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1. SUBSOIL RESOURCE MANAGEMENT

1.1. Engineering-geological, hydrometeorological, geodesic, geotechnical and environmental surveys



«Scientific Research and Design Institute of Engineering surveys and Environment» of Irkutsk National Research Technical University (INRTU) works on solutions for wide range of R&D, application and production tasks in geology, hydrogeology, environment, engineering surveys and design.

The Institute holds a certificate granted by self-regulating non-profit organization "Baikal Regional Surveyors Union" allowing following types of works affecting safety of capital construction objects, including extremely dangerous and technically complicated works: engineering-geological surveys;

- engineering-environmental surveys;
- engineering-geodesic surveys;
- engineering-hydrometeorological surveys;
- engineering-geotechnical surveys;
- survey of soil under building and construction foundation.

Works are executed in close cooperation with leading design-surveying, educational and scientific institutions and organizations of Irkutsk, Moscow, Saint- Petersburg, Novosibirsk, Ulan-Ude, Chita, Yuzhno-Sakhalinsk and other cities.



Material base of the Institute includes:

- Modern boring and field equipment; Motor vehicles.
- R&D laboratory for complex engineering tests.
- R&D laboratory of environmental engineering.
- Certified laboratory for study of composition and physical-mechanical properties of rock and soil.
- Accredited hydro-geochemical laboratory.
- Laboratory for modelling of geological, hydro-geological and engineering-geological processes.
- Laboratory of radiation control.
- Mobile laboratory for study of composition and physical-mechanical properties of rock and soil.

The Institute currently completed over 250 surveying, geological explorations, geological surveying and environmental operations in Siberian and Far Eastern Federal Districts.

The most interesting and largest works were the following:

- examination and expert assessment of technical condition of East Siberian Railway Severomuysky Tunnel (hydro-geological and hydrological surveys);
- surveying and development of environment impact assessment and environmental protection department for reconstruction of Nizhneudinsk oil pumping station;
- calculation of maximum of permissible discharges (MPD) for Korshunovsky ore mining and dressing plant;
- development and establishment of environment impact assessment procedure "Optimization of technological solutions to achieve design values at Sukhoy Log PJSC of Zapadny ore mining and dressing plant";
- environment impact assessment and environmental protection procedure for experimental-industrial production at Yarakinsky gas-oil-condensate deposit;
- environmental engineering surveys and environment impact assessment procedure included in working draft of toxic waste site and chemical plant building, development of monitoring network and development of underground water monitoring regulations for Federal State Unitary Enterprise "Angarsk Electrolytic-Chemical Plant";
- engineering surveys at field well sites in Kovyktinsky, Markovsky, Yarakinsky, Danilovsky, Verkhnechonsky oil and gas condensate deposits;



- technical inspection of engineering surveys, examination of hazardous geological processes and phenomena (frozen-ground and karstic) at pipeline rout "Eastern Siberia – Pacific Ocean";
- development environment impact assessment procedure for motor way and pipeline "Verkhnechonsk oil-gas condensate deposit";
- engineering surveys for construction of ore mining and dressing plant at KimkanoSutarsky ferruginous quartzite deposit;
- engineering-geological surveys at site of designed Far Eastern Federal University at Russki island in Vladivostok;
- baseline environmental survey, rock jointing examination, engineering-geological surveys and temperature studies, hydro-geological studies to assess water supply sources of Udokan ore mining and dressing plant;
- engineering-environmental surveys and underground water monitoring at sites of Irkutsk Aviation Plant – branch of "Irkut Science-Production Corporation" OJSC;
- electric exploration by 3D near-field transient electromagnetic sounding and shallow near-field transient electromagnetic sounding at Kovyktinsky licenced site in Irkutsk region;
- engineering and geological surveys at gold ore deposits in Eastern Siberia (ZunKholbinskoe, Kirchenovskoe, Vladimirscoe, etc.);
- preparation of preliminary feasibility report for mining in coal deposits of Zabaykalsky Krai open acreage to supply branch of "Kharanovskaya State District Power Plant" with fuel.



1.2. Development of effective mineral dressing technologies, design and R&D support of ore dressing factories construction



University, together with enterprise of Science Park of INRTU "R&D Institute "Technologies of Mineral Dressing" LLC ("RDI TMD" LLC) performs R&D and scheduled works in field of mineral and man-made raw materials dressing, design of ore dressing factories and plants for all types of solid minerals, construction of ore dressing factories, engineering works, engineering support.

Technologies developed enable increase in ore dressing efficiency for rebellious ore by following means:

- thorough fundamental and R&D works and ore dressing characteristics in order to arrange rational and complex use of mineral resources;
- use of modern analytic and laboratory equipment for study of physical-mechanical and process properties of natural and man-made raw materials;
- development of completely new methods and ways of valuable components extraction from all types of solid minerals;
- use of internationally certified methods for study of ore preparation characteristics based on conditions of a specific deposit.

Technologies developed allow to increase stocks of Russian mineral resources base by means of innovative solutions in processing of man-made deposit and ore, introduction of state-of-art ore dressing equipment.

34 ore dressing plants were designed and commissioned for the last 10 years. This enabled to increase production by 10–12 tons per year in Russian gold mining industry alone (about 10 % of gold mined in Russia annually). Our enterprise completed 4 interna-



tional projects (two in Central Africa and other two in Kazakhstan), developed project on construction of one of the largest ore dressing plants at Vasilkovskoye gold deposit (Republic of Kazakhstan) with investments of USD 500 mln and 14 t/y capacity.

Currently, over 50 study and design contracts with various ore dressing facilities of Chukotka, Kamchatka, Magadan region, Republic of Sakha (Yakutia), Siberia, Ural, Murmansk region.

1.3. Underwater engineering-geodesic works



Federal State Budgetary Educational Institution for Higher Education "Irkutsk National Research Technical University" has modern R&D complex for engineering-geodesic underwater works.

This complex was developed in 2011 together with FSBI "VNII Okeangeologia" and experimental design bureau of the Russian Academy of Sciences and passed tests at Baikal lake successfully.

We offer following services:

- diagnostics and monitoring of underwater pipeline crossings;
- search of underground pipelines;
- hydrographic surveys of water bodies;
- search of foreign objects on bottom of water body in underwater crossing;
- determination of pipeline condition;
- engineering-geodesic landscape survey and determination of planned-highaltitude position of pipelines;



- examination of ship bottoms.

Our customers are: oil-and-gas companies, water and underwater facilities (oil- and gas lines, cable lines, dams, bridges, ship docks, ship-yards) service companies.

Technical specifications of the instrument complex:

- Linear frequency modulation Profilograph, allowing to obtain profiles of bottom sediments with the resolution of approximately 10 cm.
- Side-scanning sonar, intended to detect bottom sediments and firm shadow pattern of the bottom surface of 2 km wide in the course of the research ship travel.
- Controlled underwater TV camera allowing underwater imaging at depth up to 70 m.
- Multi-beam echo sounder, intended to detect bottom sediments at each beam and 3D mapping of bottom surface in the course of the research ship travel.
- Stand-alone bottom station allows monitoring of hydro-chemical and hydro-physical parameters of water environment.
- GPS/GLONASS navigation, coordinates measurement with 10 cm accuracy.

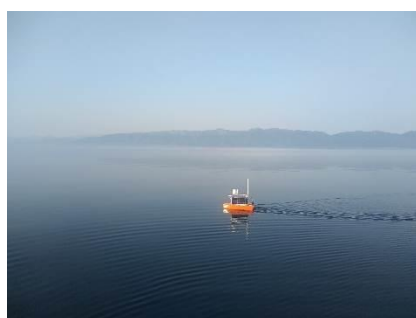
1.4. Robotic catamaran for environmental monitoring

Short description: A robotic catamaran allows performing a comprehensive automated operational measurement of main indicators of the quality of aquatic environment and atmosphere: composition, water and atmosphere properties, ocean biological resources. The catamaran follows a given route in the remote sensing mode of aquatic organisms and parameters of the surface water layer, and at reference points it measures the parameters of water and atmosphere. Thanks to the electronic anchor system, reference points are anchored with an accuracy of no worse than 2 m with respect to geographical coordinates. The time stamp for each point is set with an accuracy of 1 second thanks to satellite synchronization. The main advantage of the robotic apparatus is 24/7 areal measurement. Modern network technologies allow synchronizing and controlling the systems remotely from anywhere in the world.

Advantages: The project represents the development of technology and tools for robotic environmental monitoring of lakes and seas. Robotic systems can efficiently solve the



problem of monitoring of the ecological state of water bodies and ensure their environmental safety. The proposed mobile automatic complex of hardware devices and software products is intended for the collection, processing, storage, transformation, display and distribution of spatially coordinated information (hydrological, biological, chemical, etc.) about the characteristics of surface water and the near water air layer. The relevance of creating the automatic system is determined by the need for long-term comprehensive research and monitoring of the changing aquatic environment under condition of the optimization of marine expeditionary work.





1.5. Engineering support of well construction at raw hydrocarbon deposits in Eastern Siberia



R&D fields:

- development of cementing slurry according to geology-technical conditions of boring for casing cementing during well production;
- research and development of boring and cementing slurries based on industrial wastes by plants in Irkutsk region (Baikal pulp-and-paper plant, Bratsk forest industry complex and others);
- modelling, prevention and elimination of sidewall sticking during well construction in rough geologic environment;
- development and improvement of insulation compounds with fillers to prevent and eliminate circulation loss;
- boring solutions and process fluids for primary and secondary perforation;
- methods for prevention of water-oil emulsion formation during perforation.

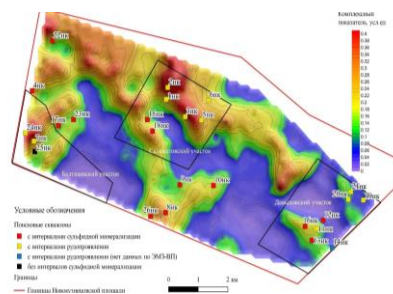
For the last 5 years, over 30 contract with oil and gas companies in the region and whole Russia were fulfilled – INK-SERVICE LLC, RN-Burenie LLC, Nedra LLC, AtlanBurService LLC, Vostok LLC, "NK Dulisma" PJSC, "Slavneft-Krasnoyarskneftegaz" LLC, "Bratskaya burovaya kompania" LLC, "Promyshlennaya Khimia" LLC.



1.6. Technology of electromagnetic sounding and induced polarization

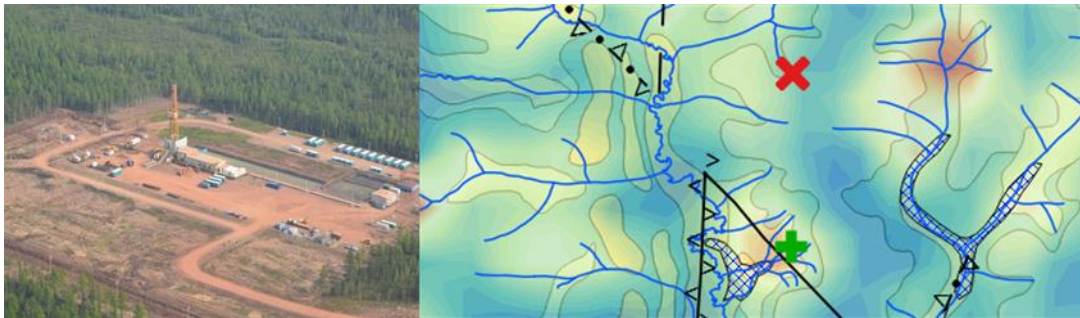
Short description: Scope: research of cryolithozone in solving engineering problems, including surveys during the construction of pipelines in the Far North; search and exploration of kimberlite diamondiferous explosion tubes blocked by spilled basalts (traps); location of ore bodies (gold, polymetals, etc.) in high-volume environments; search and exploration of underground water deposits; search for hydrocarbon deposits by the presence of polarizable sulfides over the deposits. The integrated use of the technology with seismic exploration allows increasing the probability of detecting hydrocarbon deposits up to 80%.

Advantages: Advantages of the technological complex: it allows detecting blind ore bodies (sulfides, polymetals, diamondiferous kimberlite pipes, etc.) blocked by high-capacity screens (granites, basalts, permafrost, etc.); allows lossless use of information on the form of transient processes that occur under the action of current pulses; allows reliable selection of low-contrast objects covered by overlying rocks with a thickness of up to 200-300 meters; works even in conditions of poor grounding (more than 100 kOhm); provides high resolution and sufficient dynamic range.





1.7. Geo-information technology "Gidropoisk" for survey works at underground water deposits



The University developed a technology allowing to optimize exploratory drilling and increase possibility for a well to get into water-abundant area by means of complex processing and analysis of different mapping and factual information available at first stages of geologic surveys.

Advantages:

- forecast quickness – making scientifically substantiated decisions on well locations, starting from pre-survey stage;
- high economic efficiency – allows to save up to 30 % of boring costs;
- high geologic efficiency – probability for wells to get into a perspective area reaches 80–90 %;
- independent from technologies of geopolitical rivals;
- easy interpretation of materials obtained;
- reduced costs for geo-information infrastructure.

The technology was successfully tested in the context of underground water search assessment works for multi-purpose water supply of Chonsk oil and gas facilities.

The project won first award in nomination "Best Innovative Product" in the competition "Inventor of 21st century" of All-Russian Scientific Festival 2014 (Irkutsk) and recognized as best product in section "Hydrogeology. Geo-information systems in hydrogeology" at 21st symposium "Aspects of geology and development of mineral resources" (Tomsk).

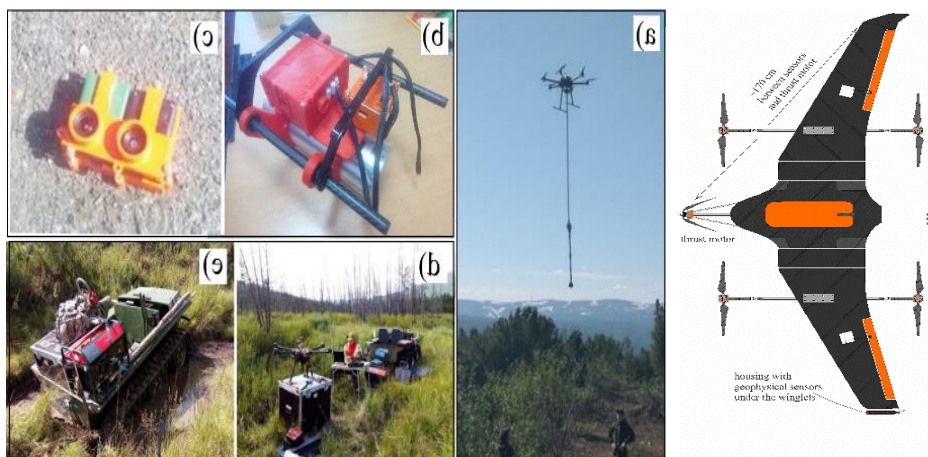


The technology proved efficient in complicated geologic-hydrogeologic environment, it can be utilized in various fields and adopted for hydrocarbon searching.

1.8. Technology of unmanned low-altitude geophysical survey

Brief description: Efficient technology of unmanned aerial geophysical surveying (using magnetic prospecting, gamma spectrometry, electrical reconnaissance, lidar scans with a solid-state lidar scanner, multispectral photography) has been developed to solve geological prospecting and other geological and related tasks. The technology provides conditioned results of geophysical surveys under complex landscape and morphological conditions at a speed significantly exceeding the pedestrian version of the method and with comparable data quality.

