



TECHNOLOGICAL OFFERS INSTITUTE OF TECHNOLOGY OF METALS OF NATIONAL ACADEMY OF SCIENCES OF BELARUS

Technological offer 1.

Development of technological process and equipment for production of hollow, volumetric billets out of ferrous and nonferrous alloys by the method of wall-by crystallization at continuously-iterative casting regime.

Summary of the offer. Intensive heat transfer from the outer surface of solidifying casting and ample feed of crystallization front with overheated melt during the whole process of its formation inside the crystallizer provide fine dispersion dense structure and high physical-mechanical properties of castings. This casting method meets international requirements of quality of produced billets, productivity and environmental friendliness. The developers offer technological process, casting equipment and machining attachments for production of high-quality hollow cylindrical billets, all based on newly realized idea of casting formation by the method of wall-by crystallization (directed solidification). We require investors to continue the works on perfection of the technology and casting equipment and development of new methods of expanding product, material and geometrical range.

Offer description. The process is performed in the following way. Liquid metal through siphon gating system gets into water cooled crystallizer and fills it till the set level. After that, metal feeding stops and a pause is made for freezing-up of required wall thickness. At that time, on the inner surface of the crystallizer's wall, due to intensive single-direction heat transfer a shell of metal grows in radial direction, the inner surface of the shell permanently contacts with overheated melt. This excludes gas and shrinkage porosity, nonmetallic impurities in the casting and allows obtaining metal with increased density and mechanical properties. After a certain aging, solid shell which is the body of the casting is extracted from the crystallizer and cooled according to the set regime. Simultaneously with extraction of the casting, liquid metal in the axis zone is released and comes in contact with walls of the crystallizer and formation of another casting starts. At that, a new portion of melt (its mass is equal to the mass of extracted casting) is fed into the crystallizer. Thus, crystallization of metal in the crystallizer is a nonstop process during the process of teeming and the castings are extracted after a certain period, i.e. the process is going in continuously-iterative regime.



Innovation aspects of the offer. The novice of the technology is in gaining increased physical-mechanical properties of the material of castings together with high productivity of the process due to creation of conditions for one-way solidification of metal at intensive one-way heat transfer and ample feed of phase transfer front with overheated melt during the whole period of crystallization of the casting.

Main advantages of the offer.

- increase of strength properties of grey cast iron billets – 15-25%;
- increase of wear- and scuff-resistance 15-20% as compared to casting into dry sandy-argillaceous molds;
- increase of wear-resistance of piston rings 15-20% and 1.3 times decrease of elasticity fall as compared to serial rings;
- Improvement of casthouse environment due to excluding of such operations as production of molds, cores, castings shake-out, cutting and drain-out;
- High productivity of casting: 100-240 castings/hour on one machine with mass 1500 kg and dimensions 2000x3000x2000. Diameter of castings from 40 to 200 mm, height up to 280 mm; wall thickness 10-25 mm.

Technological offer 2.

Development of the process of electroslag casting of bimetals.

Summary of the offer. The developed technology allows obtaining billets of different profile out of corrosion-resistant steels, nonferrous alloys, and bimetals.

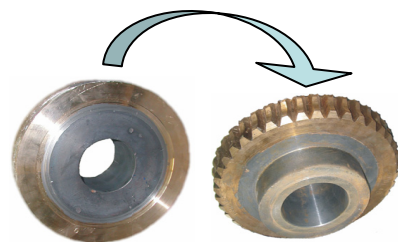
Typical parts, produced by electroslag casting are billets of forming and cutting tools, large-size gearwheels, rings, pulleys, cog-wheels, different crutches, staples, bodies, pivots, bimetal billets for worm wheels, forming rolls etc.

Offer description.

Electroslag casting is based on electroslag process of melting of consumable electrode. Electrode is melted by the heat, originated in conduction slag under electric current. The casting is crystallized in a thin rim of slag skull. As a result of boosted and strictly directed crystallization of a small amount of liquid metal, its high chemical and structure homogeneity is obtained.



