POLIGONSOFT

Professional Solution for Foundry Simulation

The system of computer simulation of foundry processes (SCM LP) "PolygonSoft" is a professional tool for a foundry technologist, designed to predict and analyze the causes of defects at the stage mold design and gate-feeding systems. "PolygonSoft" is a virtual foundry, where possible in a short time and at no additional cost develop, analyze and debug the main stages foundry technology. Doing all the work on the computer even before the start of tooling manufacturing, the technologist receives more information about the process than can be obtained in the foundry.

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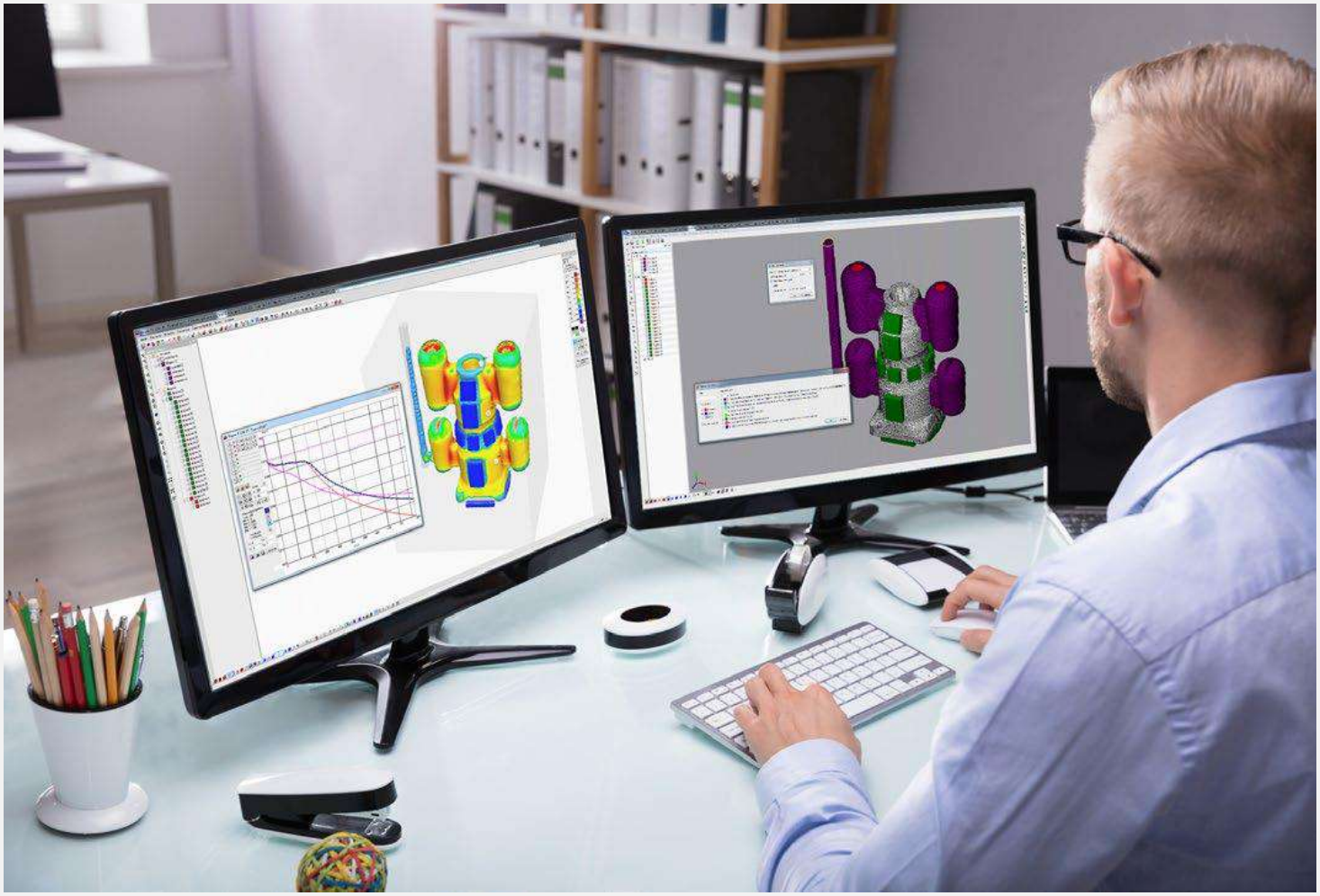


Universal Tool

The computational core of "PolygonSoft" consists of three solvers: hydrodynamic, thermal and stress. Together with a range of additional options, they simulate all traditional foundry technologies and many special processes:

- sand casting with any binder;
- die casting (including chilled or heated);
- investment casting;
- vacuum casting (including all types directional crystallization);
- casting by vacuum-film process moldings;
- casting under high and low pressure;
- centrifugal casting;
- continuous casting, etc.