Advantages: High speed of work in any landscape-morphological conditions; high economic efficiency - 2-5 times cheaper than traditional methods; data quality meets the requirements for pedestrian photography; examination of objects inaccessible to terrestrial methods - ponds, thickets, etc.





1.9. Technologies of complex extraction of noble and non-ferrous metals from low-grade and refractory gold and copper ores



The project won the competition by Decree no. 218 by the Government of the Russian Federation (4th phase).

Implemented together with OJSC Group of Companies "Yuzhuralzoloto". Total financing amount is RUB 340 mln. Deadline: 2013–2016.

Aim: Organization of high-tech production with processing capacity of 400K t/y, obtaining at least 1.2 mln tons of gold and 1.4 K tons of cathode copper per year.

Planned results:

- development of sulphide gold- and copper-containing float concentrate autoclave lixiviation technology with capacity of 5 tons of raw material per hour (over 2 times higher than any international equivalents);
- development of technology for continuous high-temperature desorption of noble metals from activated charcoal providing increase in energy saving and process performance over 3–5 times compared to international equivalents;
- for the first time in all around the world, a technology for sulphide gold- and copper-containing float concentrate autoclave lixiviation with obtaining of cathode metal at raw material processing site;



→ other (6 new technologies in total).

The technology was developed in the context of "Development and introduction of complex extraction of noble and non-ferrous metals from low-grade and refractory gold and copper ores in Southern Ural deposits" (award-winning project in 4th phase of the competition under Decree No. 2018 by the Government of the Russian Federation).

1.10. Device for automatic measurement of gold concentration in cyanide solutions



Advantages of the technology:

- continuous measurement of gold content in the flow;
- small size;
- digital indication of current value of the parameter measured;
- manual and automatic calibration of the device;
- transmission of values as analogue signal a/or via RS-232/RS-485 interface;
- information output to PC display with remote control and device calibration feature.

Application scope: gold mining plants using such technologies as milling with cyanide, cyanic leaching, gold desorption and other.

The technology was developed in the context of "Development and introduction of complex extraction of noble and non-ferrous metals from low-grade and refractory gold and copper ores in Southern Ural deposits" (award-winning project in 4th phase of the competition under Decree No. 2018 by the Government of the Russian Federation).



1.11. Device for measurement of free cyanide in solutions and pulps



Advantages of the technology:

- continuous measurement of cyanide content in the flow;
- small size;
- submersible or flow-type;
- digital indication of current value of the parameter measured;
- manual and automatic calibration of the device;
- transmission of values as analogue signal a/or via RS-232/RS-485 interface;
- information output to PC display with remote control and device calibration feature.

Application scope: Ore-dressing plants using cyanide leaching, as well as device for control of harmful impurities in waste water.



1.12. Recuperative man-made waste recycling and soil reclamation technology



The university developed eco-concreting technology allowing to neutralize man-made wastes and to extract valuable components from them (gold, silver, arsenic and other).

Advantages:

- simple (does not require complex process equipment);
- the prime cost is 1.5–2 times lower than any analogues from Russia or other countries.

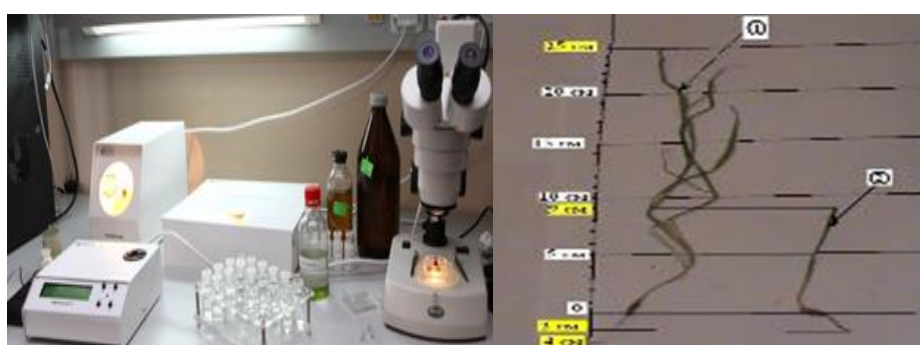
The technology successfully passed the appraisal during implementation of project for recycling of 200k tons of arsenic production wasters in Svirsk city, Irkutsk region 13.5 ha of land was recultivated, 280 mln roubles were used.

The project was awarded with gold medal "Warranty of Quality and Safety" at international salon "Complex Safety 2011" (VDNKh, Moscow city). The project won "National Environmental Award 2009" (hosted by RAS) in the nomination "Science for Environment".

The technology can be used for recycling of accumulated bottom ash waste of TPP, sludge-lingin from pulp-and-paper productcion (including Baikol Pulp-And-Paper Plant), manmade waste of Usoliekhimprom LLC, waste of ore mining and processing facilities (Korshunovsky and Darasunsky Ore Dressing Plants and other), wastes of hydrometallurgical production (Irkutsk Aluminium Plant OJSC, Bratsk Aluminium Plant OJSC and other).



1.13. Modified organic-mineral complex for reclamation of arsenic-containing soil



Processing of toxicant-contaminated soil with the offered preparation (solution of lime milk, humic preparation (Gumat-80) in proportion off 1:3) allows to bind heavy metals and arsenic into insoluble forms hard-to-access for plants, thus decreasing soil toxicity to regulatory levels.

Appraisal: Pilot testing were performed at household plots of municipal settlement Svirsk city, decree no. 2546903 on issuing patent for this organic-mineral complex was granted.

Figure no. 2 shows samples of grown oat for determination of phytotoxicity of arseniccontaminated soil of gardening lots in municipal settlement Svirsk city after (1) and before (2) treatment with detoxicating preparation.



1.14. Accredited laboratory for ecological monitoring of natural and man-made environment

POCC RU. 0001.518897



Complete quantitative chemical and agro-chemical analysis of environmental objects and industrial waste by accredited methods (over 250 components).

R&D and monitoring works, environmental support of design and process works in environment-saving field. Distinctive feature of the laboratory is analysis of any industrial waste with high content of contaminants by specially developed methods.

1.15. Resource-saving technologies for exploitation of mineral deposits, including coal, gold, construc- tion materials





"Gornyak" design bureau of INRTU develops and introduces new resource-saving technology and process designs improving production capacity and environmental friendliness of mining works.

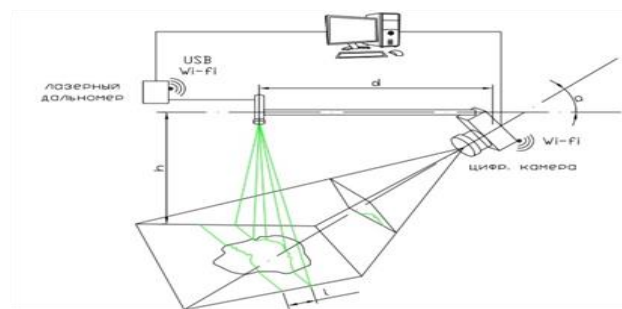
The projects developed provide the following:

- decrease of mining land-consumption to 20–30 %;
- decrease of waste water dumping by 15–25 % and loss of minerals 10–20 %.

Annually, patents are granted for newly developed technologies.

For the last five years, the projects designed were successfully introduced to "ALROSA", "Verkhnechonsk-neftegaz" OJSC, "Irkutsk Oil Company" LLC, "Lenzoloto Oil Mining Plant" CJSC, "Bratsk Ferro-alloy plant" LLC, "Marakan", "Svetly" CJSC, "Sibirsk-Ural Ore Mining Company" LLC, "Sakha-ruda" LLC, "KNAUF GIPS BAIKAL", CJSC "LenaBamstroy" Managing Company, "Buryatugol" LLC, "GGK Bilibino" LLC, "Baikalruda" CJSC, "Transugol" LLC, "Regional Housing and Communal Services" OJSC and others. Over 70 projects in total.

1.16. Development and research of technology of volume survey control in indoor storages and conveyors



Most mining and processing plants utilize indoor storages in ore dressing/processing chain. Monthly, surveying service is required to determine volume of stored raw mate-



rials in such premises. Such works are related to many difficulties: mainly confined areas, many obstacles (walls, partitions, etc.), moving along the raw materials themselves are often obstructed.

This complicated and labour-consuming task nowadays is solved by means of onground laser scanning, but the laser scanning system costs a lot, and not many plants can afford it. This caused members of the surveying department and geodesy of the university to developed another imaging method.

Department specialists developed a prototype of system allowing to image vertical sections automatically. General design of the prototype consists of calibrated digital camera, laser surface plotter and laser ranging device. The system is mounted on moving platform that can travel along whole storage building.

Currently, an experiment confirming working efficiency of the technology. Difference of result obtained by new method and result of on-ground laser scanning is within range of 0.1 %.

Solving task of surveying volume control at indoor storages will significantly facilitate surveyor's work, increase work quality and response speed and will improve planning of the enterprise process chain in general.

The offered technology can be used in neighbouring industrial fields, such as grain amount accounting, vehicle load control, etc.

1.17. Technology complexes for diagnostics, cleaning and repair of special pipelines





6 Russian patents for this design have been granted.

The university developed technology complex including equipment for pipeline condition diagnostics, cleaning from sediment, preparation of pipelines for anti-corrosion coating, application of protective coating with required parameters to inner surface of pipelines. Competitive advantage:

- quick trenchless repair of pipelines (the access to the pipeline is provided at surface at flange connections with fasteners);
- feature of diagnostics and restoration of pipelines with branches and elbows;
- 5 time decrease in repair costs;
- increase of pipelines service life from 5 to 10 years;
- possibility of wide use of the technology in household and utility systems.

The complex is successfully used at major plants:

- "Bratsk Aluminium Plant" OJSC.
- "Angarsk Oil-Chemical Company" OJSC.
- "TNK-VR Management" OJSC.

1.18. Process and design support of construction and update of low-capacity plants for primary crude oil processing to supply fuel to hard-to-reach regions and deposits





R&D fields:

- design and update of mini oil refineries and process equipment;
- development of effective additives for motor fuel and new methods of oil desulphurization;
- development and implementation of resource and power supply activities, optimization of oil refining process;
- development and adaptation of methods for quantitative and qualitative oil products and other organic compounds analysis to production process conditions.

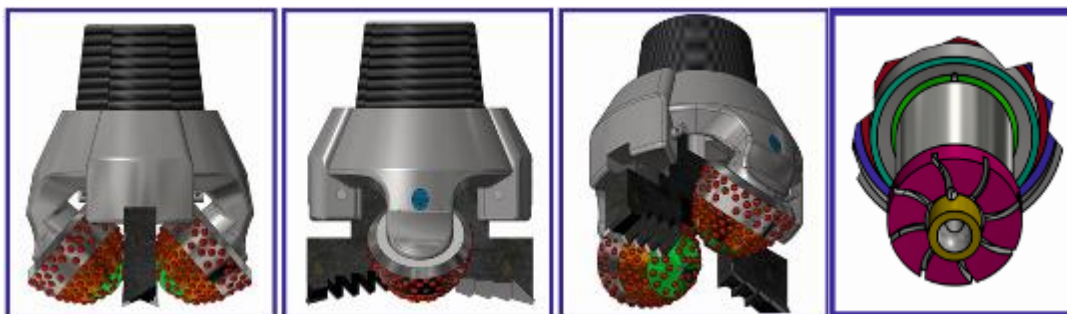
Introduction of R&D results allows to improve following qualitative characteristics of mini-refineries oil products:

- increase of light oil products;
- increase of qualitative characteristics of the oil products obtained;
- decrease of sulphur content in oil products.

The works are performed under following orders: Angara Petrochemical Company OJSC, DITEKO Production Company CJSC, Kaskad Oil LLC, Albion Grupp LLC, Sayanskkhim-Plast OJSC, Sakhaneftegazsbyt OJSC.

For the last 5 years, amount of R&D performed under orders by abovementioned enterprises was over 10 mln rub.

1.19. Combined drilling bit



Annual expenses of mining plants for drilling tools are 6 ÷ 6.5 bln rub. This is why it is required to significantly reduce drilling expenses.



This issue is most relevant for mining enterprises in Siberia, Yakutia, North-Eastern Russia (ever-frozen rock masses, complex structure with sandwiched rock layers with different physical and mechanical properties (hardness coefficient 1.5–15).

Use of developed combined roller cutter drilling tool allowing to perform drilling in differential hardness rocks and providing normalization of temperature conditions during drilling.

The developed tool allows to improve performance of a drilling rig to 50 % and decrease cost of well line meter passage to 30 %.

Main features of the tool:

- longitudinal travel along the cutting bit body, allowing to destroy weaker rocks with the most effective method – shearing with frontal cutting edge, and, when meeting hard layers and patches, moving inside the body, providing rock destruction mainly with abrasion wheels in this case;
- limitation and regulation of axial force transferred to cutting tool by spring, installed inside the bit body, preliminary compressed with nut;
- cutting tools can be replaced if worn down;
- free flow and directionality of compressed air into drilled depth to rock-destructing tools for efficient cleaning of drilled depth from debris.

1.20. Development of a towed system of electromagnetic sounding of the seabed for a shallow shelf with the ability to work in freshwater pools

Short description: The development is intended for conducting electrical exploration with electromagnetic sounding methods in shelf zones. The development is a system towed by a marine vessel, consisting of a positioning system as well as generating, research, receiving and software complexes.

Advantages: Using a towed electromagnetic system in the engineering survey complex will make it possible to obtain geoelectric sections, maps and three-dimensional models of the shallow shelf zone and the bottom of freshwater reservoirs. This information combined with echolocation and seismic data will significantly increase (up to 90% or more) the probability of identifying potentially dangerous geological formations: accu-



ulations of gas hydrates, gas pockets, active fault zones and areas of permafrost development at depths of up to 150 m with a sea depth of up to 50 m. Up to 90% increases the likelihood of drilling confirmation of the presence of potentially hazardous objects, which allows to reduce the volume of drilling by at least 30%.

High-quality engineering surveys increase the safety of construction work and reduce the accident rate during the construction and operation of shelf facilities. Monitoring is necessary to identify changes that are potentially dangerous for production facilities in the geological section.





2. ELECTRONICS. ENERGETICS. ENERGY SAVING

2.1. Planar nanostructured heating elements



Project won programs "START - 2010", "START - 2013", innovative projects competitions hosted by Irkutsk region and Irkutsk city administration, and also won first and second Baikal Venture Fairs.

Competitive strengths:

- decrease in power consumption by 35–40 %;
- high fire and electric safety;
- self-regulated power consumption.

Application scope: warm floors, wall panels, radiator heaters, therapeutic heaters, mobile cooling units, workwear/clothing stand-alone heating devices, stand-alone light indicators, stand-alone setback and emergency lighting, recuperating plants, power-saving life support systems.

Obtained series of certificates of conformance by Gosstandard granting right to export products abroad.



In 2010, investment contract was executed with Pusan National University (South Korea) with planned investment amount up to USD 1.2 mln. Currently, series of low-temperature heating elements was developed for various life supporting systems, joint Russian-Korean venture was established.

