot speed and strokes
- Early detect in runner or in shot sleeve air entrapment



Time: 0.000000
PiQ2 - CastleRun

Typical calculation time: tenth of minutes

MAIN FEATURES



STEADY STATE CALCULATION

Provides a **complete map of flow pressure and speed** which helps to identify the trajectory of metal flow, any turbulent flow, gates which aren't working as expected, air entrapments and bottlenecks.



TRANSITORY, TWO-STAGE CALCULATION

The software allows the operator to **optimize the first phase** speed profile to reduce air entrapment, and to define the optimum **settings** for the start of the **second phase** for a more uniform filling of cavities.

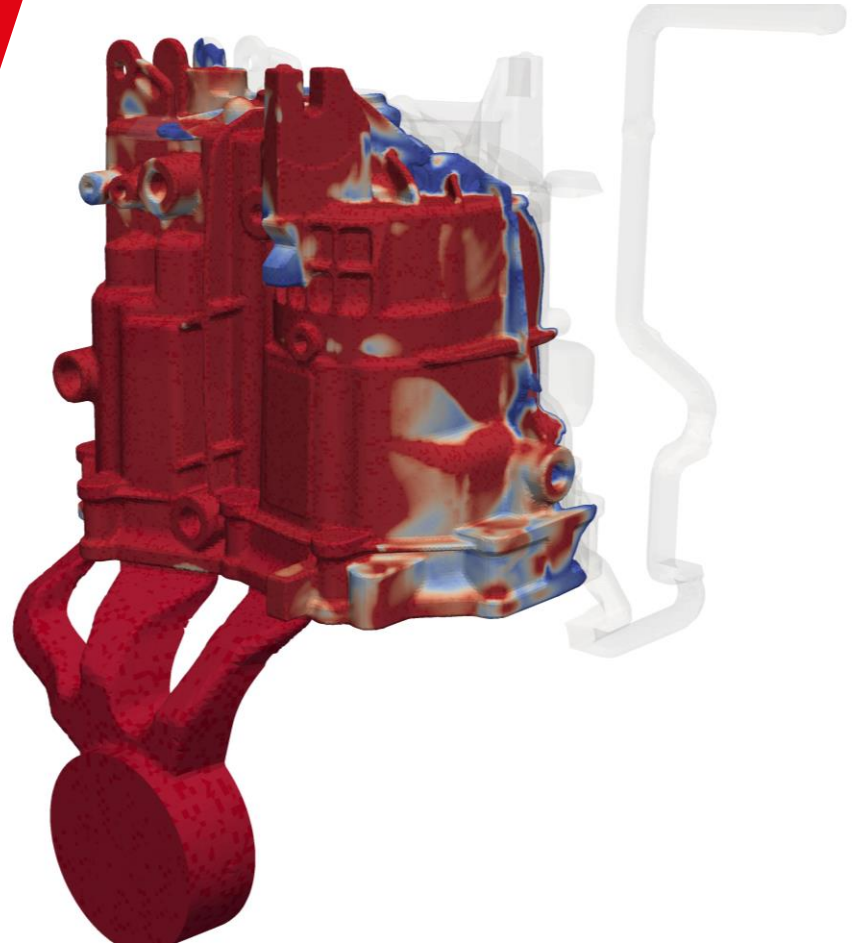


3rd step: simulate the actual filling...

- Specifically designed tool for **HPDC**
- Maximum **operator time** reduction
- Intuitive **user interface**
- **Hybrid mesh**
- **Overcomes** the weaknesses of the current software solutions

[castle^{FE} BODY

Dual-phase solution: simulates the combined action of a liquid (metal) and a gas (air), two elements with very different behaviour and density. Prepares the mesh calculation and sets up the simulation in a few minutes from any kind of geometry.





What's the amount of air entrapped in a die cavity?

Example:

2,7Kg aluminum casting weight (1L)

