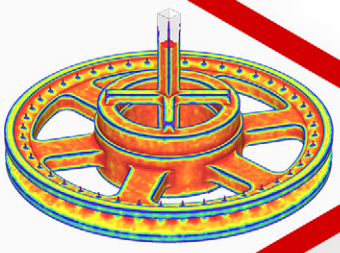
PoligonSoft

CASTING SIMULATION SOLUTION



CSoft development

PROFESSIONAL SOLUTION FOR SIMULATION OF CASTING PROCESSES

PoligonSoft Casting Simulation Solution (CSS) is a professional tool for casting engineers used for prediction and analysis of the defects occurrence causes at the phase of designing a casting mold and a gating system. PoligonSoft is a virtual foundry that allows, within a short period of time and without any additional costs, developing, analyzing and adjustment of the basic phases inherent in the casting process. By using the computer throughout the work the foundry engineer obtains, well before manufacturing of a tool set, more information of the process than it can be obtained at a foundry.

Multipurpose Casting Tool

The compute kernel of PoligonSoft consists of three solvers: hydrodynamic, thermal and stress. Together with a set of add-ons, they simulate all the traditional casting technologies and a number of special processes:

- Gravity Sand Casting;
- Permanent Mold Casting (including a cooled or heated die);
- Investment Casting;
- Vacuum Casting (including all types of directed solidification);
- V-Process Casting;
- High & Low Pressure Die Casting;
- Centrifugal Casting;
- Continuous Casting, etc.

End-To-End Simulation

The quality and reliability of the simulation are directly connected with an opportunity of end-to-end simulation of the process. PoligonSoft allows a consistent simulation of all phases of the casting process: mold heating, mold filling, solidification, casting removal from the mold, cutting the gating system and risers, etc.

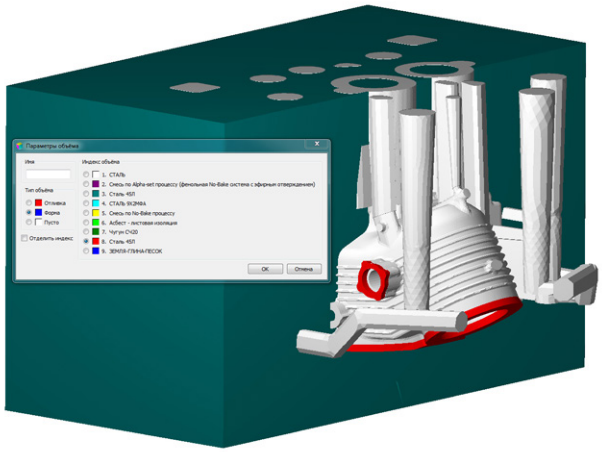
Quick Start of Simulation using Templates

During a casting process design, computing of a number of gating/feeding system alternatives or technological modes is often required. It is usually connected with alteration of the casting mold geometry or pouring temperature, with all materials and heat transfer conditions remaining unchanged. In order to avoid routine operations connected with a model set-up, PoligonSoft uses templates of technological processes that provide the user with the ready-made well-adjusted data sets characteristic of each technology. Certainly, all the templates and data may be edited in accordance with the specific production requirements.

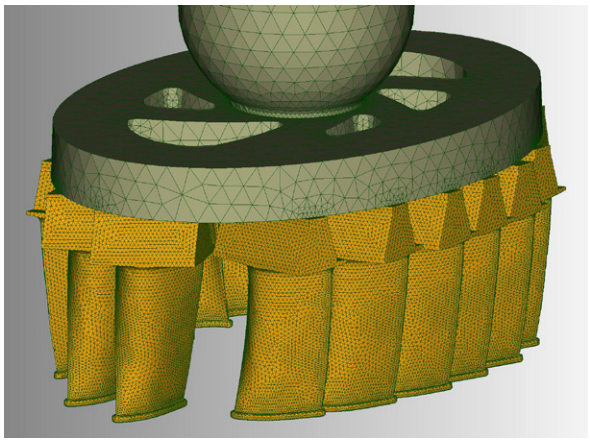
In addition, PoligonSoft has a built-in capability of inheriting all parameters from any previous simulation into the current model. Therefore, a foundry engineer can start computing with a few clicks and focus on the creative process.

Working with Geometry of any Complexity Level

PoligonSoft uses a casting block model and molds of any complexity levels, including a number of components of whatever shape. Coolers, cores, sand or ceramic mold, heat-insulating and exothermic materials and metallurgy equipment may affect, to a greater or lesser degree, the casting quality and must be involved in computation.