The developed heating elements were used to create an experimental energy-saving system for yurt heating, which was equipped in 155 yurts of Ulan-Bator city (Mongolia) in 2011 and 2012. For 3 years, tests proved energy saving effect of over 40% and undeniable advantage over other analogues in reliability and durability. Obtained certificate for serial production No. POCC RU.XП28.B08042. In future, over 160 yurts must be equipped with the system (planned sales amount for nearest 3 years can be about USD 32 mln).

Implemented project for effective energy-saving system for electric transport with over 50 % energy-saving effect. The tests were held at trolley bus park of Irkutsk city, resulted in obtaining certificate for serial production No. POCC RU. XП28.B08042.

Completed development of new type of heating equipment fro premises with varying climatic environment (concession stands, train stations), for premises with critical climatic environment (preschool facilities, explosion- and fire-hazardous premises). The device can be used for household purposes instead of oil and convective heaters, obtain certificate for serial production POCC RU. АГ92.B06824.

Development of new type of hot plates at glass ceramic surface is at completion stage, eliminating all disadvantages of existing hot plates: lack of low-temperature heating, lack of smooth transfer from various temperature modes, energy saving effect over 22 %.



2.2. Technology of electro-impulse crushing, treatment, purification and plasma spheroidization of quartz particles



A technology allowing to manufacture products (spherical quartz granules and crushed quartz) with primary cost 1.5 lower than analogue ones and with higher purity (about 99.995 % for the base material).

In 2011–2012, the developed technology was implemented in the facilities of "Carboprocess" LLC (Zelenograd city). Launched pilot granule production with the capacity up to 500 tons per year.

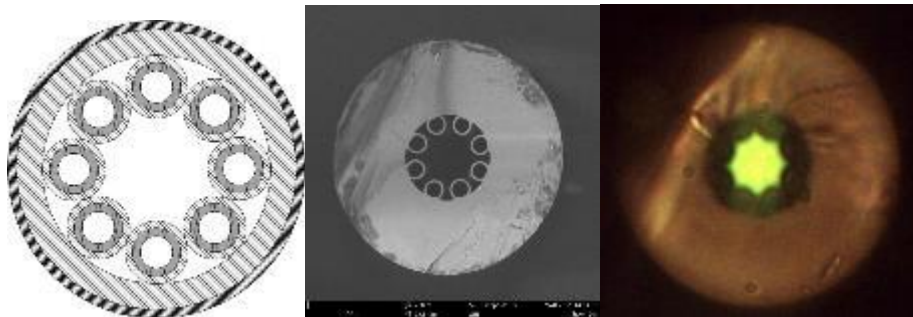
Full-scale industrial production of spherical quartz granules and crushed quartz using the developed technology will provide the output of more than 5 thousand tons per year (about 10 % of world demand).

Also, the developed technology can provide basis for fibre glass production in Irkutsk region with production volume of about 10 mln km/year, as world market demand is 200 mln km/year.

The technology has been developed in the context of "Organization of high-purity spheric quartz granules for electronic component base of the Russian Federation" project (won award in 1st stage of competition according by Decree No. 218 by the Government of the Russian Federation).



2.3. Microstructured hollow fiber light conductor with dynamically adjustable optic properties



Russian Foundation for Basic Research 2014–2015 Competition winning project.

Technology advantages: Using the developed fiber guide as a base technology, it is possible to create the following:

- adjustable spectral filters;
- dynamic fiber Bragg gratings;
- switches and polarization rotators;
- sensors for various physical quantities.

The fibre guide is intended for:

- localization of high optical power radiation;
- transmission of light in a wide spectral range, including THz range.

Advantages of the light-orientation-based control mechanism:

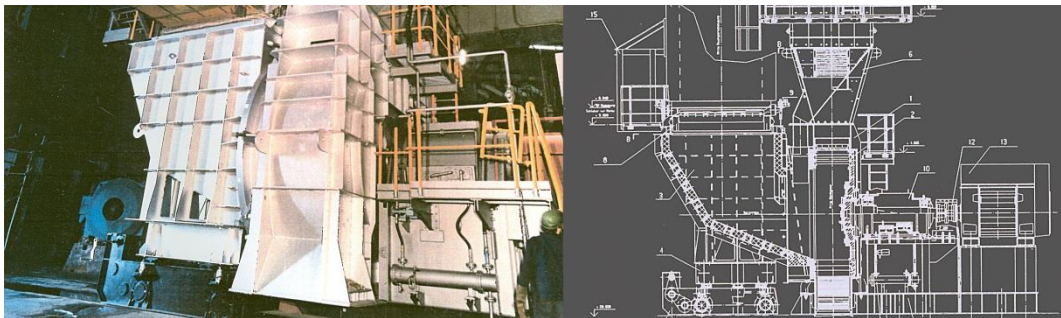
- high stability;
- low energy consumption.

Application scope:

- creation of new optics and photonics devices such as lasers, quantum amplifiers, controllers of radiation characteristics, spectral and mode filters;
- transmission of high optical power radiation in a wide spectral range.



2.4. Increasing explosion and fire safety of pulverized coal preparation systems of thermal power plants



A complex of reconstructive measures is proposed to improve pulverized coal preparation systems of power-generating boilers with calculated maximum pressure of coal dust explosion of (0.35 MPa).

The purpose of the reconstruction is the elimination of burst relief devices, fire emissions from which pose a threat to personnel, cause fires and secondary explosions in the boiler room.

In order to reduce metal consumption during reconstruction, a number of original components and design solutions have been developed.

Projects are carried out in accordance with the requirements of "Regulations on Explosion Safety of Fuel Supply and Pulverized Coal Conditioning and Burning Systems" (RD 153-34.1-03.352-99):

- all components of the pulverized coal system located in the boiler room are calculated for the pressure of 0.35 MPa;
- in the case of a pulverized coal system with a storage hopper, components located outside the premises of the boiler shop and equipped with burst relief devices calculated for the pressure of 0.15 MPa;
- the maximum permissible stress is assumed to be equal to the yield strength of 240 MPa for Article 3 as the most common material for pulverized coal systems.



As of today, the university has completed and put into operation reconstruction projects for all types of pulverized boiler coal preparation systems:

- BKZ-160-14 (Ulan-Ude CHPP-2);
- BKZ-160-100, BKZ-210-140, TP-81, TP-85 (E-420-140) (Irkutsk CHPP-11);
- BKZ-320-140 (Irkutsk CHPP-6);
- BKZ-420-140, BKZ-500-140, BKZ-820-140 (Novo-Irkutsk CHPP);
- TP-81, TP-85 (E-420-140) (Irkutsk CHPP-9);
- PK-24 (Irkutsk CHPP-10);
- BKZ-75-39 FB (Irkutsk CHP-16);
- BKZ-420-140 (Ust-Ilim CHPP);
- PK-10 (Irkutsk CHPP-1);
- TPE-215, BKZ-640-140 (Gusinoozyorsk SDPP);
- TPE-215, BKZ-640-140 (Khabarovsk CHPP-3).

2.5. Large-scale information and measuring system for heat consumption accounting using GPRS technology



An information and measuring system for heat consumption accounting, providing:

- collection of data from heat meters over cellular networks;
- heat consumption information processing;



- provision of technical, financial and economic reports via the Internet to the operator, the enterprise management, concerned authorities and organizations;
- analyses of thermal conditions of the objects for a certain period based on comparison of actual consumption with estimated one;
- performance of parallel control over "Fire" and "Security" sensors with immediate reporting to the operator;
- possibility of counting of other resources (cold water, electric power, gas).

Main advantages:

- unlimited number of assemblies and consumers;
- communication from across Russia;
- high ease of implementation;
- low cost of turnkey solution;
- developed analytical possibilities.

In Irkutsk 2720 heat metering units of 3250 successfully use this system.

Nowadays the system is tested in 10 regions of Russia.

The system implementation in INRTU allowed to reduce cost of utility services on 37.5 % (saving in cost is 13.5 mln rub per year).

2.6. Solar collector SUN 1

Short description: The flat solar collector SUN 1 is designed to convert solar energy falling on its surface into thermal energy, which in turn can be used for heating and hot water supply systems.

Advantages: simple design; meander-shaped tubes provide a higher temperature at the outlet of the collector; increased thermal insulation properties allow its use in colder regions; use of local materials to simplify and reduce manufacturing costs; dismountable design allows its repair and replacement of individual parts, which reduces the need for its complete replacement.



2.7. Energy-efficient smart lighting control system based on a self-organizing wireless network



The project is the winner of the Competition of innovative projects held by the Government of Irkutsk region.

The university developed a conceptually new wireless system that control lights dynamically depending on the natural lighting and the presence of moving objects.

Advantages:

- The developed system makes it possible to reduce energy consumption by up to 70 % and increase the service life of lamps by up to 50 %.
- Flexibility (the system can be used to control lightning with incandescent lamps, LED and fluorescent lighting fixtures).
- Reduction of energy consumption for lighting up to 70 %.



- Increase the service life of lamps by 50 %.
- Cost is lower than for commercially available equivalents by 1.5 times.
- In comparison with equivalents, the payback period of the system is reduced by more than 2 times.

The use of wireless technology for building self-organizing networks does not require laying of dedicated communication lines, or connecting to existing ones, which provides for significant speed-up of installation and adjustment of the lighting control system, as well as eliminates significant capital costs associated with laying dedicated communication lines.

The wireless network is easily scalable and does not require reconfiguration when new lighting fixtures are connected to the existing network.

The developed system can be used to control lighting of administrative and residential buildings, industrial sites, highways, parks, squares, etc.

Currently, negotiations are underway on the implementation of the system at the Irkutsk Aviation Plant, a branch of Irkut NPK JSC and ALROSA Airlines.

2.8. Power quality monitoring and management



INRTU has 25 years of experience in the field of study, measurement and analysis of electric power quality and electromagnetic compatibility in electric power systems of Siberia and the Far East of Russia.

For the first time, the Department of Power Stations, Networks and Systems developed a unique set of methods and software for calculating the contributions of electrical



energy consumers to general voltage distortion. There are measuring devices and software for performing experimental and design work in the field of electric power quality and electromagnetic compatibility.

The following types of monitoring are carried out on the basis of the developed methods:

- Monitoring the indicators of electric power quality at various facilities of electric power systems, developing measures to improve electric power quality indicators.
- Monitoring of the electromagnetic environment at various facilities of electric power systems, developing measures to improve reliability of electrical equipment.
- Monitoring of induced voltages on disconnected 110, 220 and 500 kV overhead lines to ensure safety during the performance of work on the lines.
- Monitoring the causes of increased damage to 110, 220 and 500 kV power lines and developing effective methods for determining the location of damage to lines to reduce the time for their repair.

Area of application: generating and power grid companies, power supply systems of industrial enterprises, external power supply systems of Russian Railways OJSC.

Over the past 5 years, the University has performed more than 10 contract-based works on commission of Irkutskenergo OJSC, Irkutsk Electric Grid Company OJSC, Russian Railways OJSC, Usolie-Sibirsky Silikon LLC, etc.



2.9. Power and power-engineering surveying of enterprises and organizations



In a collaboration with INRTU Technopark Testing Centre Energoeffektivnost LLC, the University performs research works in the field of developing and implementing measures to improve energy efficiency of enterprises and organizations, including:

- Optimization of thermal and hydraulic regimes of heat supply systems and systems of heating, ventilation, air conditioning of buildings based on the results of the survey.
- Design, implementation and technical support of energy-saving systems, including developing autonomous heating systems using renewable and unconventional energy sources.
- Developing measures for the adjustment and improvement of boiler efficiency; developing thermal behaviour diagrams.
 - Improving the efficiency of solid fuel combustion in bed furnaces with vortex flue movement.
 - Preparation and incineration of wood waste.
 - Recycling and incineration of waste oil of internal combustion engines.
 - Technologies for combustion crude oil and gas condensate.
 - Introducing muffle burners to improve the efficiency of combustion processes when burning solid and liquid fuels.
 - Developing and introducing production waste incineration technologies, including lignin incineration.



Technologies created and developed by the university make it possible to significantly increase the energy efficiency of heat and water supply systems and energy consumption through the use of innovative and renewable energy sources and loss reduction:

In recent years, the Innovation Centre has performed work on development and implementation of energy saving measures in steam supply and heat consumption systems of various facilities of Angara Petrochemical Company OJSC, Irkut Scientific and Production Corporation OJSC, Baikalsk city heat network, heating and water supply systems of Irkutsk-2 microdistrict and others, increasing the efficiency of boiler units.

2.10. Development of heat supply, water supply and drainage schemes



The University performs research in the field of survey, analysis of trends and factors of prospective development and creation of heat supply schemes, water supply and sewage schemes of municipalities in accordance with Federal Laws No. 190-ФЗ "On Heat Supply" and No. 416 "On Water Supply and Sanitation", as well as work on assessment and justification of heat and heat transfer agent losses in heat supply systems, unaccounted expenses and water losses in water supply and sanitation systems, including:

- carrying out documentary and instrumental survey of the systems, computational analysis;
- research and assessment of trends in prospective development of municipal settlements;
- projecting long-term balance plans for heat supply, water supply and sewage;
- developing measures to optimize and improve the efficiency of system operation;



- developing heat supply schemes; water supply and sanitation schemes of municipal settlements and resource providers.

In recent years, the innovation centre has carried out work on developing heat supply schemes for Baikalsk city and municipal settlements of Cheremkhovsky and Ust-Ilimsky districts; water supply and drainage schemes for Angarsk city; municipal settlements Bolshelugsky and UstOrdynskoe; estimation of losses and unaccounted water consumption in the water supply system of Irkutsk city.

2.11. Electro-explosive technology for end termination of electrical connections



An innovative development in the field of electric power engineering, which consists in creating electrical connection of cores of wires and cables during electrical installation by an electro-explosive method, which ensures reduction of electrical energy losses in power distribution networks.

Implementation of this method allows for more reliable and high-quality connection of cable lugs for a cable core by ensuring the weldability of the inner surface of the lug and the outer surface of the cable core during their installation and operation in the electrical equipment of enterprises.

Unlike existing equivalents, this is the only method that provides welded joining of components without requiring the provision of the required welding conditions (tempera-



ture, humidity, inert environment), and also makes it possible to connect heterogeneous poorly weldable parts (for example, copper and aluminium).

Fire and explosion safety are ensured during installation.

Competitive strengths:

- the technology keeps a low level of transitional resistance throughout the entire service life (reduction of electric power losses on the lines);
- the cost of electric power to perform a single connection is $0.01 \text{ kW} \cdot \text{h} \approx 0.015$ roubles (50 times lower than that of available equivalents).

2.12. Hardware and software system to detect leak location in pipelines



Competition winning project: UMNİK, BritishPetroleumRussia, StartupTour 2016 ("Computer Science" section).

Project summary: the hardware and software system is designed to monitor leak tightness of pipeline systems and is aimed at the prompt determination of the location of a leak.

Advantages of the technology:

- reduction of losses of substances transported through the pipeline through prompt detection of leaks;
- human usability of the hardware and software system, as well as its adaptability in accordance with the consumer's requests;
- non-susceptibility to the influence of external noise on the measurement results;



- possibility of replacing imported technology with domestically produced;
- in the future, the development may find application in the field of hydrocarbon transportation (major oil and gas pipelines).

Project partners: Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences (ISEM SB RAS).

2.13. Hardware and software system “Microvisor”



START-2016 Competition winner.