End-to-End Modeling

The quality and reliability of the calculation are directly related to the possibility of end-to-end modeling of the technology. In "PolygonSoft" all stages of the technological process of obtaining a casting can be sequentially simulated: heating the mold, filling the mold with a melt, solidifying on the parade ground or in a thermostat, removing the casting from the mold, cutting off the gating system and risers, etc.

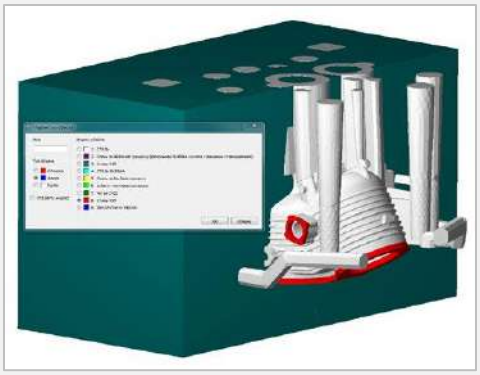
Quick launch of template-based calculations

In the process of creating a technology, it is often necessary to calculate many variants of the gating-feeding system or technological regimes. In this case, usually only the geometry of the casting block or the pouring temperature changes, while all materials and heat transfer conditions remain unchanged. To avoid routine operations when starting the calculation, PolygonSoft uses templates of technological processes that provide the user with ready-made debugged data sets specific to each technology. Of course, all templates and data can be edited according to the requirements of a particular production.

In addition, PolygonSoft has a built-in mechanism for inheriting all parameters from any previous calculation for the current task. All this allows the technologist to start the calculation with just a few mouse clicks and focus on the creative process.

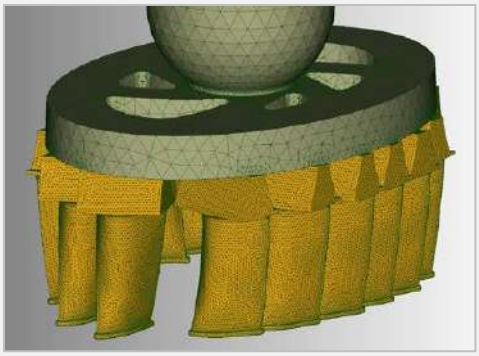
Work with geometry of any complexity

"PolygonSoft" works with a model of a casting block and a mold of any complexity, consisting of many elements of arbitrary shape. Refrigerators, rods, sand or ceramic moulds, heat insulating and exothermic materials and metallurgical equipment can affect the quality of the casting to some extent and should be included in the calculation.



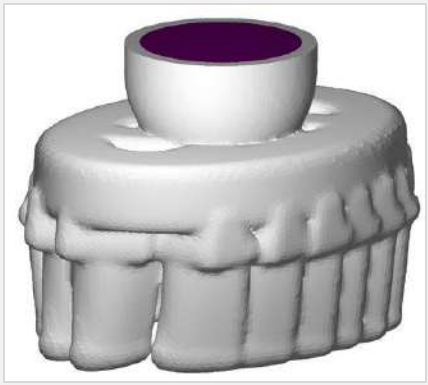
Casting model "Korpus" with refrigerators and chill mold, prepared for calculation (JSC "AAK" Progress" *named after N.I. Sazykin")*

PolygonSoft uses a modern and accurate finite element method to make the surface area and volume of the shaped casting model as close as possible to the original. The finite element mesh generator on the SALOME platform is supplied as a set and allows you to flexibly and easily control the process of creating a mesh model for calculation. The user decides where better detail is needed, and where a coarser mesh can be used for optimal use of computer resources.



Grid model of the casting block of turbocharger blades, built in SALOME (LLC "SKBT")

In investment casting, the ceramic mold has a geometry that depends on the thickness and surface shape of the wax master model. Our own shell generator will allow you to create a grid model of a ceramic mold with a given thickness without preliminary constructions in a CAD system. In a similar way, simple elements can be formed: covers, lining, heat-insulating and exothermic mixtures, etc.