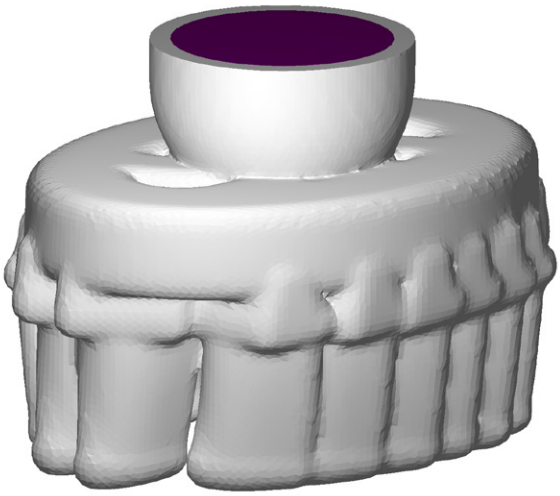
Body casting model with die and chills prepared for simulation (AAK Progress)



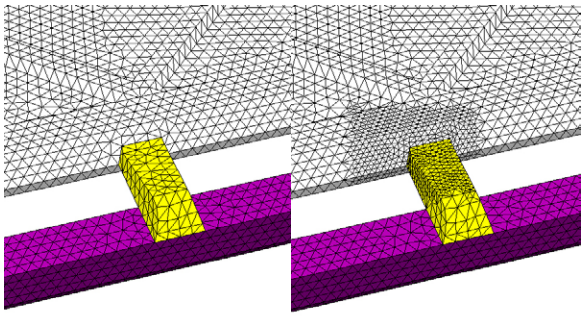
Mesh model of turbo compressor blades casting generated in SALOME (SKBT)

PoligonSoft uses an up-to-date and accurate finite elements method in order to make the surface area and volume of the shaped casting model to agree with the original product to the extent possible. The SALOME platform based finite elements mesh generator is supplied with PoligonSoft and allows a flexible and simple management of the mesh creation process for simulation. The user decides by himself where a better detailing is necessary, and where just a coarse grid is sufficient for the best possible use of the computer resources.

In case of investment casting, the ceramic mold has a geometry depending on thickness and shape of surface of the master model made from wax. The own shell generator allows creation of the ceramic mold's mesh model of the given thickness without a prior building in the CAD system. Such a method may be used for generation of such simple elements as lids, lining, heat-insulating and exothermic mixes, etc.



A ceramic mold created automatically in PoligonSoft preprocessor (SKBT)



a) *б)*

Local mesh refinement in PoligonSoft preprocessor:
a) initial mesh;
b) refined mesh

The built-in controls of quality and the editing of the finite elements model allow an efficient dealing with grid, without alteration thereof in the grid generator.

Checking the grid quality by given parameters allows identification of the elements with critical angles or of an irregular shape, and either adjust or delete them.

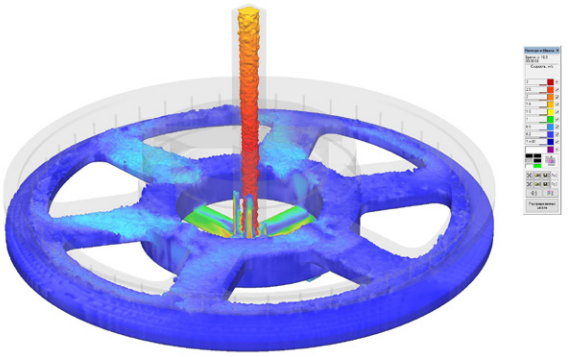
Special tools analyze geometry for existence of thin walls and desintegrate the grid locally to increase the computation accuracy.

Mold Filling

An up-to-date and powerful Eiler flow solver simulates filling the mold with a molten mass in the same manner as at a foundry:

- From a tilting ladle or bottom-tap ladle;
- To one or more pouring gates;
- With topping-up the gate or riser;
- With a permanent or alternating flow rate or pressure drop.

The molten mass temperature drop in contact with the mold walls and heat exchange with the environment, as well as the solid phase recovery that can stop flowing and lead to a misrun is calculated. A special algorithm allows investigation of the gating system's operation, identifying its bottlenecks and finding out the best dimensions, location and number of feeders.



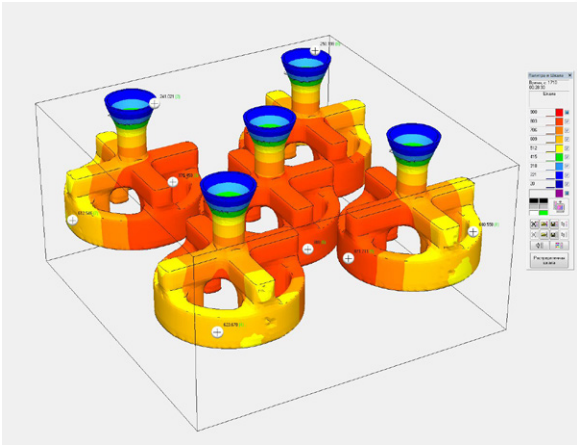
Gravity sand casting (DimAl)

Casting Solidification

Fourier heat solver computes temperature/phase fields, taking into account the heat exchange (heat conductivity, convection, irradiation) and heat generation during solidification.

