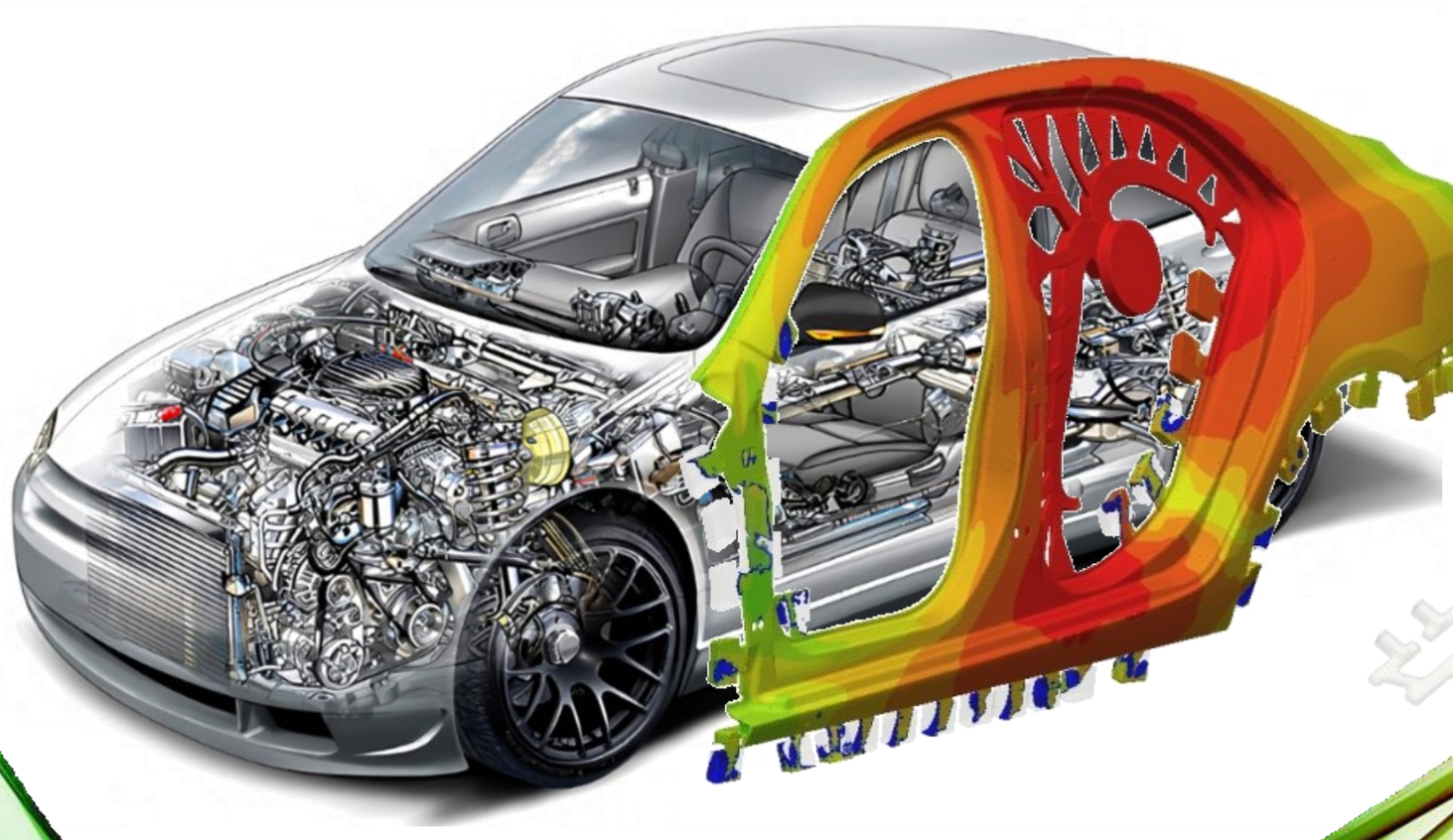
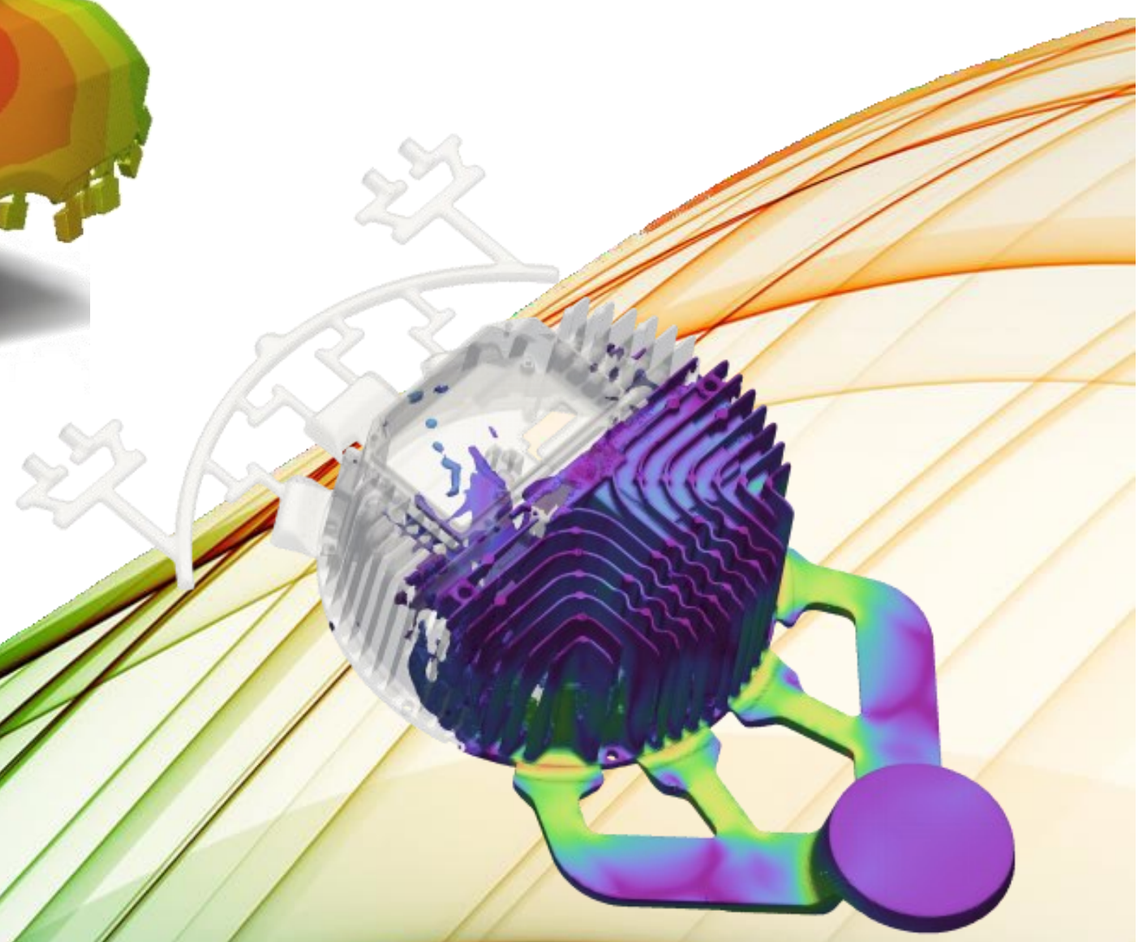
CAST-DESIGNER

END TO END SOLUTION FOR CASTING BUSINESS

ADVANCED CFD BASED CASTING SIMULATION SOFTWARE

- MATERIAL
- DFM
- QUOTATION
- GATING DESIGN
- THERMAL-FLOW & SOLIDIFICATION
- MICROSTRUCTURE
- STRESS-STRAIN & DISTORTION
- CASTING PRODUCTION
- CASTING PERFORMANCE
- DOE
- FULL CAD DRIVEN PART-GATING-PROCESS-PRODUCTION OPTIMIZATION





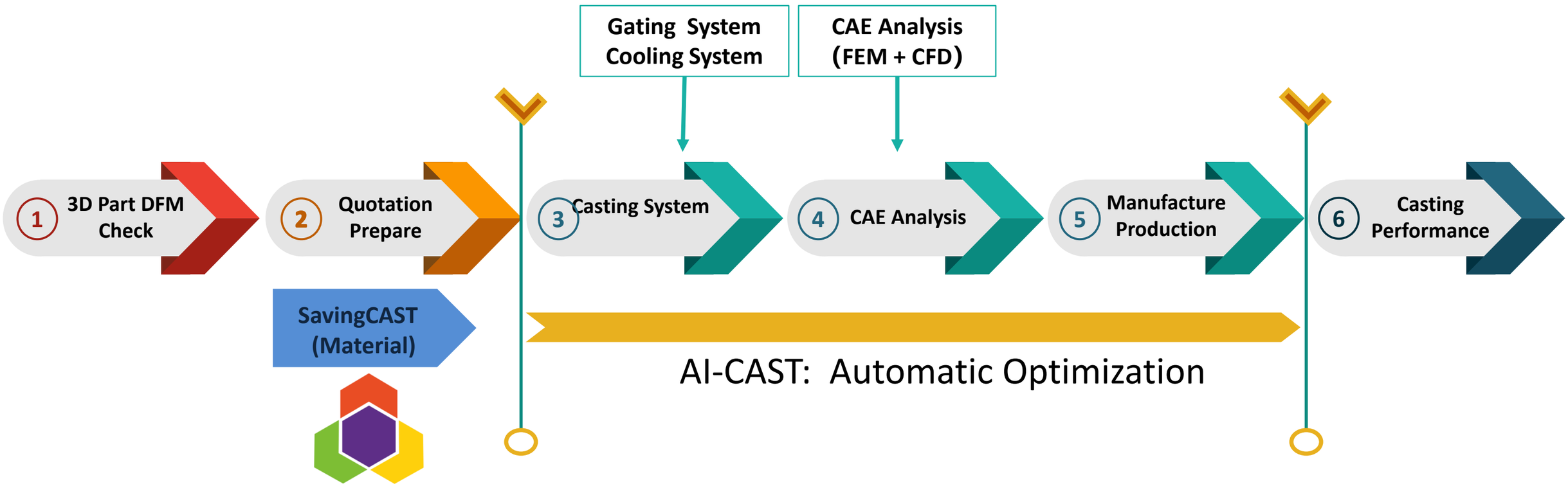
- EASY
- FAST
- ACCURATE
- AFFORDABLE

C3P SOFTWARE

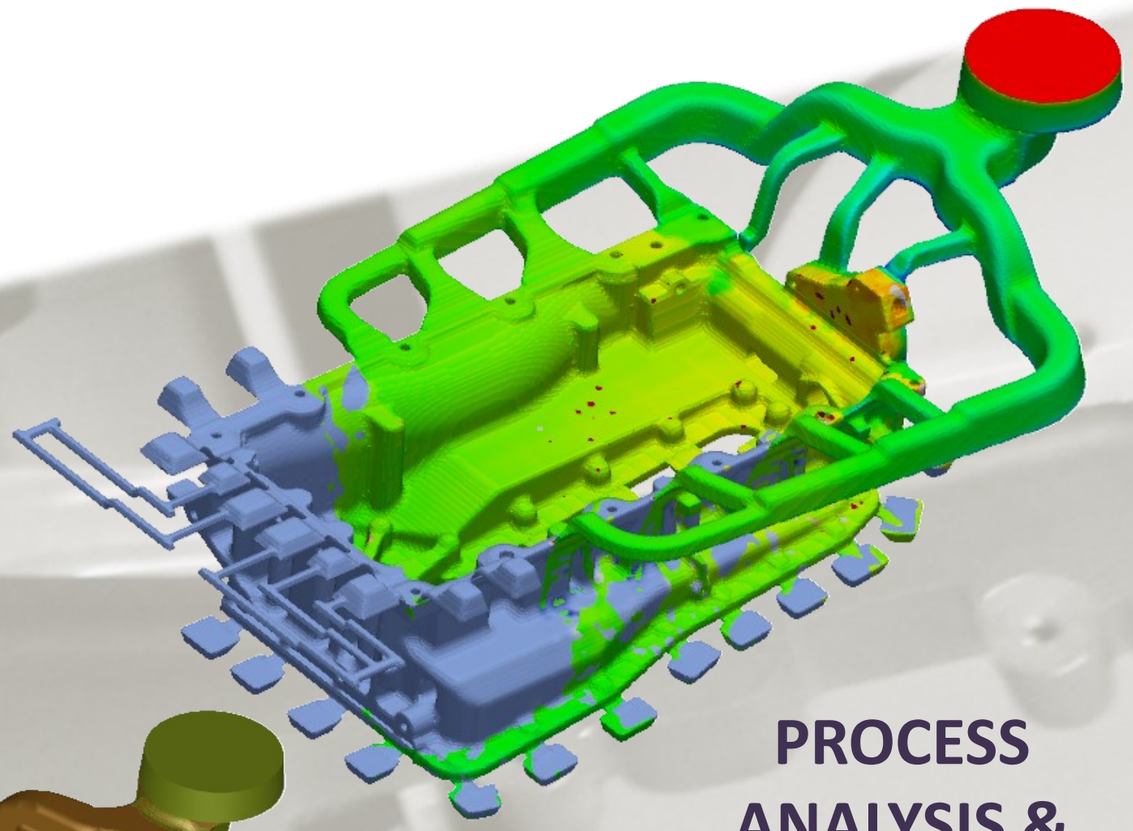
HELPING TO REFINE
THE COMPETITIVENESS OF CASTING INDUSTRY

CAST-DESIGNER OVERVIEW

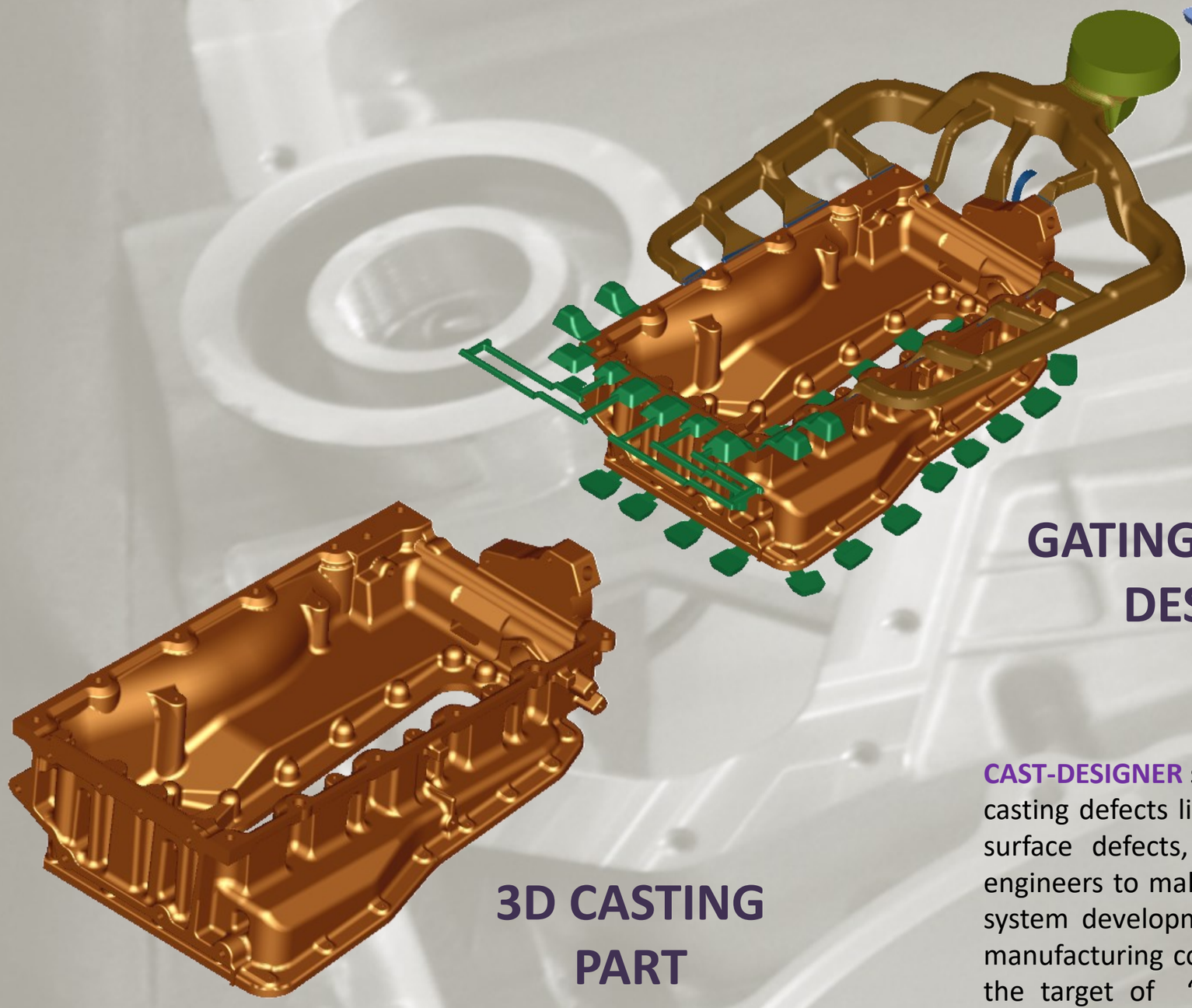
CAST-DESIGNER



CAST-DESIGNER from C3P Engineering Software International Co., LTD. is a software specially designed for casting business, has more than 50 years of industry experience, provides end-to-end solution for foundry industry, ranging from metal charging, DFM analysis, step-by-step guidance in gating system design, advanced thermal, flow, solidification, microstructure, and stress simulations and artificial intelligent based automatic optimization.



PROCESS ANALYSIS & OPTIMIZATION



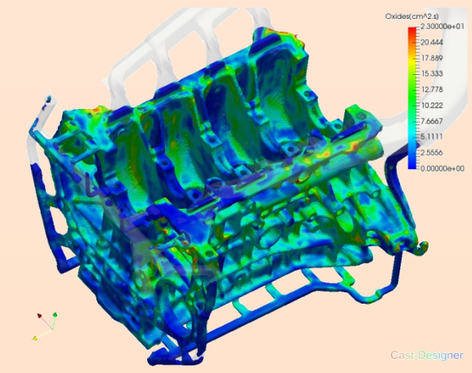
GATING SYSTEM DESIGN

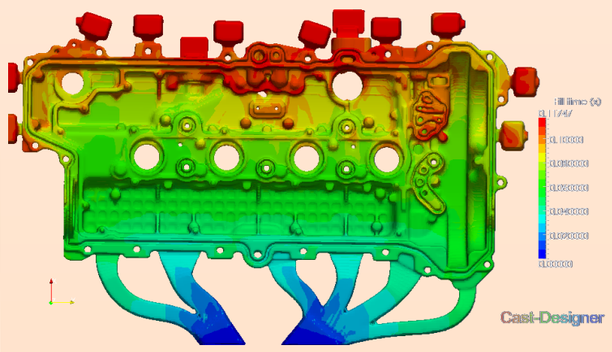
3D CASTING PART

CAST-DESIGNER supports all major foundry processes and predicts the casting defects like shrinkage porosity, gas porosity, air entrainments, surface defects, residual stresses, distortions, etc, Helps foundry engineers to make right decisions early in the design stage of casting system development and to improve quality & yield, thus reducing manufacturing cost. **CAST DESIGNER** can help the industry to achieve the target of ‘**Time to Market**’, ‘**Quality to Market**’ and remain ‘**Competitive**’.

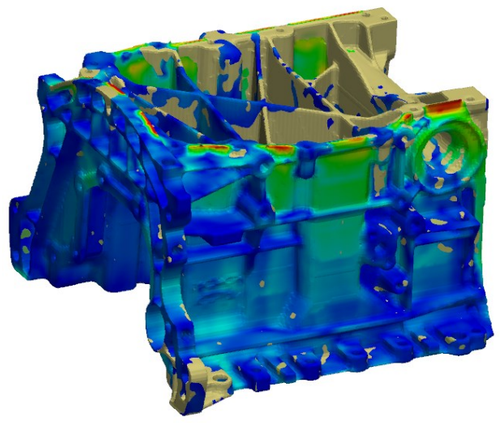
SELECTED APPLICATION

CAST-DESIGNER

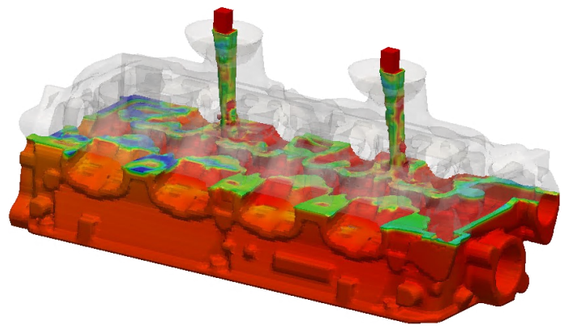




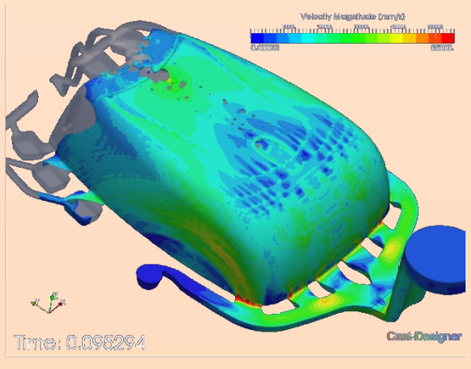
General Motors

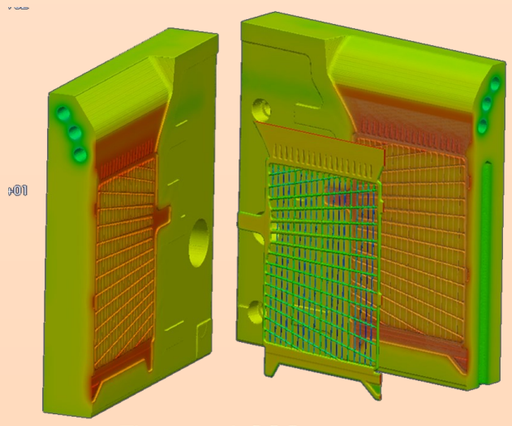


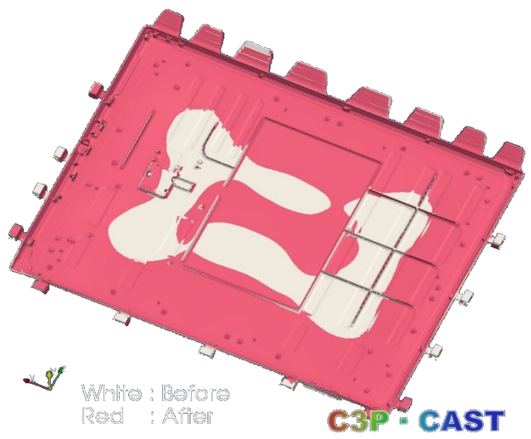
Ford

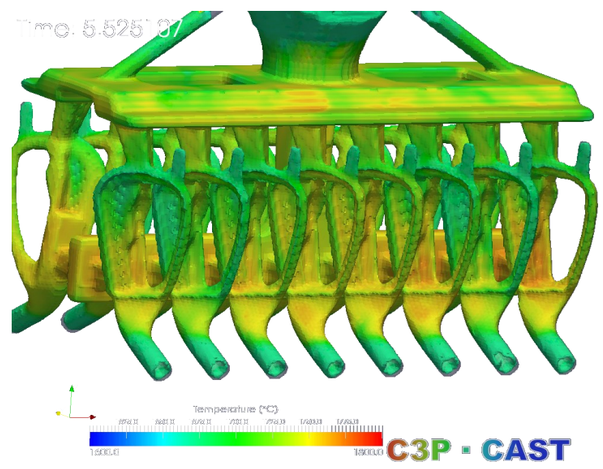


VOLVO





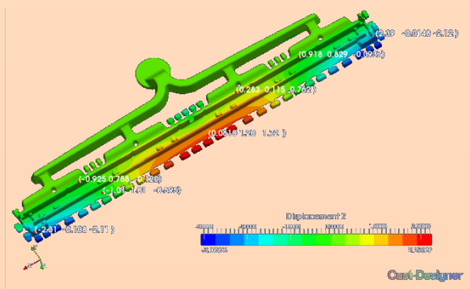




RAMCAR TECHNOLOGY INC.
Sta. Maria Industrial Park, Brgy. Bulac, Sta. Maria, Bulacan, Philippines.
Tel: +63-2-2996300 to 09 loc 8443 / 8376 / 8377 | Fax: +632-299-6300 loc 8329
Mobile Hotline:+63-9209818458 | Direct Line: +63-2-3918244

巨騰國際控股有限公司
JU TENG INTERNATIONAL HOLDINGS LTD.

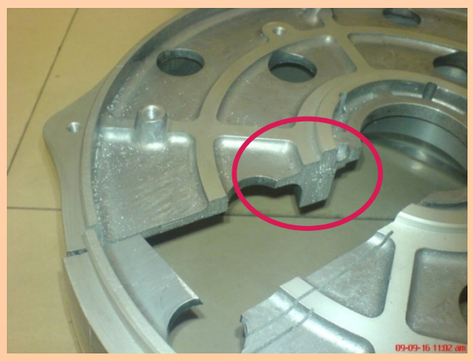
大田精密工業股份有限公司
O-TA Precision Industry CO.,LTD.