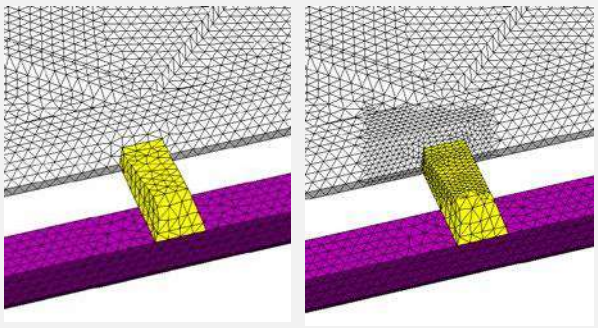
Ceramic mold automatically created in the PolygonSoft preprocessor (SKBT LLC)

Built-in quality control and finite element model editing tools allow you to quickly work with the mesh without rebuilding it in the mesh generator.

Checking the quality of the mesh according to the specified parameters will identify elements with critical angles or irregular shapes and correct or remove them.

Special tools analyze the geometry for thin walls and refine the mesh locally to improve calculation accuracy.

a) b)



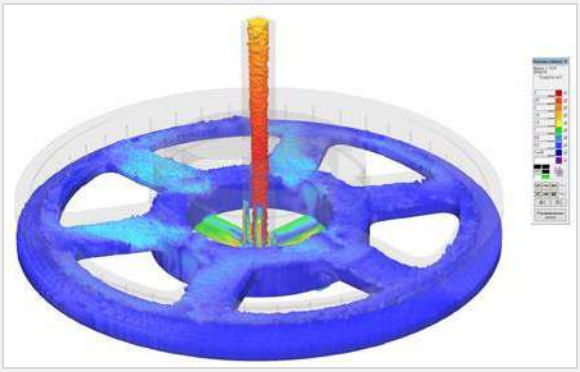
Local mesh refinement in the "Master" preprocessor:
a) original mesh; b) after local grinding

Filling the mold with melt

The state-of-the-art and powerful Euler flow solver simulates the filling of a mold with melt as it happens in a foundry:

- from a rotary or locking bucket;
- in one or more risers;
- with topping up in the riser or profit;
- with a constant or variable flow rate (pressure drop).

The temperature drop of the melt is calculated upon contact with the mold walls and heat transfer to the medium, as well as the release of the solid phase, which can lead to a flow stop and non-spillage. A special algorithm allows you to explore the operation of the gating system, identify its bottlenecks and find the optimal size, location and number of feeders.

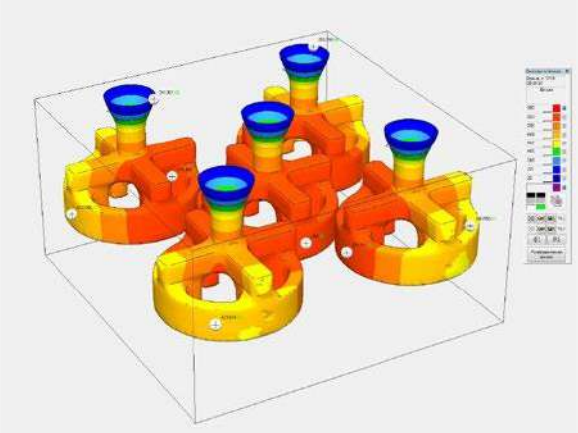


Sand casting (KZE DimAl LLC)

Casting hardening

The Fourier thermal solver calculates temperature and phase fields, taking into account heat transfer (thermal conduction, convection, radiation) and heat release during solidification.
At this stage, the technologist learns:

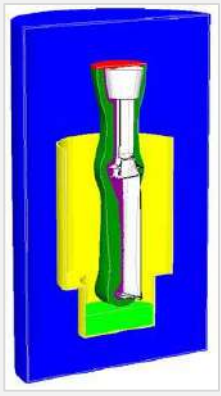
- how the temperature changes in the casting and mold;
- How does casting harden?
- where and why thermal knots are formed;
- the magnitude and distribution of residual stresses in the casting;
- the magnitude and distribution of stress strains in the casting;
- warping of the casting as a whole and along the coordinate axes;
- zones of probable hot and cold cracks.



The temperature of the molds in the flask before pouring (Ussuriyskiy LRZ JSC "Zheldorremmash")

Heat transfer by radiation

Thanks to the use of the finite element method, PolygonSoft can solve problems of complex radiative heat transfer, taking into account reradiation and shading. This is necessary when casting in a vacuum and when pouring casting blocks-"bushes" according to the investment casting technology (LVM) without the use of a support filler.
In these cases, the location of castings on a bush or casting blocks relative to each other can significantly affect the porosity pattern.