Portable microvisor for microscopy in reflected light in visible, ultraviolet and infra-red range with optical magnification up to 200x.

Together with the software package, the system makes it possible to measure geometric dimensions and quantitative assessment of the materials in the image.

It can operate connected with any portable storage, output or data transfer device that has a USB port (PC, smartphone, tablet computer).

Application scope:

- assessment of the condition of steel structures and products at industrial enterprises during non-destructive testing;
- evaluation of evidence materials during investigative measures and forensic examinations;
- assessment of the share of useful minerals in mineral ore;



- evaluation of materials and samples in metallographic studies;
- veterinary checks (including as a trichineloscopy equipment with the use of additional accessories);
- verification of authenticity of signatures in banks and various organizations, during electoral campaign, if requested by court;
- determination of the personality psychotype based on the analysis of the shape (imprint) of the signature.

2.14. Method of determining the location of a short circuit on a 110-500 kV overhead power transmission line with non-synchronized measurements at its two ends



Operating principle: A widespread method of locating a fault in power lines is based on measurement of vector values of currents and voltages at the ends of the line to determine the fault location. The large error in determining the location of damage arises from the fact that the measured values at the ends of the line are unsynchronized in time. In recent years, the method of synchronization via satellite communications (GPS, GLONASS) is increasingly used. The use of satellite communications is expensive and has not yet gained widespread use in Russia.

A different method is proposed for synchronizing voltages and currents at the ends of overhead lines using a replacement circuit. The synchronization method using a replacement circuit was developed at INRTU's Power Station Department.



Competitive strengths:

- The error in determining the fault location during a real short-circuit on a 110 kV overhead line did not exceed (1–2 %).
- No special equipment required. Standard current transformers, voltage transformers and standard current and voltage detectors are used.

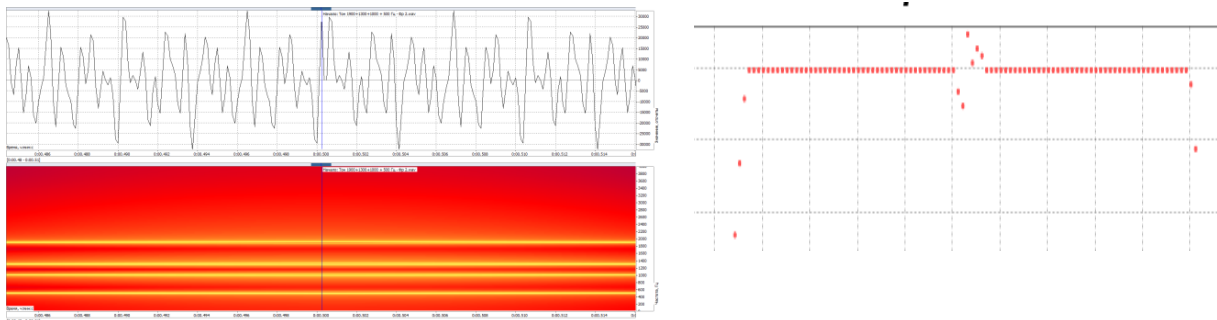
Application scope:

The method is applied on 110–500 kV overhead lines.

2.15. Algorithmic and software used for identifying signs of audio recording editing

Short description: One of the tasks that arise during phonoscopic forensic examination is the identification of editing in audio recordings submitted as evidences. Standard test methodology aimed at detection of editing in audio recordings is a quite long and laborious process. The present technology uses network platforms to detect the signs of editing and also demonstrates the reliable existence of a marker, a metric that responds to editing audio recordings.

Advantages: High-performance automation of the search for recording editing.





2.16. Hot-water boiler with pneumatic firebox

Short description: Organization of the vortex method of burning on a small-capacity hot water boiler of previously prepared solid fuel - sawdust and coal can be used in the power system of the industrial, municipal and agricultural sectors of the economy. The invention is based on the idea of the development of a hot water boiler with a pneumatic firebox, which does not require the use of mechanical furnace devices. The elimination of the furnace device is achieved by preliminary preparation of the fuel and the use of a combustion chamber; the configuration of the latter allows full filling of the furnace volume with flue gases and forming a stable vortex flow with a horizontal axis, for which a lower blast nozzle is located in the lower part under the rear screen, which directs the flow of heated air towards the fuel supplied from above. Preliminary preparation of the fuel allows the vortex flow created in the combustion chamber to keep the ignited particles in the vortex, which allows to achieve the minimum values of the mechanical underburning of the fuel and the minimum indicators of harmful emissions into the atmosphere. Located in the lower part of the combustion chamber, a fixed grate with secondary blast in the amount of 5-10% of the total air supplied to the furnace ensures the burning of dips, thereby reducing the mechanical underburning of fuel. The gas outlet window is located in the upper rear part of the combustion chamber, which allows for a very compact layout of the furnace with a convective gas duct and to avoid additional lining. The present invention is featured by the fact that the pneumatic furnace is used on a hot water boiler containing no afterburning chamber in its construction, while the gas outlet window is located in the upper part of the combustion chamber. The mouth of the gas outlet window of the combustion chamber is blocked by a discharged tube bundle of the furnace top screen - festoon, which is made in the zone of passage of flue gases from the finned tubes. The finned tubes are installed in the direction of movement of the vortex with an inclination of 45 - 50 degrees down to the rear wall of the furnace, which provides an obstacle to the removal of unburned particles into the convection duct.

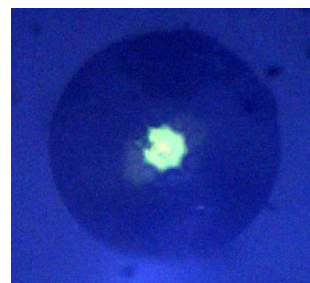
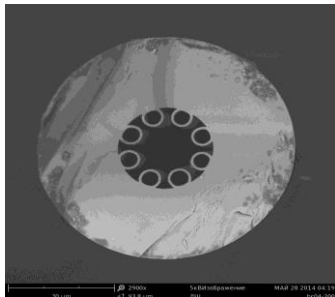
Advantages: use of various types of fuel; increased efficiency; reduction in equipment operating costs; reduction of harmful emissions into the environment; autonomy; the possibility of use in all areas of economic activity; the cost of equipment is lower than the nearest market analogues.



2.17. Microstructured fiber light conductor with a hollow core of negative curvature as a promising material for the creation of photonics devices in the near and middle IR range

Short description: The project is dedicated to the development of scientific principles for creating photonics devices based on a micro-structured fiber with a hollow core of negative curvature, the shell of which is filled with media with different physical properties. The light conductor proposed in the project has a simpler design than other types of micro-structured conductors. The radiation in the conductor is localized in the region of the hollow core and a waveguide mode is organized in a wide spectral range from UV to mid IR.

Advantages: Based on the proposed technology, it becomes possible to manufacture a wide range of photonics devices - controlled attenuators, tunable optical and terahertz broadband filters, tunable polarizers to operate in a wide spectral range from visible to far infrared, devices for manipulating high optical power radiation, quantum amplifiers and generators, sensors of physical quantities.





2.18. Implementation of Building Information Modeling (BIM)

BIM definitions from various sources: “Building Information Modeling is a digital representation of physical and functional characteristics of an object, creating a co-shared information resource of the given object and forming a reliable basis for decision-making throughout its life cycle, from early concepts to disposal.” (National BIM standard: version 2. US National BIM Standards Committee (NBIMS), 2014).

Short description: Building Information Modeling (BIM) is a process of collective creation and management of information about a building or structure, which forms a reliable basis for decision-making throughout its entire life cycle. BIM technologies allow creating digital (information) models of structures under construction (buildings, bridges, etc.) at all stages of the life cycle, from research, design, operation up to disposal.

Advantages for builders: The use of technology by construction organizations allows to achieve as follows: significant cost savings during the construction phase; reduction in operating costs; improving planning accuracy and transparency; reduction of temporary losses for internal approvals; providing a common vision of project objectives by all its participants.

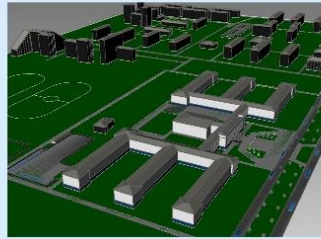
Advantages for designers: acceleration of the process of coordination of design decisions; multivariate elaboration of a conceptual model: assessment and comparison of space-planning indicators at the stage of a building’s concept development (construction volume, estimated and total area, specific volume indicators); efficiency of transferring design information between disciplines, variability of decisions, reduction of design time by 40%, resolution of conflicts, high quality of project documentation; minimization of project errors: identification of conflicts before the construction start allows reducing the cost of construction up to 10% as well as minimizing the risks associated with litigation; reduction of time for estimates development up to 80%, accuracy of calculations up to 3% -5%; visual representation of the project model to various participants.



Совмещение видов и сферических панорам



Создание информационной модели ИРНТУ



Создание информационной модели ИРНТУ



Моделирование инженерных сетей и расстановка санитарно-технического оборудования

Создание информационной модели ИРНТУ



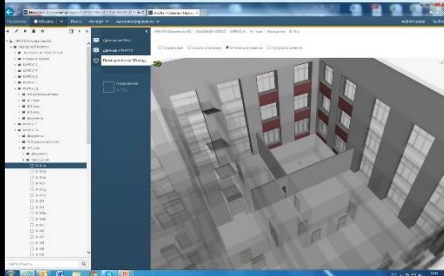
Моделирование инженерных сетей и расстановка санитарно-технического оборудования

Создание информационной модели ИРНТУ



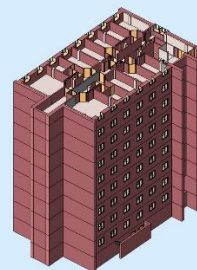
Моделирование инженерных сетей и расстановка санитарно-технического оборудования

Пример представления информации в системе
Неосинтез



Создание информационной модели ИРНТУ

Архитектурная
модель общежития
№13





2.19. Underwater wireless instant messaging system between divers

Short description: An underwater wireless navigation and messaging system between divers is intended for use by divers during repair works, inspection of underwater objects and engineering networks, rescue operations, search and monitoring works, underwater archeology, geodesy, supervision by the head of underwater operations and divers' location and status; can be used by amateur divers by recreational diving. Providing divers with the possibility of communication and navigation in the absence of communication cables has undeniable advantages consisting in better ergonomics during underwater operations. The project aims to develop and create a Russian navigation and communication system through the sonar channel for divers. When carrying out diving operations, reliable communication among divers themselves as well as with a diving operations manager located on the surface is very important. In case of simultaneous work of a group of divers, this problem is extremely difficult to solve using traditional conventional signals or wire telephone systems. Wireless communication, helps to increase the efficiency and coordination of actions, the speed of decision-making, the prevention and efficiency of assistance to the diver in emergency situations, all this helps to optimize costs.

Advantages: The most widely used wireless communication systems for divers are complexes produced by Ocean Technology Systems and Ocean Reef companies; they consist of a base station and underwater communication devices for divers. The complexes do not have navigation facilities and provide only voice wireless communication at ranges up to 200 meters. The disadvantages of voice systems include a significant dependence of the quality of signal reception on the presence of natural and man-made noise arising during underwater operations of divers, speech distortion, errors and extraneous noise in the transmitted voice message; divers and operators can furthermore miss or not hear the voice message due to external noise or distractions.



2.20. Hardware-software complex to account and control access to hand tools

Short description: Hardware-software complex to account and control access to hand tools allows keeping track of access to storage units for tools and to the hand tools directly. Application of this system eliminates the possibility of unauthorized access to hand tools, reduces the human costs for tools issuance, detects the fact of tool damage through identification of a user and time of tool relocation.

Advantages: User identification by access to storage units along with the record-keeping system of tool relocation; use of a remote server with information transfer via GSM; use of special tags to access tool storage units as well as to control tool relocation; event timekeeping and provision of statistical information about system operation. The system assumes the possibility of expansion up to the n^{th} number of nodes with access control to storage units, availability of a GSM module, RFID tags.



Figure 1 – Hardware-software complex



Figure 2 - RFID tags

Метки инструмента		Добавить метку	
10 сообщений на странице		Поиск:	
Галечный розовый ключ 12 мм	44444444444444	На складе	Редактировать Удалить
Сварочный аппарат МСПТ-160У4	8255233137	На складе	Редактировать Удалить
Торцевой ключ 18 мм	152019889	На складе	Редактировать Удалить
Торцевой ключ 19 мм	8888	На складе	Редактировать Удалить

Показано с 1 по 4 из 4 сообщений

Предыдущая 1 Следующая

Figure 3 – Sample page of test tools for a web application

2.21. Database “Electronic passport of office equipment”

Short description: The developed application allows keeping track of computing and office equipment location on the territory of the organization, technical condition, availability and type of parts and peripheral devices. The application enables to keep record of existing software, view stocks, components, etc.

Advantages: cross-platform accounting system that does not use outdated libraries such as jquery (a own library is developed for query generation) and is therefore open for transfer even to mobile platforms with other implementations of SQL language (PDO merit); dynamic generation of possible values of elements depending on users’ actions without



page reload with AJAX mechanism to unload the server (no need to provide the client all the data at once); dynamic generation of lines for categories of hard- and software to ensure future use of the application even when in an organization there will be workstations with several storage devices, multiple monitors, many peripherals and large number of programs; dynamic generation of event handlers for new elements on a page; generation of output documents in a format unsuitable for editing to reduce the chance of its easy fake.

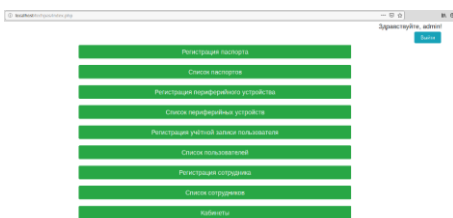


Figure 1 – Administrator's desktop

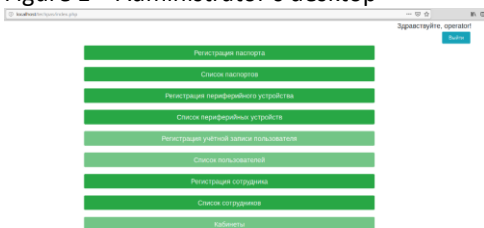


Figure 2 – Operator's desktop

Имя рабочей станции	Кабинет	Инвентарный номер	Действия					
Имя	Кабинет	Номер	Поиск по заданным полям					
ПК-1	Кабинет №13	4800	Удалить	Изменить	Ремонт	Экспорт	Ответственный	Ремонты
ПК-2	Кабинет №5А	10203040506070	Удалить	Изменить	Ремонт	Экспорт	Ответственный	Ремонты
ПК-4	Кабинет №5А	1223	Удалить	Изменить	Ремонт	Экспорт	Ответственный	Ремонты
Тестовый ПК	Кабинет проверки	8800	Удалить	Изменить	Ремонт	Экспорт	Ответственный	Ремонты

Figure 3 - Passport registration

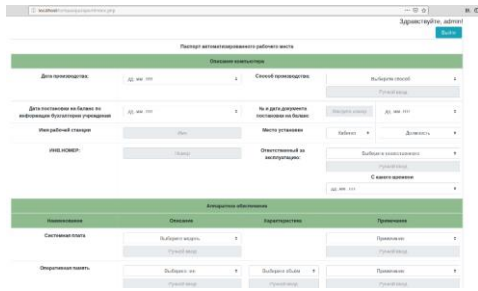
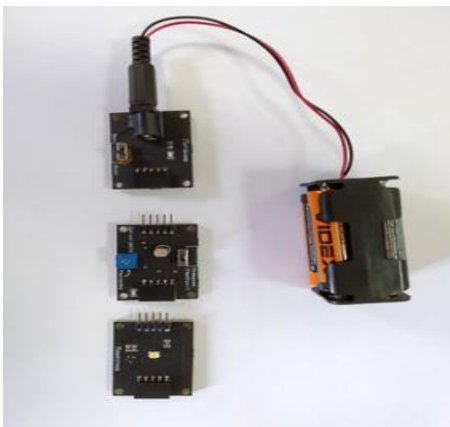


Figure 4 - Passports list

2.22. Large-block robotics kit

Short description: The kit contains large-block elements: sensors and actuators. Elements are easy to handle in order to quickly assemble simple and interesting devices.