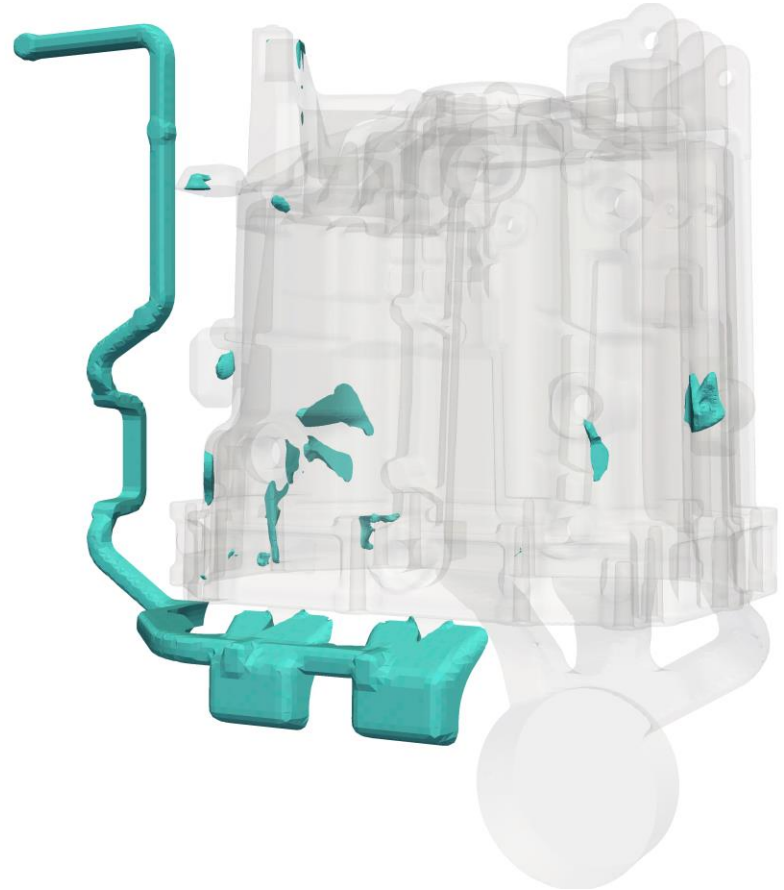
50% shot sleeve filling ratio

about **1 litre** air in the shot sleeve

about **1 litre** air in the die cavity

2 litres air compressed

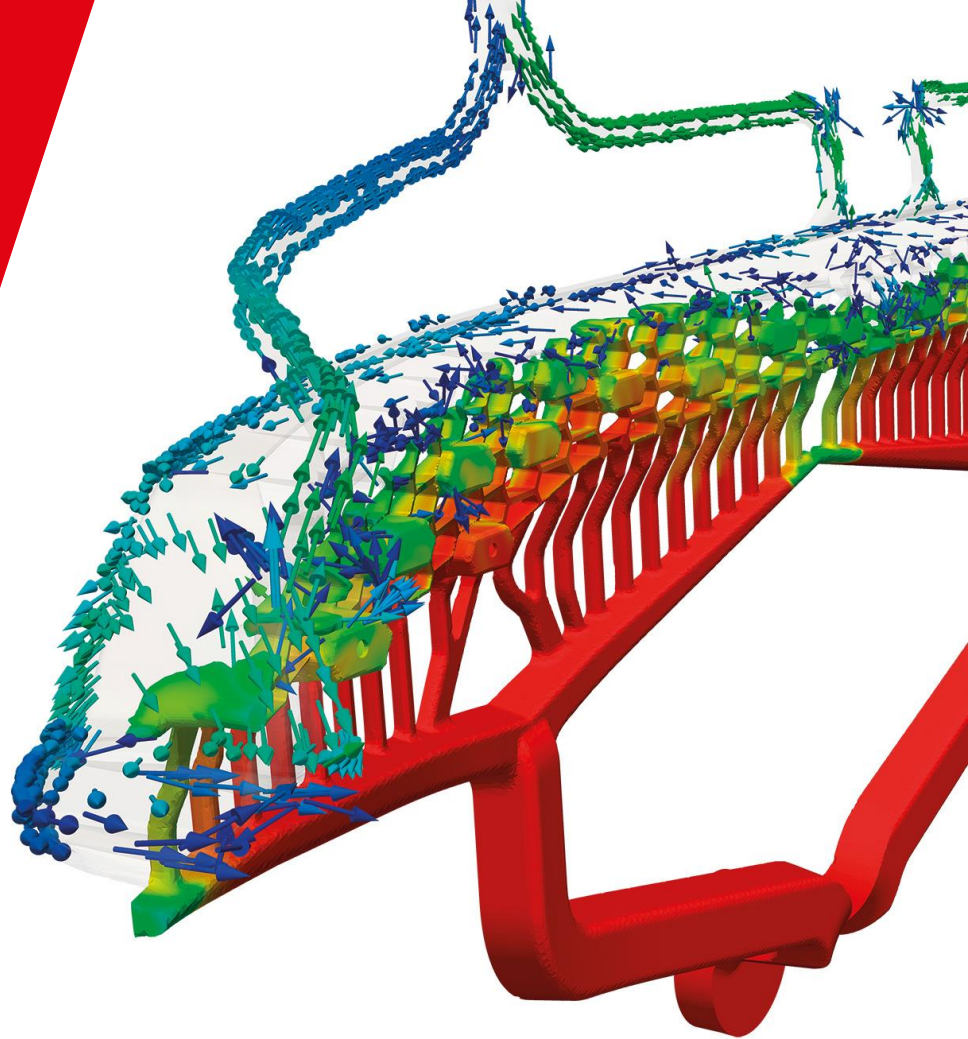
at 1000 bar = 2 cm³ porosity





Goal: correct metal/air interaction modelling

- Simulate the effect of metal spraying caused by the speed and the impact of the fluid against the air
- Consider the **flow of both metal and air**
- Physically simulate the effect of vacuum and air vents and evaluate their performance