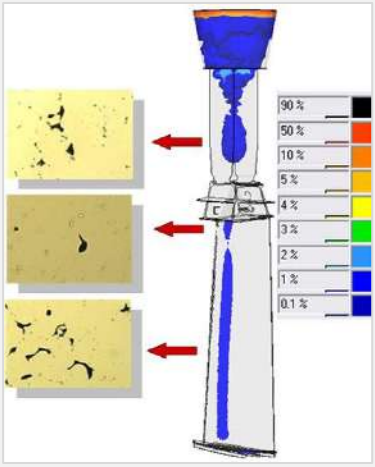
Simulation of LVM in vacuum (JSC "UEC" - "Salyut")

Shells and porosity

One of the undoubted advantages of SKM LP "PolygonSoft" is the model of shrinkage macro and microporosity, which allows you to accurately predict the formation of defects, which is especially important in the manufacture of critical castings (working and nozzle blades of gas turbine engines, monowheels, pump impellers, etc.).

Special algorithms that take into account the capillary effect and pressure drop during the solidification of closed thermal units make it possible to more accurately calculate the pattern of defects when using closed risers.

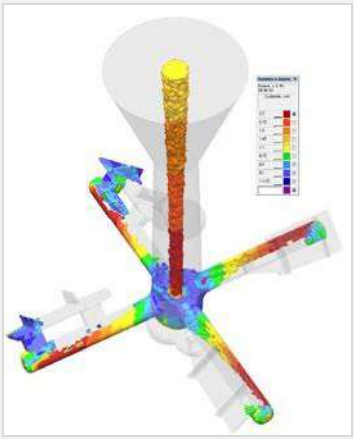
- At this stage, the technologist learns:
- shape, size and location of shrinkage shells;
- size and location of macroporosity zones;
- size and location of microporosity zones.



Centrifugal casting

"PolygonSoft" has special models for the analysis of mold filling and shrinkage porosity in the production of castings by centrifugal casting. The user specifies the axis, direction and rotational speed of the mold.

In combination with the possibilities of modeling investment casting in vacuum, PolygonSoft becomes an indispensable tool in the production of castings from titanium alloys.

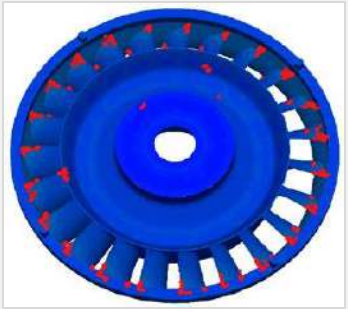


Centrifugal casting of titanium castings into a ceramic mold in a

Warping and cracks

The Hook solver is designed to calculate the residual stresses and strains that occur in the casting during cooling and interaction with the mold. The built-in cracking criterion shows areas of possible failure.

Special algorithms will calculate the final state of the casting after demolding and removal of the gating system.

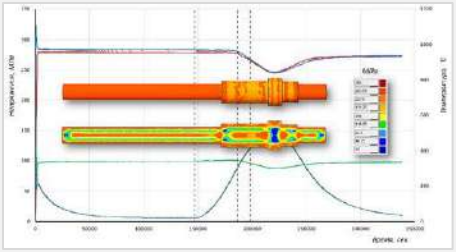


The reliability and stability of the algorithms make it possible to use the solver even for modeling heat treatment processes (quenching in various media, annealing, tempering, etc.) in order to determine residual stresses, deformations, warping, and possible destruction.

At this stage, the technologist learns:

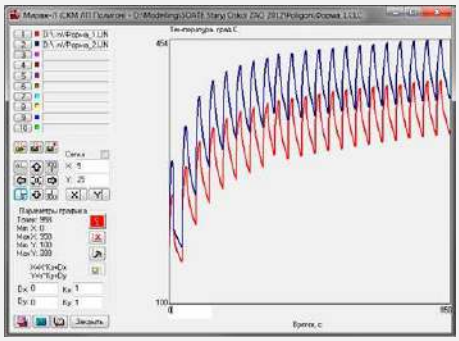
- the magnitude and distribution of residual stresses in the casting;
- the magnitude and distribution of stress strains in the casting;
- warping of the casting as a whole and along the coordinate axes;
- zones of probable hot and cold cracks.