Technical characteristics	
Circuit 2 phase, V	380
Secondary winding voltage, V...45.....	75
Secondary winding current, kA.....	0...10
Power consumption, kW.....	650
Weight of castings, kg.....	up to 300



Main advantages of the offer.

Developed equipment allows production of several billets per one operation, beside that, only one portion of flux is used to create the flux bath and energy expenses are decreased, because there is no need to melt the consumable electrode for each separate casting. All these factors decrease the production cost of one article and increases productivity of the plant.

Technological offer 3.

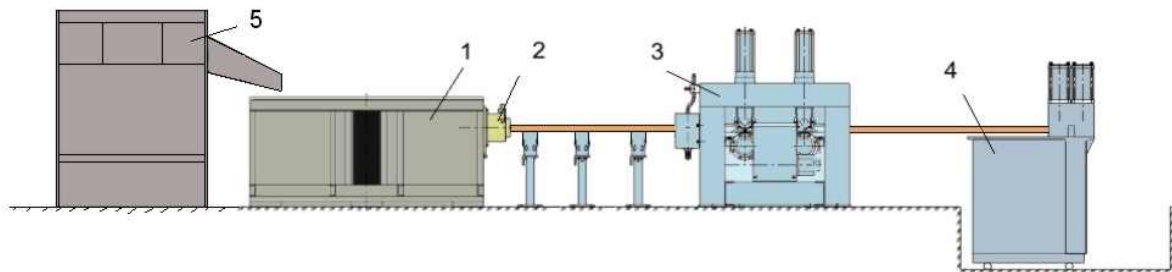
Development of technological process and equipment for continuous casting of copper-based alloys.

Summary of the offer.

The process of production of billets by the method of continuous horizontal casting meets modern requirements of quality of produced billets, resource-saving and environmental friendliness. The equipment and the technology provide production of high quality billets of various diameters and sections out of raw materials and production waste (scrap, cutting waste etc.).

Offer description.

Equipment for continuous horizontal casting of copper-based billets includes: induction melting furnace, induction channel mixer, withdrawal-roll set with servomotor, billet cutting mechanism, control panel and crystallizers. Metal is melted in induction furnace, and then is delivered into the mixer. Molten metal out of mixer gets into the crystallizer, where the casting is formed, then it is pulled out by withdrawal-roll set and cut into required billets by the cutting mechanism.



1 – Mixer; 2 – crystallizer; 3 – withdrawal-roll set; 4 – automatic cutter; 5 – melting furnace.

Diameter of produced rods: 30-200mm;

Rectangles with section from 30x50mm to 150-200 mm.

Number of streams – 1-4 (depends on required production volumes of castings)

Consumed power: melting furnace – 180 kW; mixer – 70 kW

Capacity: melting furnace – 500 kg; mixer – 500 kg.

Installed power of electromotor of withdrawal-roll set – 5 kW.

Equipment is designed individually for every specific customer, according to his preferences in production of castings, production volume and other

requirements, which determine technological parameters and the price of the equipment.

Main advantages of the offer. The advantages of process are realized in the spheres of production of castings, mechanical treatment and exploitation of new articles.

The technological process and equipment allow producing profile continuous-cast bronze billets with homogeneous mechanical properties throughout the section and over the whole volume of a billet.



Technological offer 4.

Development of software for quick processing of blurred and distorted images.

Summary of the offer. Software for quick processing of images, distorted and blurred at passing through scattering medium. Author's original algorithms, used in this software, minimal possible mean-square error of recovery of initial object.

The software allows processing of video signal with simultaneous digital magnification. There is a possibility of processing of several images of the same object, taken at different circumstances. The software can be used in processors for



processing of signals, installed into various image recording devices.