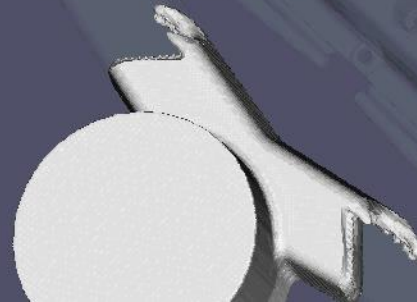


Goal: simulate correctly
the behaviour of the
liquid, taking into
account heat loss

- Realistic simulation
of the metal flow
- Take into account the
characteristics of the fluids



PIQ2
Time: 0.030000

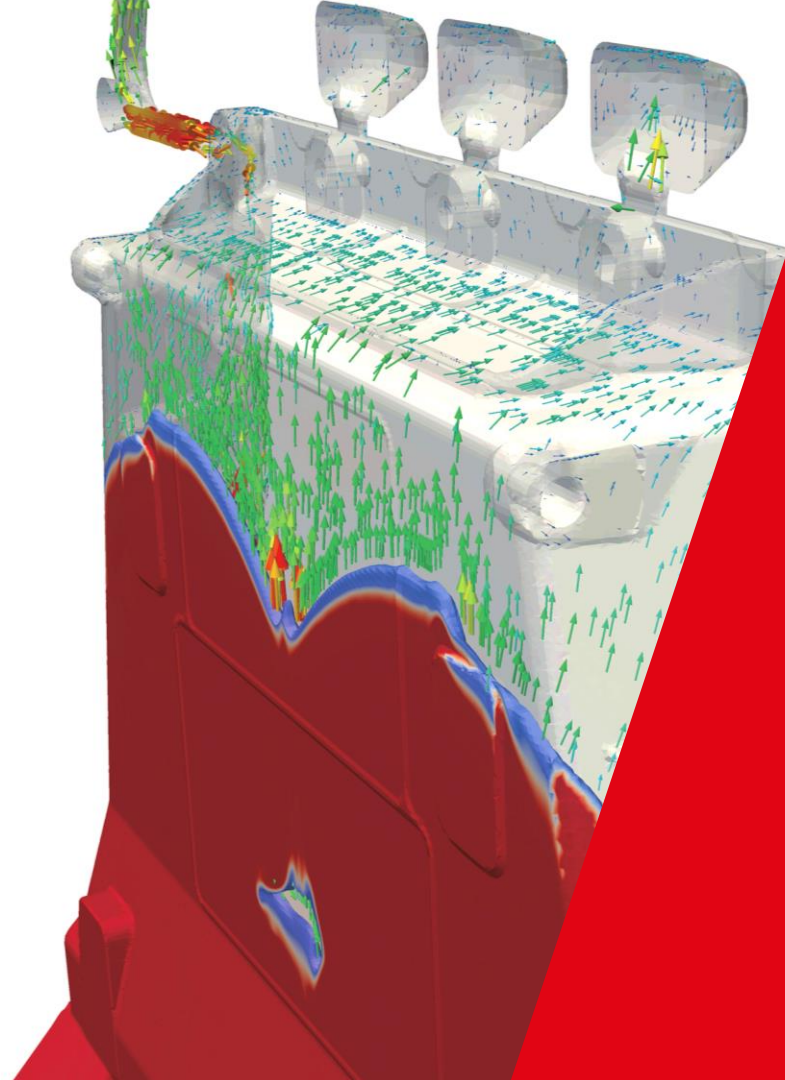


CastleBODY

Dual phase simulation software

Air, liquid metal and their emulsion can be modelled simultaneously.

The behaviour of the air flow during filling can be simulated so that even the smallest air entrapments can be identified, avoiding blisters and surface defects, to optimize the shape, section and design of the ventings as well as the injection profile.