Cracks in the casting
(JSC UEC - Salyut) vacuum



Cyclic processes

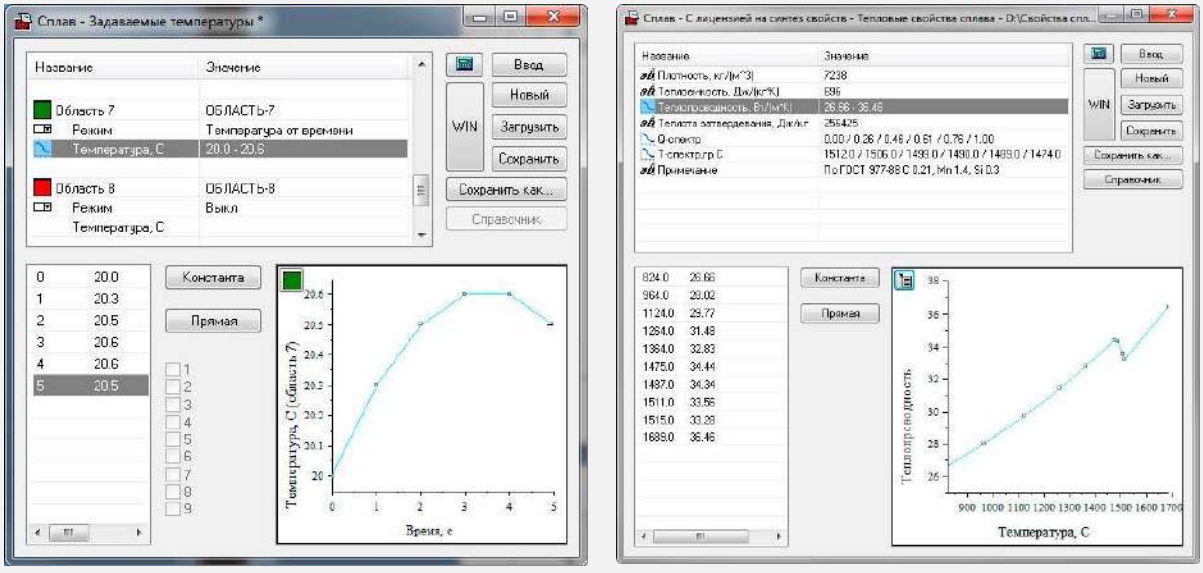
With some casting methods (for example, injection molding), it is important to establish the moment when the mold reaches that temperature regime, which will determine the quality of the product. "PolygonSoft" allows you to perform cyclic calculations and take into account the heating of the mold in previous cycles, the cooling of the mold during its parting, the installation of rods, etc.



Control of mold temperature
change by cycles during LPD

Base of materials

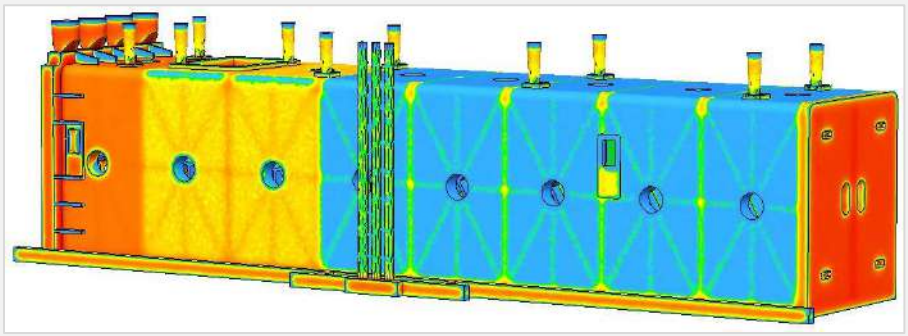
PolygonSoft comes with its own database of domestic materials and alloys, which includes the properties of many steels, cast irons, aluminum, nickel, titanium, copper, zinc and precious alloys. In addition, it contains data on mold materials (sand-clay, liquid-glass and cold-hardening mixtures, ceramics, fireclay, asbestos, shot, heat-insulating and many other materials used in foundry production). The database can be edited and updated by the user.

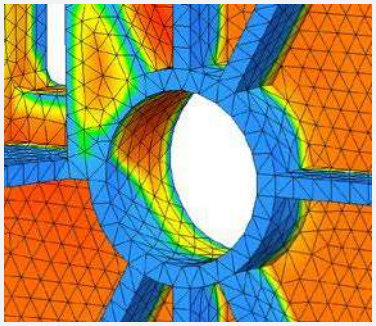


Editors for material properties and boundary conditions

oversized casting

Due to the use of the finite element method, PolygonSoft is successfully used for modeling very large and at the same time relatively thin-walled castings. Combined with the ability to use symmetry and multi-threaded calculations, the simulation process takes quite acceptable time. At the same time, computing resources (primarily the amount of RAM) are used, which do not go beyond the scope of ordinary office PCs.