SAMSUNG

SCHAEFFLER

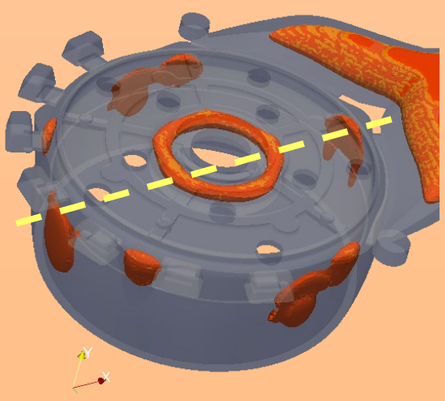
TE connectivity

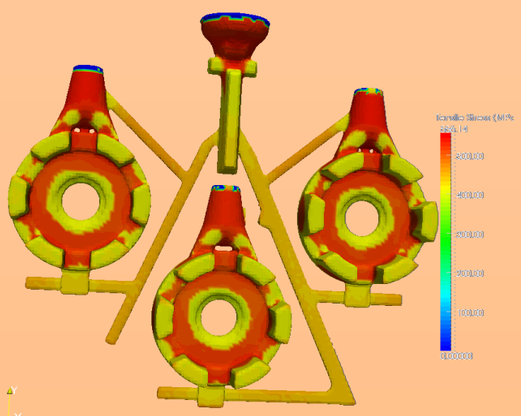


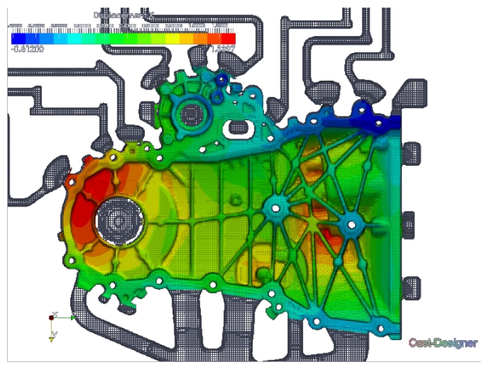
蔚来 nio

CSSC
中国船舶集团有限公司
CHINA STATE SHIPBUILDING CORPORATION LIMITED

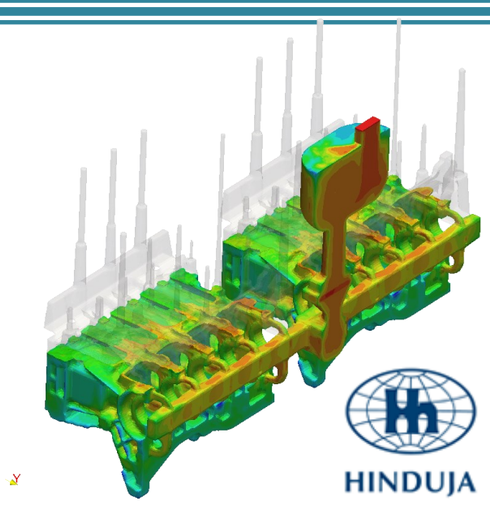
SHIMANO







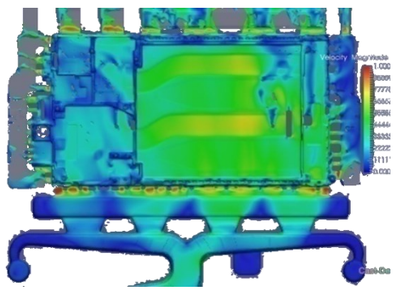
TVS Sundaram - Clayton Limited



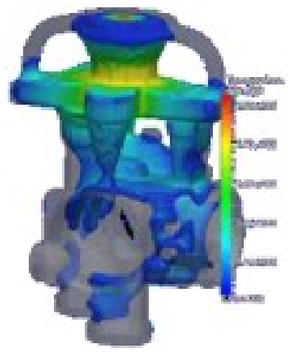
HINDUJA

CAST-DESIGNER CHECKLIST

CAST-DESIGNER

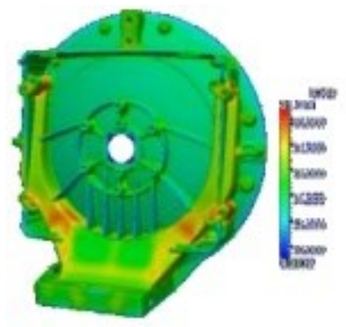


Filling



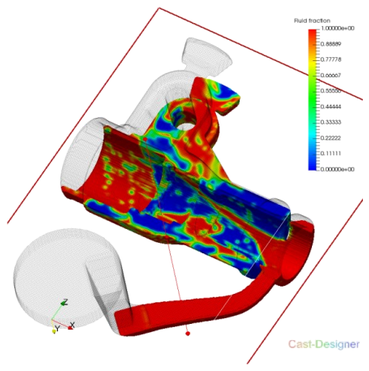
Solidification

Porosity

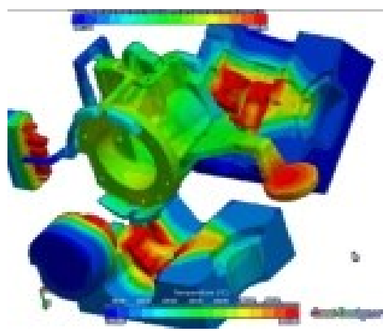


Stress

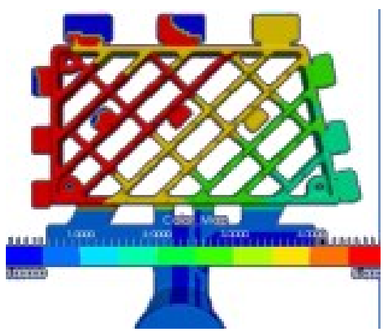
Distortion



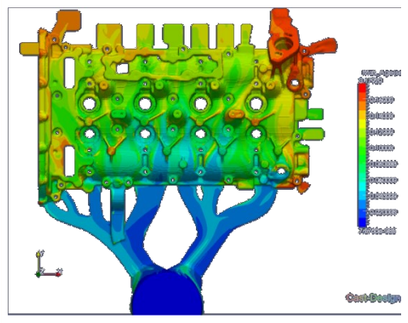
Gas Entrapment



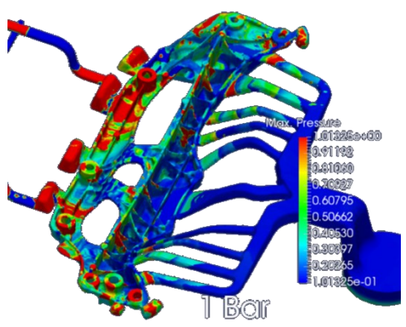
Full Mold



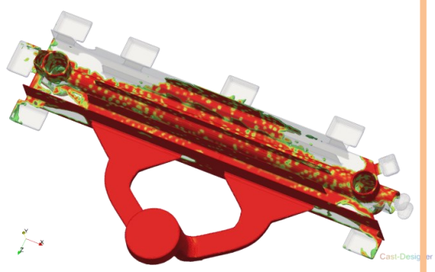
Gate Color



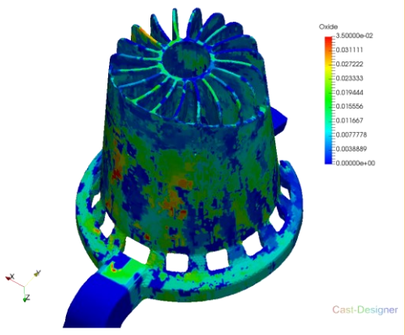
Material age



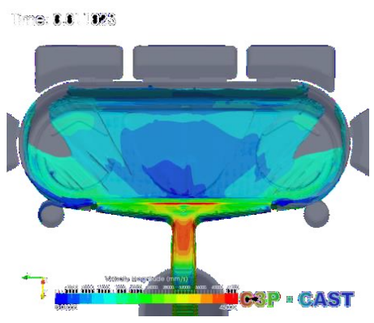
Pressure



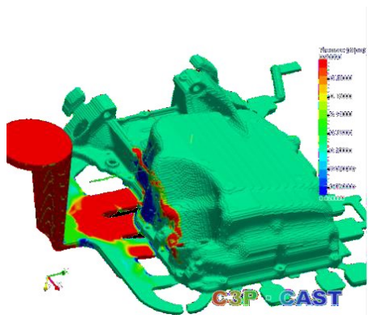
Metal Flow



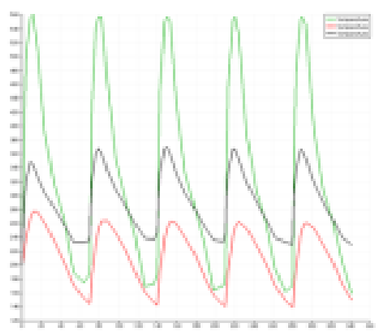
Oxides



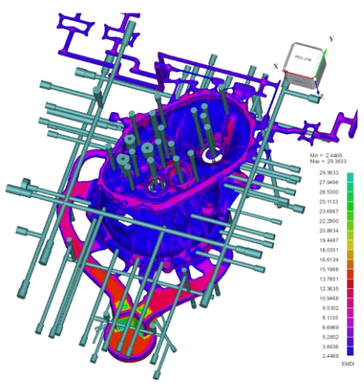
Velocity



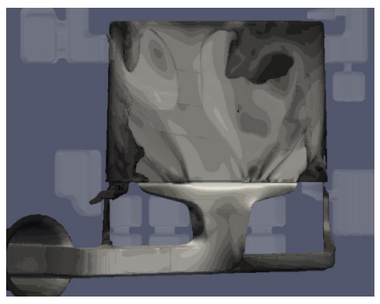
Gas Pressure



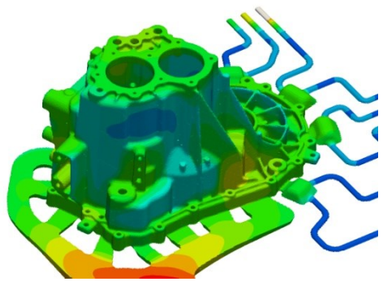
Mold Cycling



Fast Cooling Check



Flow mark



SDAS

FLOW RESULTS

- Flow Fluid Fraction
- Flow Temperature
- Flow Velocity
- Flow Velocity Vector
- Flow Pressure
- Flow Gas Entrapment
- Flow Length
- Flow Material Age
- Flow Oxides
- Flow Vs Gate in colour
- Flow Material Trace lines
- Gas Entrapped Inside Casting
- Gas Entrapped at surface
- Flow Velocity graphs vs Time
- Flow Temperature graphs vs Time
- Maximum Air Pressure
- Filling Time
- Mould Erosion (…)

SOLIDIFICATION RESULTS

- Solid Fraction
- Solidification Temperature
- Casting Temperature
- Mould Temperature
- Thermal Modulus
- Solidification Time
- Shrinkage Porosity
- Niyama Micro Porosity
- Cooling Rate
- SDAS
- Dendrite Arm Spacing
- Ultimate Tensile Strength
- Elongation
- Piping
- Pin Squeeze Analysis
- Temperature graphs (…)

STRESS RESULTS

- Distortion / Displacement
- Compensation for Distortion
- Normal Stress
- Effective Stress
- Strain
- Fatigue
- Hot Tearing (…)

MICRO-STRUCTURE RESULTS

- Phase Contour
- Ferrite etc.
- Hardness
- Grain Radius
- Elongation
- More….

(Animation & Image)

CAST-DESIGNER CHECKLIST

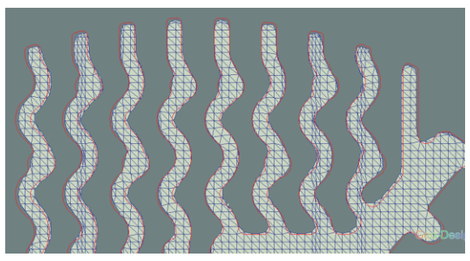
CAST-DESIGNER

CAST-DESIGNER CORE TECHNOLOGY

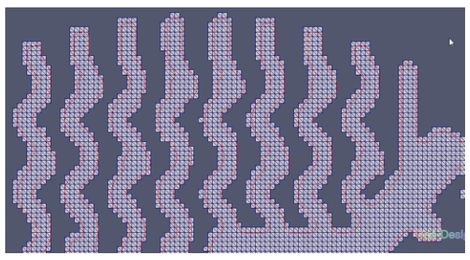
- Dual solver technology, the **FVM solver** and **FEM solver** are fully coupled in the same mesh system.
- Simulate the physical phenomena and mechanical behavior of metal filling, solidification and cooling process. The thermal, flow, stress and micro-structure solvers are fully coupled.
- Stress simulation for both thermal stress and mechanical stress.
- Innovation technology to speed up simulation in express, less than three hours for almost cases.
- Build in CAD kernel, fully parametric gating system design with KBE system.
- Excellent parallel computing performance.
- Full CAD driven automatic optimization solver, all geometry and process parameters can be optimized.
- Special quick mould simulation technology to speed-up the modeling time, but take account the affection of cooling system and physical cores with high accuracy..

UNIQUE MESH TECHNOLOGY

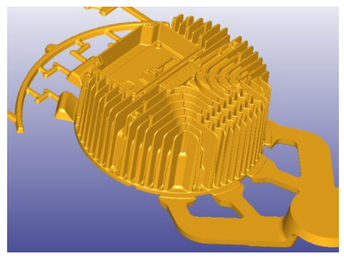
- Very strong 3D hexahedron and tetrahedron mesh capability, fully automatically
- Support GUI mode and batch mesh mode, fully parametric, easy to remesh.
- Special treatment for CAD defects, i.e. geometry gap, overlay, intersection or unclose, face lose etc.
- Rich mesh options: local mesh, mark point, tin region mesh, 2D surface mesh, shell mesh, advance mesh smoothing, quality control etc.
- Fully automatic mould assembly with node connection, support mixture mesh type.
- Parallel meshing capability, suitable for the Giga casting part and complex mould assembly.



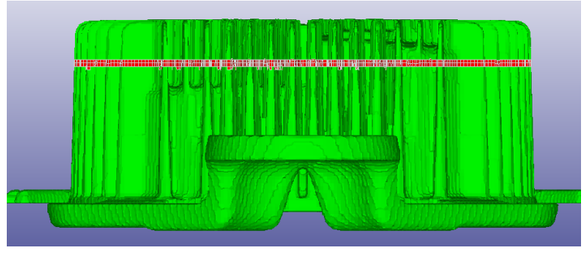
Section of Cast-Designer mesh



Section of traditional FDM mesh
Geometry was not accurate
(Red line: CAD profile)



CAD Geometry

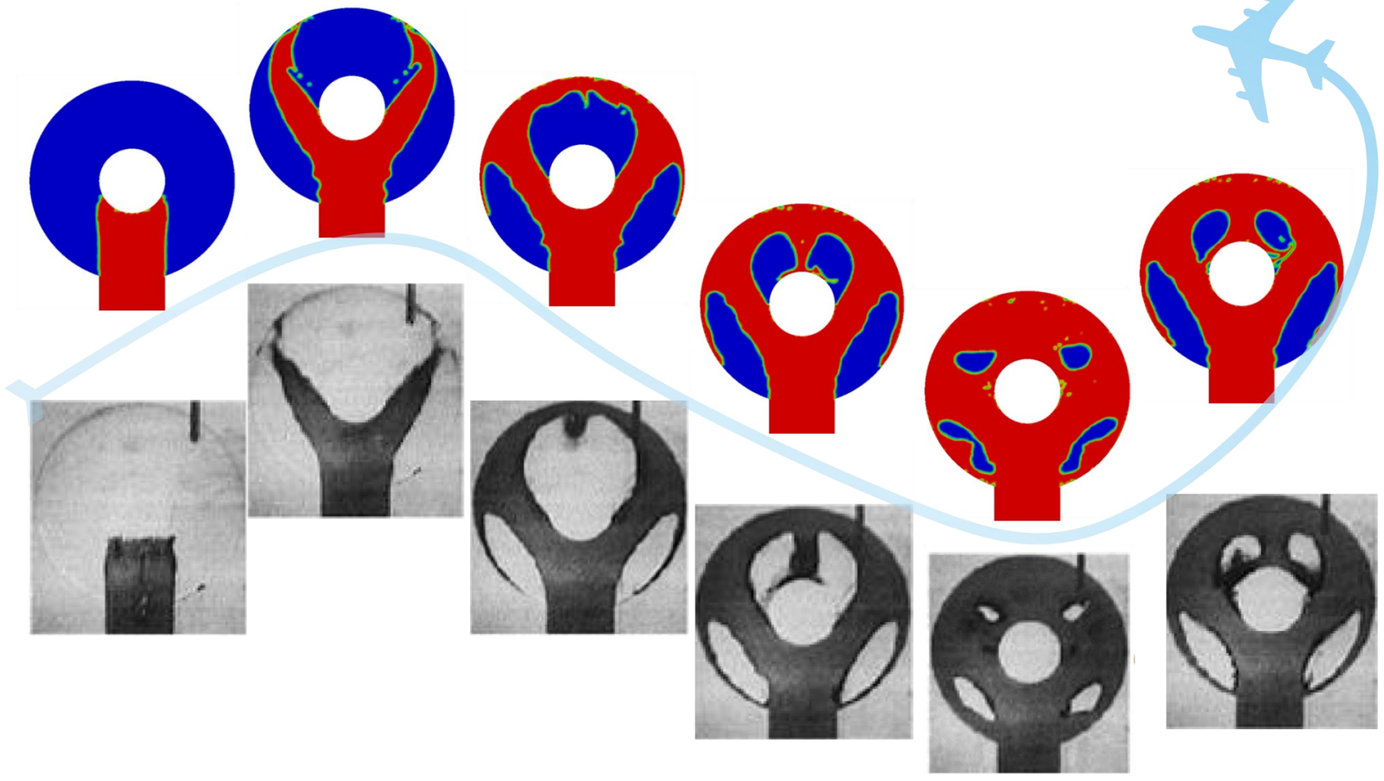


Cast-Designer Fastmesh result
(in 301,516 elements)

Traditional FDM mesh
(in 1,298,853 cells)

ADVANCED CFD SOLVER

CAST-DESIGNER's powerful Computational Fluid Dynamics (CFD), FVM based solver, incorporates many advanced features in flow the calculation like surface tension effects, viscous shear stress combined with gravity leads to buoyant flow, turbulent phenomena greatly enhance the diffusion of momentum and enthalpy also modeled. For fluid dynamics simulation, the algorithm solves equations of conservation of mass and momentum for any number of immiscible, incompressible fluids, and tracks the interfaces between them, two fluid model (liquid metal + air) effective in bubble formation.



Simulation result of Cast-Designer CFD Solver (up) vs experiment (down). The experiment was performed by Dr. Markus Schmid at ARGE Metallguss in Aalen, Germany

DESIGN FOR MANUFACTURING

Upfront quick casting part analysis tool to find Hot-Spots, Mass distribution, Wall Thickness, Slider zone, Ejection force calculation and Core model extraction as well as Part optimization.

GATING DESIGN

- Gating Design Tools and Advisors for HPDC, LPDC, Gravity and Investment Casting Processes etc.
- CAD modeling capability
- Export to 3D CAD system directly

CASTING PROCESSES

Gravity Casting
- Sand / Permanent / Tilt Pouring
- Investment / Shell Casting
- Lost-Foam Casting

High & Low Pressure Die Casting
Semi-Solid Casting
Continuous Casting
Centrifugal Casting
Core Blowing

SPECIAL PROCESSES

- Mechanical & Thermal Stress
- Micro-Structure Analysis

AUTOMATION & OPTIMIZATION

- Casting Part Optimization
- Gating Optimization
- Process Optimization
- Design of Experiments
- Production Optimization
- Distortion Compensation

RAW MAYERIAL OPTIMIZATION

SavingCAST, can provide optimized mix of raw materials, scrap, or return materials at lower cost for the specified alloy mix.

MATERIAL DATABASE

CAST DESIGNER has more than 400 industry standard materials in the database including Cast iron, Steel, Stainless Steel, Copper, Mg, Zn, Ni, Lead, Gold, Silver & Aluminum alloys and varieties of mould, sand, filter & sleeve materials

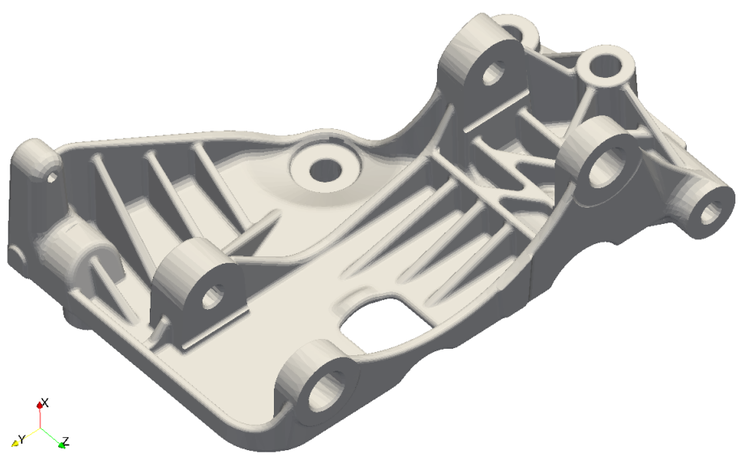
DESIGN FOR MANUFACTURE(DFM)

GEO-DESIGNER

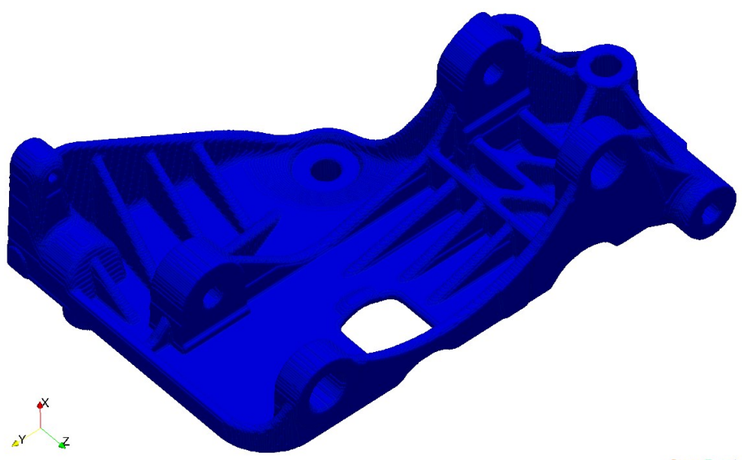
Geo-Designer is a powerful upfront Design For Manufacturing (DFM) tool for designers and manufacturing engineers with innovative technology. DFM Analysis is the FIRST STEP for part manufacturing. It is the bridge to link the part designer and manufacturing suppliers.

Find critical points in casting manufacturability and respond to RFQ quickly

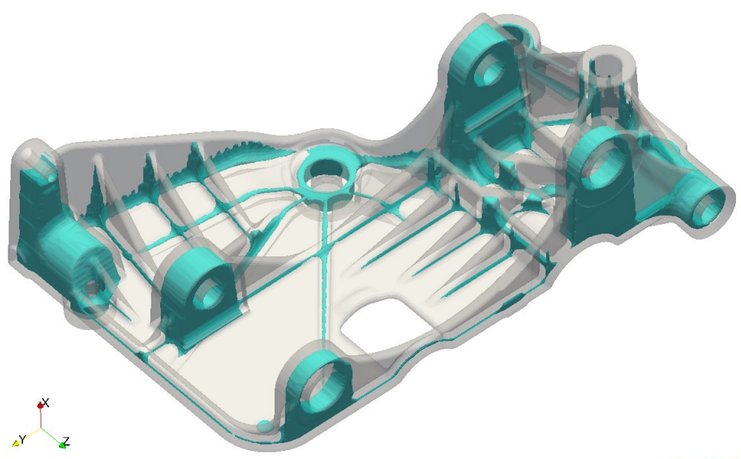
FIND HOT SPOTS! IN 3 CLICKS, 3 MINUTES



Import CAD



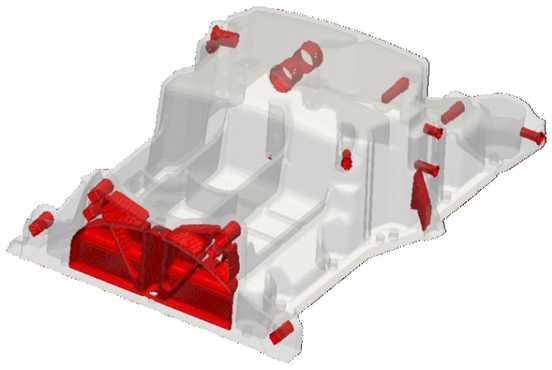
Create DFM model



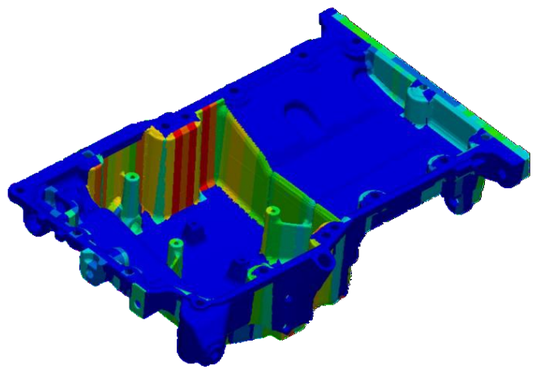
Find Hot Spots in minutes

GEO-DESIGNER FEATURES

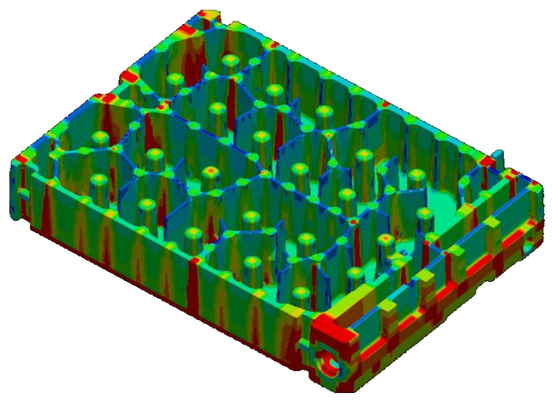
- Standalone software, also integrated into **CAST-DESIGNER** systems
- Build in last CAE technology for geometric front analysis
- Express mesh technology for STEP/IGES file object.
- Checks wall thickness, Mass Distribution Index(MDI), Heat Distribution Index (HDI) on complete model
- Build in design capability
- Support 3D ISO-surface and multi-sections mode
- Ease in locating critical thickness areas
- Advanced visualization for easy interpretation of results
- Ability to clip model at any section
- Dynamic information display at point click
- Powerful filter mechanism to concentrate on region of Interest. Detail information of analysis model: mass, volume, surface area, project area, heat modulus etc.
- Support contour, section, Iso-surface and curve, Import STL, IGES, STEP file directly
- Design result could be exported to 3D CAD system directly
- Flexible report generation, VRML output
- Support language: English, Japanese, Chinese etc.