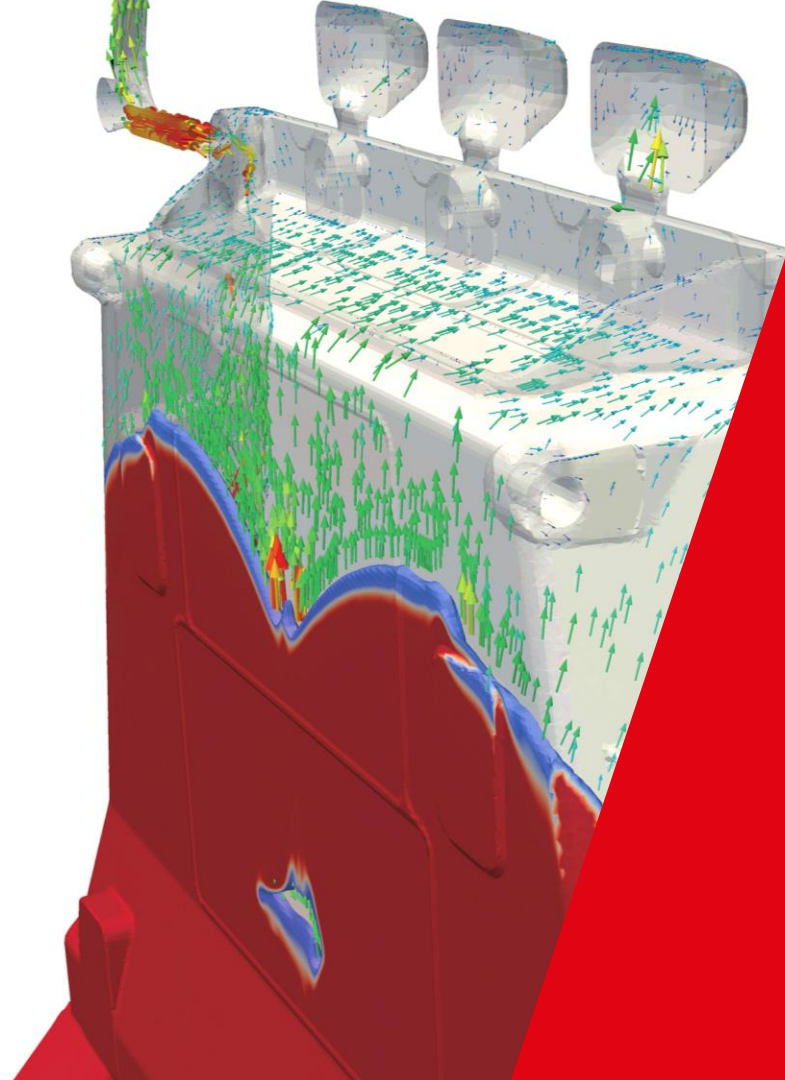
CastleBODY

Dual phase simulation software

The simulation can show the difference between:

- No air vents
- Passive chill vents
- Active vacuum

When the liquid metal reaches the air vents, they get occluded and air cannot escape anymore.



CastleBODY

Dual phase simulation software

This technology allows to **evaluate the interaction** between shrinkage and gas porosity.



Time: 0.000000
P1Q2 - CastleBody

MAIN FEATURES



HYBRID MESH

The **internal mesh** is made up of regular hexahedrons, whilst **elements close to the surface** are adapted in order to replicate the exact original CAD geometry.

The mesh can be refined in localized, more intricate areas.



PARALLEL CALCULATION

It's possible to launch **calculations in parallel** on multiple processors, exploiting 100% of CPU performance.

This represents a **significant time saving**.



SOLIDIFICATION SIMULATOR

Allows the user to **take into account potential interactions** between the porosity generated during filling and the ones deriving from the solidification process.



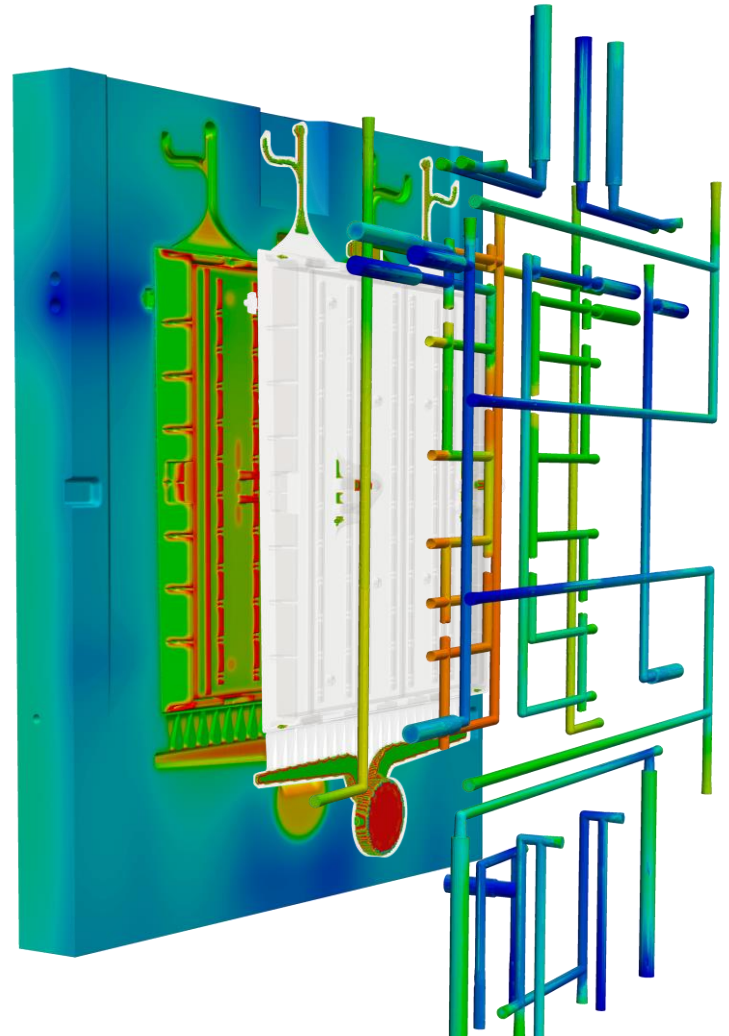
4th step: simulate the thermal cycles...