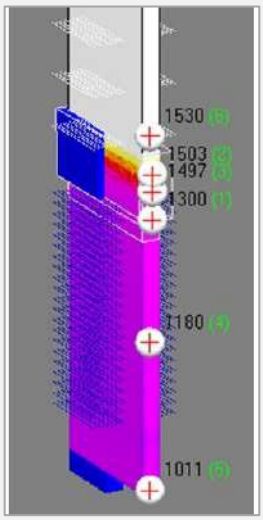


Casting "Rama"
(LLC Foundry "Petrozavodskmash")

- Dimensions: 8700x2000x2080 mm
- Average wall thickness: 30mm
- The calculation model contains 677,700 nodes and 3,170,621 elements

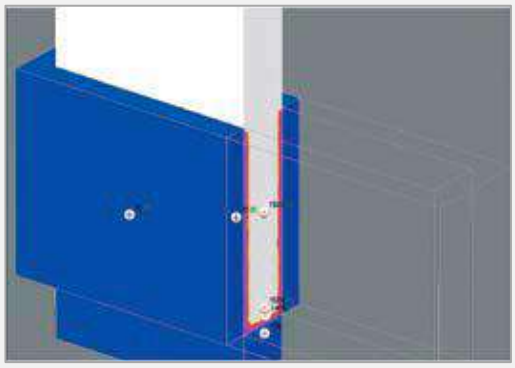
Simulation of continuous casting

Starting from version 13.1, SCM LP "PolygonSoft" can use finite element models with mismatched meshes for modeling. This not only simplifies the process of preparing the model for calculation, but also allows you to set "sliding" contacts of the "casting-mold", "mold-mold" and "casting-casting" types during mutual movement of geometric objects. New possibilities allow us to consider the problems of continuous casting - in particular, to simulate the initial stage of the process: drawing an ingot. The conditions of pre-start holding and broaching with metal cooling in the mold, in a cooling medium below the mold and then in air are simulated.

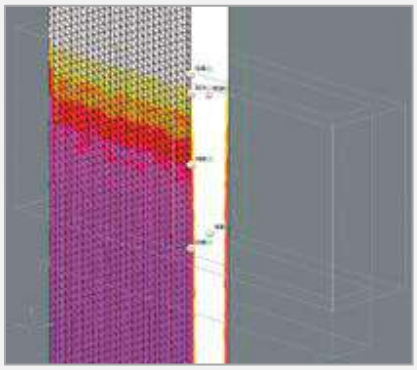


Intermediate moment of the technological process. Visualization of dynamic medium zones characterizing the thermal regime of different parts of the system:

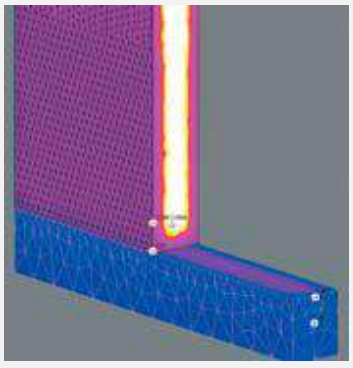
- white layers on top - metal content in the conditional bath;
- blue layers below - secondary cooling zones