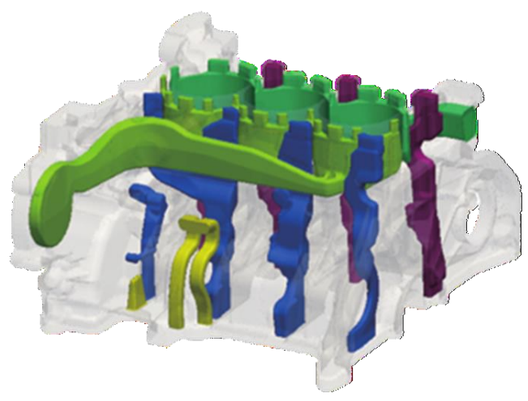
Detect Slider Zones



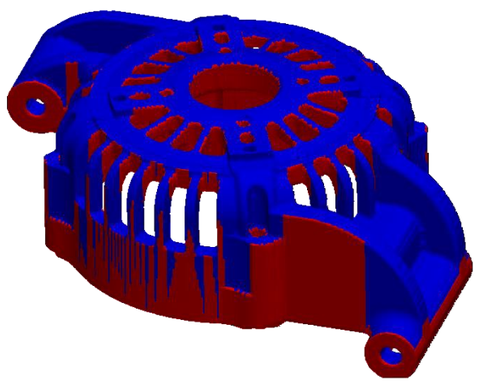
Find Ejection Force



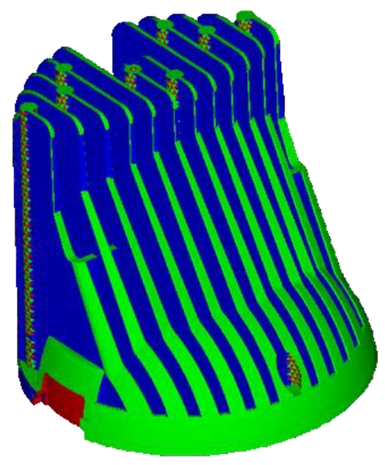
Thickness Analysis



Extract Core Shape



Find Parting Line



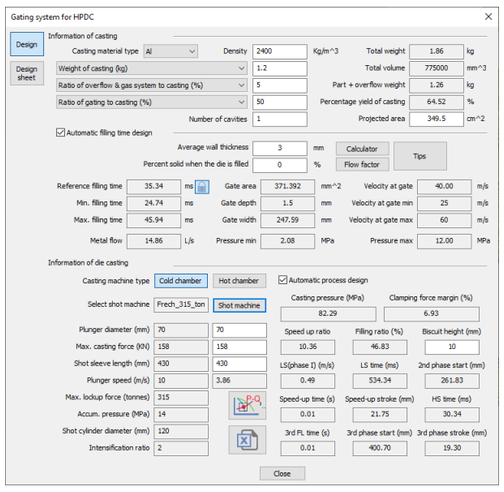
Draft Analysis

HPDC-GATING STSTEM DESIGN

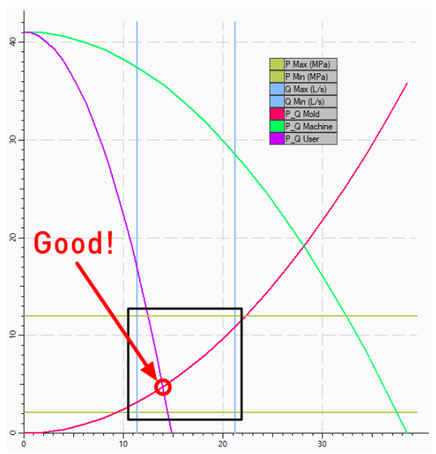
CAST-DESIGNER

CAST DESIGNER'S Gating Design Advisor is designed with 50 years of industrial experience and NADCA standard recommendations. It provides step-by-step guidance to the user to design an effective gating system, starting from the shot machine selection, inner gate area, runner section, velocity, fill-time, over flow, venting and cooling channels etc.

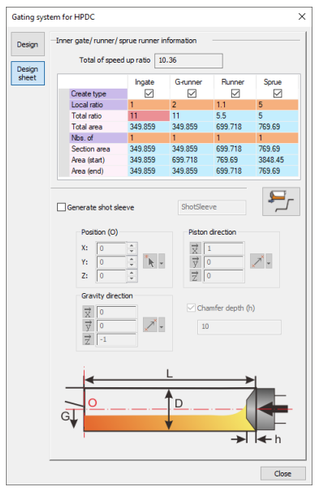
With **CAST-DESIGNER'S** Automatic Optimizer, this initial gating design could be fully optimized to produce error-free castings.



Gating Design Advisor main page

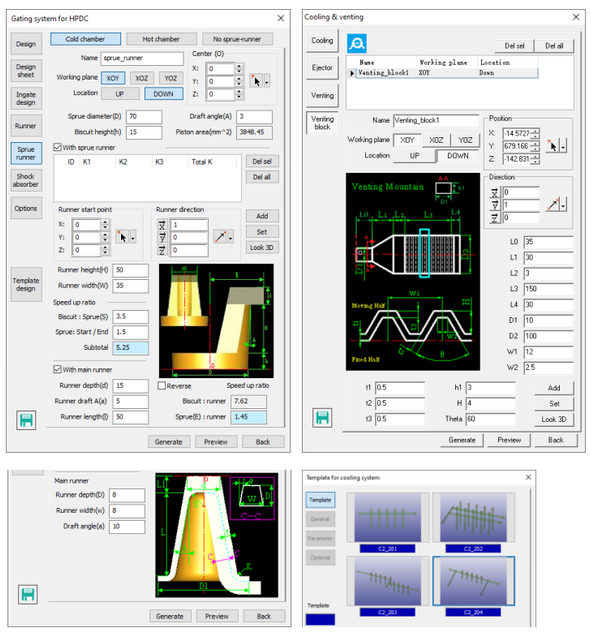


PQ Graph Evaluation of the gating system design

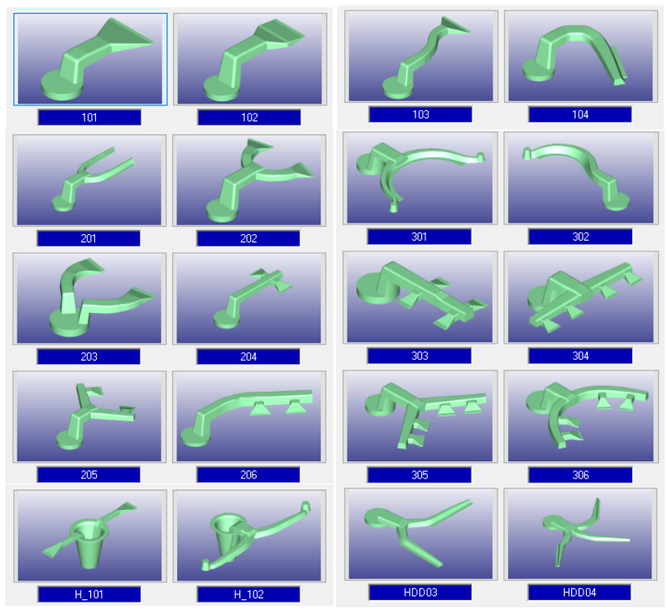


Shot sleeve and vacuum design

- PQ Graph evaluation of the design
- Provides fill time and required inner gate area
- First phase and Second phase velocity



Detail components design

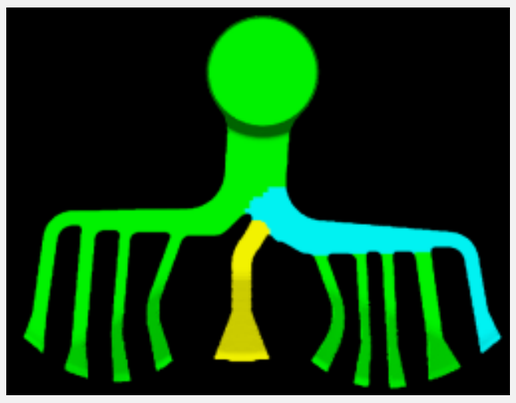


Parametrically defined "Template Gating Designs"

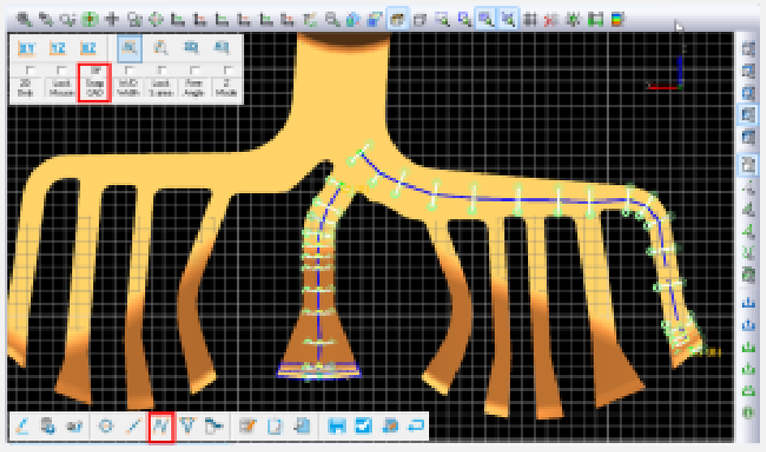
- Cooling channel calculator
- Overflow requirement calculator
- Sprue runner, venting design tools

REVERSE ENGINEERING OF EXISTING GATING DESIGN

- Special tool for Reverse Engineering of existed gating system from ANY CAD system(CAD, STL, mesh etc.)
- Convert to full parametric gating in few minutes to optimize the design performance.



- 3D runner projection is another useful function to convert the 2D plan runner to complex 3D runner.



With parametrically designed gating model, it is easy to modify the design for better flow performance results

DESIGN TOOLS FOR HPDC

• **Shot Machine Tonnage Calculation Tool**: Using user given projected-area of the casting and casting pressure category, this tool provides shot machine tonnage required to manufacture the casting.

•**Shot Machine Database**: **CAST-DESIGNER** has a collection of shot machine data. This database can be referred for machine tonnage and for PQ graph analysis.

•**Casting Wall Thickness Analysis Tool**: A handy tool to find average wall thickness of the casting and thin and thick regions in the casting.

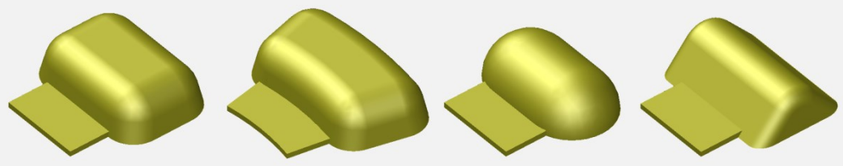
• **Casting Zone Analysis**: The QuickCAST function can help the size and location of inner gate design to define casting zone and have an uniform filling.

• **Auto Runner**: Help create smooth runner of gating system automatically.

• **Runner Combine**: Combine several runner together, all the section area and feature sections will be adjusted automatically.

• **Shot Sleeve Model Generator and Velocity Curve Generator:** CAD models are automatically created with filled, unfilled regions and piston of the shot sleeve. Piston velocity or distance curve can be created and verified for vacuum system and shot-machine's capability.

• **Overflow Design Tools :** Different standard shapes supported. The size of overflow could be adjusted by one global parameter.

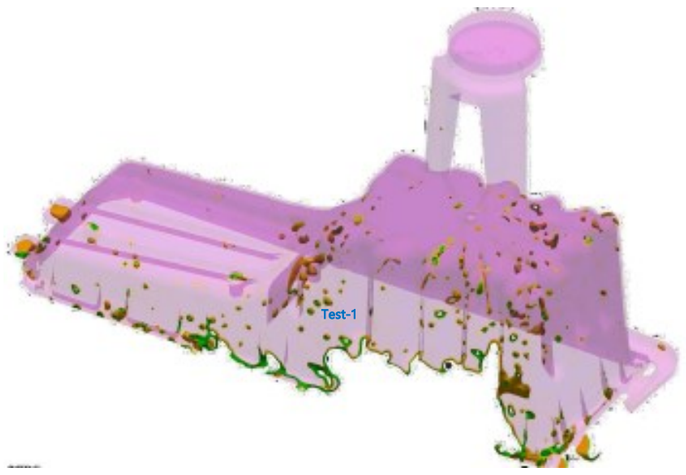


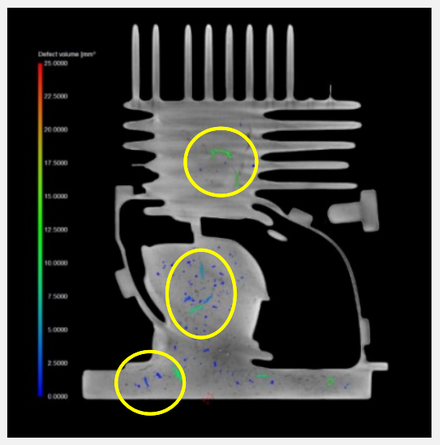
• **Cooling Calculators and Design Tools :** Cooling channels calculator helps designer to arrive at length and diameter of the cooling channels and design tools to create cooling channels for analysis.

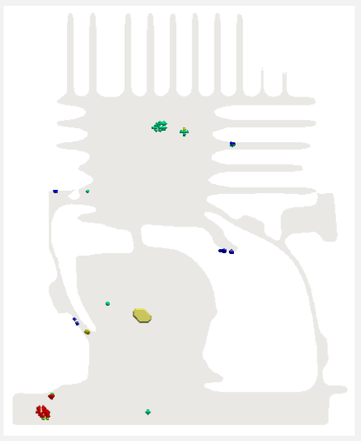
• **Venting Calculators and Design Tools :** Chill vent designer can create standard design quickly.

FLOW TURBULENCE, AIR ENTRAPMENT, BUBBLE MOVEMENT & TEMPERATURE

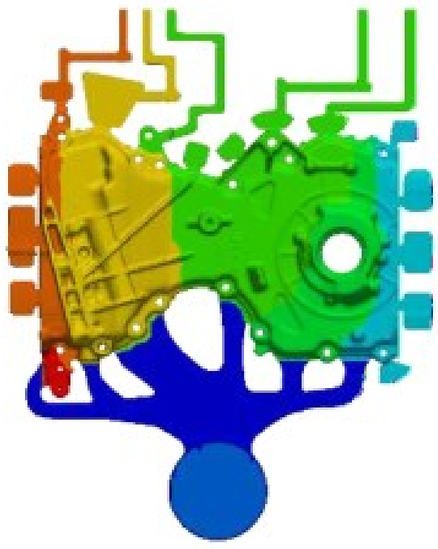
CAST-DESIGNER'S CFD solver considers surface tension effects, "slushy" flows and turbulent currents, including wall pull-away, splash effects. Two-fluid calculates air bubble formation and its movements are tracked well. These defects can be precisely analyzed which helps designers optimize their gating system and better position the vents & overflows.







GATE COLOUR / METAL TRACING



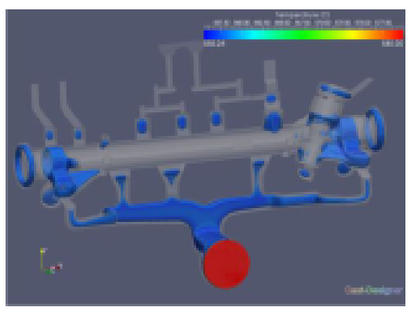
OXIDES, MATERIAL AGE, COLOURED FLOW PATH

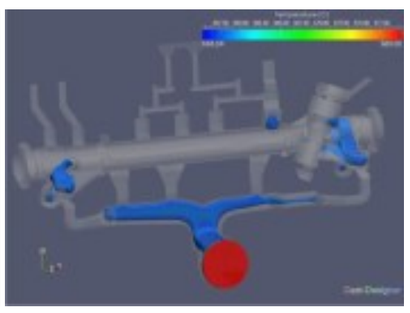
Flowing metal is tracked throughout the filling process and provides vital information such as material age, flow length and gate wise coloured flow path to help design balance the running system, in the case of multiple inner gates.

CAST-DESIGNER accurately tracks oxides formation during flow and their final locations.

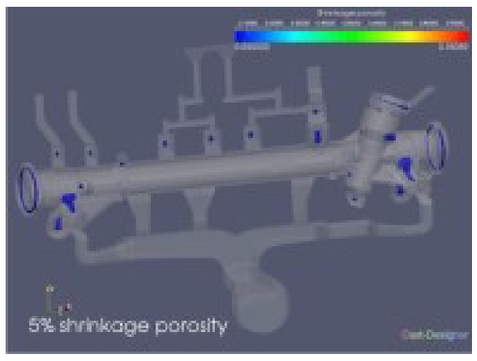
SOLIDIFICATION & SHRINKAGE POROSITY

Accurately predicts the shrinkage porosity, taking into account of the expansion of cast alloy and the density variations that occur during the cooling process in the solidification.

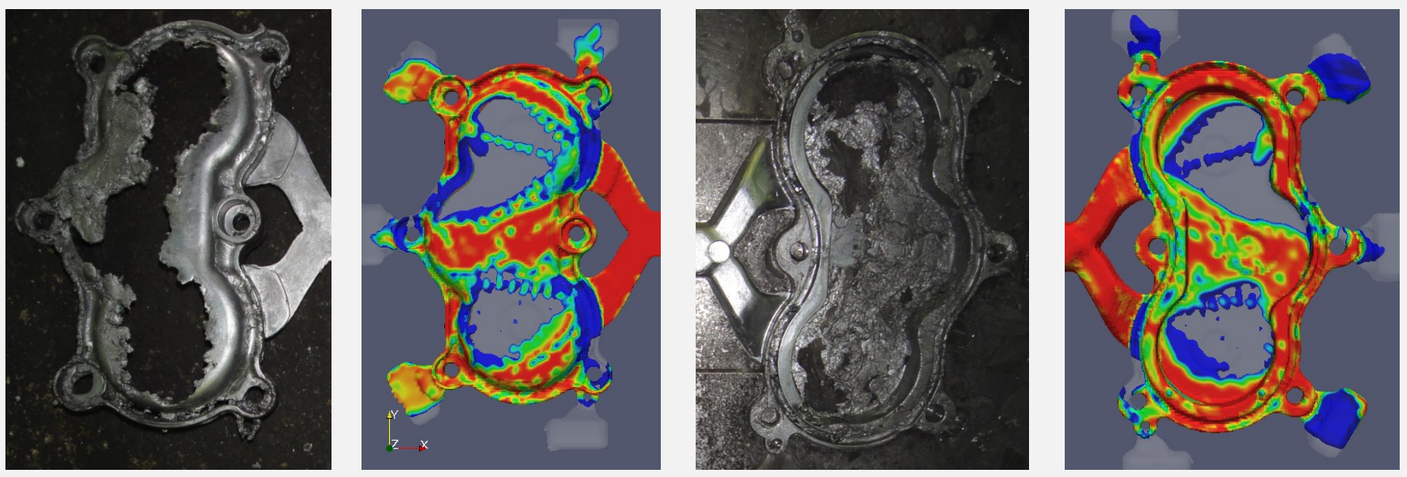




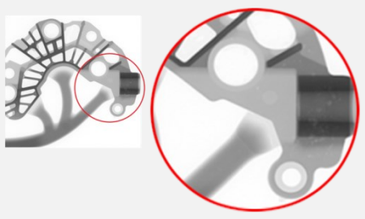
CAST-DESIGNER accurately predicts the Niyama micro-porosity occurring late in the solidification stage.



ACCURATE METAL FLOW SIMULATION

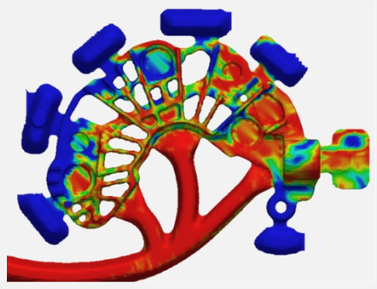


Short shot testing result and Cast-Designer simulation result of aluminum housing



(a) X-Ray photo of casting

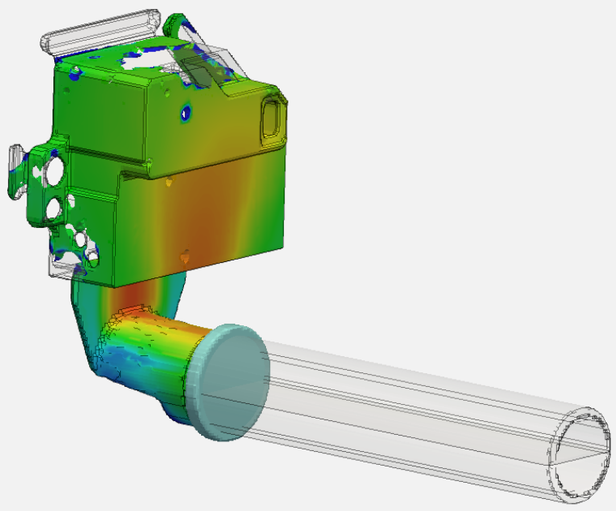
(b) Gas entrapment



(c) Flow pattern

SHOT SLEEVE PISTON MOVEMENT

CAST-DESIGNER has shot sleeve piston movement capability to exactly simulate the actual machine condition in the simulation. Useful to decide on first phase velocity and full shot curve.

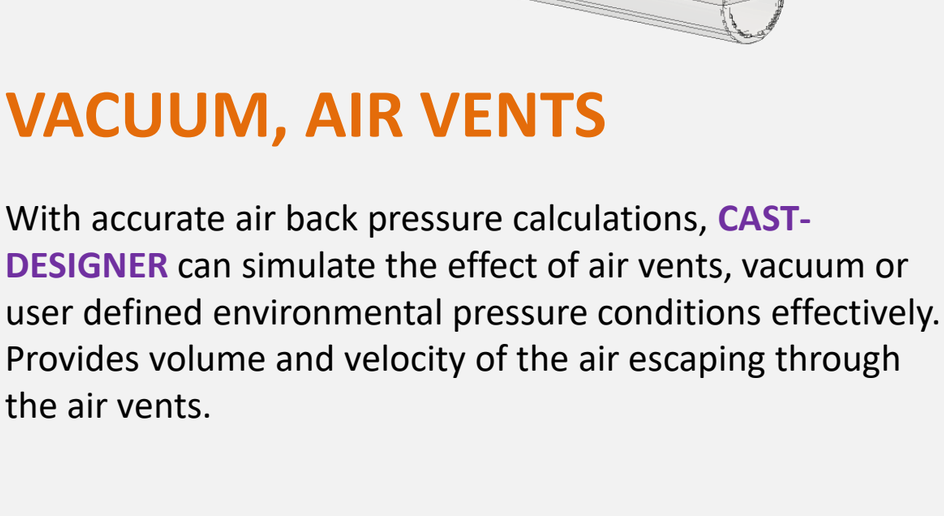


VACUUM, AIR VENTS

With accurate air back pressure calculations, **CAST-DESIGNER** can simulate the effect of air vents, vacuum or user defined environmental pressure conditions effectively. Provides volume and velocity of the air escaping through the air vents.

MAX AIR PRESSURE

CAST-DESIGNER provides regions with maximum air pressure which is important for designer to decide on the overflow and venting locations.

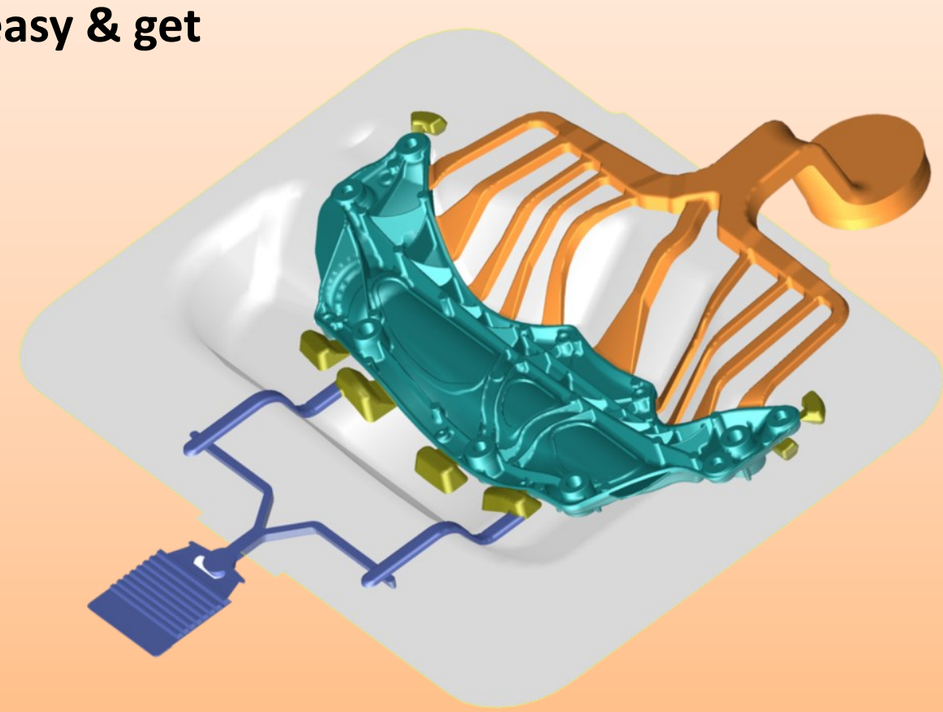


SQUEEZE PIN

Squeeze pins are used in die-casting to locally push the material to reduce shrinkage porosity. In **CAST-DESIGNER** the squeeze pins can be simulated to find its effect and decide on the timings and sizes for the squeeze pins.