At this phase, the process engineer gets to know:

- How temperature changes in the casting and mold;
- Solidification dymanics;
- How hot spots are formed;
- What is the efficiency of risers, coolers, exothermic insertions, etc.

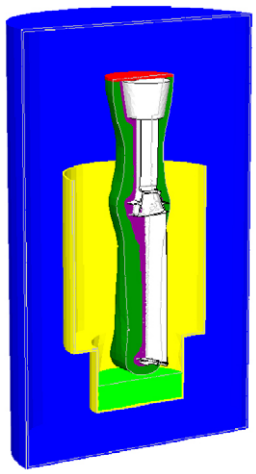


Ceramic molds temperature field before filling (Ussuriysk LRZ)

Radiation Heat Transfer

Due to the finite elements method, PoligonSoft can solve complex radiative heat exchange tasks, taking into account re-radiation and shading. It is necessary for vacuum casting and filling the casting clusters using the investment casting technology (IC) without the use of a supporting filler.

In such cases, castings' mutual layout within a casting blocks cluster can affect materially the porosity picture.



Vacuum investment casting (UEC)

Pipes and Shrinkage Porosity

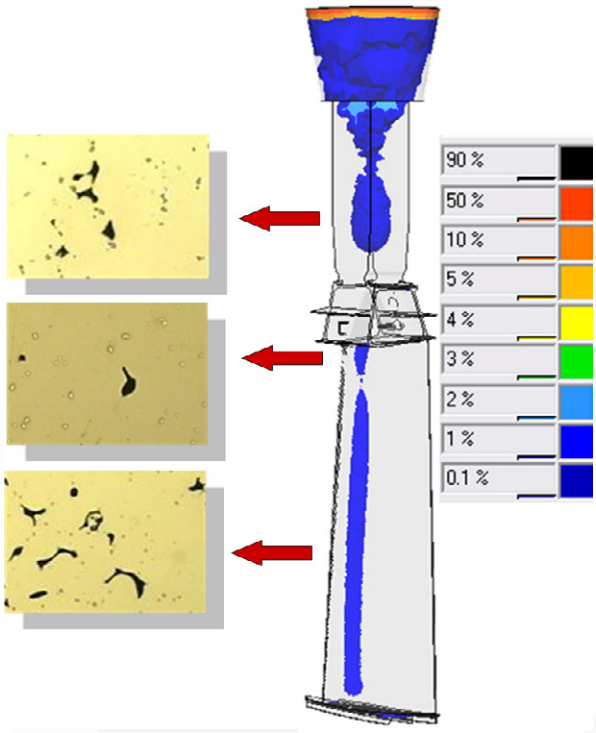
An undoubted advantage of PoligonSoft is the model

of shrinkage macro/micro porosity that allows an exact predicting of faults formation, particularly important for making critical castings (rotary blading and nozzle blading of a gas-turbine engine, blisks, pump impellers, etc.)

The special algorithms taking into account the capillary effect and pressure drop during solidification of closed heating units allow a more accurate computation of a fault picture when using blind risers.

The process engineer gets to know at this phase:

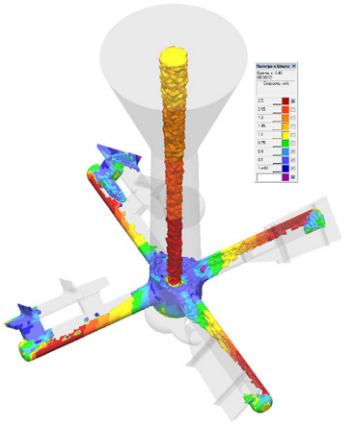
- Size and layout of pipes;
- Size and layout of micro porosity zones;
- Size and layout of macro porosity zones.



Centrifugal Casting

PoligonSoft has special models for analysis of a mold's filling and shrinkage porosity when using centrifugal casting method. The user sets axis, direction and rotation rate of the casting mold.

In a combination with the capabilities of simulation of the investment vacuum casting, PoligonSoft is an indispensable tool in making castings from titanium-base alloys.



Centrifugal vacuum casting of titanium

Warping and Cracks

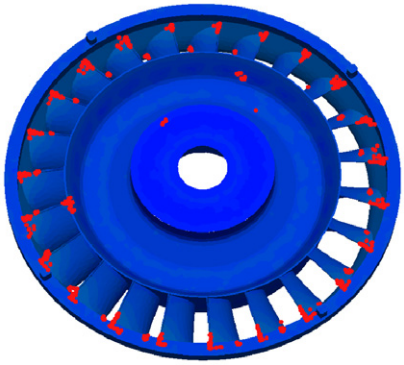
Stress solver is designed for computation of residual stresses and strains in casting when cooling down and interacting with the mold. The built-in cracking criterion demonstrates possible cracking areas.