The temperature in the system at the end of the pre-start exposure



Detailing the thermal picture in the mold zone



Detailing the thermal picture in the mold zone

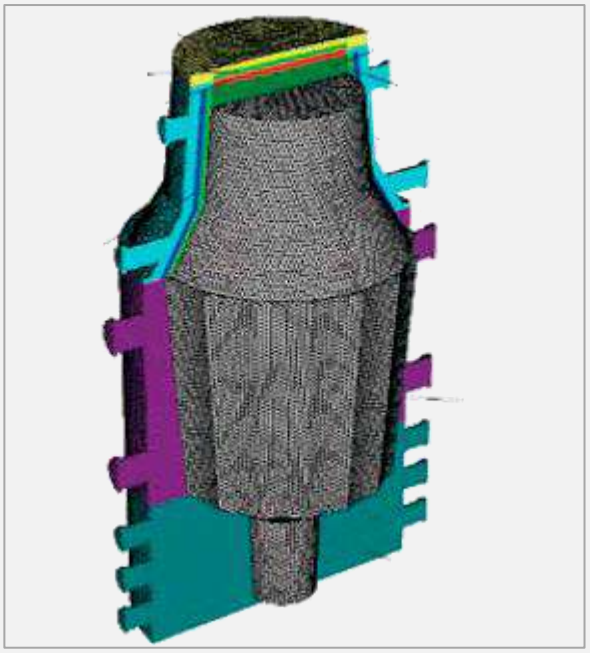
Production of large ingots

"PolygonSoft" is used in modeling the processes of formation of large steel forging ingots. Such ingots weighing from 100 to 500 tons are used as blanks for the manufacture of turbine rotors, rolling rolls, shafts for installing ship propellers. Since the duration of their pouring can reach one hour, and the duration of crystallization - tens of hours, it becomes fundamental to accurately simulate the heat transfer between the casting and the mold. The finite element method makes it possible to place grid nodes directly at the interface between bodies, which, in combination with the use of matching casting and mold grids, minimizes the error and makes it possible to calculate the ingot cooling process with high accuracy.

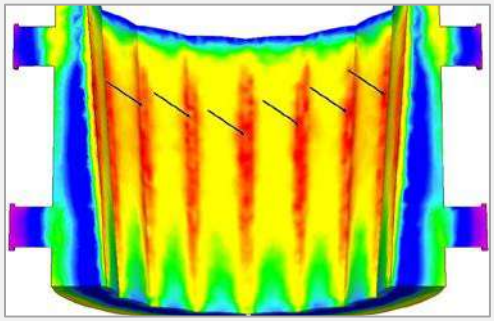
CSoft Development took part in the research work organized by Siemens together with JSC NPO TsNIITMASH. In the course of this work, the simulation of the technology for the production of two ingots was carried out and the results obtained were compared with experimental data. Comparison of the cooling curves obtained in the SKM LP "PolygonSoft" with measurements made using thermocouples installed at a depth of several millimeters under the surface of various parts of the tooling showed a good agreement between the calculation results and the experimental data.

The mold must withstand as many pours as possible, but long-term thermal stresses can cause it to crack. Therefore, the study of its stability seems to be a very urgent task. The analysis of the stress-strain state of the mold according to the criterion of the tendency to form cracks makes it possible to identify the location of dangerous

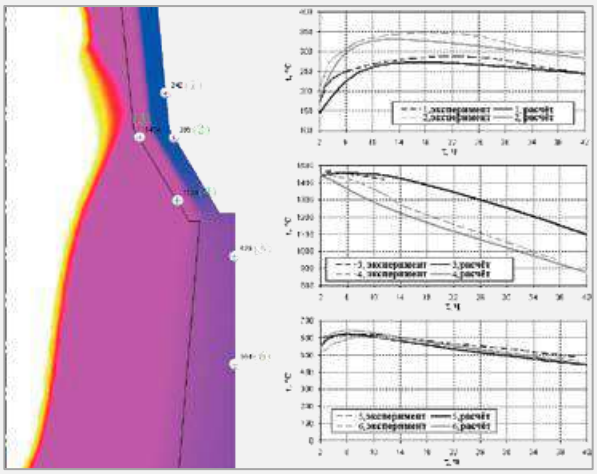
zones and, if possible, take measures to reduce thermal stresses in its body.



Finite element model of an ingot weighing 142 tons, presented in the Master-3D preprocessor



Modeling in the Guk-3D module of the tendency to cracking (dangerous zones are highlighted in red)

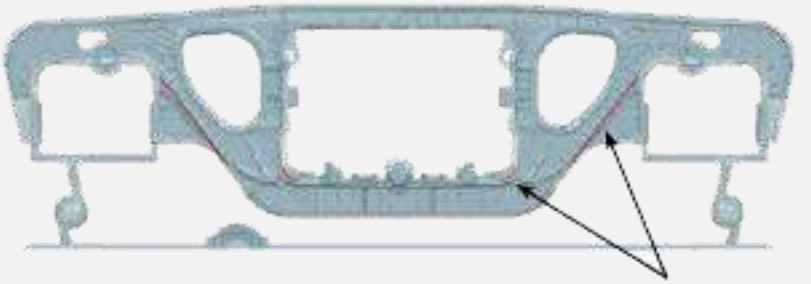


Change in time of temperatures at various points on the surfaces of the tooling of an ingot with a mass of 142 tons in accordance with the results of modeling in the SCM LP "PolygonSoft" (solid lines) and experimental data (dotted line)