FREE STYLE GATING DESIGN

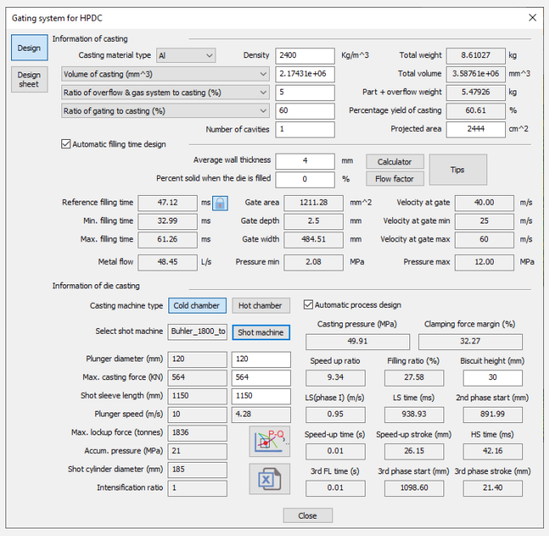
Working in “Free-Style” gating design module is fun and easy & get your design done in minutes.

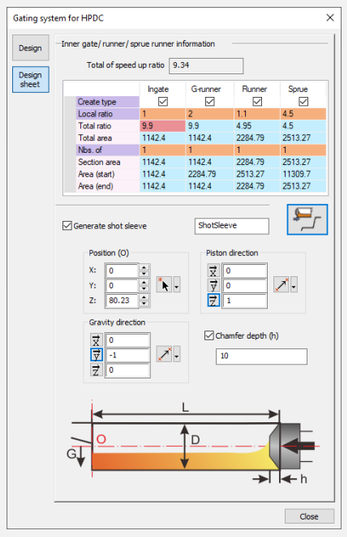


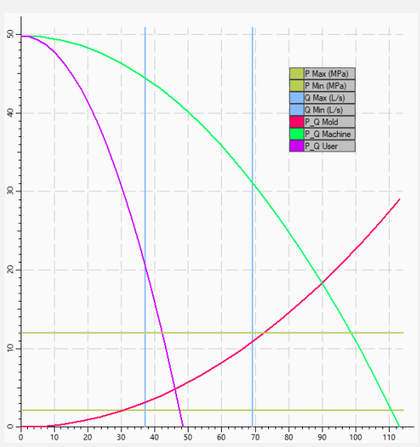
4 It’s like drawing on a paper

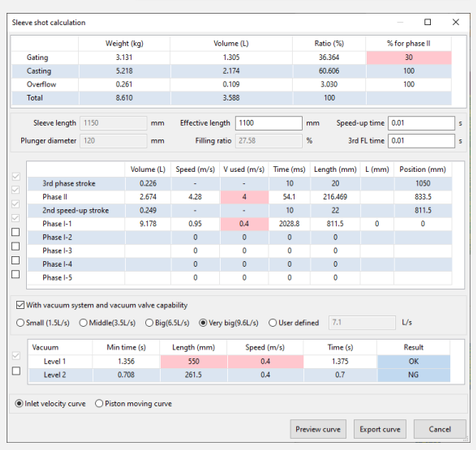
STEPS IN FREE STYLE DESIGN

1







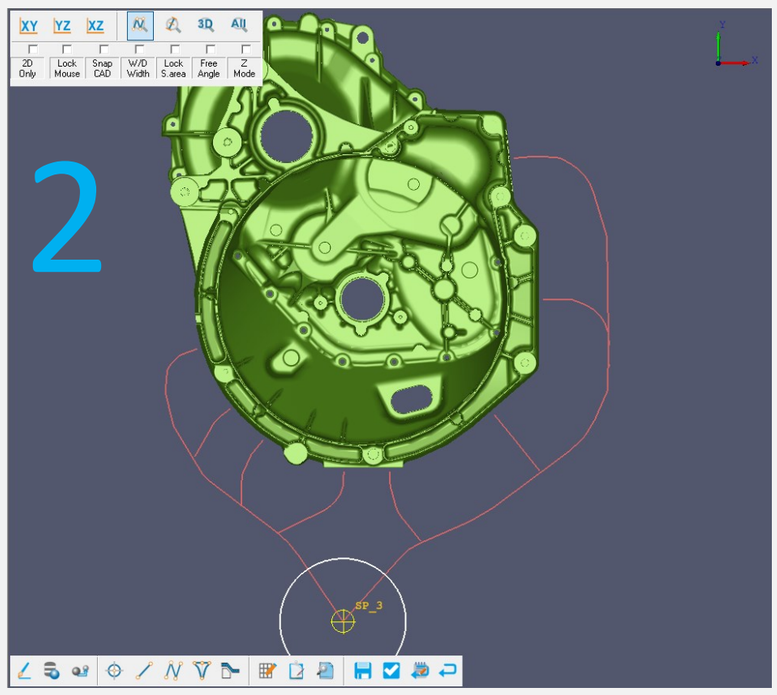


Draw directly on the 3D gating system

- ‘Free-Style’ gating design tool has intelligence about the standard definition of different runner shapes.
- By simply picking few points on the parting surface a spline is created as a projected 3D spline.
- Taking this spline as controlling center line, runner geometry is created in 3D with required draft, rounds etc.
- 3D runner is always created as a swept blend with smooth bends.
- Based on the designed local speed-up ratio, runner section’s start area and end areas are controlled.
- Free design also supports pre-defined template library. The customize tool can help user to make customization in a few clicks.

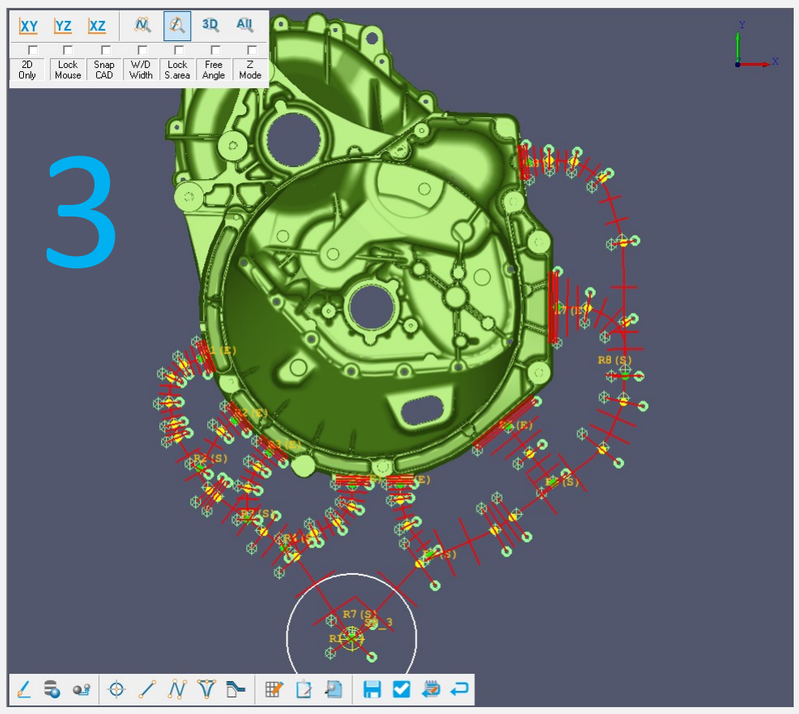
Get Design from Gating Design Wizard

2



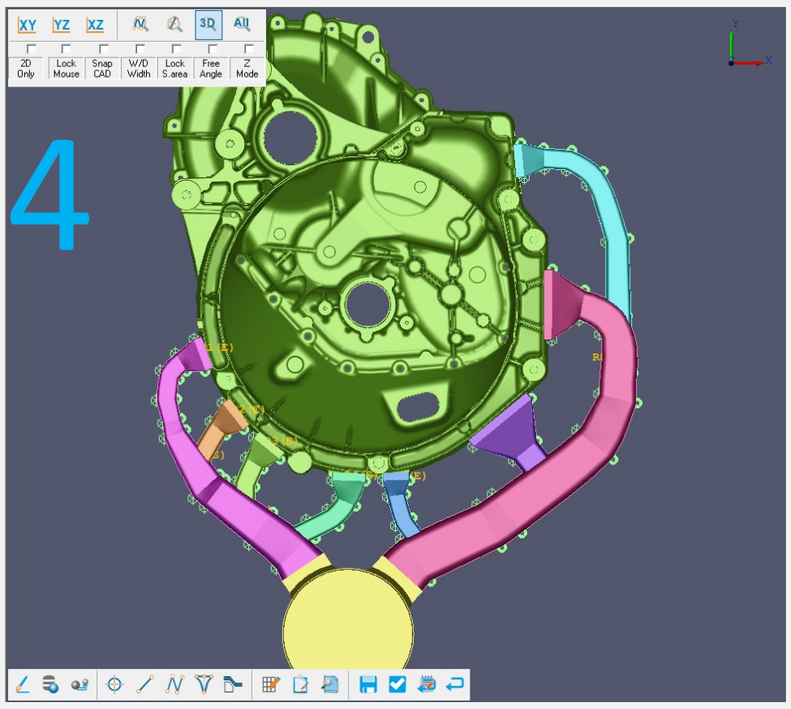
Draw your concept lines using 4 simple tools – main runner, runner, gate runner and sprue

3

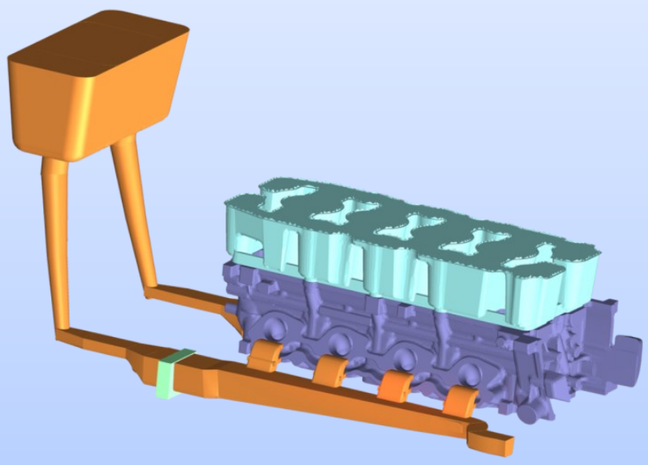


Apply Design from Wizard, runner section areas are copied from the design sheet.

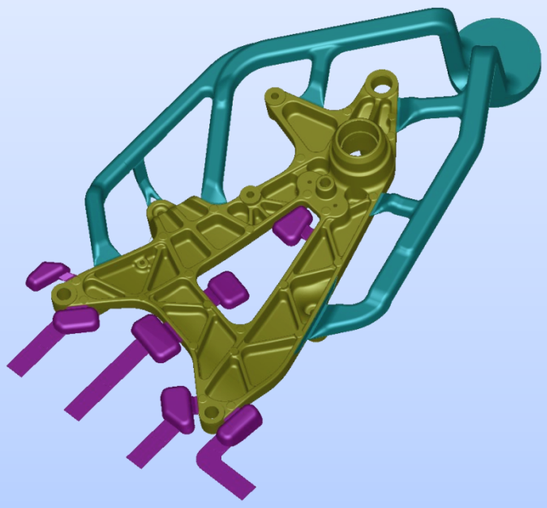
4



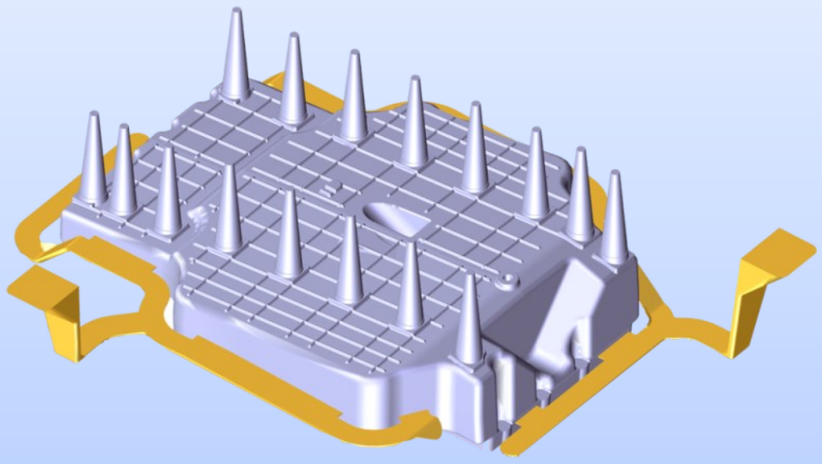
Runners, in-gates and sprue are created with design sheet values in 3D in a single click. Adjust, if required.



Gating system of engine block



Gating system of motorcycle part



Gating system of permanent mould casting

SMART RISER & CHILL DESIGN

CAST-DESIGNER

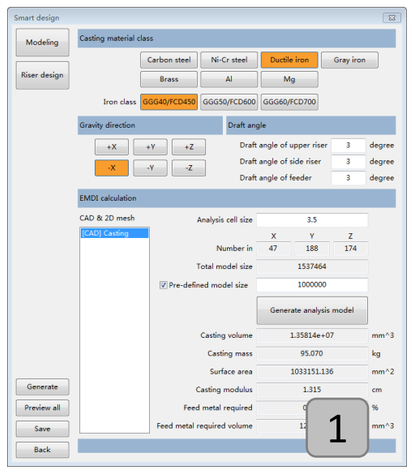
CAST-DESIGNER provides an unique method named ‘Smart Riser’ to design the riser for gravity casting process.

- ➢ Generate the riser design model, to display the EMDI contour in the design space
- ➢ Select the riser type and general parameters
- ➢ Click ‘Smart design’ to design the riser size and the best location.

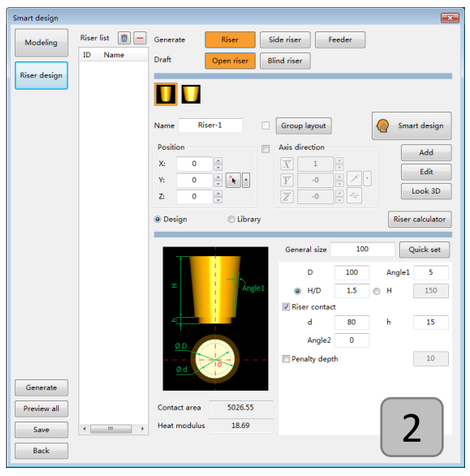
Predict the riser size by
- ✓ EMDI
- ✓ Part geometry
- ✓ Alloy
- ✓ Riser type
- ✓ Guide by safe factor
- ✓ Similar method for chill design

Predict the best riser location
- ✓ Part geometry
- ✓ Alloy affection range
- ✓ Update the location immediately
- ✓ Riser layout design (line, cycle, array etc.)
- ✓ Conformal chill design

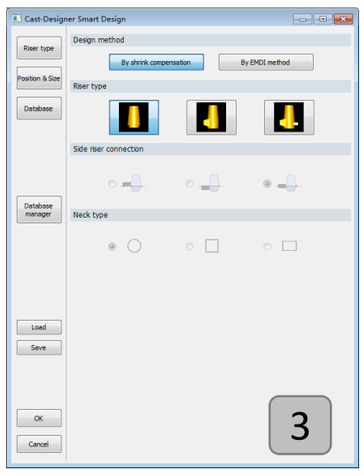
Select riser from database
- ✓ As the designed data, such as diameter, thermal modulus to select riser from database
- ✓ Support user’s riser
- ✓ Support any shape of riser
- ✓ Support any type of riser.
- ✓ Flexible search function.



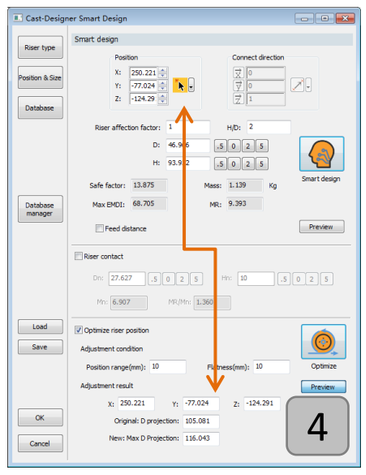
Riser design modeling



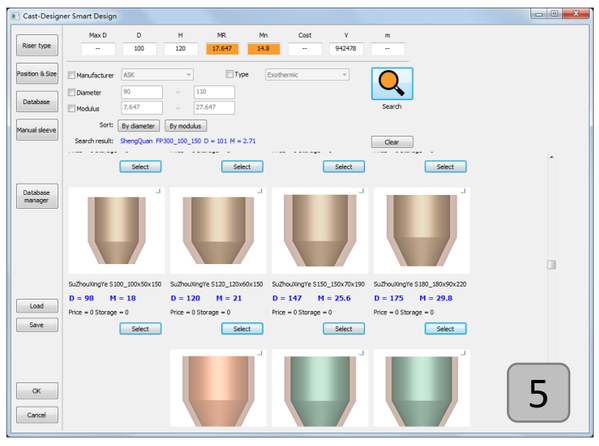
Smart design



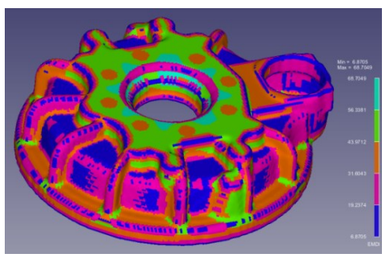
Select riser type



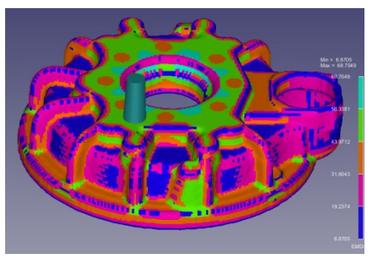
Define riser size & location



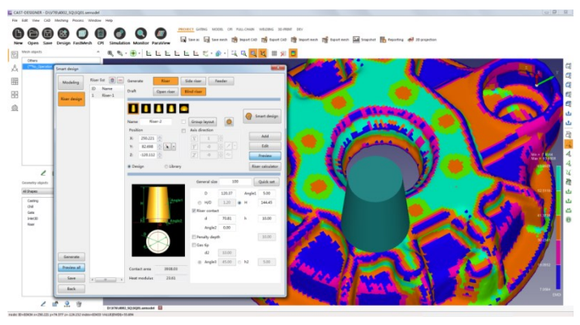
Select riser from database



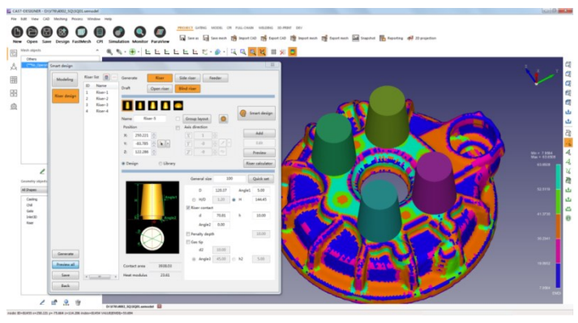
Riser design modeling



Define riser location



Define riser size and location



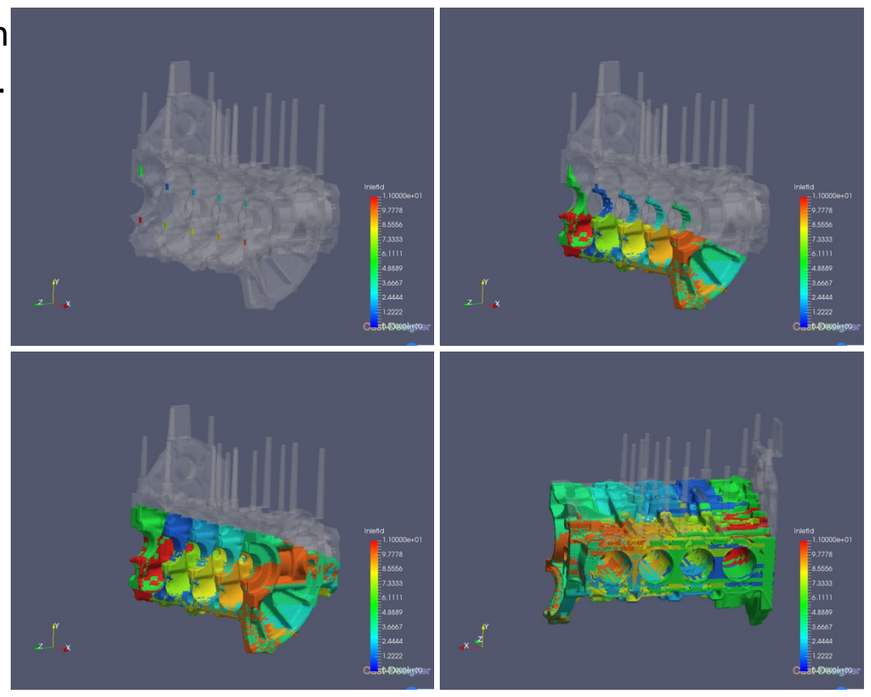
Risers layout

QUICKCAST TO EVALUATE CASTING SYSTEM

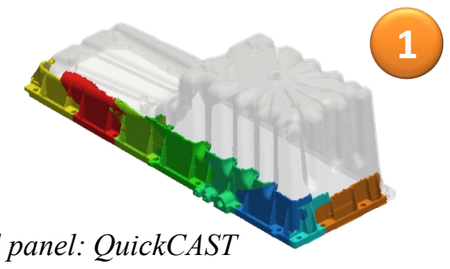
CAST-DESIGNER

QuikCAST is a special technology to predict the metal flow in an express way to help the gating system design (Cast Zone).

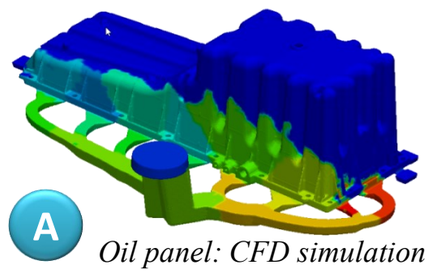
- ✓ Geometric base calculation and very useful for inner gate design (size and distribution)
- ✓ Very fast (a few seconds) and flexible parameters
- ✓ Good result while compared with the CFD solver
- ✓ Support almost casting process: HPDC/LPDC/ Gravity (3 modes) / Disa casting (vertical)/ thixo-casting, lose foam casting, user defined control parameters.
- ✓ Very easy to use and good accuracy.



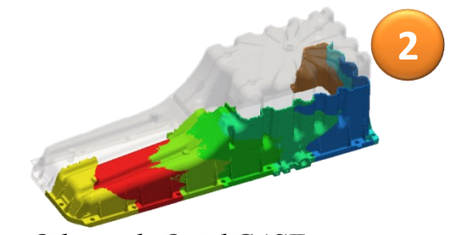
QuickCAST analysis for engine block (Gravity casting)



Oil panel: QuickCAST



Oil panel: CFD simulation



Oil panel: QuickCAST

QuickCAST Optimization

Start optimization

Run & Manual opt | Auto Optimization

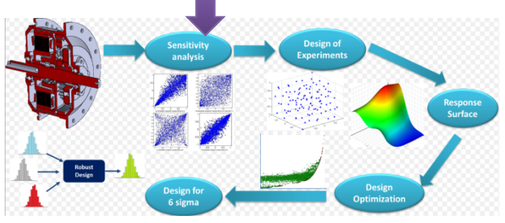
ID	Name	Ingate S	Flow Volume	V/S	d(V/S)%	OPT	Adj_S(%)	Result S
1	R1	107.476	385.56	3.587	2.661	☑	3	110.701
2	R2	107.476	385.573	3.587	2.664	☑	3	110.701
3	R3	107.476	377.92	3.516	0.626	☐	0	107.476
4	R4	107.476	377.906	3.516	0.623	☐	0	107.476
5	R5	107.476	350.87	3.264	-6.575	☑	-6	101.028
		537.384	1877.83	3.49439				537.384

1st optimization result

Run & Manual opt | Auto Optimization

ID	Name	Ingate S	Flow Volume	V/S	d(V/S)%	OPT	Adj_S(%)	Result S
1	R1	110.701	397.276	3.588	2.699	☐	0	110.701
2	R2	110.701	397.29	3.588	2.703	☐	0	110.701
3	R3	107.476	377.258	3.51	0.45	☐	0	107.476
4	R4	107.476	377.231	3.509	0.443	☐	0	107.476
5	R5	101.028	328.773	3.254	-6.871	☐	0	101.028
		537.384	1877.83	3.49439				537.384

GA optimization



The last optimization

Run & Manual opt | Auto Optimization

ID	Name	Ingate S	Flow Volume	V/S	d(V/S)%	OPT	Adj_S(%)	Result S
1	R1	124.381	434.261	3.491	0.571	☐	0	124.381
2	R2	131.158	457.896	3.491	0.565	☐	0	131.158
3	R3	137.432	479.669	3.49	0.538	☐	0	137.432
4	R4	73.975	252.995	3.419	-1.484	☐	0	73.975
5	R5	73.975	253.008	3.42	-1.479	☐	0	73.975
		540.924	1877.83	3.47152				540.924

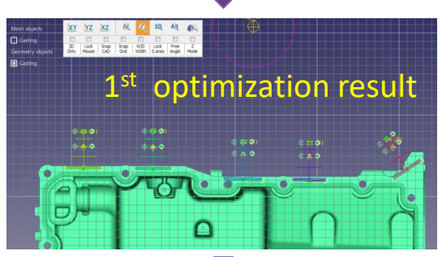
Gate runner define

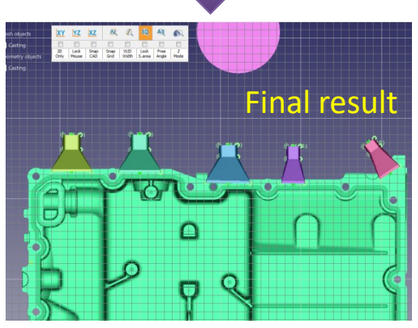
Active	ID	Name	S_end	W	D	S_time	Vel
☑	1	R1	124.381	49.752	2.5	0	40
☑	2	R2	131.158	52.463	2.5	0	40
☑	3	R3	137.432	54.973	2.5	0	40
☑	4	R4	73.975	29.59	2.5	0	40
☑	5	R5	73.975	29.59	2.5	0	40

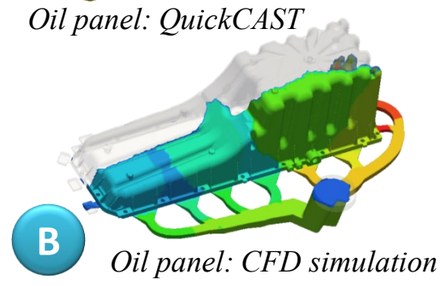
Final result

Automatic optimization of QuickCAST design

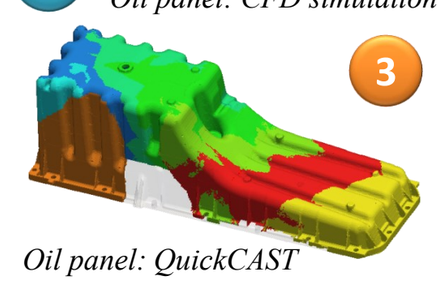
- The QuickCAST can make optimization in manually or automatic in the GA technology.
- No need to open post-process each time, the system can collect result automatically
- Give clear guide line for inner gate adjustment
- Multi design plans and fully automatic (Auto optimization)
- Balance the flow length as criteria with rich analysis result: gate color and flow length, filling time etc.