There are two types of simulations:

- Simulation with implicit or **virtual die** (casting only)
- Simulation **with real die** (modeling the die parts)

[castle]TH THERMO

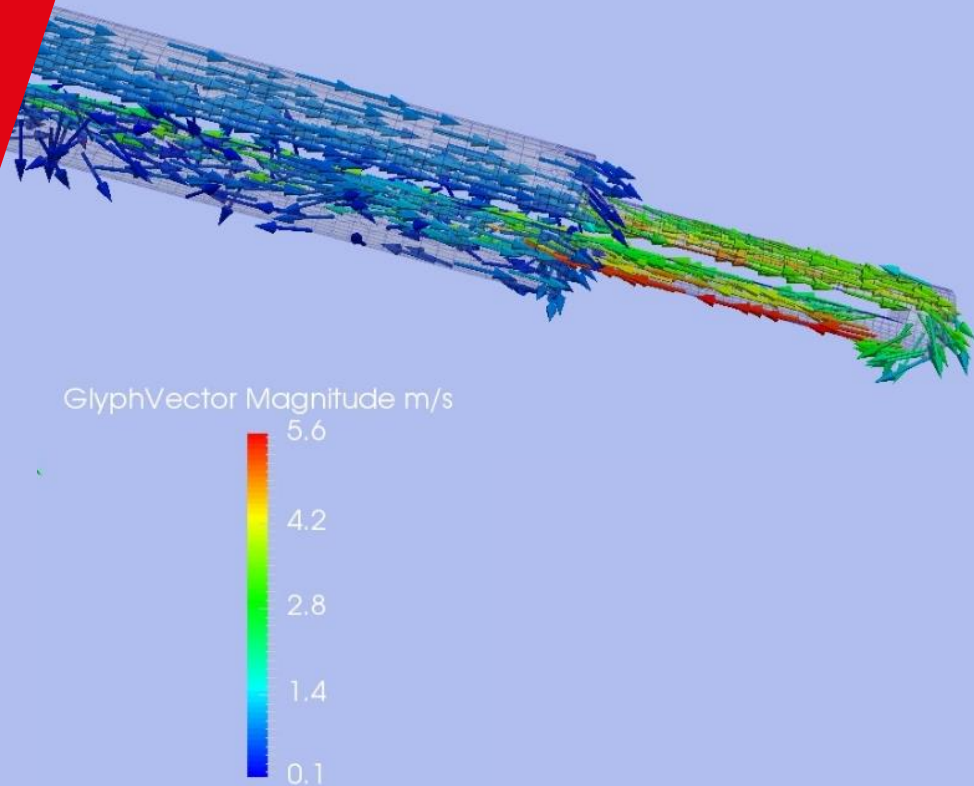
An innovative approach
for the realistic simulation
of the thermal behaviour
of the entire die.