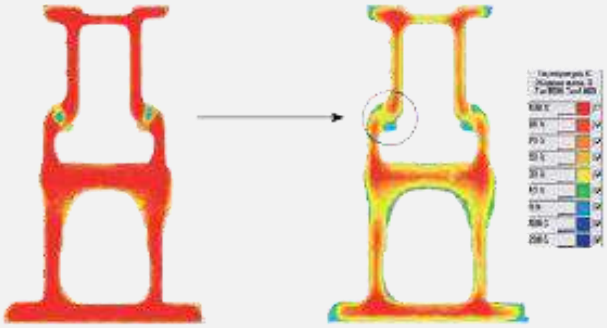
Internal refrigerators

Internal coolers are usually made from the same alloy as the casting and are mounted inside the mold cavity that forms the body of the casting. When filling the mold with a melt, the internal coolers are partially or completely melted and welded to the base metal. Technologists are interested in how the designed refrigerator affects the thermal pattern of the casting, its crystallization, and how effectively it prevents the occurrence of shrinkage porosity.

The ability to simulate this process is a feature that distinguishes SCM LP "PolygonSoft" from many similar systems. Modeling the melting of the refrigerator, taking into account the absorption of heat during the phase transition, makes it possible to correctly predict the occurrence of porosity and thermal stresses in the places of their installation.



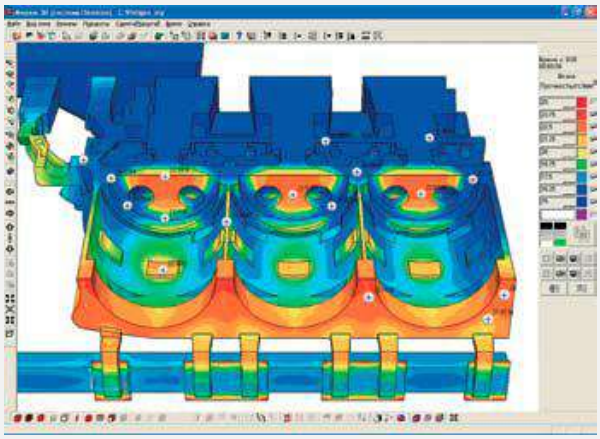
Installation locations for indoor refrigerators



Melting of internal refrigerators in the casting "Side Frame" (PJSC "AzovElectroStal")

Additional features of SCM LP "PolygonSoft"

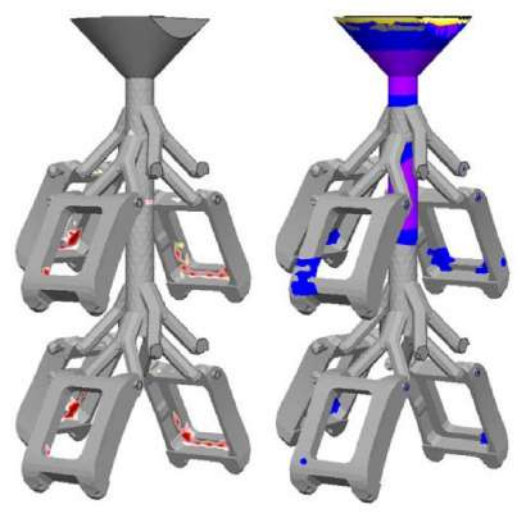
SCM LP "PolygonSoft" has great potential for criteria analysis of the obtained results. Using the "Criterion-3D" module, you can calculate and analyze such properties and parameters as structure, hardness, sticking, mold erosion, cooling rate, etc. The module contains a wide range of built-in functions that allow the user to create their own analysis criteria that meet a specific production: powers, trigonometric logarithms, gradients, rates of change of values, search for minimum and maximum values, and much more.



Strength calculation (JSC Zvezda)

Niyama criterion

Although SCM LP PolygonSoft predicts shrinkage porosity using its own specialized model, the user can use the Criterion-3D module to calculate the Niyama criterion. This dimensionless criterion, which takes into account local thermal conditions, has long been standard in all casting simulation software packages. Many foundries around the world still use it to predict porosity in castings. Modeling casters analyze maps of the Niyama criterion and assume that shrinkage porosity will form in areas where the Niyama criterion is below a certain critical value.



Prediction of shrinkage defects in the casting: standard model of shrinkage porosity SKM LP "PolygonSoft" (left); Niyama criterion obtained using the Criterion-3D module (on the right) (JSC POLET-ELITE)

Experience and knowledge

Years of experience and a team of professionals

Unique solutions

Integrated automation and implementation, the ability to combine foreign and own developments

Technical support

At all stages of implementation and use of the product

Education

We provide individual training for your tasks