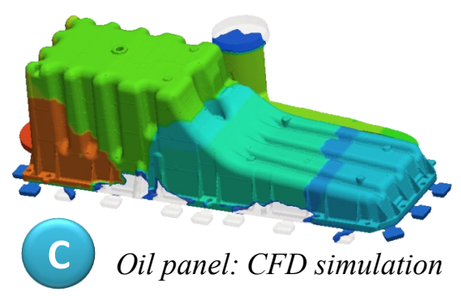




Oil panel: CFD simulation



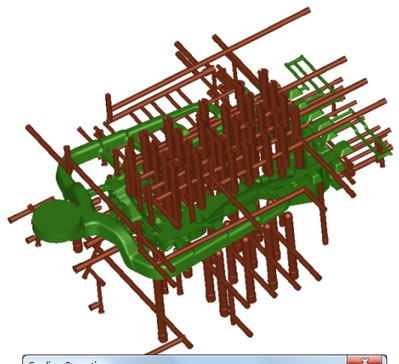
Oil panel: QuickCAST

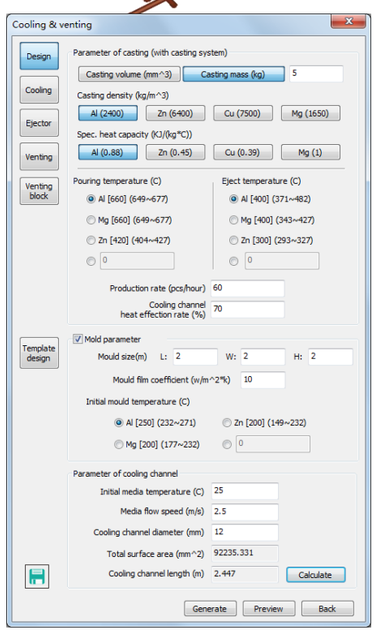


Oil panel: CFD simulation

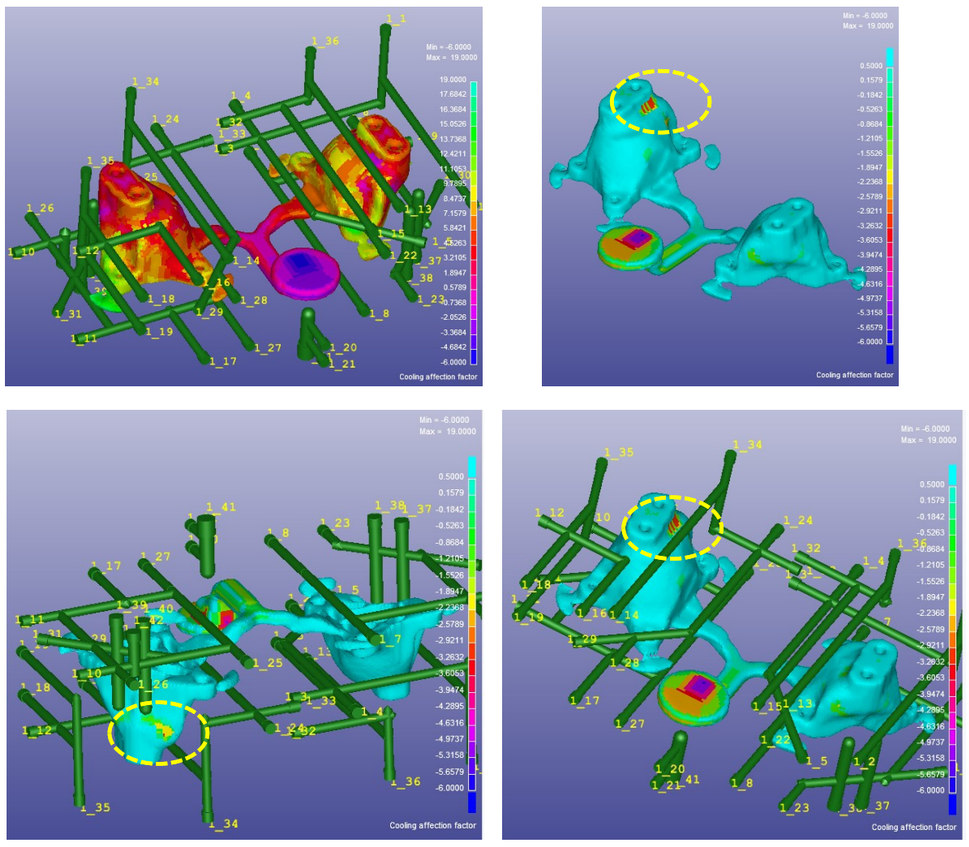
COOLING SYSTEM DESIGN

CAST-DESIGNER





Cooling system design wizard



RED colored region indicates thick region and as well as that cooling is not sufficient, may leave a shrinkage porosity

Cooling system design is another very important task in mould design. It will affect the solidification process and final result directly, such as the shrinkage porosity, stress and distortion after casting. Also, the die life time and production rate are related to the cooling system directly.

The cooling system designer is a CAD base module to help cooling channel generation in **CAST-DESIGNER**. It provides a very flexible way to generate any complex cooling system, like cooling channel and heat channel.

Instead of numerical simulation, **CAST-DESIGNER** Introduces an online cooling system analysis method to help designer check the cooling system design at the very early stage, it is fully integrated to the cooling system design interface and the user can get result within 3 to 5 minutes.

CAST-DESIGNER brings a new concept to cooling system design and analysis, full parametric design for cooling system, following a fast cooling system analysis to check the design performance.

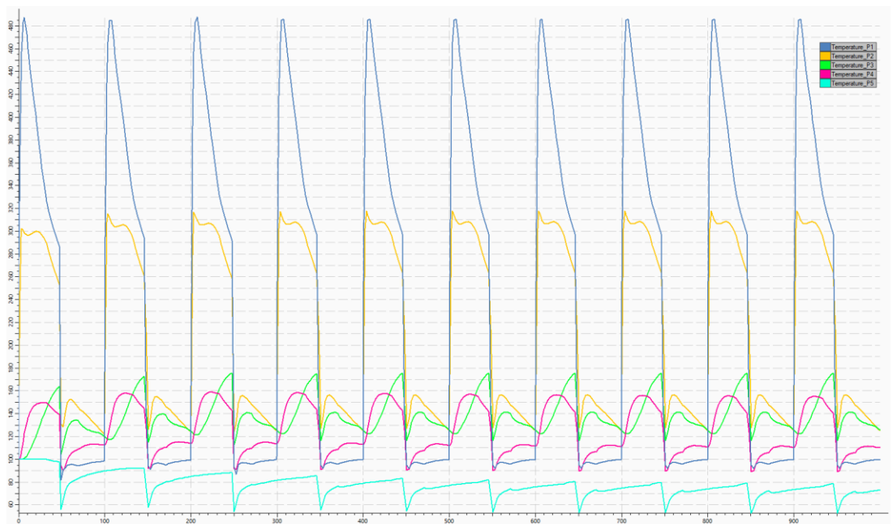
FULL MOULD AND CYCLING

CAST-DESIGNER

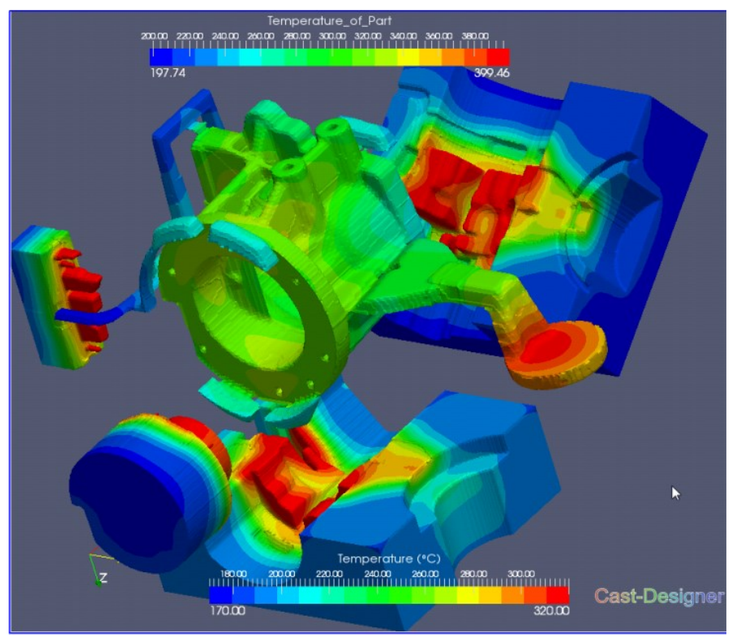
The die casting process module provides the capability for mould cycling in permanent die.

Definition of all important parameters influencing heat flow and the thermal balance of mould.
Comprehensive definition of the entire cycle process

- Ejection time (controlled by time or casting temperatures)
- Die opening sequence (as function of time)
- Delay time (simulating effect of cycle interruptions on the thermal balance)
- Die closing sequence (as function of time and temperature)
- Lead time until beginning of the next cycle
- Variations in the lead time can be simulated
- Three spraying modes could be selected



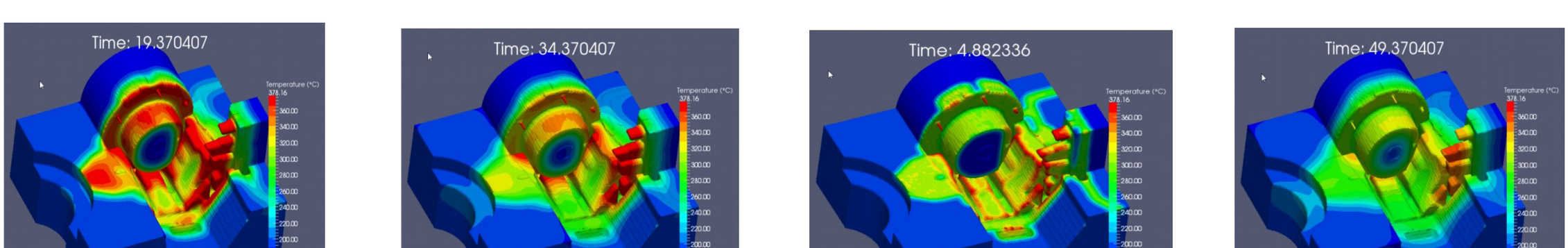
Cycling simulation to achieve the thermal balance



Casting and mould temperature of the casting process

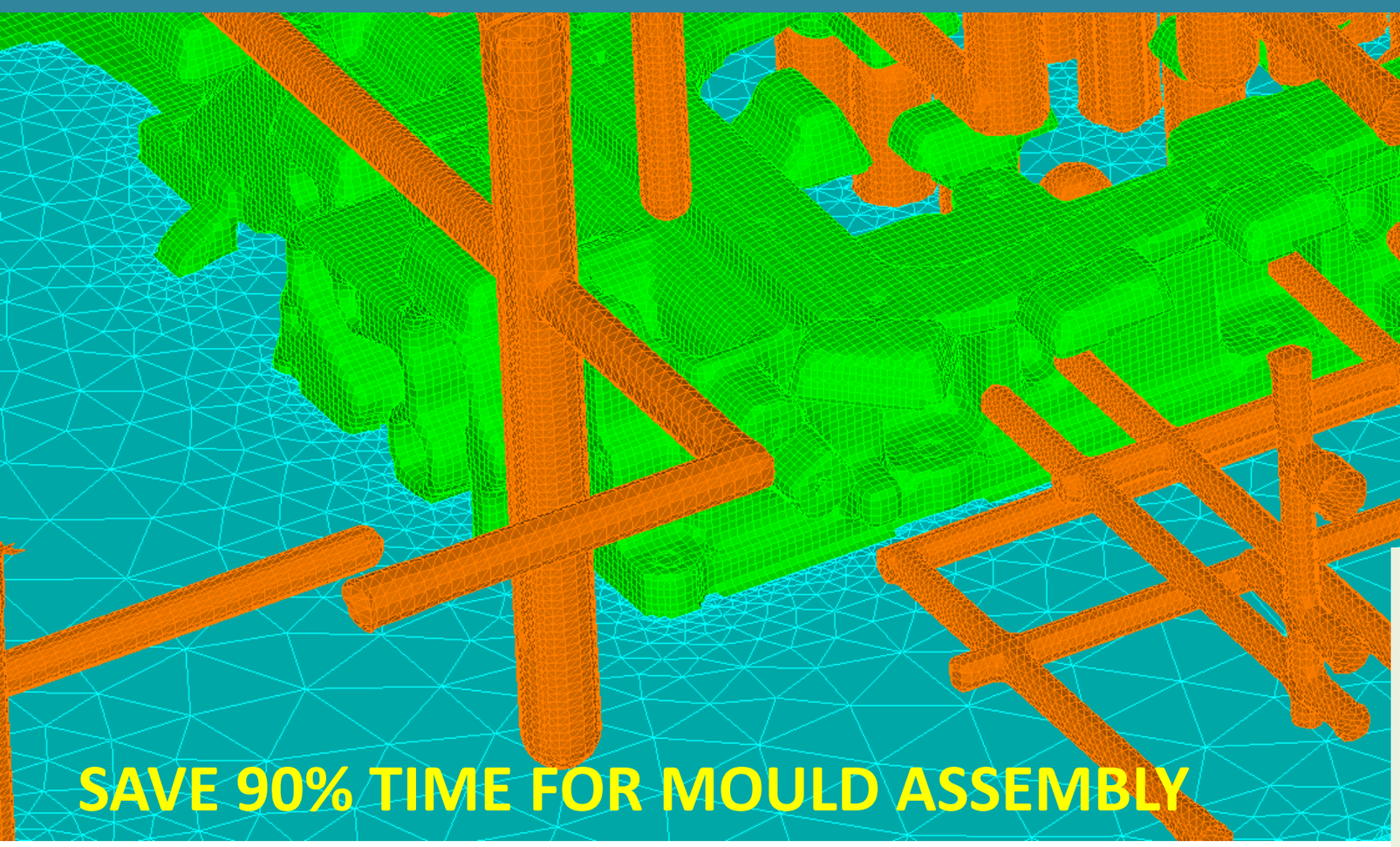
DIE COOLING & TEMPERING

- Complete consideration of die cooling and tempering system
- Individual control of each cooling or tempering channel
- Channel control can be dependent on time or temperatures



Temperature distribution on the die surface during the complete casting cycle

MOULD ASSEMBLY MESH SOLUTION



SAVE 90% TIME FOR MOULD ASSEMBLY

BEST-IN-CLASS MESHING TECHNOLOGY

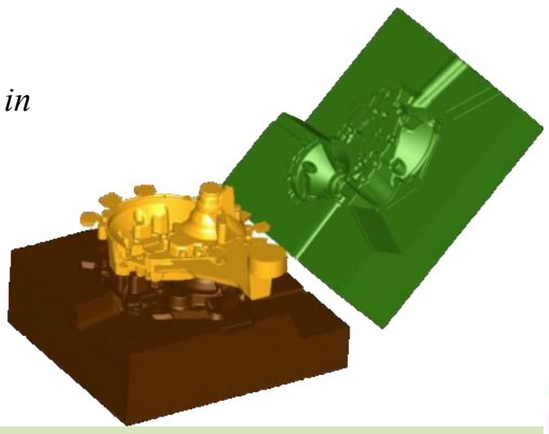
CAST-DESIGNER mould assembly can build complex meshes from a full 3D CAD assembly that includes casting and all major components of the die for HPDC, GDC and LPDC. The full mould assembly meshing is fully automatic and done in one click, it saves more than 90% of manual work and meshing time. Innovative technologies, such as the re-mesh technology of different contact interface, coarse mesh technology, mesh mapping technology and automatic driving batch mesh technology. Parallel meshing is used in the whole process.

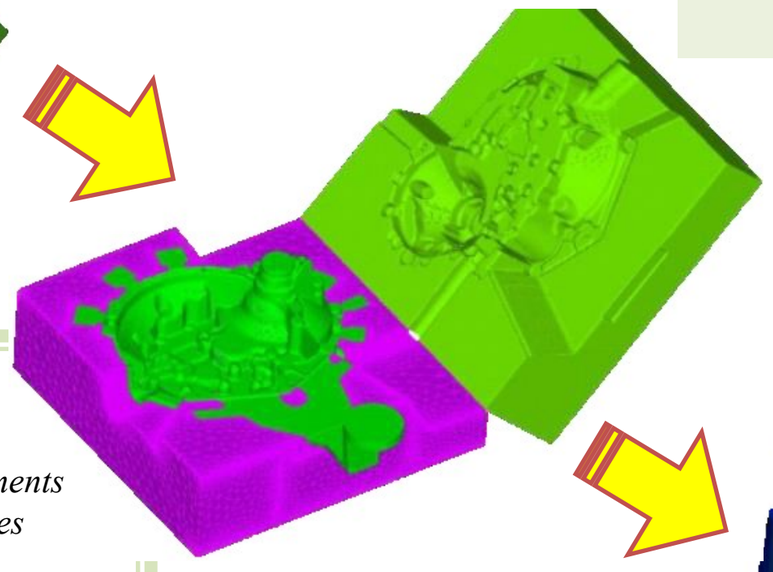
MIX OF ELEMENTS TYPES: SAVE 90% TIME

Inclusion of exact mould geometry in the simulation is important for cyclic and thermal balance of the mould.

- Hexahedral mesh for casting parts: good for flow analysis
- Tetrahedral mesh for mould parts: good for heat transfer and mechanical stress analysis and it is robust and gives faster results. It can change its size ratio drastically.
- The challenge is node-to-node connectivity between different mesh types, and **CAST-DESIGNER** handle it automatically and effectively.
- 10 times faster than traditional method.

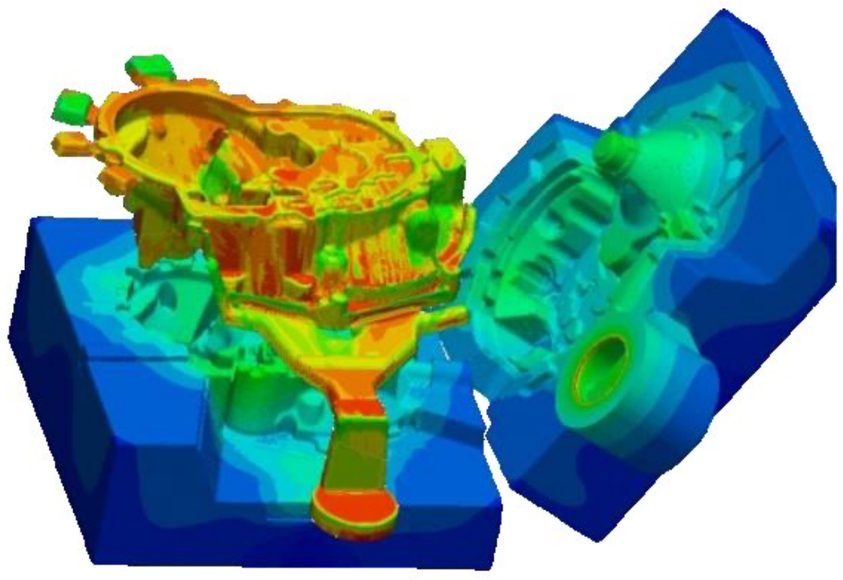
Full mould in CAD

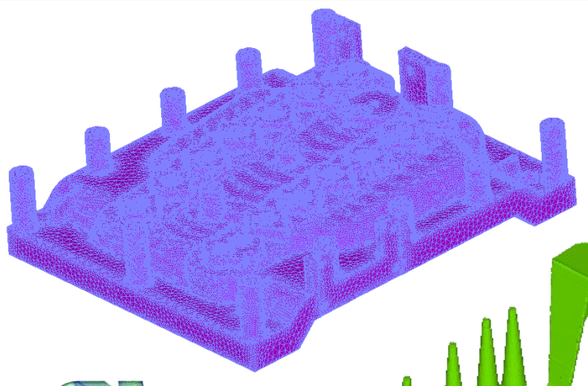




Full mould mesh created in 5 minutes

Temperature in casting and in mould



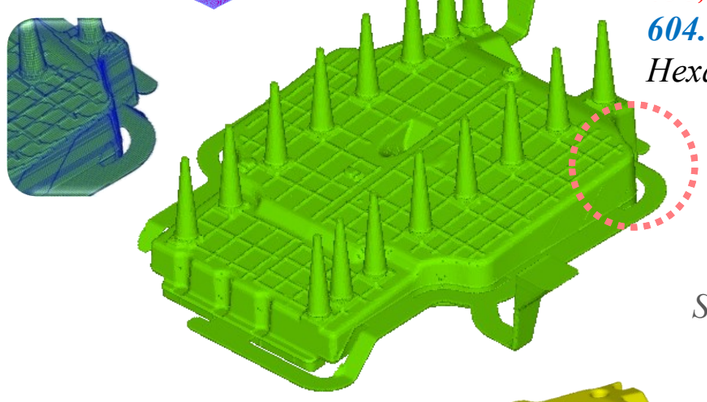


Top Die

721,320 elements
195,099 nodes
Tetrahedron

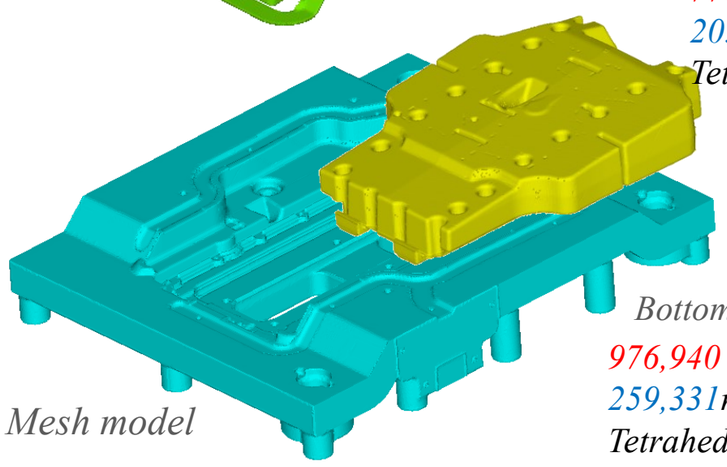
Casting Part

436,679 elements
604.052 nodes
Hexahedron



Sand Core

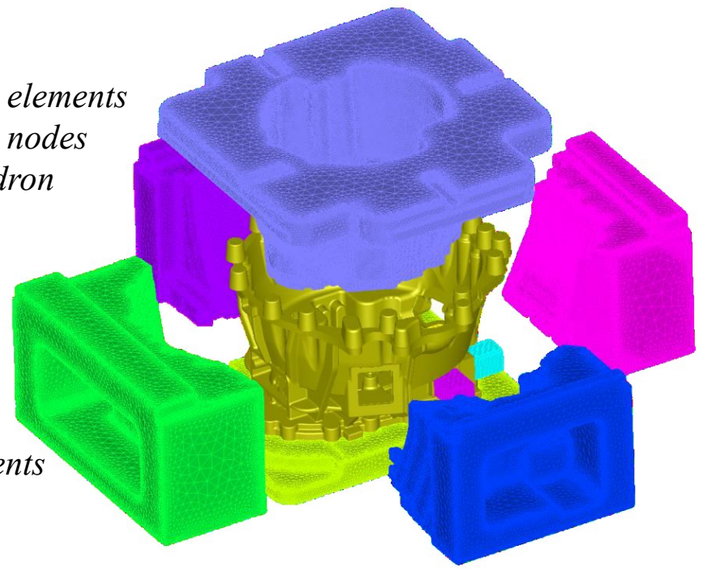
776,328 elements
203,632 nodes
Tetrahedron

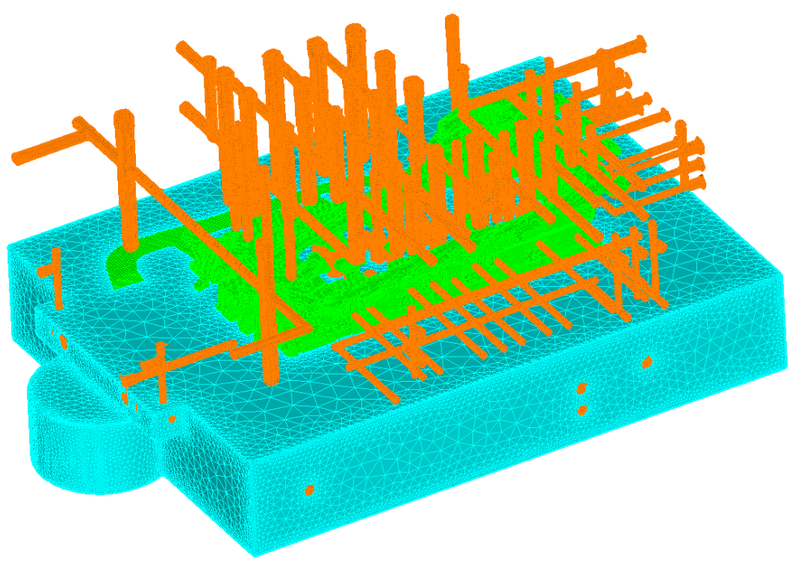


Bottom Die

976,940 elements
259,331nodes
Tetrahedron

Mesh model





Full mould of GDC Casting

Full mould of aluminum wheel in LPDC

Full mould with cooling Channels in HPDC

ADVANCE SPRAYING

CAST-DESIGNER

The advance spraying model of Cast-Designer lets users to model all facets of die preparation, taking into account the influence of the shape of the mold surface and the position and movement of the spray nozzles. It can accurately predict the exact temperature distribution on the die surface with reliable and realistic input parameters for thermal die cycling simulations.