Advantages: Simplicity and clarity of assembly. Robotics kit does not require prior knowledge of circuit technique and programming.

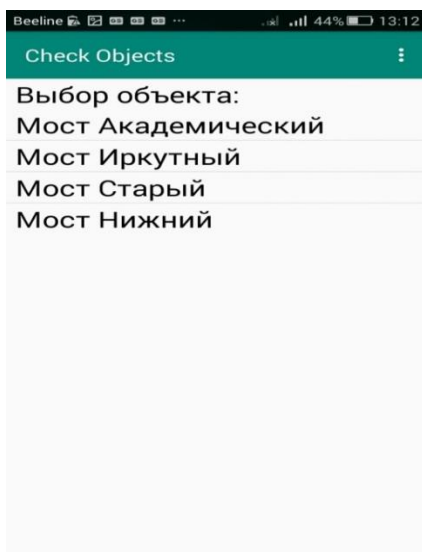




2.23. Cloud-based software package of photo / video archive of the condition of artificial structures on roads

Short description: The software package is designed to monitor the status of various structures and their critical nodes. The developed mobile application allows selecting an object and its node, making and uploading photos to a server, and commenting the photos. On the server, uploaded photos are automatically attached to respective objects and thus form an archive with convenient access.

Advantages: Simple and user-friendly interface. Flexible platform that allows customizing the solution for a specific customer and generating check lists.





3. CONSTRUCTION AND URBAN INFRASTRUCTURE

3.1. Technology for the production of anti-icing systems for roofs including roofs of complex architectural forms (architectural monuments)

Short description: The most effective way to combat icing of roofs is an integrated approach where anti-icing systems not only prevent the formation of significant masses of ice on roof elements, but also ensure the absence of ice in gutters and pipes.



In order to protect roofs from weather conditions in an efficient way, it is necessary to ensure their optimal heating; the latter is achieved through the uniform arrangement of heaters along the roof perimeter.

Advantages: The system fits into the general appearance of a house without violating the aesthetics and, unlike analogues, its mounting does not damage a roof. The heating system uses heating blocks on a flexible polymer base of БЭН type (ТУ 3442-007-64864241-2014). Their main advantage over cable systems is increased heat transfer area and insignificant mass of the heating element. Estimated power of the anti-icing system is 300-450 W / sq.m. Control is done by automation. Organization of production, staff training is carried out in 1.5-2 months.



3.2. Attachable equipment for Bobcat road construction vehicles



The university has developed prototypes of a sand-salt material distributor and a device for splitting ice (frozen snow crust) for small-sized road vehicles. The distributor is intended for spreading salt over frozen snow crust or ice of areas adjacent to residential houses. Application:

- sidewalks;
- yards;
- footpaths;
- bike lanes.

Advantages:

- connection to any types of equipment with a hydraulic motor (Bobcat, Belarus, mini-tractor);
- adjusting the spread width;
- adjusting material consumption
- easily removable;
- easy to maintain;
- easy to operate.

Specifications:

- bunker capacity: 0.33 m³;



- spreading area length: up to 700 m;
- spreading area width: from 1.2 m to 4 m. Cost of equipment: from 80,000 roubles to 230,000 roubles.

3.3. Technology for production of new building materials from bulk power industry waste (fly ash from thermal power plants) and waste plastics



Vinizol is a versatile eco-friendly material whose properties can be modified in order to obtain a wide range of products for various areas of application in order to replace wood.

It is produced from fly ash from thermal power plants and waste PVC.

The material is applicable for both exterior and interior decoration. The new building material possesses such properties as low thermal conductivity, increased strength, complete waterproofness, and higher incombustibility properties compared to any equivalents.

Filler (fly ash) reduces the cost of production, reduces surface flame spread and smoke in case of fire.

The project is the winner of innovative projects competitions held by the Government of Irkutsk region and the Administration of Irkutsk city, it was also shortlisted in BIT-2012 competition.

The following approval documents are available: Russian patent No. 2469976 dated 20.12.2012; TU 5770-001-90978809-2013; Fire Report No. 693/РД on assignment of the material to ПП1 group (non-flame spreading) and assignment of the class of combustibility



Г2; Expert opinion on the compliance with the Uniform sanitary, epidemiological and hygienic requirements No. 924; Certificate GOST R/

Application: terrace boards, facade tiles, floors, baseboards, attic floorings, doors, window frames, etc.

Consumer properties: can be easily sawn, planed, drilled; easy to paint; keeps nails, can be glued and welded, bends if heated.

Existing material equivalent: wood-polymer composites.

Competitive strengths:

- Fire resistance class Г2 (Г3-Г4 for equivalents).
- Water absorption 0.2 % (0.5–4 for equivalents).
- Impact strength, kJ/m²: 10 (3.2–4 for equivalents).
- Unlike equivalents, has biological and chemical resistance.
- Cost up to 1700 roubles/m² (up to 4000 roubles for equivalents).

Penozol is a porous fire-resistant heat-insulating material produced from fly ash from thermal power plants and polymer binder.



The use of fly ash as filler decreases the cost of thermal insulation, reduces surface flame spreading and smoke forming, which meets the requirements of the Federal Law No. 123 on fire safety of construction materials.

Application for efficient and fireproof thermal insulation of industrial and residential buildings of any height, as an insulating layer of exterior wall panels and internal partitions, attic floors, counter floors, etc., as well as for thermal insulation of major oil and gas pipelines, and local heat pipe mains.



Penozol is a substitute for polystyrene foam and other materials of a similar class, which are now widely used despite being combustible.

The following approval documents are available: Certificate of compliance with fire safety requirements C-RU.ПБ57.В.02012 (Г1; В2; Д1; Т2); Expert opinion on compliance with the Unified sanitary, epidemiological and hygienic requirements No. 923; Certificate of conformity GOST R № РОСС RU. АВ24.Н06569 dated 30.08.2013

Competitive strengths:

- fire resistance class Г1 (Г4-Г2 for equivalents);
- density of 35–100 kg/m³ (from 35 to 160 for equivalents);
- heat-conduction coefficient 0.035 (up to 0.039 for equivalents);
- compressive strength 0.15–0.25 MPa (0.05–1.0 for equivalents);
- as opposed to equivalents, possesses biological and chemical resistance;
- cost up to 7000 roubles/m³ (up to 10,000 roubles/m³ for equivalents).

3.4. Production of sulphate-containing cements from industrial waste



Composition:

- 25–35 % production waste (lignin pulp ash, LPA) formed in the course of incineration of lignin pulp from Baikol Pulp and Paper Mill OJSC and Selenginsky Pulp and Cardboard Mill OJSC;
- 20–30 % carbide sludge, a waste from acetylene production at Usolyekhim-prom;
- 15–25 % fluoroanhydrite slurry, as well as waste from sludge fields of Angarsk Electrolysis Plant.

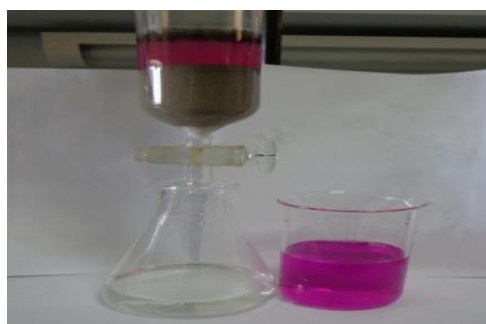


Main characteristics: fast-hardening corrosion-resistant high-quality cement of grade 600-700.

The cost of production is 40% lower than the market value of available equivalents.

Approbation: There were pilot tests of the main engineering characteristics of the materials obtained, a decision on issuing a patent for the raw mix No. 2552288 has been received.

3.5. Sorbent produced from lignin pulp of Baikalsky Pulp and Paper Mill OJSC



Raw material: lignin pulp sediment in the amount of 4 million m³.

Technology: pulp incineration on the existing equipment of the sediment processing shop of Baikalsky Pulp and Paper Mill at the temperature of 940 °C with formation of aluminium oxide as a by-product.

Application scope: treatment of wastewater of various compositions, including those that are difficult to oxidize and contain heavy metals, and also as filler for household wastewater treatment cartridges.

Performance:

- it is not inferior to industrial CKT coal sorbents in its performance;
- the cost of production is lower by 30–35 % in comparison with available equivalents.



Testing: industrial introduction at Baikal Pulp and Paper Mill OJSC for sorption purification of high-colour wastewater from the boiling shop. A patent for invention (No. 2136599) has been granted.

3.6. Energy-saving wastewater treatment system using small-scale combined complexes



The proposed system will make it possible to ensure a reduction in energy consumption by 30–40 % in comparison with equivalents.

Unlike available equivalents, the developed system eliminates the use of electrically driven agitators through the use of a new aerator design, which, in addition to aeration of the liquid, provides effective mixing by using Segner wheel design (which makes it possible to eliminate the use of an electric motor, which is mandatory for conventional mixers).

In addition, the developed design of the aerator will solve the problem of maximum saturation of the liquid with gas bubbles. The proportion in volumes of gas and liquid leaving the aerator is 50:1, while for the best of the used devices of this type this parameter does not exceed 20:1.

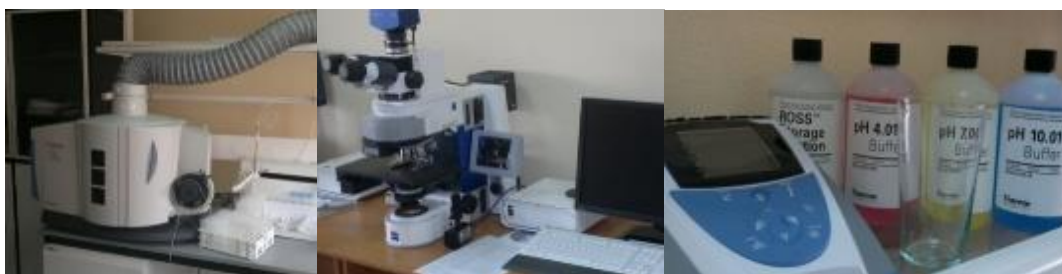
Competitive advantages of the aerator:

- different performance for gaseous state;
- controllable particle-size distribution for the gaseous state;
- obtaining size of gas bubbles from 0.2 to 5.0 mm;
- simple in structure and easy to use;
- reliable in working with usual and corrosive medium;
- easily mates with any technological equipment.



Application scope: wastewater treatment, mineral processing, saturation (oxygen enrichment) of beverages and juices in the food industry, aeration of water bodies for fish farming.

3.7. Certified water quality laboratory POCC RU. 0001. 519165



Laboratory's mission: "Reliability and objectivity, competence and confidentiality".

Laboratory's unique character: an arsenal of state-of-the-art instruments assembled together, unmatched among Eastern Siberian institutions, making it possible to conduct ordinary and high-precision studies of natural and waste waters, sewage sludge and production wastes, as well as biotesting of these environments with the highest performance and in one place. The laboratory fully complies with international standards in this field, which has an indisputable advantage over laboratories of a similar class.

Reliability and objectivity of testing are ensured through strictly regulated sampling systems, an internal test quality assurance system, efficient workflow management, the use of state-of-the-art equipment, high staff qualification, never-ceasing improvement of testing methods, as well as internal and external supervision.

Competence of the Analytical Centre is ensured by the system of standardization and certification of laboratories in accordance with the requirements of Rospotrebnadzor and Rosstandart.

Confidentiality is ensured by the fact that all tests and definitions made in the Analytical Centre remain the exclusive property of the customer and cannot be transferred to anyone without the customer's consent.



3.8. Software product “Svetofor”

Short description: Software is used to calculate modes of traffic control and design of geometric parameters of controlled intersections.

Advantages: Software product “SVETOFOR” is intended for the design of traffic lights objects: design of traffic control mode with account to conflicts, selection of road lane number, estimation of traffic delays, levels of transport service, calculation of length of transport queues to assess network congestion and the length of the extension. The application is based on modern foreign calculation methods, which were already introduced in the Russian regulatory documents in 2012 - 2016 (the team of the University Research Transport Laboratory was a co-author of the developed standard for the Ministry of Transport of the Russian Federation). The proposed product does not require expensive and lengthy calculations, it is easy to use.

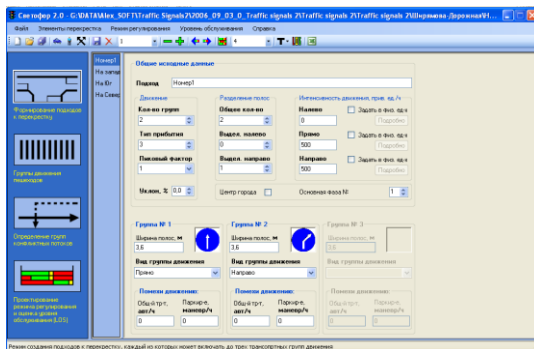


Figure 1 – Design of ways to controlled intersection

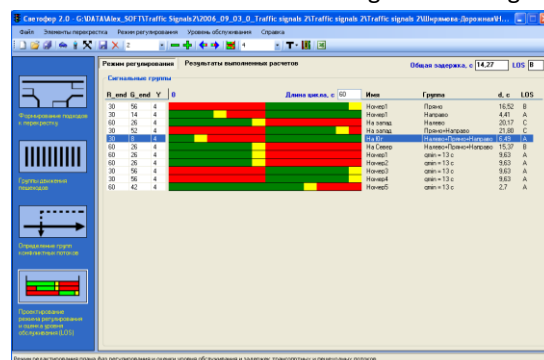
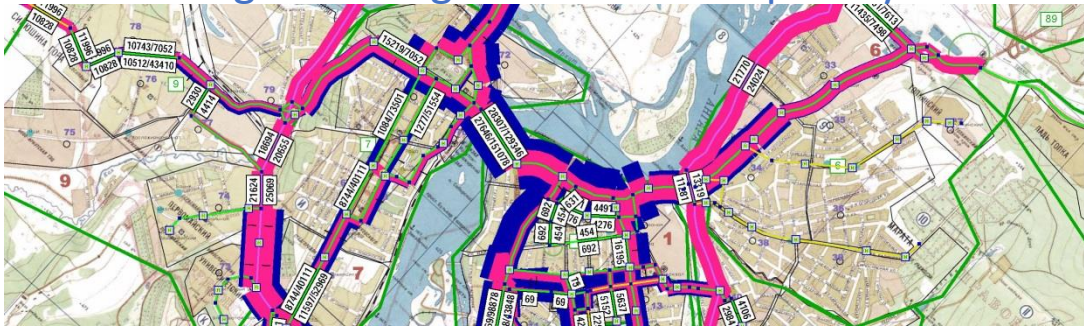


Figure 2 – Control mode design



3.9. Planning and design of urban transport systems



The University staff designs transport systems of cities based on macro and micro modelling approach. At the moment, the following work has been completed:

- calculation of the traffic flow for the new bridge across Angara river;
- comprehensive scheme of traffic management in Irkutsk city for 2009–2015;
- concept of the development of Irkutsk city public transport;
- design of the system of public transport routes in Komsomolsk-on-Amur;
- comprehensive scheme of traffic management for Ulan-Ude city;
- guidelines for assessing traffic capacity of roadways, section "Signal-controlled junctions" (Customer: Ministry of Transport of the Russian Federation);
- concepts of the development of Irkutsk region transport systems, section "Road transport".