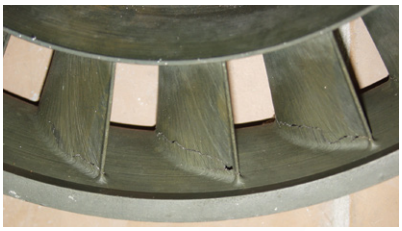
Special algorithms will compute final condition of the casting after removal from mold and removal of the gating system.

Reliability and stability of the algorithms even allow using of the problem solver for simulation of heat treatment processes (tempering in various environments, annealing, stress relieving, etc.) in order to determine residual stresses, strain, contraction and possible destruction.

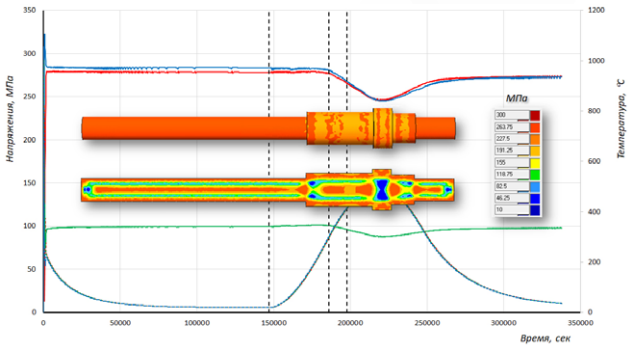
At this phase, the process engineer will get to know:

- Residual stresses in the casting;
- Plastic deformations;
- Crack risk;
- Distortion and deformation of casting.



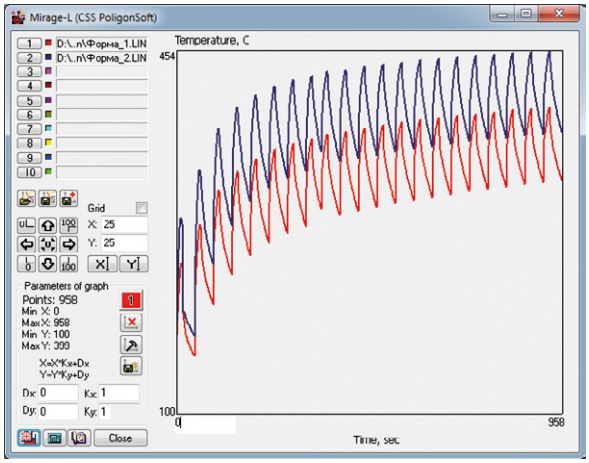


Cold cracks in casting (UEC)



Cyclic Processes

It is important, when using some casting methods (such as pressure-die casting), to determine the moment when the mold reaches the temperature mode that will determine the product's quality. PoligonSoft allows cyclic computations and taking into account heating of the mold during the preceding cycles, cooling the mold when splitting, setting cores, etc.



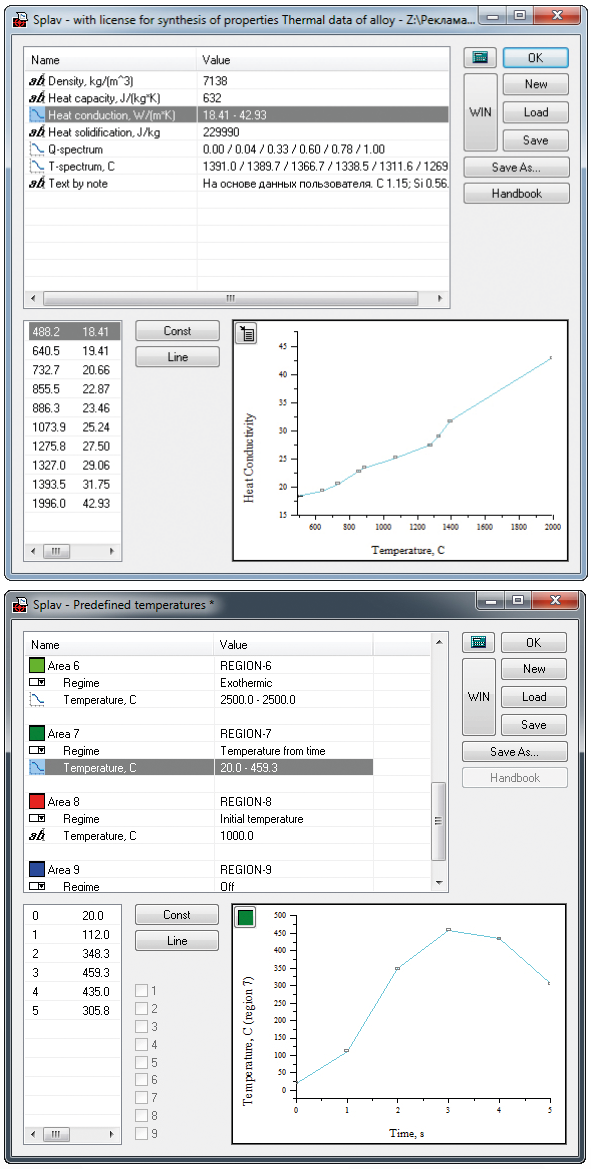
Mold temporary changes control by cycles, for PDC

Material Database

PolygonSoft is supplied with a database of materials and alloys, which includes properties of many steels, cast irons, aluminum, nickel, titanium, copper, zinc and precious alloys.