This can help the metal casting engineers to better design and evaluate the internal cooling structure of the die, and the spray cooling parameters.

For every spray surface element, the HTC is computed by multiplying the base HTC by dependence factors,

$$HTC = HTC_0(T) * F_d(d) * F_a(\alpha) * F_c(\Theta)$$

$F_d(d)$ is the distance d dependent factor function.

Fa(α) is the spray angle **α** dependent factor function.

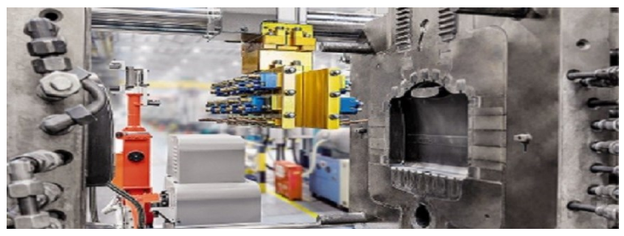
Fc(Θ) is the die face normal and the spray direction **Θ** dependent

Mould opening

- Define the mould opening distance and opening direction.
- Consider different mould types (fix mould or moveable mould) and different movement. For example, slider attached to different mould.
- Support multi-objects.
- Define general lead time of each mould spray.

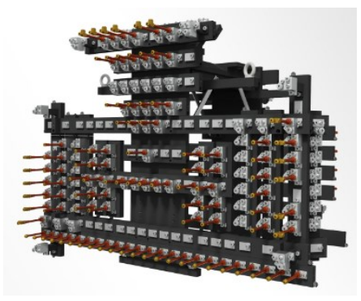
Head plate

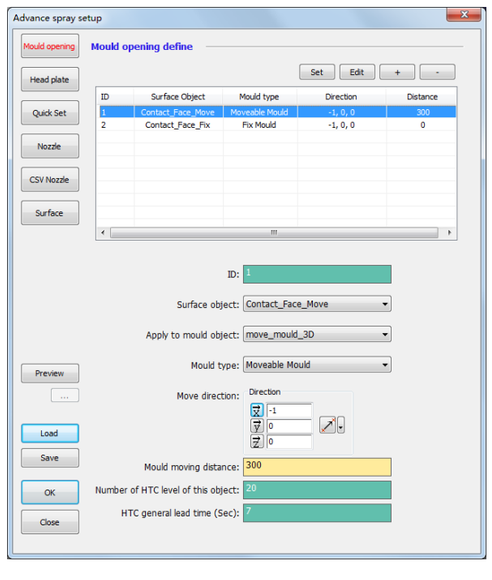
- Define the head plate of the spraying. It also could be controlled by robot arm in NC program.
- Head plate information:
  - Working plane
  - Size of the head plate
- Head plate can move to different position in different lead time.
- All parameters could be defined by user in the interface.

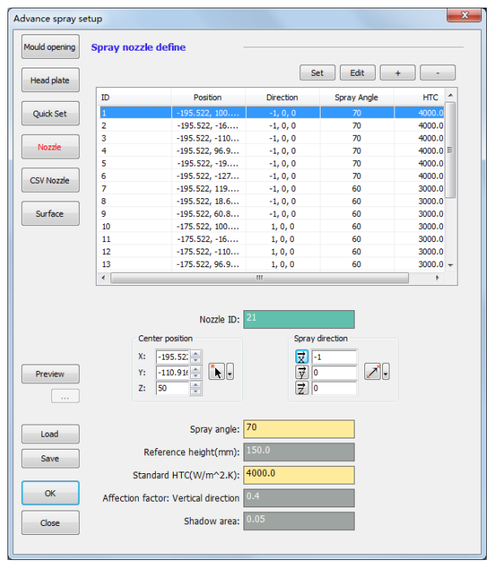


Nozzle define

- Define the nozzle for spraying. Four methods provided in the system.
  - Face type: Set the whole face as nozzle.
  - Quick Set: set multi-nozzles in array.
  - Nozzle: define nozzle one by one.
  - CSV nozzle: read nozzle data from external CSV file.
- The reference height and standard HTC could be defined by user.
- The affection factor in surface normal angle and shadow area could be defined by user also.





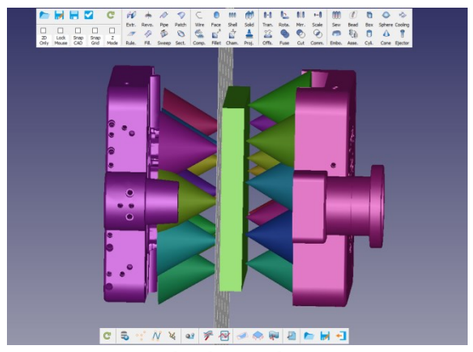


Advance spraying user interface (Mould opening & Nozzle define)

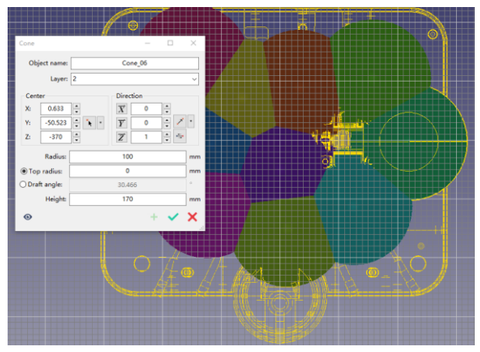
Nozzle design & online validate

CAST-DESIGNER provides rich tools to design the spraying nozzle and make the layout, then validate the design online.

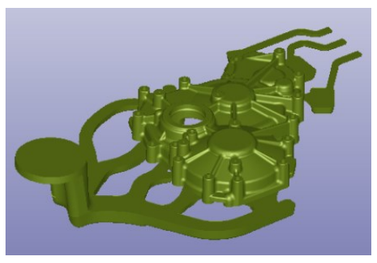
- ✓ Design the head plate at first to define the reference.
- ✓ The ParaCAD design environment could design the spray nozzle and make the layout easily.
- ✓ The special designed cone includes all the parameters of spraying nozzle. It could be dragged and placed to anywhere in the ParaCAD environment.
- ✓ The casting part or mould could be used as background to define the nozzle position.
- ✓ Designed result could save to CSV file and imported by advance spraying of CPI setup.



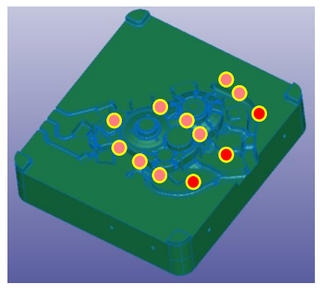
Head plate design



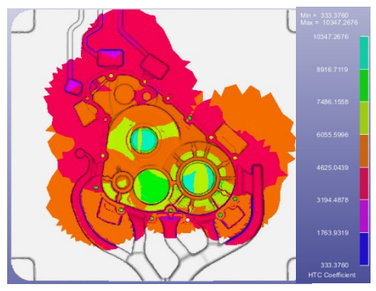
Nozzle design & layout



Casting part

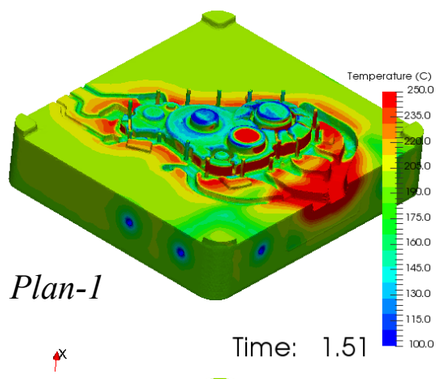


Nozzle layout

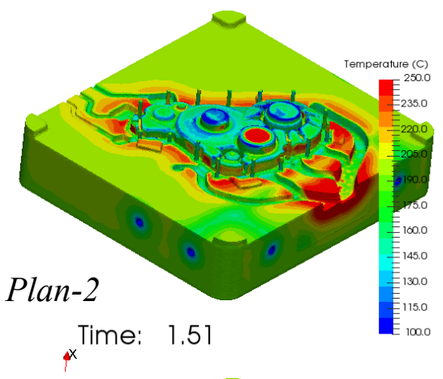


Online validation

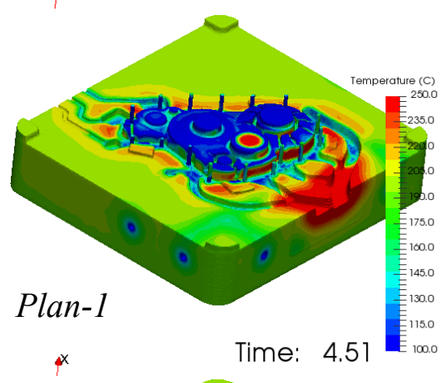
Simulation result



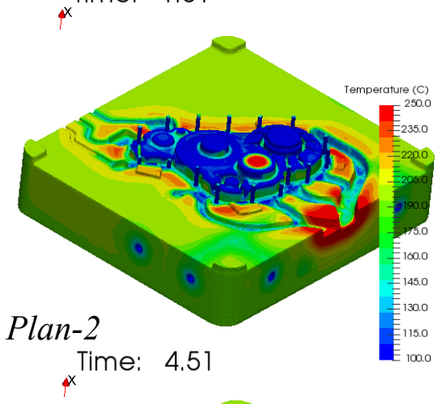
Plan-1



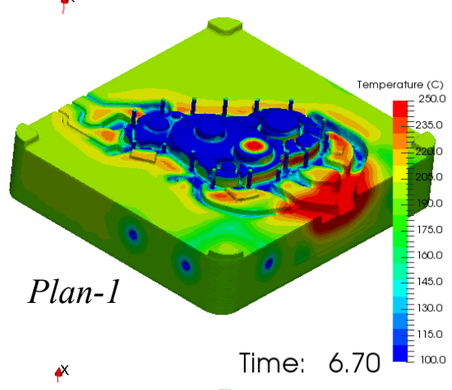
Plan-2



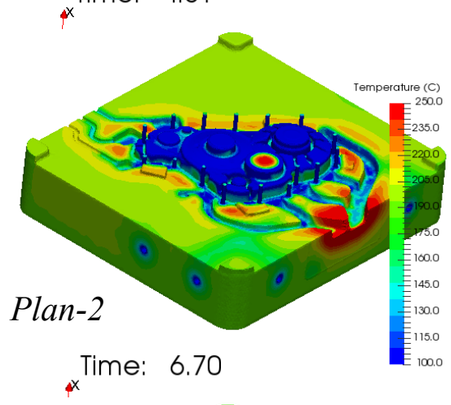
Plan-1



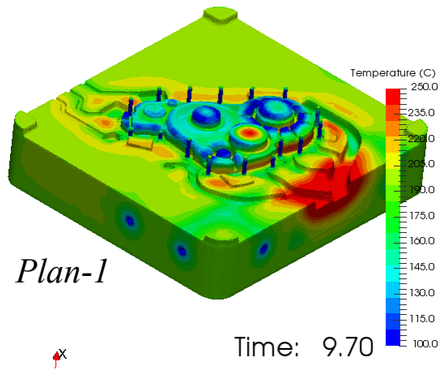
Plan-2



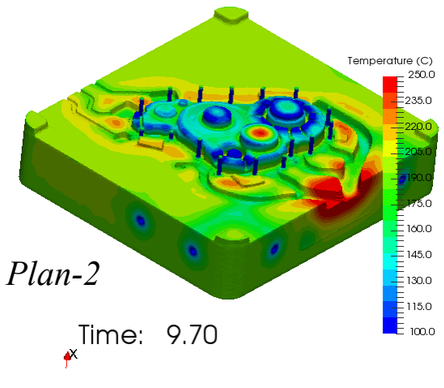
Plan-1



Plan-2



Plan-1



Plan-2

There are two design plans for advance spraying. One is no nozzles on the main runner region and another one was three nozzles on the main runner region.

The lead time of spraying was 5 seconds only and the whole simulation was 10 seconds.

The result of 4.51 second shows the different of temperature distribution of the vertical region and this affection is continue until the end of the simulation.

CASTING PRODUCTION

CAST-DESIGNER

The exact industrial conditions in die casting can be simulated in **CAST-DESIGNER** with cycle time, die cooling, die heating etc.
CAST-DESIGNER Production Optimizer automatically adjusts the die opening, die spray, cooling or heating channels and individual production cycle timings for a reasonable thermal balance of the mould and optimizes production cycle time for best productivity.

Mould Cycling and Automatic Thermal Balance

DIE SPRAY, COOLING & HEATING

- Complete consideration of die cooling and heating system
- Individual control of each cooling or heating channel
- Different die-spray and die-coatings can be considered

PRODUCTION OPTIMIZATION

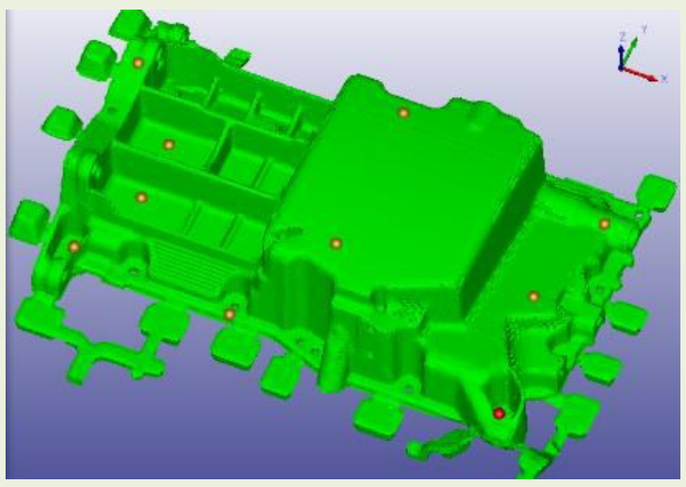
- **CAST-DESIGNER** Production Optimizer automatically adjusts the cooling/heating channels and individual production cycle timings, to maintain a reasonable mould temperature to avoid cold-shut or die soldering conditions.
- Achieve best productivity and cost rate, as well as the product quality.
- Achieve better die-life, and reduced die maintenance cost.

PRODUCTION COST CALCULATION

- Casting Production can make a quick calculation of the production cost based on the optimized cycling. It could be used for the quotation purpose, price estimation or for the production phase cost control.

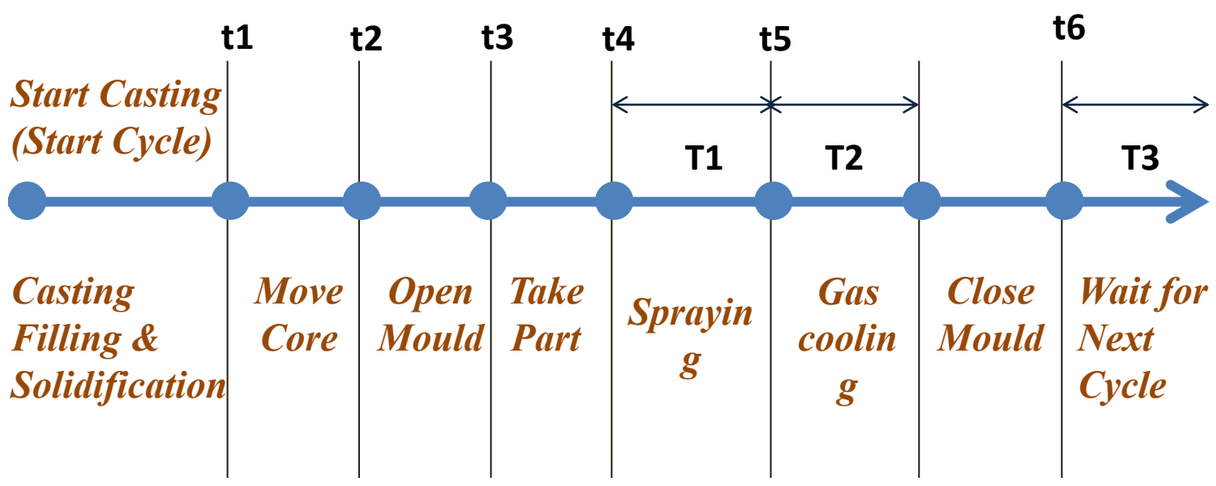
SAMPLE OPTIMIZATION RESULT

- Use Sensor(s) on the casting part or on the mould to check the conditions to optimize.
- Sensor can be attached to the cooling channel or heater to optimize it.
- User defined weight factor to different sensors.
- In 3 iterations, cycling time is optimized from 86 sec to 66 sec.

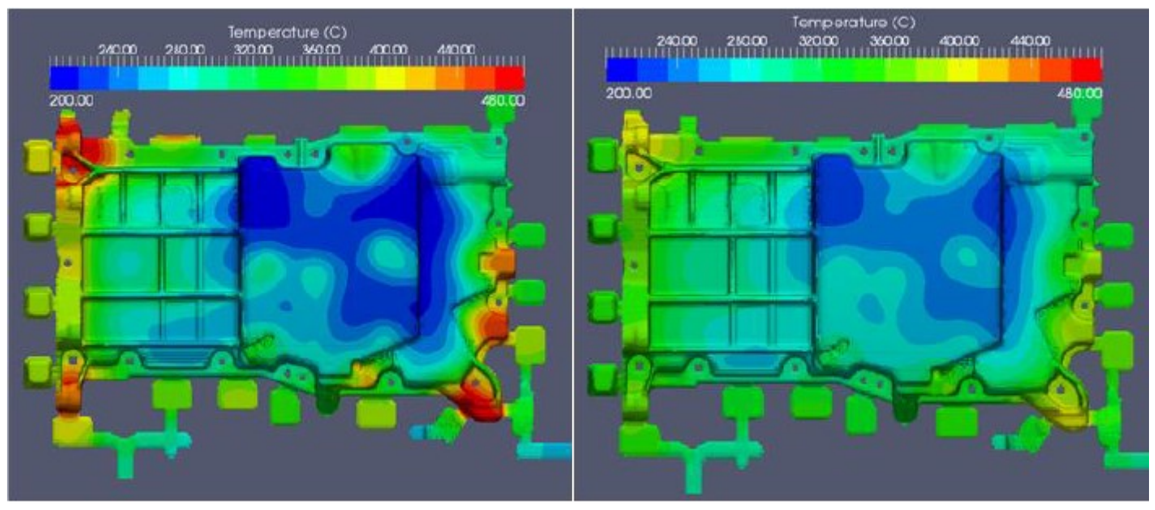


Operation & Time in Sec	Original	Opt iter-1	Opt iter-2
Waiting next cycle	26	9	8.1
Die Closing	27	27	27
Part Ejection	14	14	14
Die Opening	19	16	17
Total in Seconds	**86**	**66**	**66.1**

CYCLE TIME DEFINITION

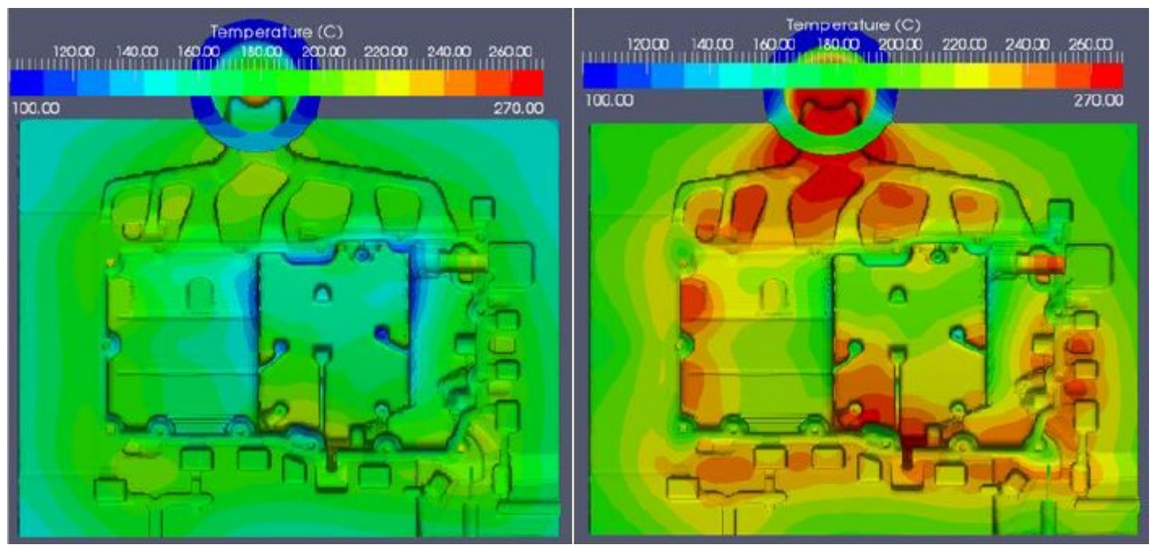


Definition of all important parameters influencing flow temperature and the thermal balance of mould.



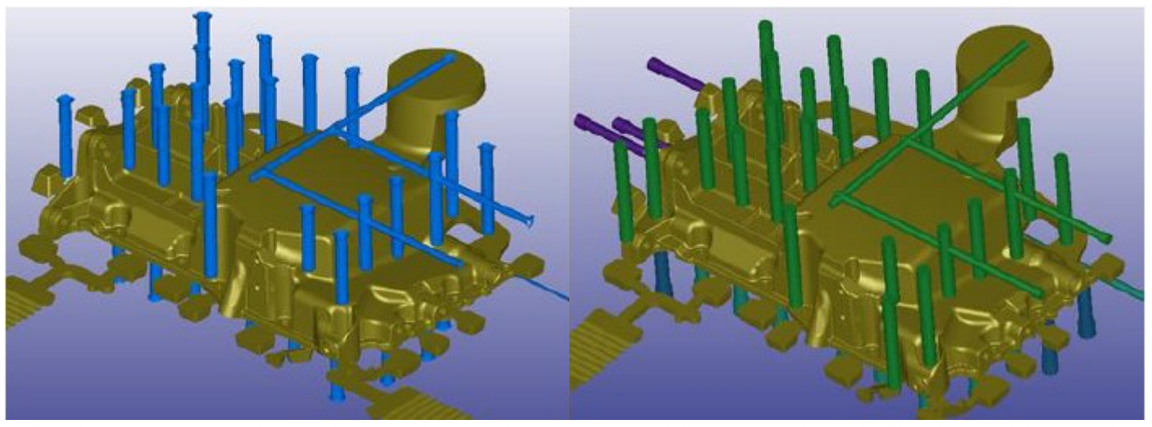
Before: *Casting Temperature with Hot Spots with 480 °C can cause Mould Stick.*

After: *Casting Temperature is now more balanced around 400 °C can avoid Mould Stick.*



Before: *Mould Temperature is below 120 °C and can cause Cold shut.*

After: *Mould Temperature is now 260 °C and more balanced and can avoid Cold shut.*



Before: *Original Cooling Channel Design*

After: *Modified Cooling Channel Design*

AUTOMATIC OPTIMIZATION

CAST-DESIGNER

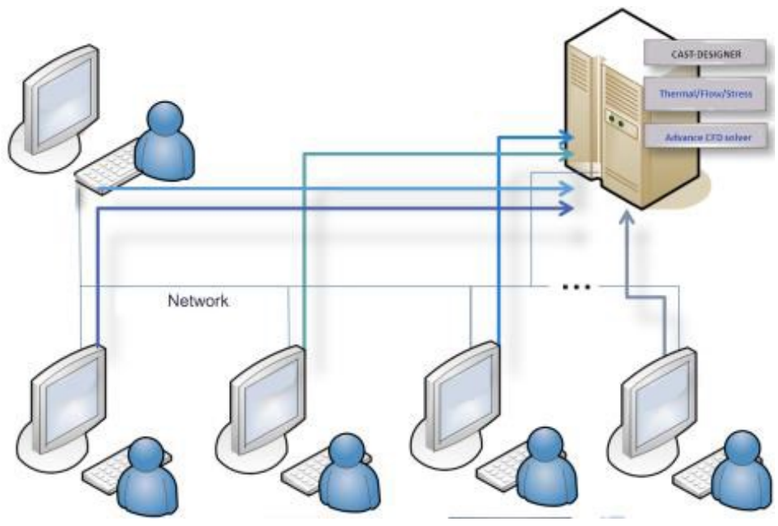
Cast-Designer optimizer can execute multi-criteria non-linear optimization based on Genetic Algorithm as known in Artificial Intelligence.

- **Multiple Criteria Targets**: All physical problems could be optimized, including the flow, thermal, stress, warpage, microstructure, material properties etc. For Example: Single or multiple targets of the simulation, what the foundry engineer is trying to achieve like to maximize the yield, minimize shrinkage or the minimize gas entrapment and balance the flow during the filling process.

- **Multiple Design or Process Variable**: Design elements that are allowed to vary, could be the Parametric CAD Geometries like runner dimensions, inner gate locations or riser diameter, even original casting part, or process parameters, like pouring temperature, velocity, or the HTC.

- **Genetic Algorithm** in **CAST-DESIGNER** Optimizer, checks the results of each optimization iteration like shrinkage porosity volume and intelligently sets the new value for the design variables like size and location for the riser. Such iterations are continued until the targets are achieved.

- **Complex user formulas** are supported.



*Cast-Designer Optimization supports **parallel automatic optimization**, this is a breakthrough technology to reduce the lead time of optimization.*

GATING OPTIMIZATION	PROCESS OPTIMIZATION	PART OPTIMIZATION
Find the best locations and sizes for:	Find the best process variables like:	Find the best dimensions or locations of
Gating system **Runner, Overflow** **Cooling, Riser, Chill**	**Pouring temperature** **Die temperature** **Pouring rate, Ejection time**	**Part Features** For Defect-Free Castings

DESIGN OF EXPERIMENTS

Design of Experiment (DOE), to study a process window and its robustness so as to obtain a set of ideal parameters which provide good result inside an user defined goal.