Their implementation will improve the efficiency of the functioning of urban transport systems:

- reduce vehicle delays by 10–30 %;
- increase traffic speed by 10–20 %;
- increase the use of traffic capacity of the road network by 10–30 %;
- reduced fuel consumption and air pollution.

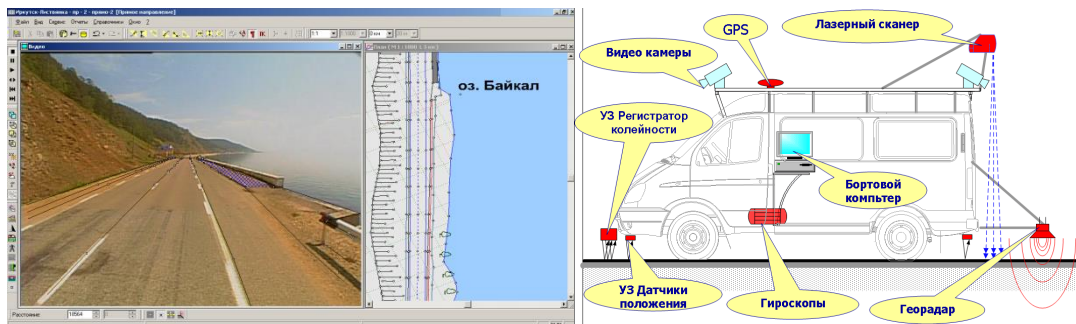
In order to contribute to the development of Baikal region, the University is ready to offer a number of promising developments:

- optimization of the work of traffic lights systems in cities of Irkutsk region;
- development of the project of a network of public transport routes for Irkutsk city;



- development of a system for quick assessment of the conditions of movement of road transport based on data from vehicle navigation systems;
- development of a model of the transport system and a design of a network of public transport routes for Irkutsk region (Cheremkhovo–Irkutsk–Slyudyanka).

3.10. Comprehensive video monitoring of roadways, development of traffic management projects and assessment of the current transport and operational status of road networks



Make-up of street and road network monitoring system:

- System for real-time displaying of a linear diagram of a roadway and video footage, including a 3d-model of the road situation.
- System for generating reports on roads or a summary on a subnetwork of roads, including the determination of the scope of components in physical measures.
- System for maintaining databases on road accidents and generating analytical reports (focal points of road traffic accidents, action plans, etc.)
- System for generating reports on roads or a summary on a subnetwork of roads, including the determination of the scope of components in physical measures;
- System for assignment of works on the defective statements with the definition of the scope of work in physical measures;



- Maintenance of a database of planned and completed works with reference to a linear diagram and a digital topographic base.

Package of the prepared documents:

- Technical dossier (mandatory for the roadway registration and maintenance financing).
- Road traffic management project (mandatory for registration of a roadway with the traffic police).
- Assessment of the current transport and operational status of a roadway (required for the purpose of budgeting projects for repair and reconstruction of parts of roadways).

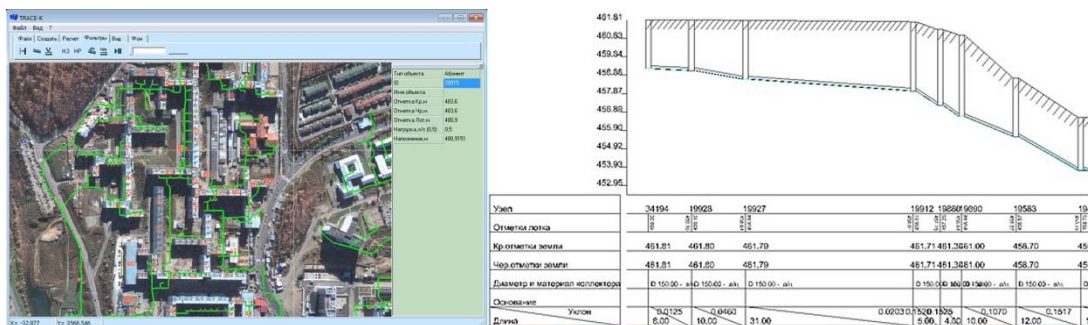
Estimated cost of work:

- street and road network: Dossier and traffic management project: 12–15 thousand roubles per 1 km;
- Dossier, traffic management project and assessment, thou.: 18–20 thousand roubles per 1 km;
- highways outside populated areas: Dossier and traffic management project: 5–7 thousand roubles per 1 km;
- dossier, traffic management project and assessment, thou.: 10–15 thousand roubles per 1 km.

Completed projects: assessment with the creation of a road database of public highways of regional significance of the Irkutsk region with a total length of 1,885.525 km (the Customer is the Directorate for Roadway Construction and Operation of Irkutsk region), etc.



3.11. Methodology and software complex for intensification and optimization of piping systems of housing and communal services and industrial enterprises



We have developed a unique TRACE-VK software package to enable municipal utilities enterprises and large industrial companies to quickly model and solve problems of optimizing operation, reconstruction and development of heat networks, water supply and wastewater systems.

Over the past 20 years, TRACE-KV software package was at various industrial enterprises and in more than 50 cities of Irkutsk region, Khabarovsk territory, Tver region, the city of Tbilisi (Georgia), the city of Erdenet (Mongolia), etc.

TRACE-KV has served as a basis for a number long-term programs for integrated development of engineering infrastructure, schemes of water supply and wastewater systems of these cities and populated areas. The application the proposed methods and software package resulting in economic benefits ranging from tens to hundreds of millions of roubles for different cities.



3.12. Electric furnace for burning of vermiculite and other thermo-active materials

Short description: The furnace is intended for burning vermiculite concentrates and producing expanded vermiculite, which is an excellent thermal, heat-insulating as well as soundproof bulk material. The furnace is intended for small enterprises of small and medium business engaged in the production of building materials.

Advantages: Unlike furnaces operating on hydrocarbon fuel, the proposed furnace operates on electricity, which makes it safe, both from environmental and industrial point of view. Fire and explosions are impossible during its operation. Moreover it has a significantly lower energy intensity of 120 ... 145 MJ/m³ while fire furnaces intensity is higher: 180 ... 230 MJ/m³.



Electric furnace: 1 - case, 2 - unit (on the left picture the thermal covers are removed), 3 - door, 4 – dust collector, 5 - tray, 6 – drum dosing unit, 7 – thyristor regulator, 8 – dosing unit drive, 9 – belt drive,



3.13. Technology of water-air regeneration of synthetic load in an aeration tank/bioreactor



A method of air-water and mechanical regeneration of immobilized sludge with the use of an inactive brush loading located in the aero-tank bioreactor is proposed.

High levels of sewage sludge regeneration efficiency (> 90 %) based on the increased intensity of water-air treatment and frequency of mechanical impact on the brush loading have been obtained. We show both necessity and feasibility of using both regeneration methods to intensify biological wastewater treatment.

The proposed regeneration methods make it possible to completely eliminate secondary pollution of the treated water. The introduction of the proposed methods will increase the oxidative capacity of the aeration tank/bioreactor. The best technological conditions were selected for a given load regeneration performance.

Application scope: Treatment of sewage in any aerated structures.



3.14. Real-time quality monitoring system for drinking water and lubricating fluids



The system is designed to monitor the purity of drinking water and determine the concentration of wear particles in lubricating fluids of engines and mechanisms by continuous automatic counting and determining the characteristics of suspended particles in fluids.

Principle of operation

The fluid is automatically sampled from the main pipe or filled into a measuring tube. Microscopic photographs of samples of the fluid (water or lubricating oil) are taken in an optical cell to obtain an array of images of suspended microparticles with sizes of 5–100 μm . Image processing in the computing unit includes determining the concentration of suspended particles, the distribution of particle sizes and shape distribution. The results are continuously recorded on a data storage device. If the concentration threshold is exceeded, an alarm is sent to the display unit.

Application:

- drinking water quality monitoring;
- monitoring water pollution for natural water bodies;
- diagnostics of the conditions of components and assemblies of various types of engines (gas turbine aircraft engines, internal combustion engines, transmissions) for the presence of suspended particles (contaminants, wear particles).

Advantages:

The system operates in real time without the need for sample preparation, promptly reacts to an increase in particle concentration, and makes it possible to respond to an emergency situation in a timely manner.



3.15. Plant for intensification of the process of reinforced concrete block hardening using fly ash from heating power plants



A Russian patent has been granted.

Device and its principle of operation:

A system for production of concrete blocks with the replacement of a part of cement with fly ash and induction of secondary short-circuited electric currents is a movable alternating current electromagnet with expandable poles for installation of a formwork with concrete mix on a vibrating table between them.

The electromagnet induces secondary short-circuited currents, resulting in the process of electrolysis in the concrete mix. All components are activated in the process of electrolysis, including fly ash compounds, chemically combining with all components of the mixture, which accelerates concrete setting process and increases the strength of concrete blocks at the molecular level.

Constructive advantages:

- solution of the environmental problem of the disposal of fly ash generated by central heating and power plants;
- reduction of the cost reinforced concrete blocks due to replacement of part of the cement with fly ash;
- acceleration of the process of reinforced concrete setting with the use of fly ash;
- increase in the strength of reinforced concrete blocks using fly ash.

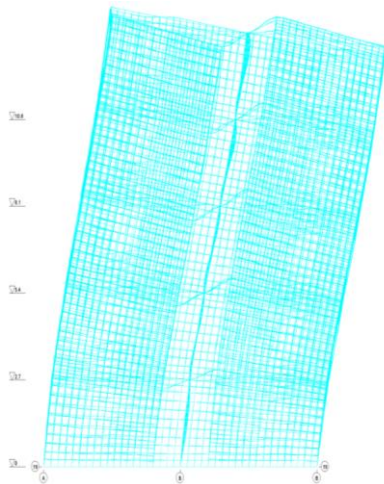


3.16. Rapid method for evaluation of defect accumulation in buildings and structures based on laser projection of dynamic processes

Description:

The method and technology for the evaluation of defect accumulation in buildings and constructions that have been developed at the Department of Mechanics and Strength of Materials of INRTU are based on the value analysis of parameters of self-induced vibrations measured by a contactless highprecision vibration meter. Spectral conversion of the laser projection of the vibration enables the assessment of the residual stiffness of the structure and the loss of stiffness properties, which is a quantitative measure for an assessment of defect accumulation. We have developed a method for the evaluation of stiffness by own frequency response corresponding to the lowest frequency vibration that shows the best resistance to calculation errors.

A RSV-150 contactless laser vibration meter by POLYTECH (Germany) is used for the evaluation.





Advantages:

- The developed method provides for rapid presentation of self-induced and constrained steady and non-steady oscillations in constructions and devices in a contactless highly precise procedure with saving the digital data in a personal computer.
- The absence of sensors and connector cables eliminates errors in the measurement accuracy that may be caused by defects in junctions, fixings and the effect of wire circuit resistance.
- There is no need for sensors fixing or connector cables laying allows very fast obtaining a presentation of oscillatory processes, since time is only required for laser beam guidance and the measurement itself.
- High sensitivity and measuring accuracy (up to fractions of a micrometer) of oscillatory processes enables performing building inspections at very small applied shock to avoid structural damage.
 - Generation of a total quantitative assessment of the level of safety loss for buildings and structures based on the measurement of their own dynamic parameters.

Application:

- Inspection of industrial and civil buildings and structures, hazardous production facilities.
 - Monitoring the oscillation activity of machines, equipment and structures.

Planned activities:

Monitoring of 335 series buildings in Irkutsk for the purpose of defect level mapping.

Approbation:

The method and the equipment were applied for sample inspection of 1–335 multi-apartment houses in Irkutsk, as well as in a study of oscillating in various technical facilities.

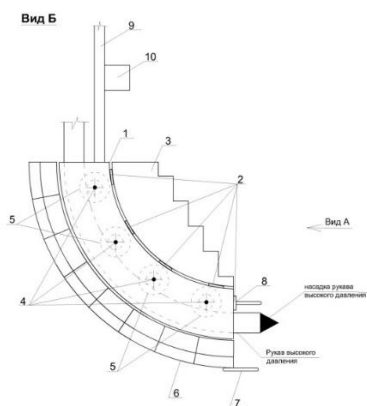


3.17. Device for supporting and controlling the direction of a high-pressure hose of sewerage flushing machines

Short description: The useful model relates to municipal mechanical engineering, additional equipment for sewerage flushing machines, and is designed to support and control the direction of a high-pressure hose in sewerage lines. The purpose of the proposed technical solution is to expand the functionality of the device and increase efficiency.

Advantages: The main objective of the development is to ensure safe working conditions, increase the life of high pressure hoses, and improve the efficiency of blockage elimination and preventive flushing of sewerage and storm pipelines.

Устройство для опоры и контроля направления движения рукава высокого давления канализационных канало-промывочных машин



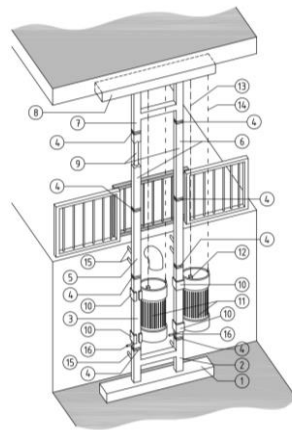
Фиг.1



3.18. Device for rough treatment of wastewaters from coarse impurities at sewage pumping stations

Short description: The useful model relates to municipal mechanical engineering, additional equipment for sewage pumping stations, and is intended for rough treatment of wastewater from coarse impurities at sewage pumping stations in automatic mode.

Advantages: The useful model can be used for the development of a device providing controlled, efficient and uninterrupted process of wastewater treatment at sewage pumping stations.

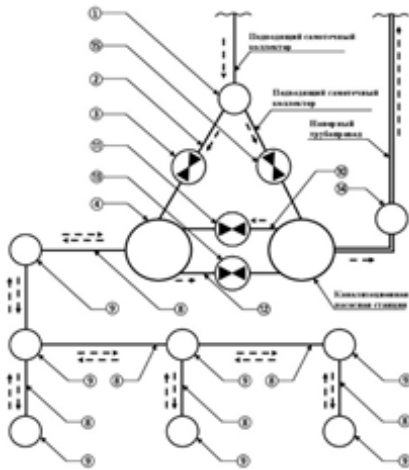


3.19. Automated damping tank of sewage pumping stations

Brief description: The useful model relates to the field of drainage systems and environmental protection, in particular to additional constructions of sewage pumping stations, is designed to dampen fluctuations in the flow of wastewater and accumulate them during an emergency stop of pumps in automatic mode as well as the operation of sewage pumping stations under restricted conditions for emergency wastewater discharge.