Importance of fluid flow in the channels

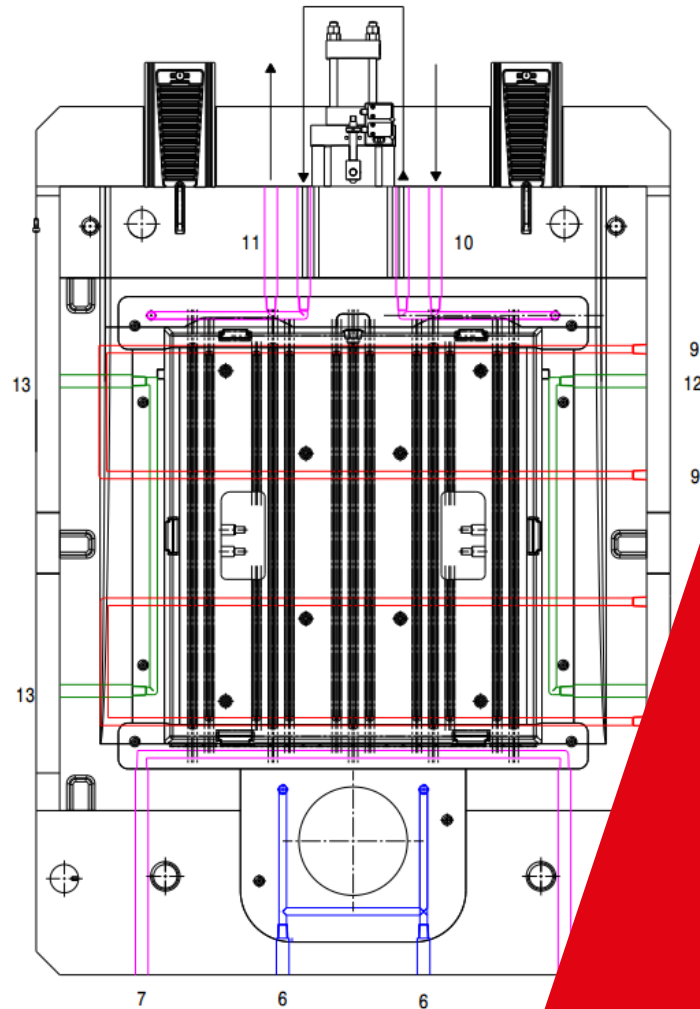
- The heat exchange in thermoregulation channels **depends on the flow**.
- The more the **speed and turbulence**, the more the heat exchange.
Stagnant flow = lower exchange.
- The **channel shape** can therefore locally have significant influence on the **removal of heat**.



CastleTHERMO

Innovative approach

It is possible to simulate the external interconnection between different circuits. The outgoing fluid from one channel can be sent to another channel. The outgoing temperature from the first circuit is incoming fluid temperature in the second circuit.