For Example:

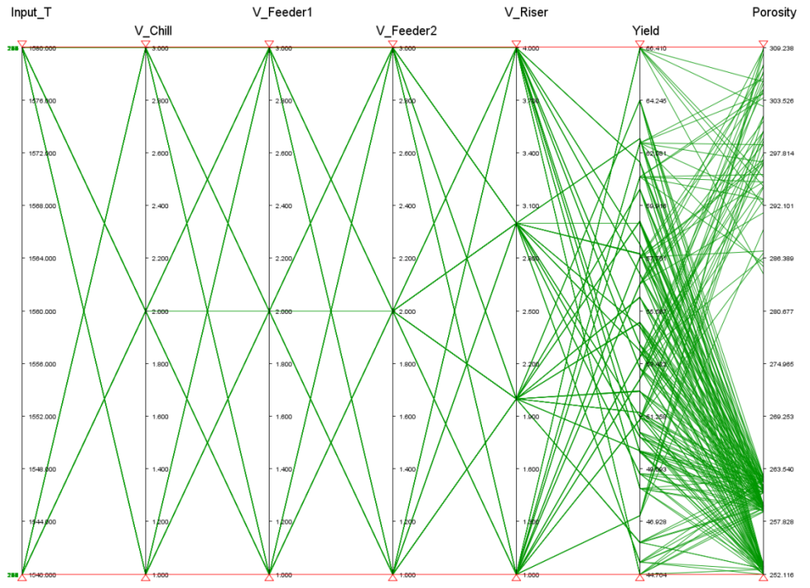
- **Yield:** To find best location and size of risers to minimize shrinkage porosity.
- **Sensitivity:** To identify the sensitivity of the influential process parameters like increasing the mould temperature vs. adding insulation sleeve.
- **Cost:** Compare costs for maintaining higher melt temperatures vs. rejection/production losses.
- **Feasibility:** Determine the optimization goals, manufacturable aspects during production, in-line with the known production constraints of a foundry

PROCESS ROBUSTNESS

Stochastic approach to check that the given process is robust.

For Example:

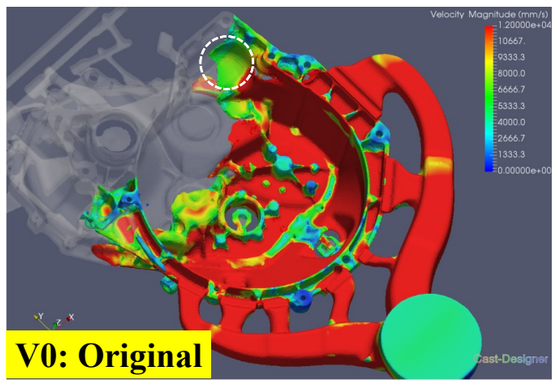
Vary the furnace temperature with in the known range to check that the process is robust, Find out the maximum and minimum variations allowed in the process while still obtaining the desired good quality parts.

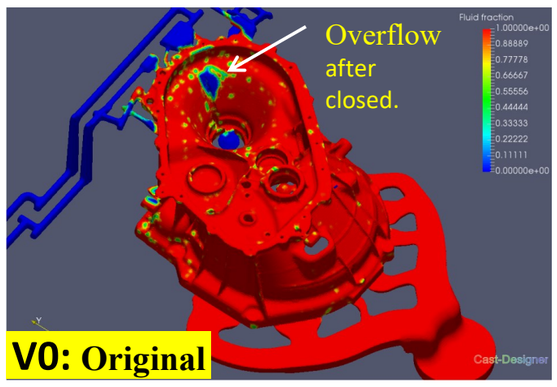


The Taguchi DOE method provides best possible combination of variations. For Example: out of 512 combinations, it is possible to get desired results by trying 16 combinations

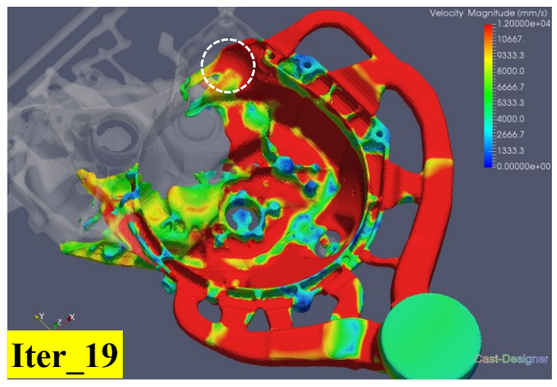
HPDC: RUNNER OPTIMIZATION

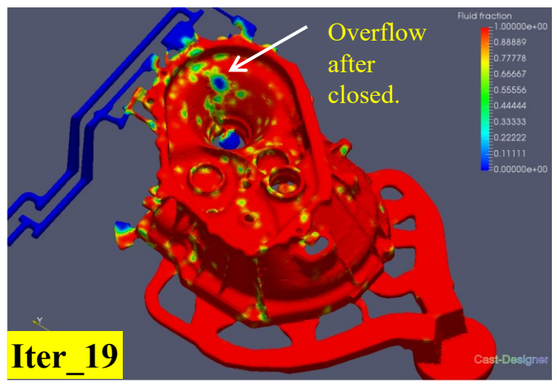
ORIGINAL DESIGN





OPTIMIZED DESIGN





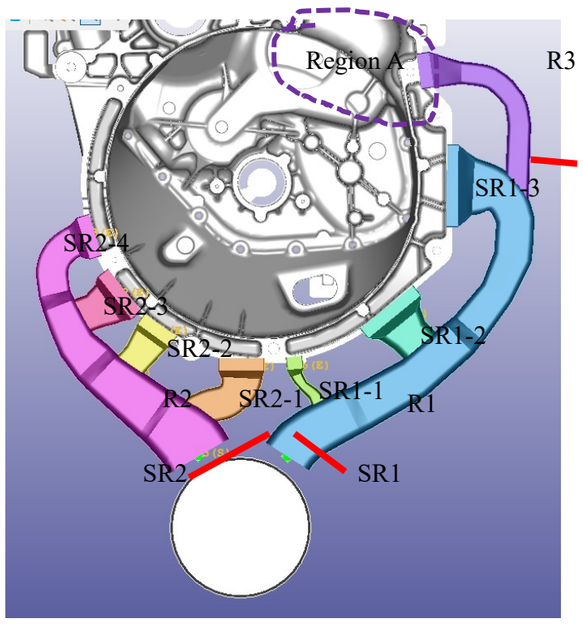
OPTIMIZATION SETUP

To have a balance flow and avoid the gas entrapment of the flow process, we set parameters to optimize the model.

Parameters:

- K1 = SR1/SR2
- K2 = SR3/SR1

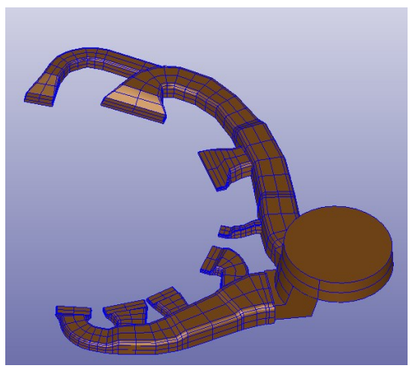
When K1 and K2 change, the section area of runner R1 and R2 also will be adjusted, and the linked sub-runner SR1-1, SR1-2, SR1-3, SR2-1, SR2-2, SR2-3, SR2-4 also will be updated. If K2 <0.20, then the runner R3 will not be generated.



We make the optimization for K1 and K2.

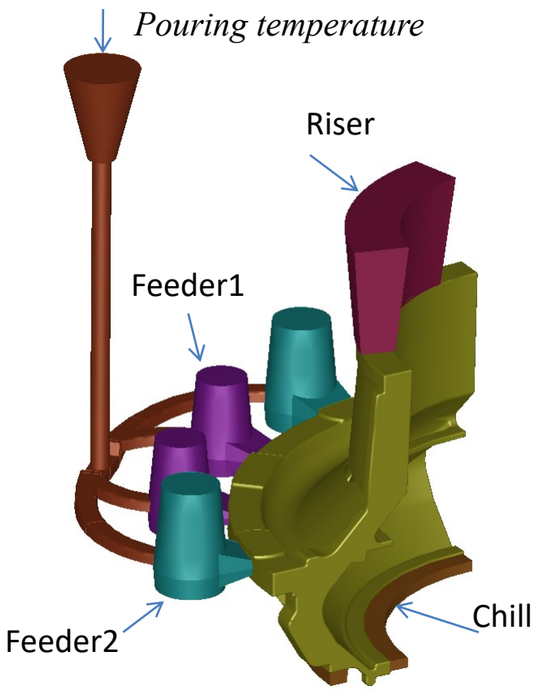
K1: 0.80 ~ 1.40

K2: 0.05 ~ 0.35

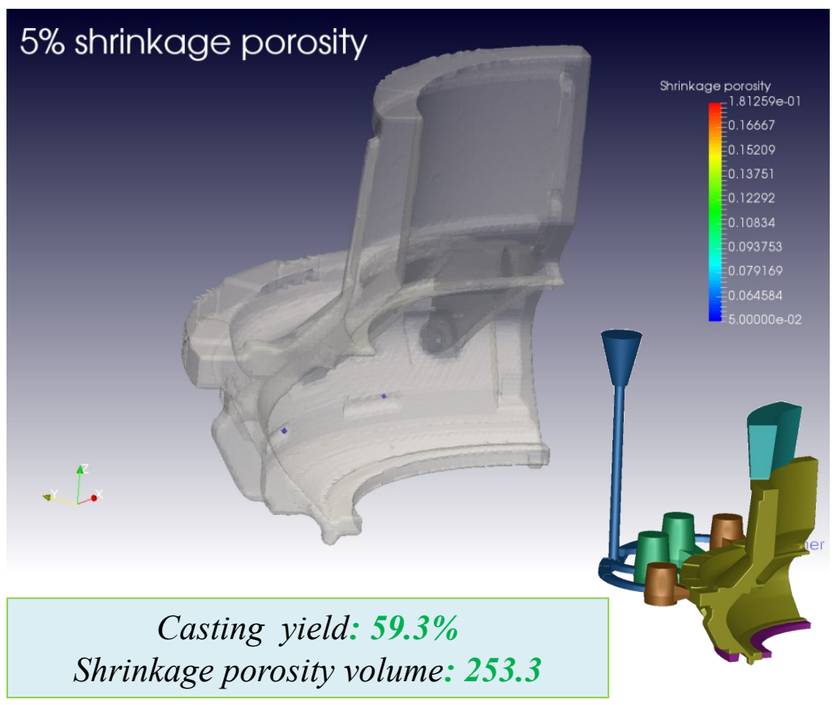


The final optimized gating.

GRAVITY CASTING: RISER OPTIMIZATION

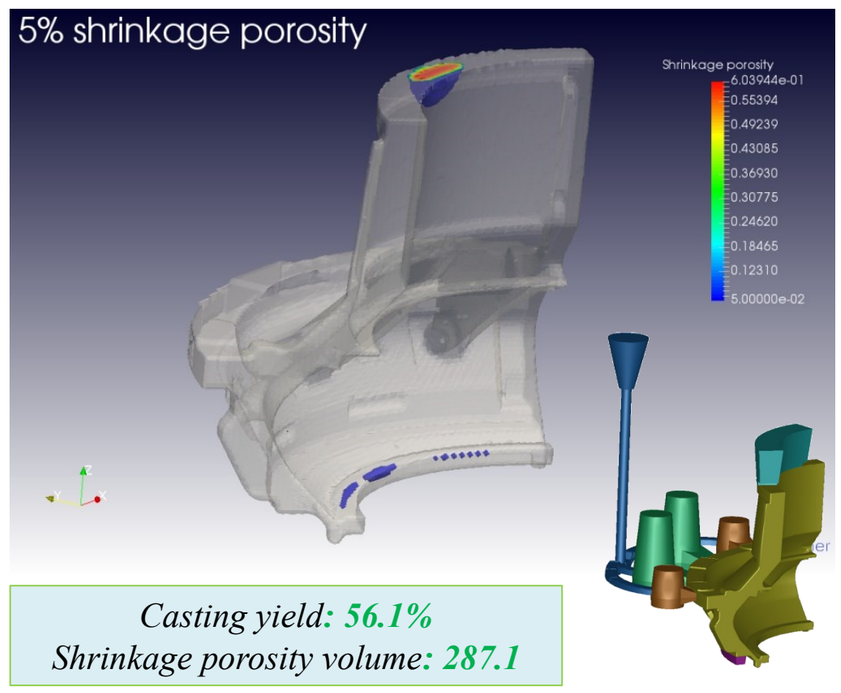


OPTIMIZED DESIGN (The best one)



*Casting yield: **59.3%***
*Shrinkage porosity volume: **253.3***

OPTIMIZED DESIGN (The worst porosity)

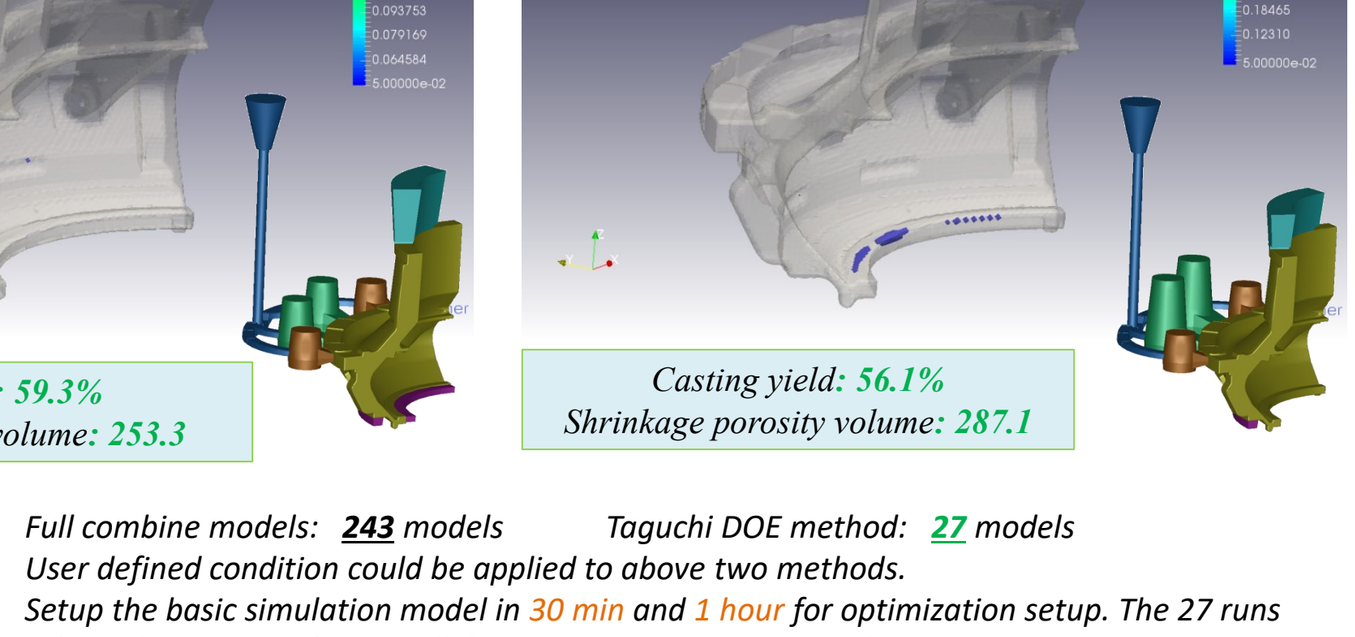


*Casting yield: **56.1%***
*Shrinkage porosity volume: **287.1***

OPTIMIZATION SETUP:

Variables	Start	End	Step
Chill	1	3	1
Feeder 1	1	3	1
Feeder 2	1	3	1
Riser	1	3	1
Pouring temperature	1540 degree	1580 degree	20 degree

*Full combine models: **243** models Taguchi DOE method: **27** models*
User defined condition could be applied to above two methods.
Setup the basic simulation model in 30 min and 1 hour for optimization setup. The 27 runs token 3 hours in 5 token parallel optimization in 20 core Intel E5 computer.



BENEFITS

CAST-DESIGNER Optimizer enables lower research expenditures and shorter implementation time. The main purpose of the system is to relieve a designer or researcher of the sufficiently complex and very labour-intensive process of searching for optimal system design parameters which simultaneously meet a great number of sometimes controversial requirements.

To optimize the casting yield ratio and shrinkage porosity of an automotive part. Using the GA method to find the Pareto front points. The X axis was the total riser volume and the Y axis was the total shrinkage porosity volume.

STRESS & DEFORMATION

CAST-DESIGNER

CAST-DESIGNER can perform the full couple simulation of thermal, flow and stress together. The stress simulation includes both thermal and mechanical stress, accurately predicts casting residual stresses and distortion.

Automatic Distortion Compensation

In addition, with the stress module, the user can achieve the following goals:

- Casting and mould stress & strain distribution
- Part deformation and distortion
- Gap formation between the casting and mould
- Predict elastic spring back
- Hot tearing and cracking indication
- Die life fatigue

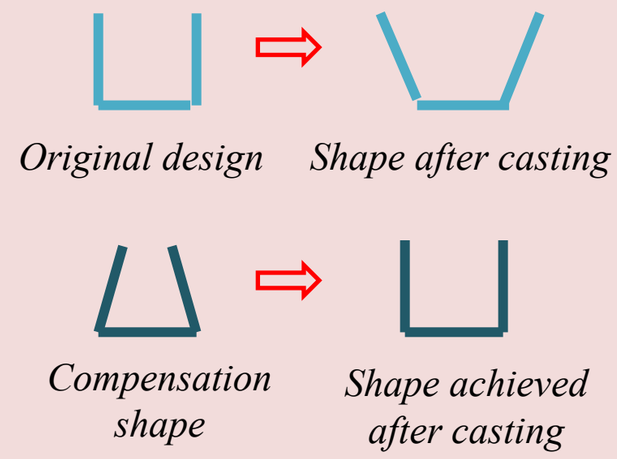
CAST-DESIGNER stress module helps casting part designers and die designers to consistently predict the dimensions of a casting part after cooling, with being able to closely predict casting dimensions will lead to

- **Better Part Design**: Helps designer to make better casting part design
- **Better Die Design**: Helps die designers to compensate for the part distortion during the die design stage. Thus, reduce the rate of scrapped castings
- **Quality Improvement**: Being able to closely predict casting dimensions will lead to tighter tolerance and thinner walls results in high quality castings and reduced scrap
- **Save Time**: Saves development time
- **Save Cost**: Reduces operation cost due to improved first shot capabilities and fewer number of interruptions
- **Improved Efficiency**: Better products with reduced cost help to redefine competitiveness

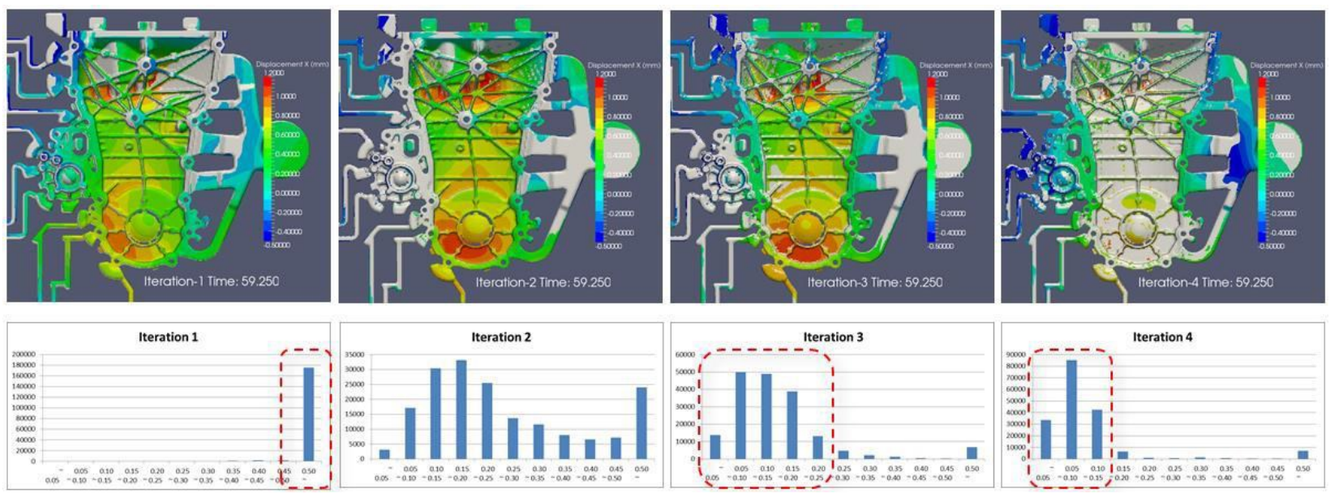
DISTORTION COMPENSATION

- In **CAST-DESIGNER**, a Distortion Compensation Solver (**DCS**) was developed based on the mechanical stress solver to find compensation geometry automatically.
- In DCS, user can select a set of Sensor points/ Critical points, where user wants to control the distortion.

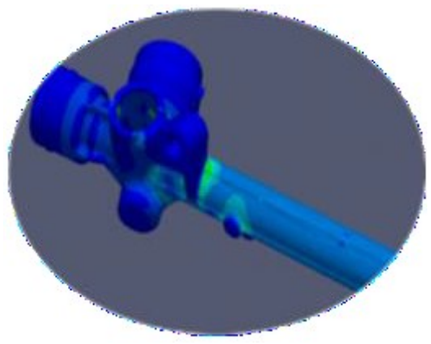
General shape Compensation



- It is an iteration method to find the best geometry shape to avoid the distortion in the casting and the importance is given to the selected sensor points in the final casting.
- Finally the adjustment distance of feature points are reported and can be used in CAD system. It is an unique product in the market.

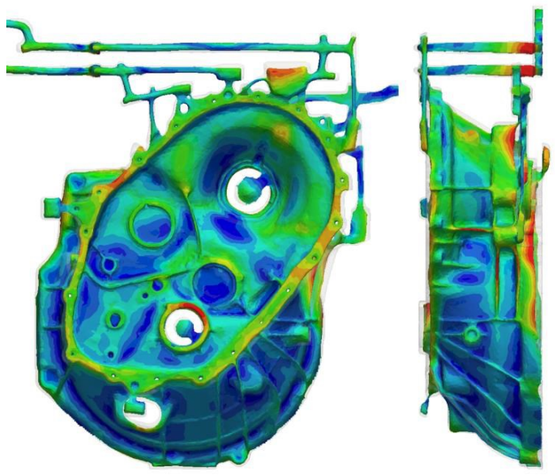


After the first iteration, the amount of deformation exceeded the tolerance and reached above 0.8mm. The flatness requirement of the product was 0.5mm. After four automatic iterations the product flatness is maintained between 0.05 and 0.15, and the product 100% meets the requirement.

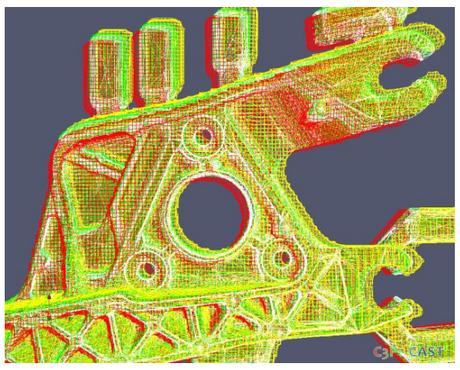


Hot-tearing indicated in simulation

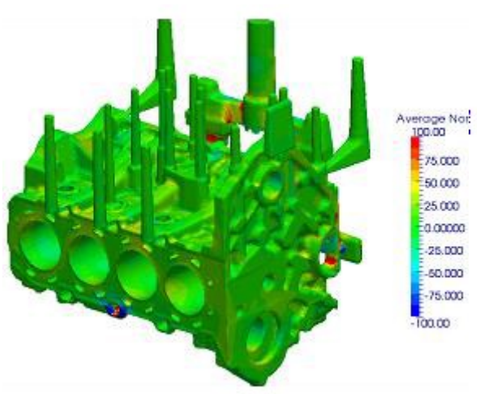
Actual part failed at the same location



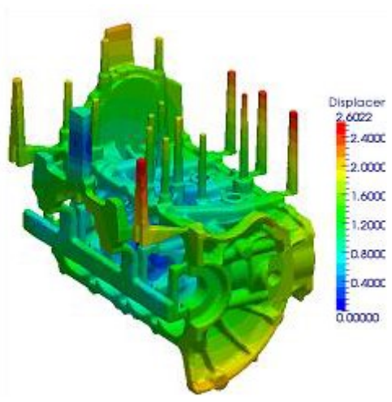
Distortion in HPDC Part



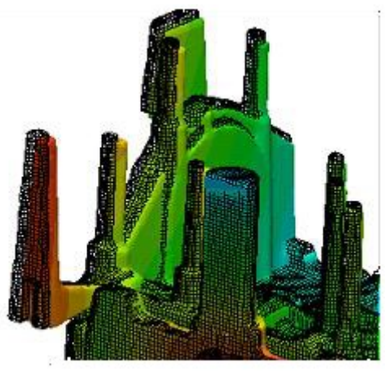
Compensation shape vs Actual design



Average Normal Stress

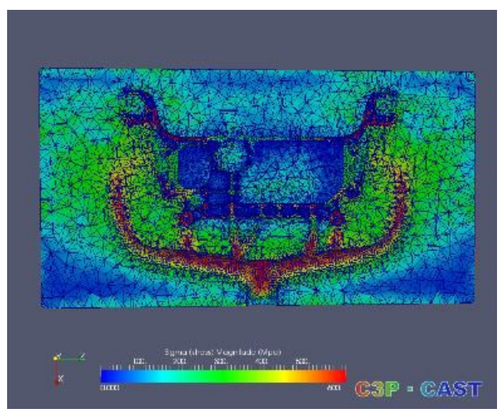


Displacement



Displacement (close-up)

Distortion in LDPC Part



Mould section stress

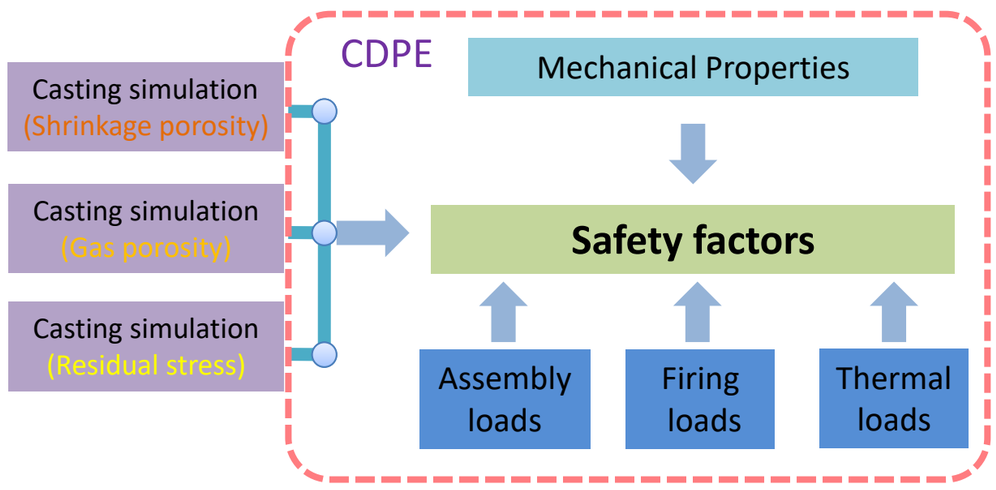
Couple the casting result to performance simulation

CDPE (**CAST-DESIGNER** PErformance) is a software module for the solution of large-scale, 3-D solid models subjected to static and dynamic loads. The software includes specific features oriented toward the investigation of fatigue and ductile fracture in metals and non-metals.