Advantages: The claimed useful model is intended for creating a device to prevent negative environmental impact and flooding of sewage pumping stations in the face of increased sewage flow or in cases of emergency shutdown of main pumping units as well as with restrictions or inability to emergency discharge of sewage pumping stations. This useful model can be used in new construction as well as reconstruction and modernization of water disposal systems.



3.20. Containers for dust-free loading and handling of powders including by the production of plastics

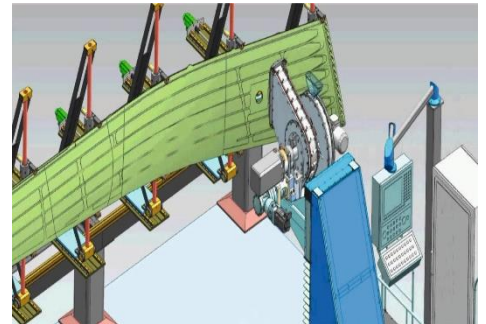
Short description: To exclude dusting of powdered materials by production of different matters including plastic, the construction consisting of flexible containers with filtering elements was proposed to work with powders to be moved or poured. The dusting process results in loss of powder materials, change in the composition of powder compounds, and formation of flammable and explosive aerosols.

Advantages: The use of flexible containers allows abandoning the construction and use of supply and exhaust ventilation in workshops to remove explosive or toxic aerosols resulting from powdery products during dusting. This provides a significant economic effect (about 2 million rubles).



4. MACHINE BUILDING

4.1. Comprehensive technology for large-size panel shaping



Major results:

In a collaboration with Irkut Scientific and Production Corporation PJSC and NIAT OJSC, Irkutsk National Research Technical University developed a comprehensive technology for shaping large-size panels and platings using “elastoplastic deformation—shaping by shot-blasting—cleaning—surface hardening” process sequence. 8 Russian patents and 2 certificates of state registration of software have been granted.

A set of special equipment with software control and associated software for calculation of process parameters for the following processes were developed:

- bending and rolling lengthy platings in the longitudinal direction;
- shaping ribbed panels by rolling out ribs;
- shaping/abrading by shot-blasting;
- hardening by shot-blasting.

Advantages in comparison with counterparts (advanced shaping methods):

- 2–3 times increase in the output;
- increased stability of the process;



- improved accuracy of the shape and life of shaped parts (reducing deviations from the set contour by a factor of 2–3).

Achieved indicators:

- deviation of the reinforced panel from the set contour, mm 0.5–0.8
- deviation of a sheet plating from the set contour, mm 0.1–0.5
- 12 m sheet plating processing time, hours 3–5;
- 12 m reinforced panel processing time, hours 4–6

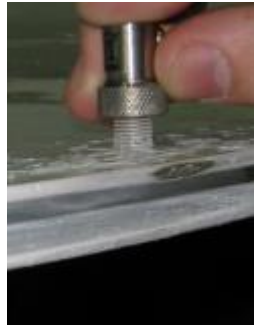
The developed technology can be used in aircraft engineering and shipbuilding.

Services provided to enterprises with the use of the developed technology:

- Development of comprehensive technology and equipment for shaping, abrading and hardening of large-sized panels and platings.
- Development of technology and equipment for shaping and straightening of ribreinforced parts by local plastic deformation methods: rolling with rollers, setting, shot-blasting, punching, etc.
- Development of production processes for surface hardening of aluminium, titanium alloy and steel parts, taking possible distortion into account.
- Development of calculation methods and software for calculating the parameters of shaping and straightening operations based on CAD models of parts and control program generating.
- Optimization of surface hardening modes for aluminium, titanium alloy and steel parts. Selection of equipment and blasting media.
- Setting up workshops for shaping and straightening using the developed equipment and the Customer's facilities.
- Development and coordination of regulatory and technological documentation on part shaping, hardening and straightening with institutions in the industry.
- Training of the Customer's personnel to work with the developed equipment.



4.2. Mechanical processing, repair and diagnostics of polymer composite materials



Major results:

In a collaboration with Irkut Scientific and Production Corporation PJSC Irkutsk National Research Technical University developed a technology for machining mixed assemblies of polymer composite materials and titanium alloys. 1 Russian patent for an utility model has been granted.

A technology for machining mixed assemblies of polymer composite materials and titanium alloys was developed and implemented at the Irkutsk Aviation Plant production facility.

The following was developed to facilitate the implementation of the technology:

- drill bits for machining holes in mixed PCM/titan alloy assemblies using automatic feed drilling machines;
- process guidelines “Machining holes in assemblies of polymer composite materials and titanium alloys”.

Main directions for further development of the developed technology:

- development of reamers for hole finishing in mixed PCM/Ti assemblies;
- improvement of the technology of repair and failure detection for polymer composite materials.

Development objectives:

- improving the quality of machined holes;
- reducing the cost of machining a single hole by reducing tool costs and optimizing machining parameters;



- reducing the dependence of aircraft engineering enterprises on tools imported from abroad;
- reducing the labour required for hole machining;
- timely detection of failures in PCM products to avoid costly repairs;
- restoration of PCM components damaged as a result of manufacturing or operation.

Achieved indicators:

- machine drilling time of \varnothing 14 mm holes in Ti/PCM/Ti assembly with a thickness of 30 mm, min: 3;
- tool costs per \varnothing 14 mm hole in a Ti/PCM/Ti assembly with a thickness of 30 mm, min: 200;
- grade of accuracy for holes on drilling: H9;
- PCM lamination at the inlet and outlet of the hole, no more than, mm Ra roughness: in metal layers, μm : 1.6; in PCM, μm : 6.3.

The developed technology can be used in aircraft engineering and shipbuilding.

Services provided to enterprises using the development:

- Designing production facilities for machining of openings in PCM/metal assemblies, repair and failure detection for PCM products, including selection of technological equipment, the type and characteristics of the cutting tool, development of production processes.
- Designing a special cutting tool for machining holes in PCM/metal assemblies.
- Process testing of equipment and cutting tools, development of cutting conditions taking into account the specified quality criteria.
- Development of technical design specifications and technical support of contracts for supply of equipment or cutting tools.
- Detecting failures in PCM materials, development of repair technology and performance of repairs.
- Consulting and training the Customer's personnel in all aspects regarding the improvement of the technology of hole machining in mixed assemblies, failure detection and repair of PCM materials.



4.3. Metal parts finishing technology



Major results:

In a collaboration with Irkut Scientific and Production Corporation PJSC and NIAT OJSC, Irkutsk National Research Technical University developed an integrated set of equipment and technology for part finishing after machining (milling). 3 certificates of state registration of software have been granted.

Developed and implemented into the production cycle of the Irkutsk Aviation Plant:

- Industrial robot-based integrated set on equipment for edge machining and deburring.
- Technology of vibration abrasive machining of aluminium, titanium alloy and structural steel parts using new types of cutting edge processing media (including foreign-made).
- Software modules for calculating vibroabrasive machining and brushing modes, depending on the specific nature of the process.

Development objectives:

- reducing the share of manual labour in the process of machining parts made of metallic materials;
- improving the quality of machined parts.

Achieved indicators:

- reducing the labour required for finishing, % 50–90.

The developed technologies can be used in aircraft engineering.



Services provided to enterprises using the development:

- Integrated design of areas for finishing parts under the Customer's product range, including selection of process equipment, type and characteristics of cutting tools, development of production processes.
- Reducing the complexity of finishing by optimizing operating conditions.
- Selection of the most suitable type and characteristics of the cutting tool and blasting media for finishing, testing machining modes with new and modernized equipment.
- Process tests of abrasive and blade tools and blasting media for finishing.
- Development of prescriptive process documentation for finishing procedures.
- Work on the coordination of the applied range of cutting tools and blasting media with leading industry institutions.
- Technical support of contracts for procurement of finishing equipment.
- Consulting, training and certification of the Customer's personnel in order to operate finishing equipment and advanced process equipment.

4.4. Optimization of structural and geometrical parameters of cutting tools for machining of aircraft parts





A Russian patent has been granted.

Developed and implemented:

- series of rotary cutters for high-performance roughing and finishing of aluminum and titanium alloy parts;
- technology for manufacturing rotary cutters using turning and milling machining centres.

Achieved indicators:

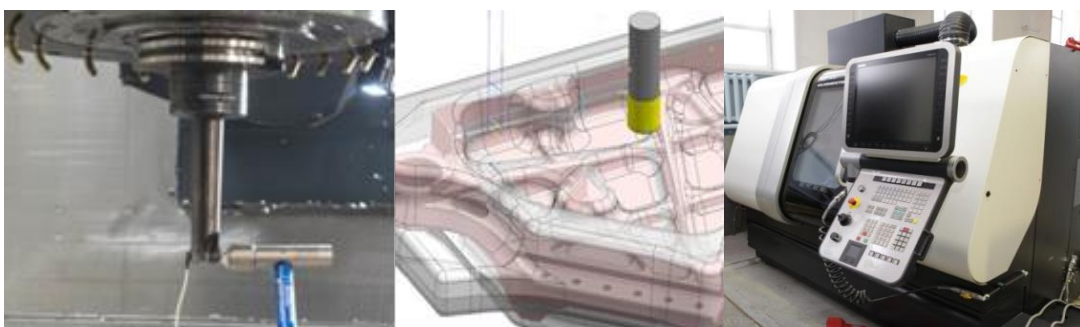
- Increased milling performance, % 30–50
- Decreased cost of cutting tools, % 50–80

The developed cutters correspond to available counterparts produced by leading world manufacturers of tools in their performance and durability, and can be used at any enterprises of the machine-building industry.

Services provided to enterprises with the use of the developed technology:

- testing and optimization of the cutting tool design;
- designing custom tools for the Customer's specific tasks.

4.5. Technology for high-speed and high-performance machining of load-bearing parts





Problems addressed in the development of the technology:

- Optimizing the technology of mechanical processing of parts of aviation equipment with high-performance equipment using modal and dynamic force analysis.
- Developed regulatory documents on high-performance machining of aircraft parts.
- Designed and implemented a system for vibration and impact proofing and failure detection in high-performance equipment to provide vibration monitoring and vibration diagnostics of any developing defects of the machine shafts in order to timely detect these defects and apply equipment maintenance based on its actual condition.

Achieved performance indicators: Aluminium alloys

- | | |
|-----------------------------------|---------------|
| → roughing, cm ³ /min | 8000....10000 |
| → finishing, cm ² /min | 1500...5000 |

Titanium alloys

- | | |
|-----------------------------------|-------------|
| → roughing, cm ³ /min | 300.... 600 |
| → finishing, cm ² /min | 200...400 |

Alloy steel

- | | |
|-----------------------------------|-------------|
| → roughing, cm ³ /min | 250.... 500 |
| → finishing, cm ² /min | 400...700 |

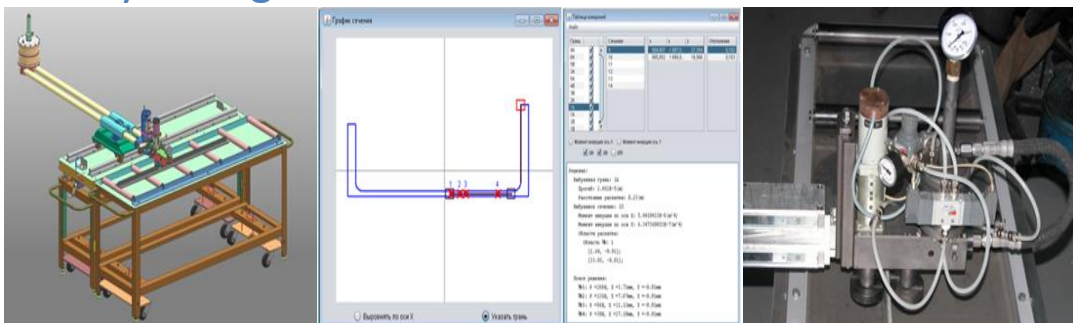
Services provided to enterprises using the development:

- reducing the labour required for of machining on CNC machines by means of tool selection and optimizing cutting conditions;



- producing parts of irregular shapes using CNC turning lathes and milling machining centres;
- measurement of geometrical dimensions and deviations of the part shape using a coordinate measuring machine;
- measurement of part surface roughness and undulation;
- measurement of cutting forces, vibrations and temperatures during the machining;
- balancing tool adjustments;
- diagnostic assessment of geometrical errors of CNC machines.

4.6. Advanced technology and equipment for shaping and straightening of reinforced parts by rolling with rollers



Major results:

In a collaboration with Irkut Scientific and Production Corporation PJSC Irkutsk National Research Technical University developed an advanced technology and equipment for shaping and straightening aircraft reinforced framing parts such as longitudinal beams, spars, frames, ribs, etc. using aluminium alloys. 2 Russian patents and a certificate of state registration of software have been granted.

A workshop for shaping and straightening using UFP-1 automated machine, software module for automated determination of the process parameters, and associated regulato-



ry and process documentation were developed and implemented in the production facility of Irkutsk Aviation Plant.

Development objectives:

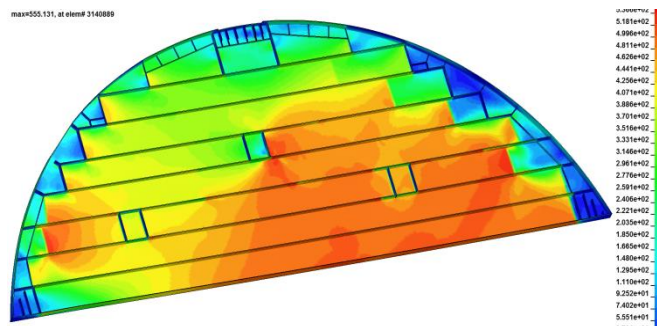
- improving the process performance;
- improving part shape precision.

Achieved indicators:

- deviation of parts such as beams, spars, etc. from the set contour, mm 0.2–0.5;
- reducing the labour required for the straightening process, % 10–15;
- elimination of losses due to cracking defects.

The developed technology is intended for use in aircraft engineering and shipbuilding enterprises, as well as other machine-building enterprises producing non-rigid parts susceptible to deformation.

4.7. Technology of surface hardening of frame parts meeting international standards





In a collaboration with Irkut Scientific and Production Corporation PJSC and NIAT OJSC, Irkutsk National Research Technical University improved an existing technology of surface hardening of frame parts, large-size panels and platings.

Problems addressed in the development of the technology:

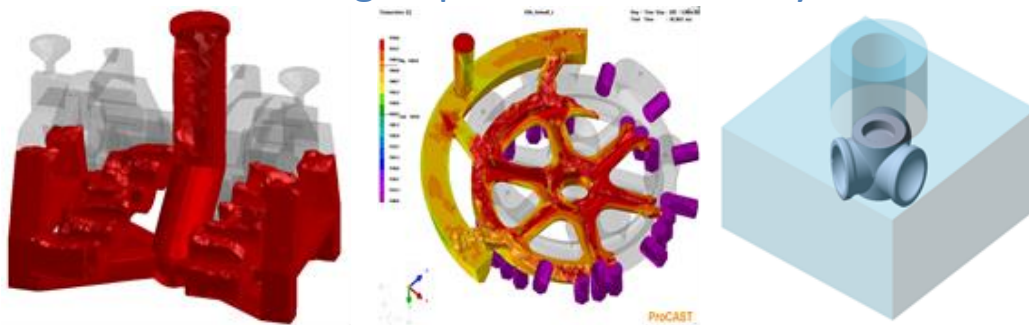
- Developed software to determine the extent of hardening treatment with deformation of witness samples.
- Received a certificate of state registration for the developed software.
- Developed process recommendations for the production of witness samples (control plates) using D16T alloy and 30KhGSA steel.
- Developed standard process documentation for certification of equipment for surface hardening and standards for treated surfaces, taking into account the requirements of international standards.
- Conducted research to determine the most suitable modes of surface hardening.
- Developed a method to control the coverage during shot-blasting hardening based on the recommendations of international standards.