It contains mold materials: sands, ceramics, insulations and exothermic sleeves and many other materials used in the foundry.

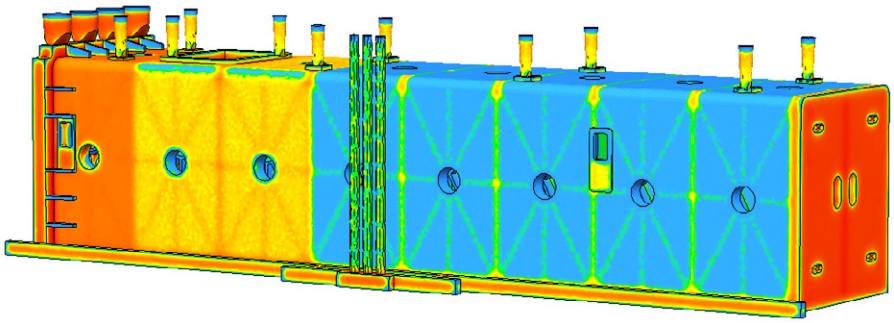
The database can be edited and updated by user.



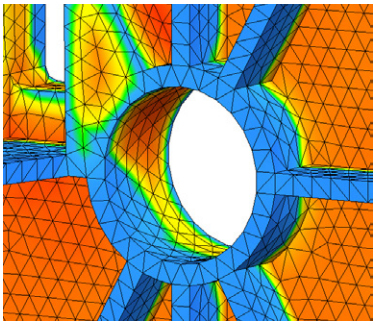
Material properties and boundary conditions database

Large-size Casting

Due to the use of the finite elements method, PoligonSoft is used successfully for simulation of castings that are very big and have rather thin walls at the same time. As combined with the opportunity to use symmetry and multi-threaded computations, the simulation process is taking quite an acceptable time. In such case, the computer resources (first of all, the random access memory) are used that are within the common office PC capabilities.



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

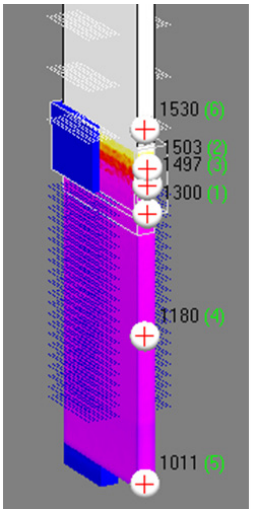


Frame casting
(Petrozavodskmash Foundry)

Continuous Casting

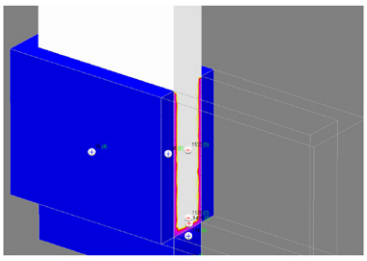
It is difficult to study experimentally the physical processes occurring within the continuous casting unit and inside the slab because of the equipment dimensions and complex technology. In such case, the most profitable approach, from the economic and time-consumption point, is to use a computational experiment that allows studying the process using a mathematical model of equipment, not the equipment as such.

PoligonSoft allows studying the effect of various technological parameters on the subproduct quality, identification of a linkage between fluctuations of such parameters and defective work.

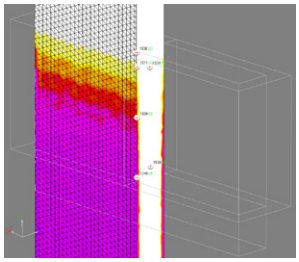


An interim moment in the technological process. Visual presentation of the dynamic environment zones characterizing the thermal behavior of various parts of the system:

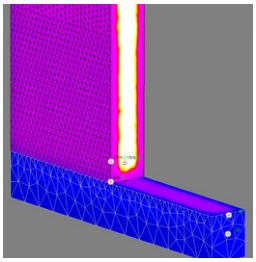
- *white layers at the top – metal content in the conventional bath;*
- *blue layers below – secondary cooling areas*