CDPE is an analysis engine and fully integrated to **CAST-DESIGNER** user's environment. The affection of casting defects to the final part performance could be considered well thanks to the full couple of **CAST-DESIGNER** solver and CDPE, such as the shrinkage porosity, gas porosity and residual stress could be mapped to CDPE solver directly.

CDPE MAIN FEATURES & APPLICATIONS

Function	Supported Contents	
Static linear	Including thermal stress analysis	
Static nonlinear	Material	Hyper-elasticity/Thermal-Elastic-Plastic/Visco-Elastic/Creep, Combined hardening rule
	Geometry	Total Lagrangian/Updated Lagrangian
	Boundary	Augmented Lagrangian/Lagrangian multiplier method, Finite slip contact, Friction
Dynamic linear	Explicit method/Implicit method	
Dynamic nonlinear	Explicit method/Implicit method	
Eigen value	Lanczos method	
Heat transfer	steady/Non-steady (implicit), Material nonlinear	
Element type	Tetra/Hexa/Prism, Shell, 1st/2nd order, Incompatible model, SRI	
Utlilities	User's subroutine, Restart, Step control of boundary conditions	



CDPE framework

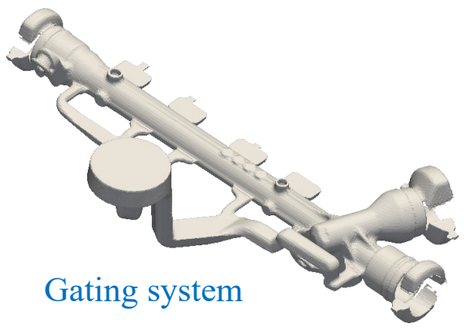
CDPE: Fully integrated to **CAST-DESIGNER** system

- Same user environment , same data structure
- Same mesh system , same CAD data
- Automatic result coupling, no data lose.
- Format from/to Abaqus, MSC Nastran and NEI Nastran.

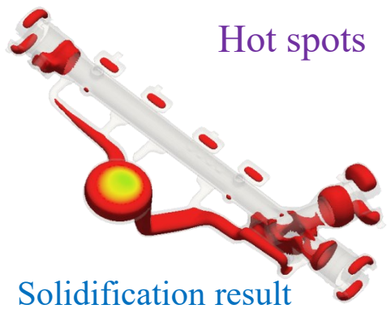
Advance Characteristics

- **Assembled structure**: MPC-preconditioned iterative solver, finite slip contact, friction
- **Multigrid method**: Convergence acceleration utilizing hierarchical meshes
- **Enhanced parallelism**: Efficient parallel computation using more than 1000 nodes
- **Parallel solver**: Preconditioned iterative solvers/ Parallel direct solver
- **Parallel visualization**: Surface/volume rendering
- **Coupled analysis**: Fluid-structure analysis with CFD

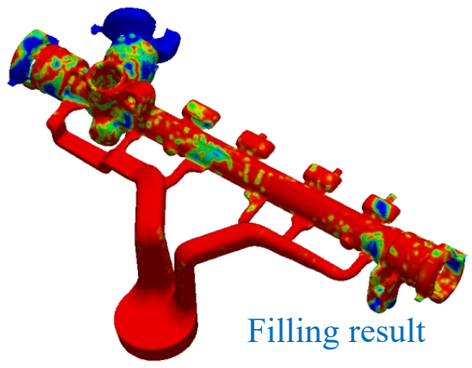
Casting Process & Defects



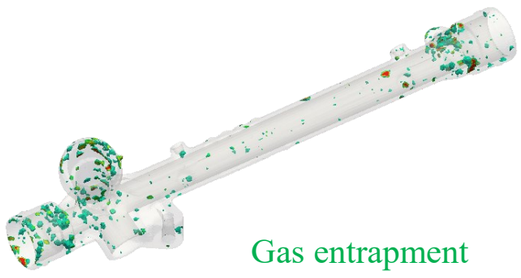
Gating system



Solidification result

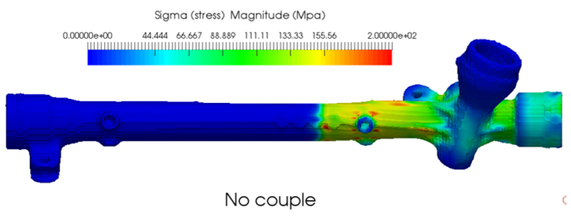


Filling result

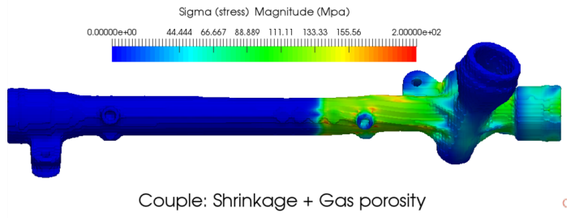


Gas entrapment

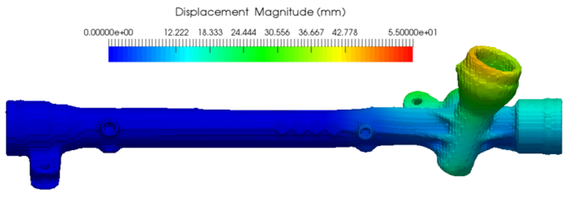
CDPE Result



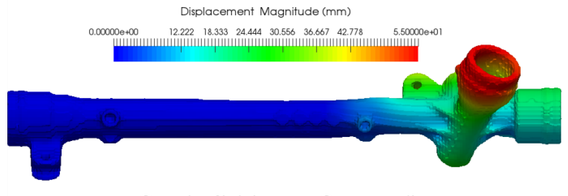
No couple



Couple: Shrinkage + Gas porosity

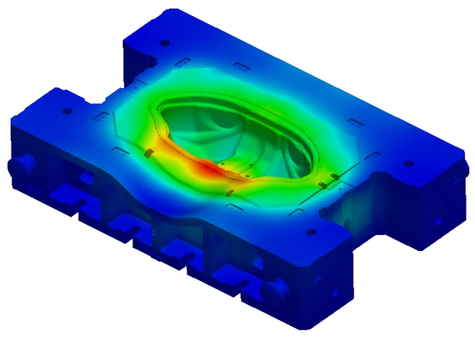


No couple

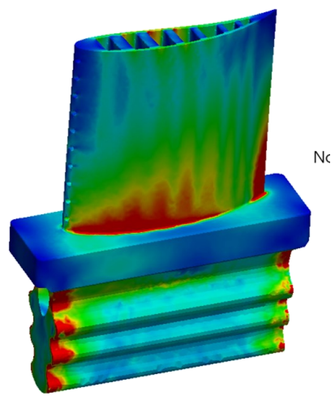


Couple: Shrinkage + Gas porosity

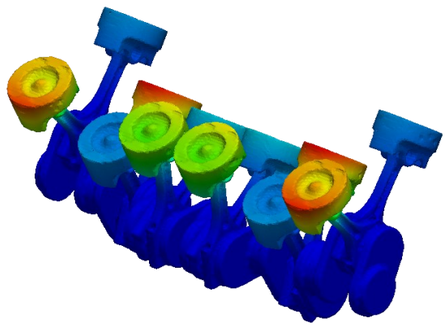
CDPE Applications



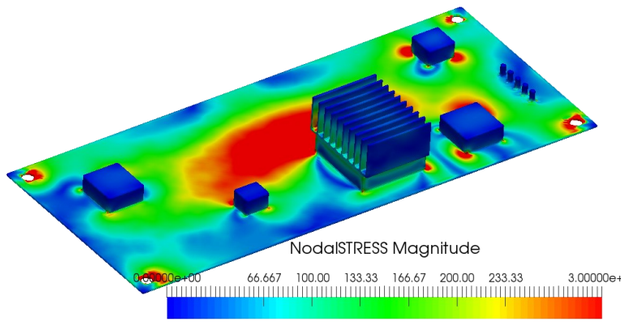
Die face pressure (stamping)



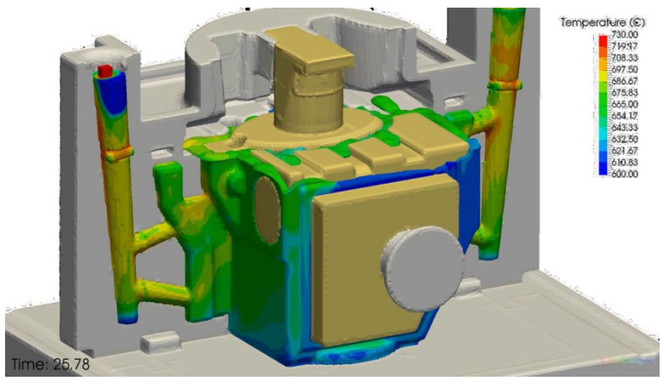
Engine plate analysis

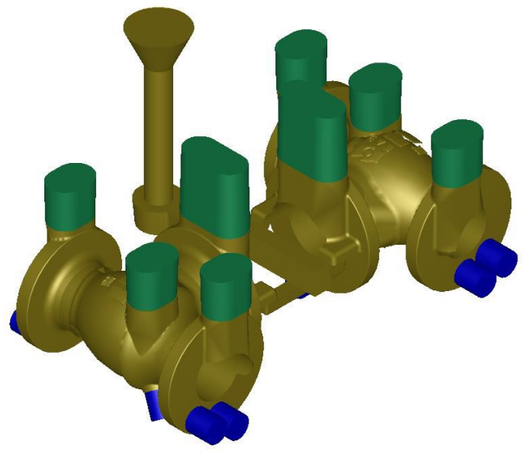


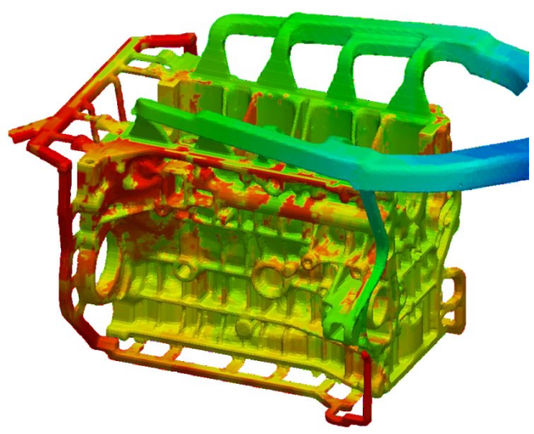
Engine piston stress

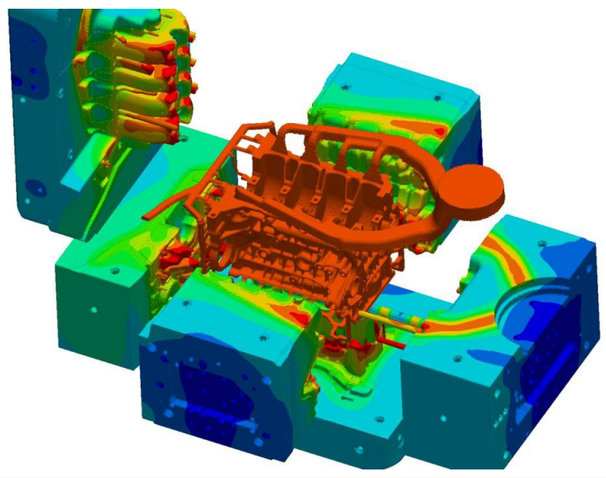


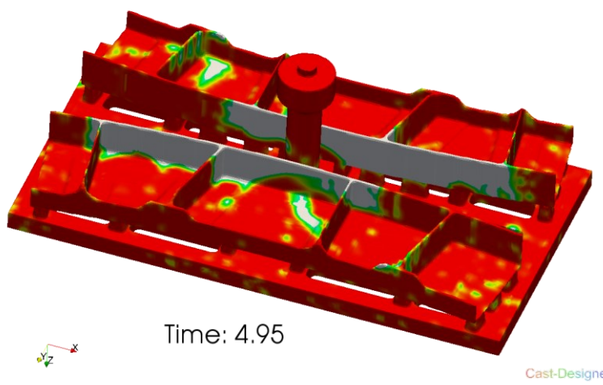
PCB board thermal & stress



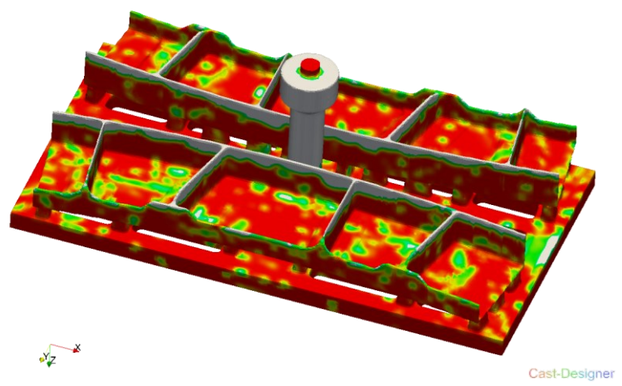




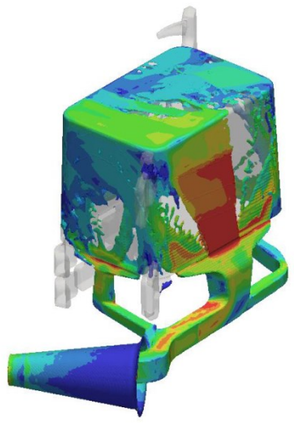


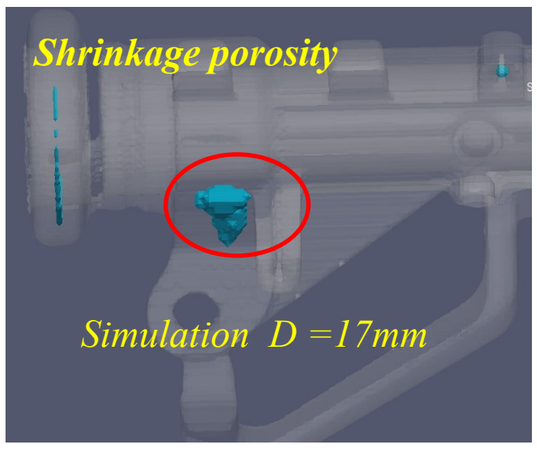


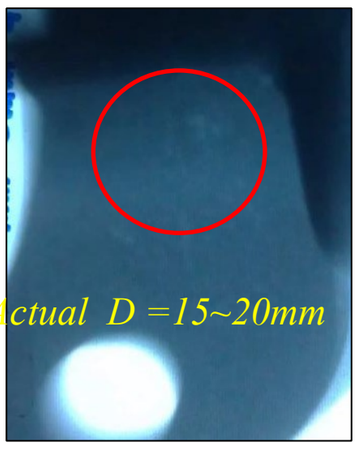
Centrifugal casting process

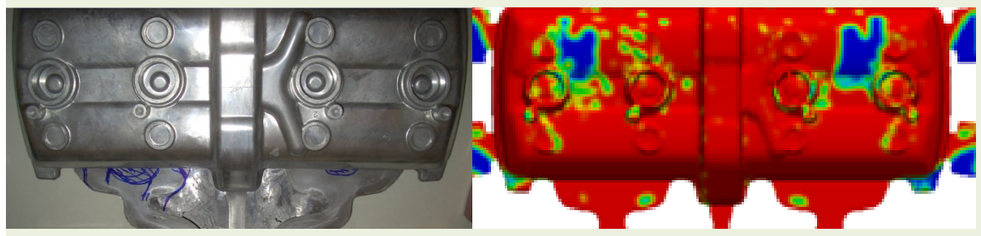


Standard gravity casting process



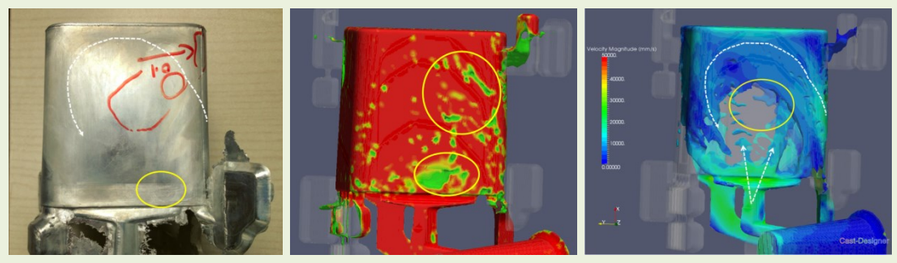




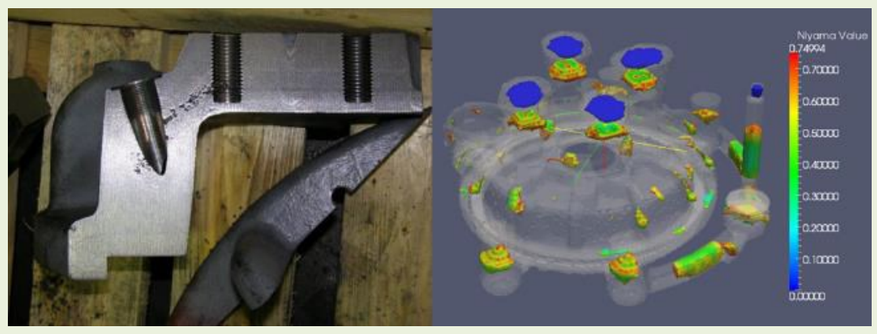


Air Entrapment

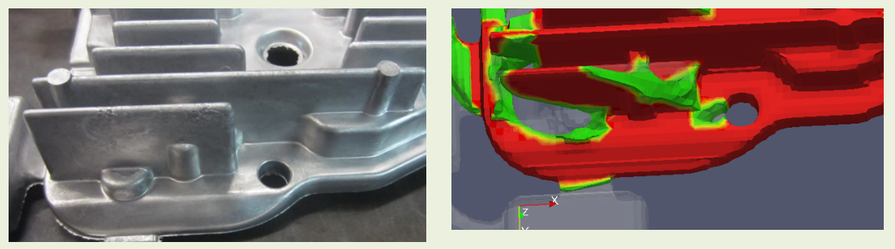
Unfilled region



Flow mark and surface quality



Shrinkage porosity



Cold shut and air entrapment

REFERENCES

AIR FORCE RESEARCH LAB, AIT, ALTUM, ALUTECH, AURANGABAD ELECTRICAL, AUTO DIE CASTING, BANGDA, DUELL MOTOR CYCLE, CELIKEL, CFG, CHENGLING, CHICAO WHITE METAL CASTING, CHUANG YUAN PRECISION MOLD, DAIMLERCHRYSLER AG, DATIAN, DEYIDA, DIETECH, DINGSHI MOULD, DONGYANG, EFILTEK, EKO, ELTEX, EXCO, FORD MOROR, FU HSIUNG METAL, FUHE, FUJI DIECAST, FUNDICAO DE EVORA, FUXIONG, G4 SOLUTION, GENERAL MOTOR, GUANGHUI, HAOFENG, HENGTONG MOLD, HINDUJA, HKPU, HONDA, HONGTE, HPMC, HUISHEN,IDEPRO, ISUZU, JANATICS, JANOME, JU TENG INTERNATIONAL HOLDING, JUBAO, KAIFA INDUSTRIAL, KARMEN, KAWASAKI, KEISHIN, KITZ, KMUTNB, LG ELECTRONIC, LILI, LINNAN, MAITERUI, MAKITA, MATPLAST, MARKS, MAXWELL, MEIWA, MENNA, MICROENG, MIN CHANG METAL INDUSTRY, MINDA, MINGCHANG, MINGLIDA, MIRDC, MIZUTANI, MORIMOTO, NAKANIHON, NEMAK, NEMARK, NISSAN INDUSTRY, NISSIN SEIKI, OAK RIDGE NATIONAL LAB, OKUBO KANAGATE, PALOMA, PINGDONG INSTITUTE, QIANFENG MOLD, QINGLING, QINGMEI GROUP, QINGWEI, RAMCAR, RAMPRASAD, RONGHENG, RUILI, RUNXINTAI, RYOBI LTD, SAMSUNG, SAN CHAN METAL INDUSTRY, SANCAST, SANCHENGFENG, SANWA, SENSITIVE, SHANGDA, SHANGHAI JIAOTONG UNV., SHANGZHAN, SHENYUAN, SHIKOSEIKI, SHIMANO, SHINKO, SUN WAY WORLD MOLD, SUNDARAMCLAYTON, SYM MOTOR, TECHSENSE, TECNOSEAL, TEKNICAST, TEP ASIAN, TIANDING, TITANIA, TOKYO, TONGFENG MOLD, TSINGHUA UNIVERSITY, TWIN CITY DIE CASTINGS, UNIQUESHELL, UNIVERSAL, VARMA, VOLVO, WANHE, WENDA, WUYI, XIANG LIAN CASTING, YANGMING UNIVERSITY, YESHASWI, YIFENG METAL, YINBAOSANXING, YINDI, YOKOGAWA, YOUZHONG, YUNNAN INSTITUTE, ZHONGCHUAN ZIP

CUSTOMER TESTIMONIALS

Nicola Giardinelli, *Direzione Tecnica Bragonzi SPA*

I use **CAST-DESIGNER** form C3P, gravity casting with accurate results (steel and high Cr and high nickel cast iron). In the past I used it with centrifugal casting lost foam and I tried with high pressure die casting ... So for me it's a powerful software.

Technical Director, *Tongfeng mould, TAIWAN*

We used **CAST-DESIGNER** for a quite longer time and the accuracy of new generation CFD solver is really wonderful, we have solved lots of problems in such advance flow simulation. The optimization module is also quite affective and easy to use.

YANG Q., *General manager, Shenyuan Group*

CAST-DESIGNER acts as a specialist in our company for mould design and validation. We have never found any other software so powerful and useful like **CAST-DESIGNER**. It can provide guideline to engineers directly, so it is not only help to find the problem but also to solve the problem.

C3P ENGINEERING SOFTWARE INTERNATIONAL

CAST-DESIGNER MAJOR SOFTWARE PACKAGES AND MODULES

S/N	Cast-Designer Package & Module	Design package	CPI package	HPDC package	Gravity package
1	Cast-Designer framwork	X	X	X	X
2	Gating system design	X	O	X	X
3	Free design of gating	X	O	X	X
4	Standard thermal and flow solver	O	X	X	X
5	Batch modeling & DOE optimization	O	X	X	X
6	Advance CFD solver	O	O	O	O
7	Stress solver	O	O	O	O
8	Microstructure solver	O	O	O	O
9	Parallel verison (CPU/Core depend)	O	O	O	O
10	Advance mesh assembly	O	O	O	O
11	Optimization (GA)	O	O	O	O
12	Geo-Design for DFM analysis	O	O	O	O
13	SavingCAST fro material charge	O	O	O	O

X: Available **O:** Option

Software language: English, Japanese, Chinese, Korean

SYSTEM REQUIREMENTS

SUPPORTED PLATFORM

- Windows / X86-64
  - Windows 11/10 /8 /7
  - Windows Server 2008/2012/2016/2019
- Linux / X86-64 (CentOS 7/8, RHEL 7/8, SUSE 15)

HARDWARE RECOMMENDATION

- CPU: Intel Core i7 process (minimum)
- CPU: Intel Xeon E5 processor (recommended)
- RAM: 8GB (minimum), 16 to 32 GB (recommended)

CAST-DESIGNER

SALIENT FEATURES

- Fast design for manufacturing (DFM) capability
- Fast upfront design validation tools
- Built-in gating system design capability
- Expert system based gating design advisor
- Tools for online design validation
- Automatic gating optimization capability
- Design of experiments (DOE) capability
- Powerful and fast assembly meshing capability
- Advanced CFD flow analysis
- Automatic optimization capability
- Mechanical & thermal stress and deformation
- Automatic deformation compensation solver
- Core blowing and core gas analysis
- Casting performance simulation
- Open system and highly customizable

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Jodovit Chemical Group

Via Lombardia, 9
21015 – Lonate Pozzolo (VA)

+39 0331 301.086
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CUSTOMER SERVICE

Mrs. Stefania de Rogatis

+39 342 55 83 983
marketing@jodovit.com

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