Offer description. In some cases, image can be blurred, for example at recording through objective lens, optical haze, fog etc. Beside that, area imager, used in modern recording devices, also distortion the image as a result of integration of emanation over the square of a pixel. Mathematically, these processes are described by Fredholm integral equation of first kind. The authors have developed an original method of solution of this equation, which allows recovering continuous initial objects by one or several linearly blurred images, recorded by area imagers. It is shown, that this method provides minimal possible mean-square error of recovery on average class of objects. Possibility of processing several images of one object may result in serious improvement of image recovery. Within this method, expressions for quantity assessment of possibility of recovery of objects, based on knowing only blur function for all

recorded images and autocorrelation functions of the object and recording distortion were developed. In practice, these can be images in different range of wavelength etc.

On this base was developed software for fast processing of blurred images, which can be used at processing of real time video signals in built-in signal processing processors or outer computers. The software allows improving blurred distorted image. There is a possibility of processing with magnification of the recovered object with consideration of blur monitoring track and characteristics of area imager. Processing of several images in some cases makes possible to gain serious improvement of resolution limit of the system. These features can be used to recover small images, size of which is about 1 pixel, which is typical for air- and satellite images.

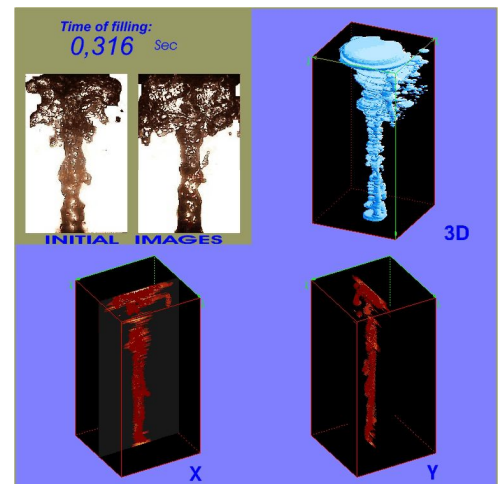
Innovative aspects of the offer. Novice of the algorithms and software is in possibility of processing blurred images with minimal possible mean-square error. Several blurred images of the same object, made by different devices can be analyzed.

Main advantages of the offer. Main advantages of the offered processing system are possibility of maximal gain of resolution limit of recording system with consideration of its characteristics and possibility of processing of several images. It is mathematically proved that for the chosen class of objects, gaining higher resolution of the given system is impossible.

Technological offer 5.

Development of special software for simulation of continuous horizontal casting processes.

Summary of the offer. 3d modeling of heat-exchange process at continuous casting of billets. Determination of 3d temperature fields in billets and crystallizers. Determination of spatial and temporal temperature gradients. Structural and parametric identification of mathematical models, determination of heat-exchange parameters by experimentally measured values of temperatures on the base of solution of inverse problem of heat conductivity. Mathematical simulation of solidification of bimetals billets. Mathematical simulation of crystallization of Al-Si alloys.



Offer description. Software, created at the Institute, allows solving tasks of heat exchange for continuous horizontal and vertical casting, continuous casting into roller crystallizers of various types. The calculations are performed for rectangular and cylindrical billets both.

Mathematical models are realized on the base of finite difference method.

Results of calculations are presented as text or graph: as isotherms and dynamically changing image. It is possible to display spatial and temporal coordinates of temperature gradients. Structural identification of mathematical

models presupposes application of different models for description of the process of crystallization and convection in the melt.

Parametric identification of mathematical models presupposes determination of values of unknown parameters, in particular, coefficients of contact and convection heat exchange.

Innovation aspects of the offer. Novice of the developed algorithms and software is in their specialization, i.e. orientation on solution of specific problems of heat exchange in 2d and 3d and consideration of specific conditions of heat exchange and requirements to quality of billets.

Main advantages of the offer. Advantages of this specialized software its development on the grounds of performed experimental-theoretical structural-parametric identification of mathematical models and is adapted to the real technological processes of casting. This allows using it for all relative casting processes.