Temperature before moving start



Detailed temperature field



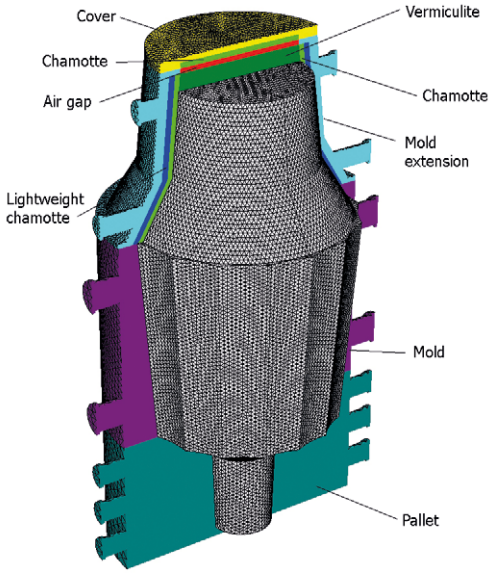
Temperature field in slab

Production of Large Ingots

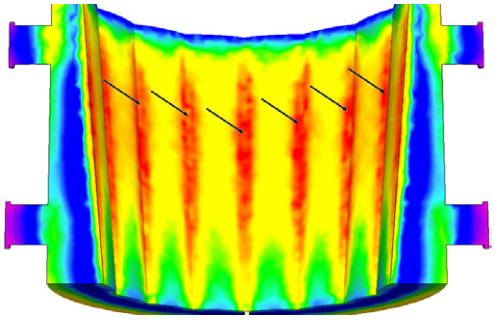
PoligonSoft is used for simulation of the processes of generating large steel forging ingots. Such ingots of a mass between 100 and 500 ton are used as subproducts for manufacturing turbine rotors, casting rollers, axles for installation of marine screws. Since their casting duration may reach one hour, and solidification can last tens hours, an exact simulation of the heat transfer between casting and mold becomes essential. The finite elements method allows placing the grid nodes directly at the borderline between bodies, which method, as combined with the use of coinciding grids of casting and mold, allows minimizing the error and computation with a high accuracy of the ingot cooling down process.

CSoft Development was involved in the scientific research arranged by Siemens together with JSC NPO CNIITMASH. This work included simulation of the manufacturing process of two ingots and comparison of the results with experimental data. The comparison of cooling curves determined using PoligonSoft with the measurements made using thermocouples installed at a depth of several millimeters under the surface of various parts of the mounting has demonstrated a good matching between the computation results and the experimental data.

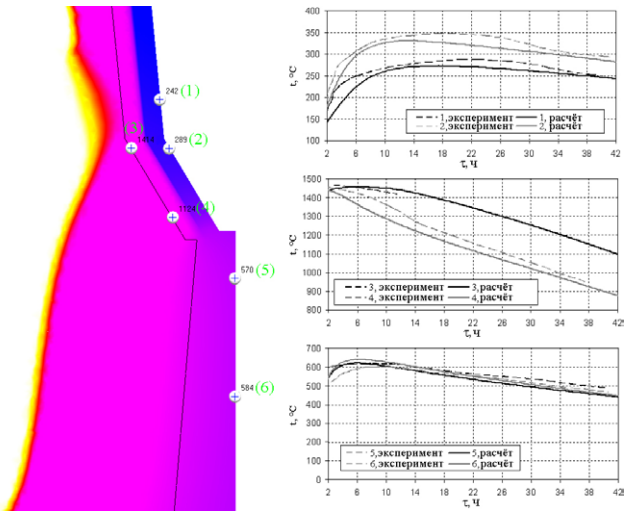
The casting mold must withstand the greatest possible number of fillings, but long-term thermal stresses are capable of causing fractures. Therefore, studying its withstandability is considered as a very important task. The analysis of the stress-strain behavior of a casting mold in terms of fracture initiation tendency allows identification of hazardous areas and, as possible, taking measures for a reduction of the temperature stresses in its body.



Finite element model of a 142 tons ingot prepared in PoligonSoft preprocessor



Cracking tendency prediction in stress solver (critical zones are colored in red)