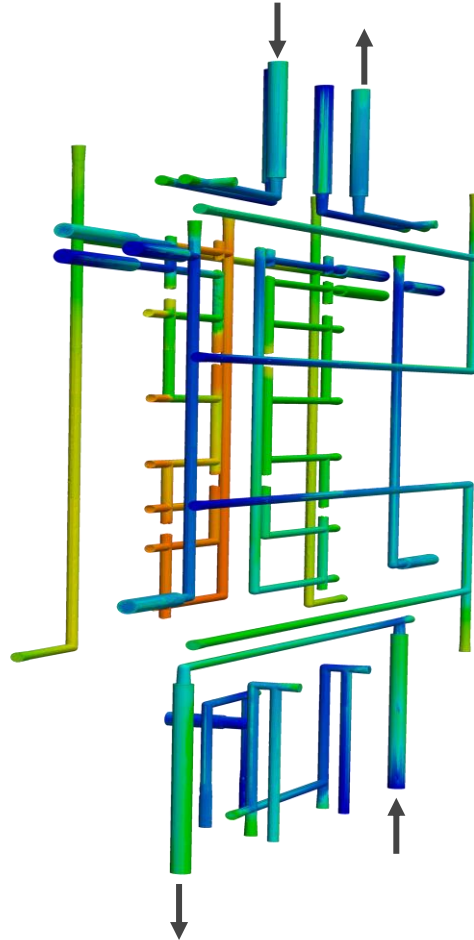
CastleTHERMO

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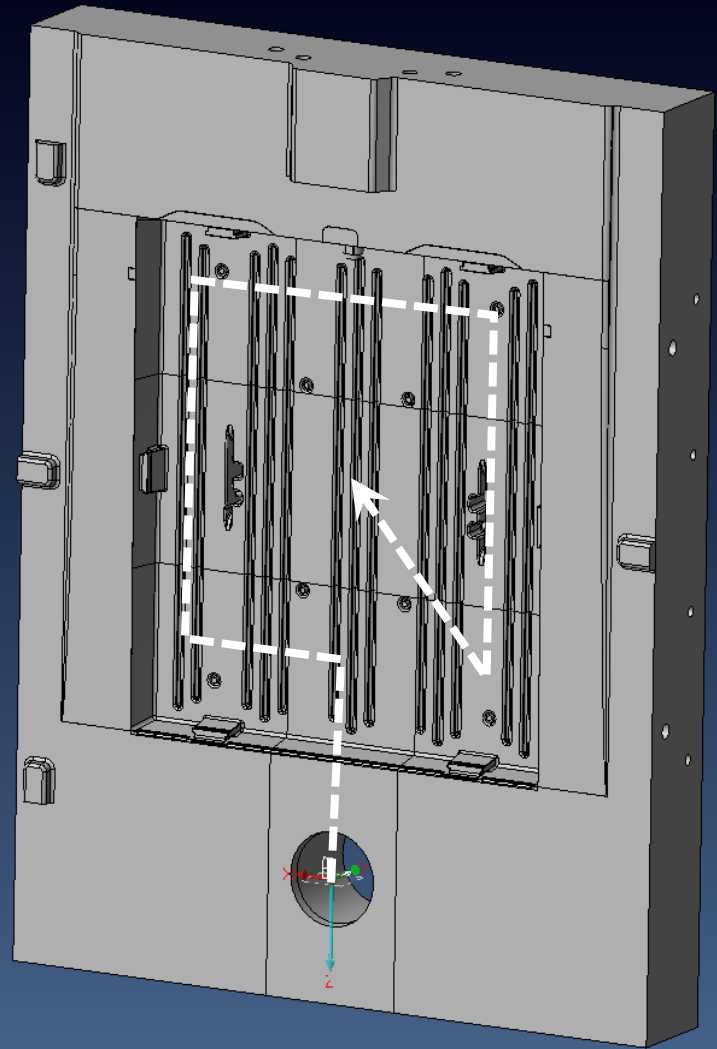
Lubrication sequence
as well as air blow off
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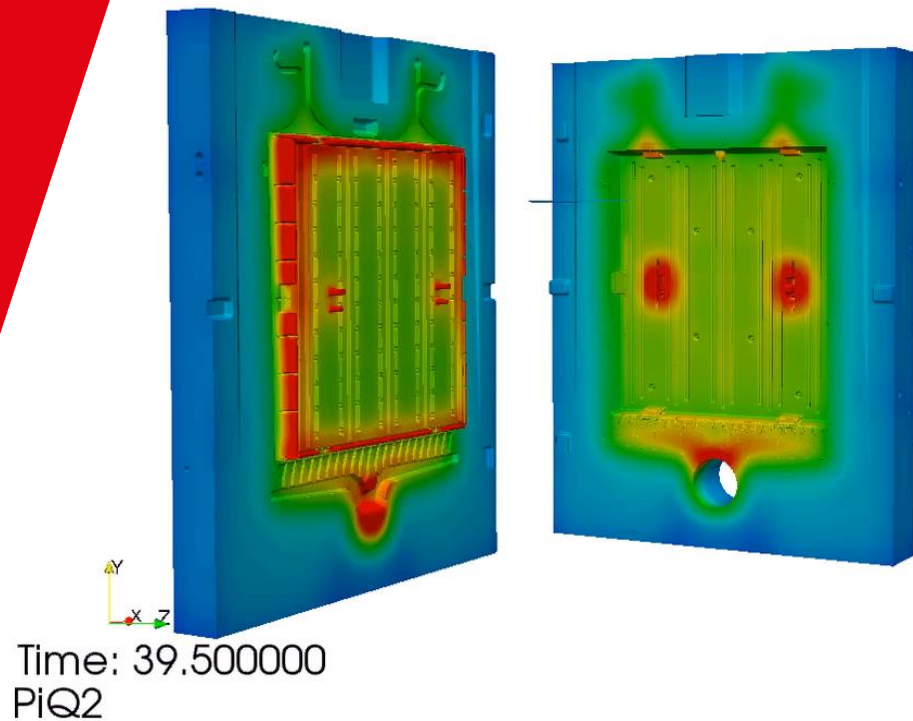
Spraying surfaces can be divided
in sub-regions, and it is possible
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MAIN FEATURES



FLUID FLOW SIMULATION

Thanks to the simulation of the flow in the cooling channels, **the thermal exchange** within the die can be **realistically and automatically calculated** at any position or moment in time.



ADVANCED MODELLING

Complex lubrication operations **can be modelled in detail** in order to preview the thermal effect of the release agent spraying on the die.



Strength points

- **Technical standpoint**
- **Economic standpoint**



Strength points

- **Technical** standpoint
 - **Extensive CAD functions and I/O interface:**
easy import and modification
 - **Simple and intuitive user interface:**
no need of particular skills
 - **HPDC optimized:** for reliable results
 - **Real time expert system optimization:**
optimize before simulate
 - **Fast runners simulation and optimization:**
optimize runners before it's too late
 - **Dual phase metal-air simulation:**
unsurpassed air entrapment prediction



Strength points

- **Technical** standpoint

- **Automated hybrid meshing with local refinement:**
for intricate geometries
- **Fluid flow calculation in cooling channels:**
actual heat transfer simulation
- **Advanced spraying simulation:**
actual lubrication thermal effect calculation
- **Free multi CPU meshing and calculation:**
lower calculation times
- **Automated video output:**
save time to produce reports
- **Facilitated results sharing:**
results sharing through free viewers



Strength points

- **Economic** standpoint
- **Extensive CAD functions included:**
no need of external CAD
- **Somehow lower sale price:** in comparison to most top level solutions
- **Low maintenance price:** faster return on investment
- **Multiple license policy:**
many users for a distributed and collaborative approach
- **Easy-learning user interface:**
low training cost and time effort
- **Fast path to calculation:** low operator cost
- **Free multi CPU meshing and calculation:**
lower simulation costs
- **Free results viewer:** can be installed everywhere



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CASTLE PACKAGE

4 steps of simulation

The 4 Castle independent modules allow for **accurate simulation of die performance** in all its operational phases, providing **comprehensible results** that can be used to optimise output.