Technological offer 6.

Multicriteria optimization of technological processes.

Summary of the offer. Specialists of the institute have developed a complex for solving problems of multicriteria optimization of technological processes. The method of optimization was developed on the grounds of fuzzy-set theory and allows considering information of fuzzy character on the stage of setting of optimization task. Beside that, the method allows considering non-equivalence, incomparability and contradictoriness of quality criteria of technological processes and limitations, put on them.

Offer description. Nowadays, fuzzy-set theory finds application in solution of such practical tasks as identification of images, development of expert systems, planning of investment policy of banks and enterprises etc. – e.g. – in situations with ambiguity of fuzzy quality character, which cannot be formalized with standard mathematical apparatus.

Technologies of casting processes are mainly based on existing scientific and practical experience. Beside that, quality of many processes seriously depends on experience of casting production engineer.

Fuzzy multicriteria optimization, developed in ITM NAS of Belarus, gave birth to software, based on it, which found its application in foundry, medicine, and banking.

The essence of this method is in finding global trade-off decision and nonequivalence of optimization criteria. For formalization of quality criteria and limitations preference function, which allow taking into consideration information of fuzzy character on the task setting stage.

Values of preference functions for each criterion vary from 0 (least preferable) up to 1 (most preferable) at the change of parameters, set by a specialist on the grounds of scientific and practical experience.

Further on ranking of partial criteria of quality and limitations and their convolution into one unified criterion. Search of ranges of quality criteria and

limitations uses a scale of linguistic evaluations of relative importance and matrix of paired comparisons of criteria and limitations.

Innovative aspects of the offer. Developed method of multicriteria optimization and software allow finding optimal decision on the base of minimalization of unified global optimization criterion, which is obtained by convolution of partial criteria of quality and limitations. At that, peculiar to optimization tasks fuzziness and ambiguity are transferred from the stage of analysis of the results to the stage of optimization problem setting.

Offered software can be used not only in foundry.

Main advantages of the offer. This method and software allow obtaining unique global solution of multicriteria optimization with maximal satisfaction of criteria of quality and limitations with the highest ranks.

Technological offer 7.

Design of crystallizer with higher productivity of casting of metals and alloys.

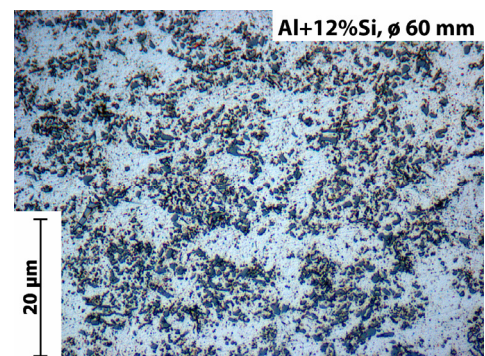
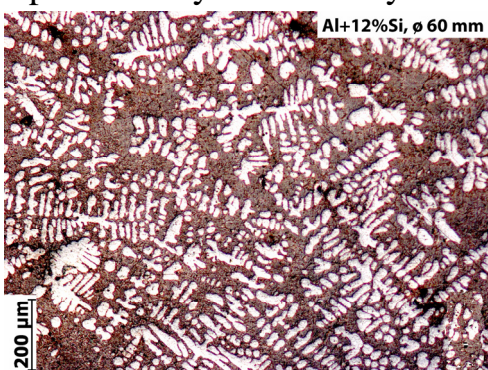
Summary of the offer. Specialists of the institute have designed a crystallizer with increased cooling speed for production of billets out of various metals and alloys. The advantages of such crystallizer as compared to the existing analogs are high productivity, stability and quality of produced billets. The institute is looking for partners for industrial application of the crystallizer on foundry and metallurgical enterprises, which deal with metals and alloys.