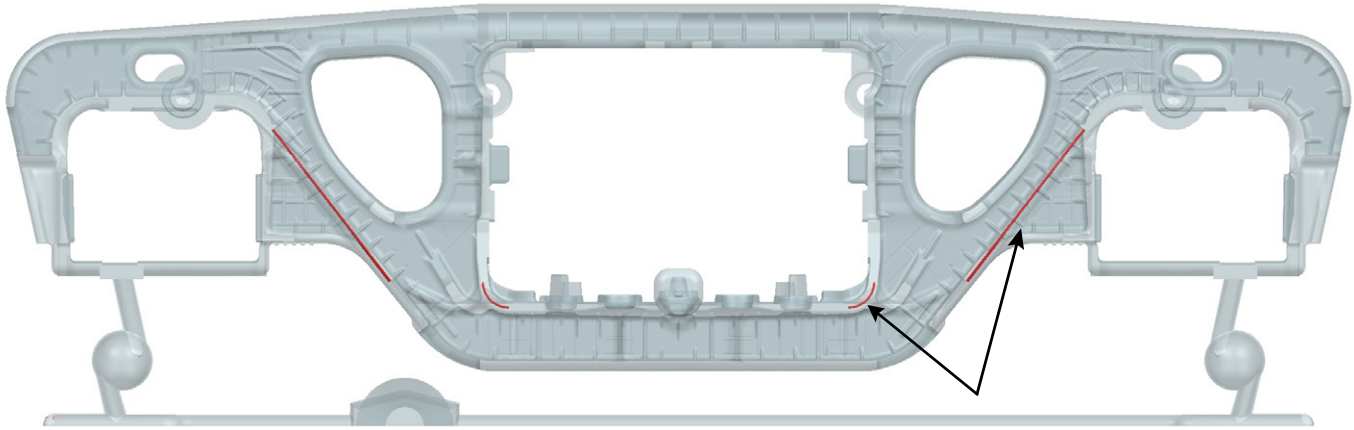


Temperature curves in different points at the mold surface of a 142 t ingot, based on the results of simulation in PoligonSoft (continuous lines) and measured data (dotted line)

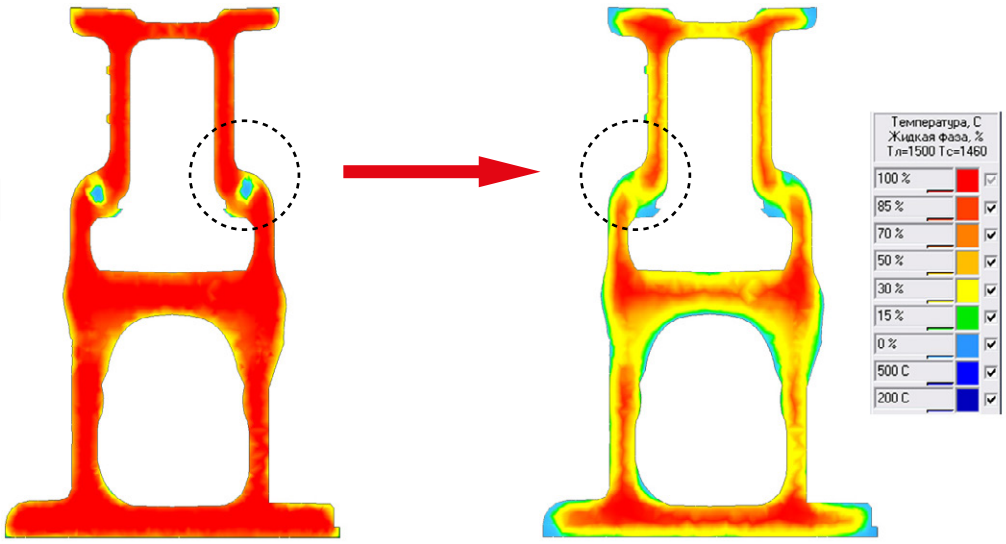
Internal Coolers

The internal coolers are usually made from the same alloy as the casting, and installed inside the mold cavity making up the casting body. When filling the mold with a molten mass, internal coolers are molten down, in full or in part, and welded together with the base metal. Process engineers are interested in the way the designed cooler affects the casting's thermal picture and solidification, and whether it can prevent efficiently the occurrence of shrinkage porosity.

The ability to simulate this process is a specific making PoligonSoft different from a number of similar systems. The simulation of cooler's melting, taking into account heat absorption during the transition between phases, allows a correct forecasting porosity and temperature stresses at their installation points.



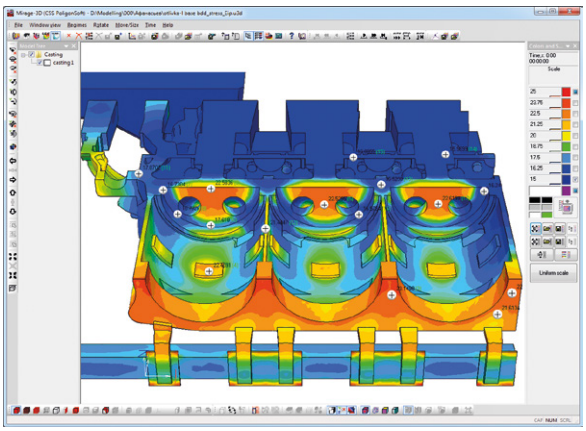
Internal chills installation points



Melting internal chills in a Side Frame casting (AzovElektroStal)