CASTLE vs COMPETITORS

Overview

- **OVERALL COST**

base package (Mind, Run and Body) costs 29.000€. The additional Thermo costs 11.000€ (official pricelist) for a perpetual license. Competitors are typically higher.

- **MAINTENANCE COST**

annual support and maintenance cost is 13%/year of pricelist (about 3.770€ for MRB). Competitors cost about 13-16.000€/year for the basic package.



CASTLE vs COMPETITORS

Overview

- **MULTIPLE LICENSES**
additional licenses cost is about 35-40% less than the first license.
- **MULTIPLE CPU CALCULATION**
free with no CPU core limitations.
Other softwares charge additional CPU calculation.



- **PRE-SIMULATION OPTIMIZATION**

optimize die configuration, casting and process **without time-expensive calculations.**

Results are available in real time.

- **OPTIMAL PROCESS PARAMETERS CALCULATION**

in order to run **optimized simulations** or to set-up the HPDC machine. **It avoids a lot of time wasting** during filling simulation rounds.

**CASTLE vs
COMPETITORS**

[castle^{3D}]_{MIND}

CASTLE vs COMPETITORS

[castle^{EF} RUN]

- **SIMULATION OF THE RUNNERS**

optimize the shape of runners and complete gating system. Simulation results are available in few minutes. It avoids a lot of time wasting.

- **FAST OPTIMIZATION OF SLOW SHOT INJECTION PROFILE**

slow shot injection profile can be quickly optimized in order to avoid air entrapment and uneven filling of cavity inserts.

No need to run filling simulations of the complete casting.



- **EASY TO LEARN AND USE**

the **interface is very simple** and only foundry parameters are needed to make it run.

The **typical training class** lasts maximum 2 days, normally 1 is enough.

- **DUAL PHASE SIMULATION**

Castle considers the air as a fluid that moves, heats up, gets compressed and can be mixed with molten metal in the die cavities.

Other software are single phase: air is considered only as a pressure and it can not be mixed with molten metal. Neither air velocity nor temperature can be shown.

CASTLE vs COMPETITORS

[castle] BODY

- **HYBRID MESHING WITH LOCAL REFINEMENT**

the mesh is conformal and follows the surfaces even in smaller details, without losing detail.

Refinement of the mesh can be applied on arbitrary zones of the casting only where needed.

Some competitors use cartesian mesh that is blocky and can not be refined on arbitrary zones.

Some other competitors use tetragonal mesh that is not optimized for CFD calculations such as filling.

- **MULTI CPU CALCULATION AND MESHING WITH NO ADDITIONAL COSTS**

competitors charge any additional CPU.

**CASTLE vs
COMPETITORS**

[castle]^{3D}_{BODY}

- **PLUNGER MOTION SIMULATION
WITH DUAL PHASE**

some **other softwares** can not run shot sleeve simulations so they are **not able to catch air entrapment** caused by shot sleeve turbulences.

- **FREE RESULTS VIEWER**

simulation results (in native format) can be shared and viewed through a free viewer.

With other softwares, results can be viewed only where the softwares license is installed, or with a dedicated license for viewing.

CASTLE vs COMPETITORS

[castle] BODY

CASTLE vs COMPETITORS



- **EASY TO LEARN AND USE**

the **interface** is **very simple** and only foundry parameters are needed to make it run.

The **typical training class** lasts maximum **2 days**, normally **1** is enough.

- **AUTOMATIC INTERFACE RECOGNITION**

the majority of interface recognitions are **automatically done** and preparation/set-up of the model for the simulation is **very fast**.



CASTLE vs COMPETITORS



- **AUTOMATIC HEAT TRANSFER
COEFFICIENT CALCULATION**

heat transfer coefficient is automatically calculated in every single channel according to flow rate, diameter and cooling media. In other softwares a separate calculation has to be done.

- **FLOW CALCULATION INSIDE COOLING
CHANNELS**

the flow in the cooling channels can be designed in order to take into account the actual heat transfer (in a more accurate way). External connections between cooling channels can be considered as well.



[PiQ²]
Developing Expertise