Offer description. Nowadays, the main drawback of existing crystallizers for casting of metals and alloys is impossibility of increasing of productivity of casting process without increasing the expense of cooling agent, which reduces stability of casting process and increases the cost of produced billets. The offered crystallizer has a brand new and effective cooling system, which allows gaining significant growth of productivity of casting process without increasing consumption of cooling agent. This also favors stability of casting process, homogeneity of cooling throughout the height and perimeter of the crystallizer, quality of produced billets.

The crystallizer was tested at continuous casting of bronze. It was proved that at equal expense of cooling agent, casting into the crystallizer, designed in the institute, is twice more effective than into standard one, casting stability and quality of ingot were also increased.

Innovation aspects of the offer. The novice is design of crystallizer with brand new and effective cooling system, which favors serious increase of productivity of casting process and quality of produced billets out of various metals and alloys without additional expense of cooling agent.

Main advantages of the offer. Advantages of the crystallizer: higher productivity and stability of casting process.

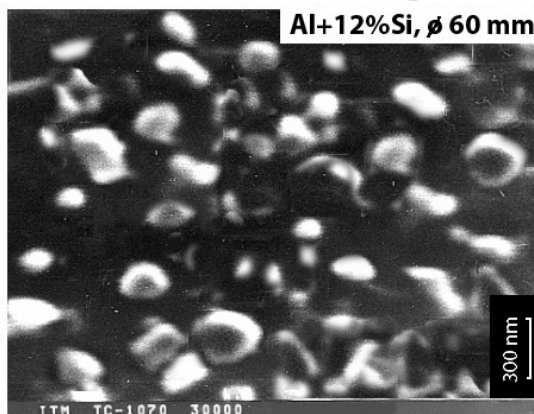
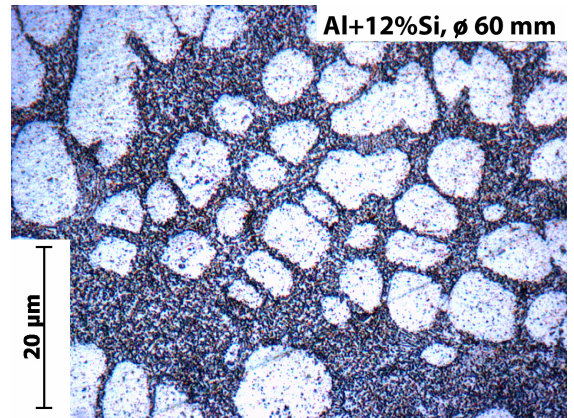


Technological offer 8.

Development of technological process of production of Al-Si alloys with nanostructure eutectic silicon.

Summary of the offer. The institute developed a unique technology of casting of billets out of Al-Si alloys with high dispersion structure without application of modifiers. The new technology allows gaining serious increase of physical-mechanical and wear-resistance properties of produced billets.

Offer description. Mechanical and exploitation properties of aluminum-silicon alloys depend mainly on dispersion of microstructure. At the moment, dispersion of phase components of castings is performed with application of modifiers. This technology has the following main drawbacks: unstableness of modification, increased tendency of metal to gasing and hazardous production environment, lack of universality of modifiers. Offered technology allows producing billets with diameter 40-120 mm with nanostructure eutectic silicon (200-250 μm) and high dispersion crystals of primary silicon (10-15 μm) without application of modifiers. This greatly increases physical-mechanical and wear-resistance properties of produced billets. This technology is based on the method of casting with increased solidification rate. Pilot cylindrical billets with diameter 50-115 mm were produced out of Al-Si alloy with application of the new



technology. The research showed, that mechanical properties of pilot samples, as compared to analogous, but produced according to standard technology with application of modifiers, turned out to be 40-70% higher. Wear-resistance of pilot billets at dry friction with steel plate and load 0.6 MPa surpassed antifriction bronze 40 times. Beside that, it was stated, that at addition of castings with nanostructure eutectic silicon into the charge in the volume of 20% - structure heredity of modified microstructure of the billet is preserved for more than 2 hours.