Additional Features

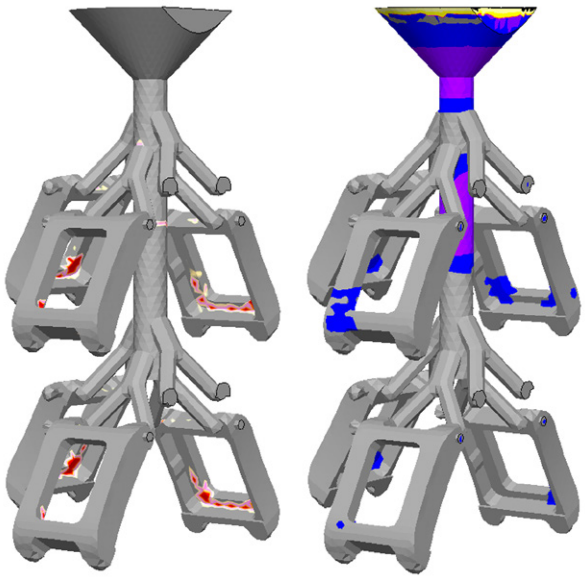
PoligonSoft has great capabilities of dimensionless analysis of result. Criterion-3D module may be used for computation and analysis of such properties and parameters as structure, hardness, metal penetration, sand wash, cooling rate, etc. The module contains a great deal of built-in functions that allow the user creating his own analysis criteria corresponding to specific criteria: degrees, trigonometric logarithms, gradients, values dynamics, search for minimum and maximum values and many other things.



Iron casting strength prediction (Zvezda)

Niyama Criterion

Although PoligonSoft is capable of predicting shrinkage porosity using its own specialized model, the user can use Criterion-3D module to optimize computation of Niyama criterion. This dimensionless criterion taking into account local thermal condition was a standard for a long time for all software packages used for simulation of casting. A lot of foundries worldwide still use it to predict porosity in castings. The casters using simulation analyze Niyama criterion values charts and assume that shrinkage porosity will occur in the areas where Niyama criterion is lower than certain critical value.



Prediction of shrinkage porocity in a casting: a standard PoligonSoft model of shrinkage porosity (at the left); Niyama criterion derived using Criterion-3D module (at the right) (POLYOT-ELITA)

About Company

The first version of PoligonSoft was developed in 1989 by the Central Materials Research Institute (CNIIM, Saint Petersburg) within the subject matters of the Defense Industry Ministry. It was the first commercial package based on a mathematic model for microporosity computation. PoligonSoft is successfully used by the aerospace industry enterprises that set higher requirements to castings quality. For about 30 years already, the system has been improved continuously, implementing the knowledge and experience accumulated during that period by major institutes and dozens of enterprises in Russia and abroad. In July 2009, the PoligonSoft development team joined CSoft Development company.

CSoft Development is the leading developer of software for the CAD systems market in the field of mechanical engineering, industrial and civil construction, architectural design, land management and GIS, electronic document flow, scanned drawings processing, vectorization and hybrid editing. The up-to-date developments on the basis of 2D/3D technologies (TechnologiCS, TDMS, Project StudioCS, Model Studio CS, GeoniCS and many others) offered by CSoft Development allow design institutions the automation of a number of everyday activities, thus enhancing their competitiveness and industrial standards significantly, opening up prospects for developing sophisticated design methods, solving CAD tasks at the top level, taking into account the Russian specifics. The products offered by CSoft Development were awarded on multiple occasions by well-known journals dealing with CAD.

Over 60 applications were developed since 1989, which applications are used by major, medium-size and small enterprises in Russia and abroad. The number of licenses issued during that period of time exceeds 1 million licenses, the commercial installations base is equal to 400,000 workstations.

EXPERIENCE AND KNOWLEDGE

Many years of experience and professional team

UNIQUE SOLUTIONS

Packages automation and implementation, combination of foreign and own developments

TECHNICAL SUPPORT

At all phases of implementation and use of a product

TRAINING

Individual training taking into account the tasks you are solving

Feedback

NPC Gazoturbostroyeniya Salyut starts production of all castings from mandatory simulation of the process. Such a method allows a reduction of casting technologies design / finalizing costs through adjustment of the gating/feeding system structure and temperature/time characteristics of the technological process using a computer model of the casting, not the casting itself.

Due to simulation, the pilot production received initial copies of castings very soon. The simulation and analysis of series technologies allows developing in some cases the recommendations as to a reduction of the shrinkage defects level.

UEC

Among the advantages of the most recent version of PoligonSoft is the opportunity to simulate jet drop, jet penetration into the melt; to simulate formation of closed blisters in the exterior part of ingot.

JSC NPO CNIITMASH

PoligonSoft has a number of advantages, as compared with similar simulation system ProCast used by CNII KM Prometey since 2014. Among other things, PoligonSoft software package allows a simulation of closed and open shrinkage cavities formation in the exterior part of ingot, and development of shrinkage porosity.

NIC Kurchatov Institute – CNII KM Prometey

When selection of an up-to-date software most fully satisfying the research center's tasks was required in 2003, we preferred the PoligonSoft Casting Simulation System .

Research Center (NIC)
of Territorial Company OMZ Izhora

CSoft development

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