According to new technology out of hypereutectic Al-Si alloy with nanostructure silicon were produced worm wheels of reduction gear and pistons of combustion engines. Tests showed that in comparison with analogous items, produced according to standard technology, work life of pilot pistons was 3 times longer. Work life of pilot worm wheels surpassed bronze analogs twice.

Innovative aspects of the offer. The technology allows producing billets out of Al-Si alloys with homogeneous high dispersion structure, increased mechanical and wear-resistance properties without application of modifiers.

Main advantages of the offer. Main advantages – no modifiers, production of nanostructure billets with increased mechanical and wear-resistance properties.

Technological offer 9.

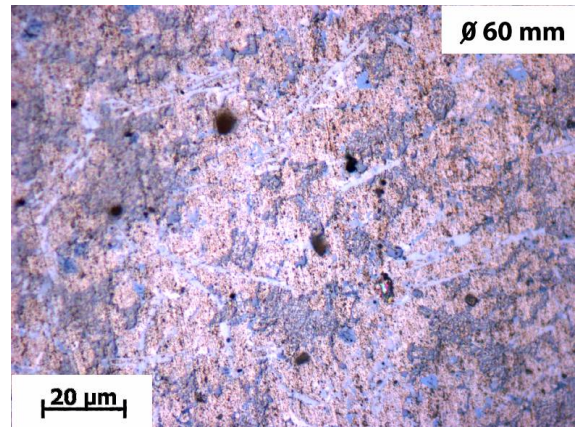
Modifier for more effective fining of grains of steel ingots.

Summary of the offer. The institute has developed a light-alloy modifier with high dispersion structure, which allows more effective fining of grains of steel ingots. The institute is looking for partners for industrial application of the alloy on foundry and metallurgical enterprises, which deal with metals and alloys.

Offer description. At casting of bulky billets out of steel into sandy-argillaceous molds on increasing the productivity of the process on continuous casting machines, serious decrease of cooling intensity of the ingot is observed. These conditions require a more effective modifier as compared to the existing.

Specialists of the institute developed 1st in the world light-alloy modifier which allows increasing the effectiveness of modification of steel ingots due to high dispersion structure of modifier. It is produced at increased rate of crystallization by continuous casting as rods of various diameters. This simplifies introduction of them into liquid steel and increases the time of modification and useful life. The modifier allows performing deoxidation of steel and modification of the ingot.

The modifier was tested at casting of steel billets 40x with diameter 100 mm into sandy- argillaceous mold at expense of modifiers 0.001 of mass fraction of the charge. It was proved, that a grain of the casting on average was fined 5 times.



Innovation aspect of the offer. The novice is in development of a modifier with high dispersion structure, providing more effective fining of the structure of a steel ingot, especially at continuous casting of steel with increased productivity of casting processes.

Main advantages. The offered modifier for steel has the following advantages: high rate of recovery, small dosage, low melting temperature (600C), a higher dispersion of phase components (less than 1 μm), and increased useful life time.

Technological offer 10.

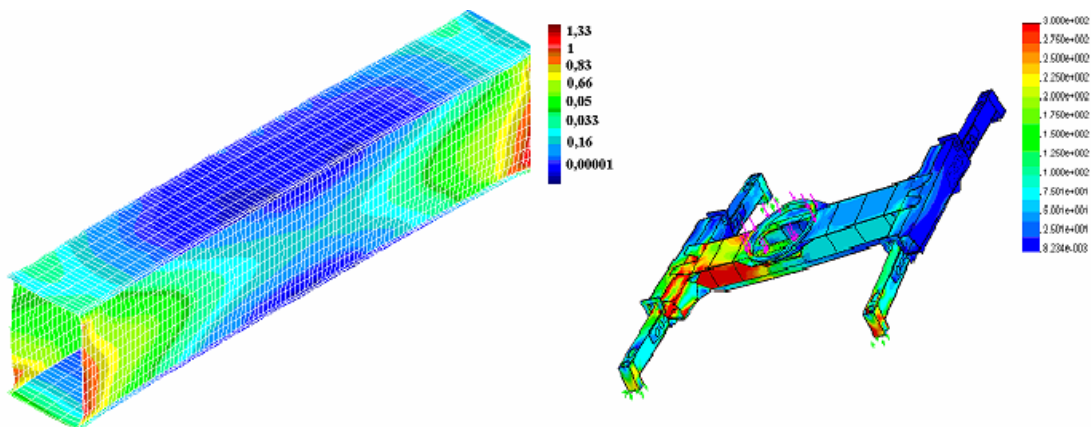
Development of the technology of calculation of mode of deformation of metalworks with consideration of residual welding stresses and deformations.

Summary of the offer. Computer technologies of projection and simulation of mode of deformation of metalworks allow performing calculation of metalworks with following analysis and working out of recommendations for improvement of technical characteristics of the article.

Offer description. Classic algorithm of calculation of mode of deformation of metalworks is based on division of the structure into elements and calculation only

considering of transmitted load. However, separate elements of complex metalworks show different variants of behavior as isolated parts and as parts of a complex due to presence of junctions on the boundaries. Application of numerical methods of calculation eliminates this limitation and allows creating and calculating a model, having real size and considering volumetric character of load. Beside that, when performing manual calculation, a constructor must put in overstated reserve coefficient, which leads to increase of steel intensity of the article.

High effectiveness of computer technologies is gained due to application of applied programs, adapting standard CAD for fulfillment of specific technological tasks. The developed algorithm and software for calculation of strength parameters of metalworks with consideration of mode of deformation, caused by welding allow performing determination of maximum permissible load, providing operation of metalworks in the zone of elastic deformations. The figure shows examples of calculation of intensity of stress distribution in the arm and main frame of truck crane with load rating 25 tons. The software allows calculating stresses and deformations, caused by welding on the stage of production of the article, find alternative variants of performing welding operations, providing higher preciseness and bearing capacity, determining parameters, which produce the most serious effect on preciseness and bearing capacity of metalworks.



Main advantages of the offer. Application of computer technologies in design and modeling allows decreasing steel intensity of the product; increase production preciseness due to consideration of weld stresses and deformations; decrease nonproductive loss during preparation of production by 15-20%; shorten the time of preparation for production 3-5 times; decrease the number of defects, caused by residual weld stress and deformations.

The Institute performs research work in the following directions:

- Research of metallurgical processes and heat engineering phenomena at melting and casting for development of technology of production of composite castings.
- Development of technology of recycling of fowl waste of nonferrous metals
- Development of technology of increasing wear-resistance of graphite materials.
- Research of structure formation, heat and technological peculiarities of processes of casting and heat treatment of billets out of white high chromium and special low-alloyed cast irons with globular and flaked graphite and also bronzes and silumins at chill casting.
- Creation of theoretical and technological basics of control of the process of graphitization of cast irons at primary crystallization and secondary transformation under intensive cooling.
- Development of technological basics of production of cast alloys with inverted structure.
- 3d model simulation of a stream of molten metal with water simulation in a transparent cast mold by the method of optical tomography.
- 3d image modeling of mold filling at die casting by the methods of water analog simulation.
- Development of technologies of continuous casting of billets out of ferrous and nonferrous metals with set structure.
- Research of the processes of structure formation and development of basics of treatment technology (thermocycling, magnetic field, pulse treatment etc.) of industrial aluminum alloys.
- Development of technological basics of production of aluminum-silicon alloys and castings with set physical-mechanical properties.
- Study of the possibility of production of castings with specified configuration and properties, depending on the compound of charge material and regimes of melt preparation of ferrous and nonferrous metals.

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