Achieved indicators:

- Increased the reliability of monitoring of the results of part surface hardening.
- Increased stability and accuracy of the process of shot-blasting hardening.
- The existing technology of surface hardening is brought in compliance with the requirements of international standards AMS 243, SAE J443.



4.8. Applying computer-aided engineering systems in the development of technological processes for manufacturing of parts and assembly units



Addressed problems:

- selection of CAE systems for numerical simulation of part production processes: casting, forging and sheet-metal stamping;
- development of methods for computer-aided engineering of production processes;
- development of design algorithms for parts, tools, jigs and fixtures based on the results of computer-aided engineering;
- introduction of a technology for rapid prototyping of parts, tools, jigs and fixtures.

Achieved indicators:

- improving the quality of manufactured parts;
- reduction of defect-related losses;
- increase the material utilization by 8–10 %;
- reduction of the production preparation cycle by 5–8 %;
- increase tool life by 5–10 %.

The technology is versatile and can be applied at any machine-building enterprises.



4.9. Technology of non-destructive residual stress measurement



Technologies have been developed for measuring residual stresses by destructive and non-destructive methods, as well as for optimization of process parameters on the basis of these measurements. UDION-2, a unique installation for residual stress measurement, was developed and manufactured. A certificate of state registration of software has been granted.

Problems addressed in the development of the technology:

- Developed a method of reduction of deformation of non-rigid aluminium alloy parts by technological methods based on residual stress measurement.
- Developed a technology to monitor the results of surface hardening by rolling fillets and grooves of parts such as high-strength stainless steel connecting bolts.
- Tested a technology of non-destructive testing both in laboratory and field conditions.
- Developed standard process documentation.
- Technology of non-destructive testing in customer product manufacturing.



Achieved indicators:

- Improved shape precision of milled parts made of thermally hardened aluminium alloy.
- Prevented loss associated with defects and damage to equipment and tools as a result of separation of workpieces from suction tables during milling.
- Achieved objectivity of monitoring of the results of surface hardening of critical parts such as high-strength steel connecting bolts.
- 100 % control over the results of special processes of surface hardening of connecting bolts and heat treatment of high-speed steel end rotary cutters.
- The developed technology has no equivalents in Russia and can be used at the enterprises of the machine-building industry.

Services provided to enterprises using the development:

- Development of technological processes for monitoring residual stresses and deformations under field conditions.
- Coordination standard process documentation on the application of methods of non-destructive testing for residual stresses with industry institutes.
- Conducting a quantitative determination of process induced residual stresses (PIRS) in surface layers of processed workpieces using an Xstress 3000 G3/G3R X-ray diffractometer.
- Investigating the nature of PIRS distribution in depth of the workpiece by a mechanical method using the UDION-2 installation of the institute's own design.
- Determining magnetic characteristics (Barkhausen noise) directly related to PIRS stresses and structural phase transformations using Rollscan 3 Barkhausen noise analyzer.
- Determining the amount of residual austenite by X-ray method using Xstress 3 G3G3R diffractometer.



- Studying the structure of the materials to be hardened using Shimadzu HMV-2T micro hardness meter, Olympus GX-51 inverted metallurgical microscope, Axio Lab.A1 material science microscope, Shimadzu XRD-7 X-ray diffractometer, INTEGRA Prima Nano Laboratory, Solver P47-Pro scanning probe microscope; LV45 scanning electron microscope, Tecnai™ G2 F20 transmission electron microscope.
- Fatigue testing of the materials under study and determination of their mechanical properties using Instron 5982, Instron 5989, Shimadzu Servopulser machines and Vic3D deformed state contactless analysis system.
- Determination of the chemical composition of materials using an S8 TIGER wave Xray fluorescence spectrometer.

4.10. Technology of shaping double curvature platings with sheet stretch presses using virtual process simulation tools



Problems addressed in the development of the technology:

- development of a product classifier using structural and process analysis;
- development of modeling algorithms for shaping processes in S3F. Modeling plating formation using S3F system;
- development of jigs and fixtures design methods using PamStamp system;

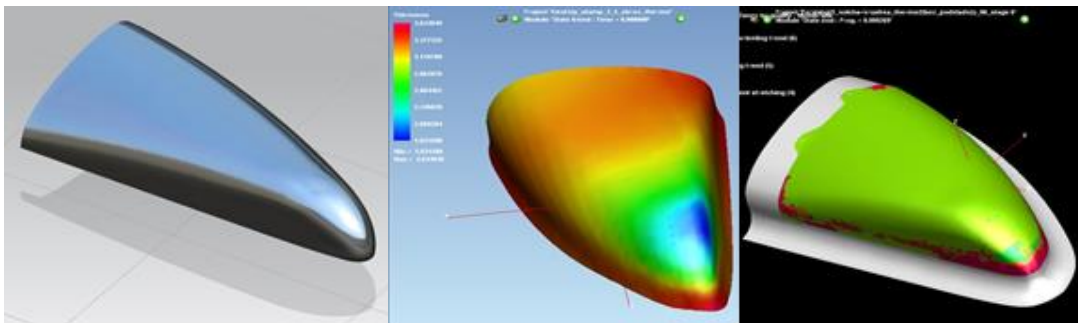


- development of actions to optimize production processes, jigs, fixtures and tools.

Achieved indicators:

- reducing the labour required for shaping process by 5–10 %;
- reducing losses due to defective parts (workpiece breaking);
- increasing the process stability by switching to program-based control mode.

4.11. Technology of production of sheet parts by shaping in an elastic medium using virtual process simulation tools



Problems addressed in the development of the technology:

- Development of a product classifier using structural and process analysis.
- Development of algorithms for virtual simulation of the elastic shaping process and selection of the most rational processes.
- Development of algorithms for designing the most suitable workpieces.
- Development of design algorithms for creation of rational equipment designs for forming parts, taking into account material springing, using NX, PamStamp and PanelShop systems.
- Recommendations for management of production of parts by shaping in an elastic medium in press machines with high specific pressure.

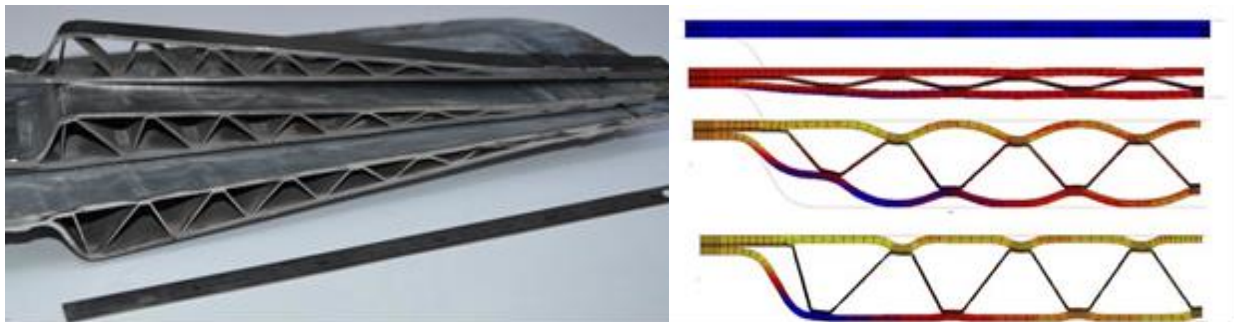


Achieved indicators:

- reduction of the production preparation cycle by 5–10 %;
- reduction of labour required by 10–15 %;
- reduction of defect-related losses by 10 %.

The developed technology can be applied at any engineering enterprises in manufacturing of sheet metal parts.

4.12. Production technology of thin-sheet parts and assemblies by thermoforming and diffusion bonding using the superplastic effect



Problems addressed in the development of the technology:

- determination of superplastic properties of materials;
- development of processes for production of parts and assemblies using superplastic thermoforming and diffusion bonding (SPF/DB);
- virtual simulation of SPF/DB process using PAM-STAMP 2G, MSC Marc, ABAQUS, LS-DYNA, ANSYS, MSC PATRAN;
- development and optimization of the tooling design;
- parts manufacturing.



Achieved indicators:

- reducing the labour required for parts forming process by 5–10 %;
- reducing the production preparation cycle by 5–9 %;
- increasing the weight efficiency of parts and assembly units;
- manufacturing irregular-shaped parts and multilayer structures with an option to reduce weight by 15–30 %, cost by 30–40 %.

The developed technology can be used at any machine-building enterprises in production of sheet parts of irregular shapes.

4.13. Assembly tooling automated installation system



Make-up of the developed system:

- KUKA industrial robot with a grip manipulator.
- Coordinate measurement system based on API Tracker3 laser tracker.
- Robot control system that provides automatic positioning of parts according to the specified coordinates, taking into account the results of coordinate measurements.
- Adapters for installation of standard structural elements of assembly tooling.
- Universal aids for fixing the position of the mounted elements on the frame of the assembly equipment.



The system is made in two designs:

- design built in INRTU laboratory, using KUKA KR10 R1100 sixx robot with a loading capacity of 10 kg;
- design built at Irkutsk Aviation Plant's test production facility (branch of NPK Irkut PJSC), using KUKA KR60 HA robot with load capacity of 60 kg.

Problems solved by the system during installation:

- matching coordinate systems of the industrial robot, laser tracker and the assembled structure;
- fastening the structure component in the grip manipulator of the robot using the developed adapter;
- moving the component by the robot into the working area for precise positioning;
- measurement of the coordinates of the element with a laser tracker;
- automatic positioning of the mounted component along a path calculated according to the results of coordinate measurements;
- fixing the component on the structure.

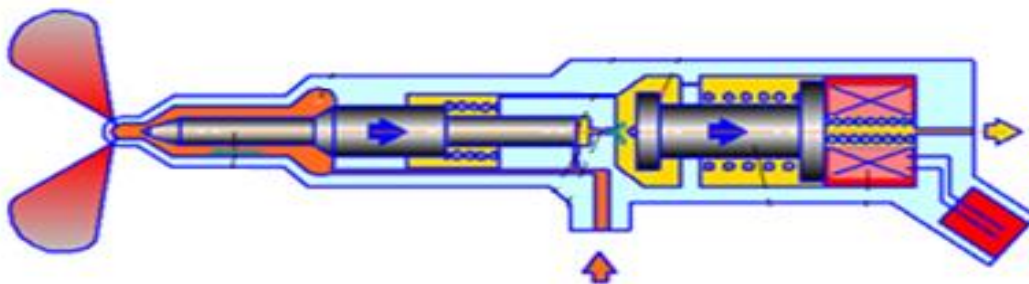
Achieved indicators:

- weight of mounted components:
 - for a robot with load capacity of 10 kg: up to 5 kg;
 - on a robot with load capacity of 60 kg: up to 15 kg;
- positioning precision: up to ± 0.05 mm;
- final mounting precision after the component fixing: up to ± 0.1 mm;
- duration of the installation process for single component: up to 45 minutes.

The developed system and automated assembly technology can be used during installation and repair of assembly tooling, as well as during installation of other structures in aircraft engineering, machine building, shipbuilding.



4.14. Methods for optimizing the adjusting effects of maintenance and repair of electro-hydraulic diesel engine injectors



Application scope: Vehicle repair enterprises, service stations, machine-building enterprises.

Summary:

The quality and labour intensity of repair of Common Rail electro-hydraulic injectors, as well as their performance after the repair largely depends on the experience and qualification of the repair specialist. The influence of the human factor on the quality and labour intensity of EHI repair can be reduced by means of a well-designed assignment of the list and parameters of adjustment and repair actions.

The developed method includes a mathematical model, an algorithm and a program implementing it using Matlab 7 software package. This method makes it possible to reasonably assign EHI repair and adjustment actions, perform calculations of the parameters of their adjustment dimensions and accordingly increasing the efficiency of repair and adjustment actions and minimizing the impact of the worker's qualifications on the quality of repair.

Specifications:

- Computer type: Pentium II/ 32 Mb RAM/.
- Software environment: Matlab 7.
- Operating Systems: MS Windows 7, 2000, XP.



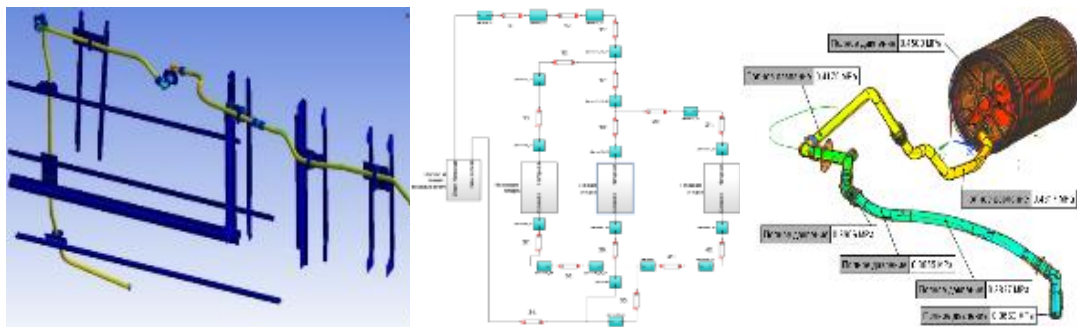
→ Program size: 789 KB.

Competitive strengths: Scientifically based method for assigning repair and adjusting actions for electrohydraulic injectors of Common Rail system enables vehicle repair enterprises and service stations to reduce labour intensity, improve the quality and efficiency of repair of fuel equipment of diesel engines by reducing errors and eliminating non-productive disassembly operations caused by the impact of the human element.

Stage of development: The program has been field-tested.

Patent and legal protection: A patent application for the developed method has been prepared.

4.15. Comprehensive technology for branching gas and fluid systems design



Problems solved through the implementation of the technology:

- Determining the most appropriate operating parameters and technical characteristics of the designed system.
- Determination of the most appropriate pipe routing for gas and fluid systems, taking into account any possible configurations based on a structural digital model.



- Development of functional diagrams based on virtual simulation.
- Kinematic analysis of the system actuators.
- Strength and fluid-gas-dynamic analysis of the designed system in static and dynamic settings.
- Development of recommendations for the design and manufacture of split-design structures of pipeline systems.
- Ergonomic-friendly design of technical compartments and equipment.
- Development of design documentation.
- Designing hydrauling testing benches and other production equipment.

Achieved indicators:

- reducing the labour intensity of installation, repair and maintenance of gas and fluid systems;
- increase in the system service life up to 15 %;
- reducing weight up to 5 %;
- reduction of the production preparation cycle by reducing the number of necessary engagement of system elements;
- reduction of injuries up to 30 %.

The developed technology can be applied at enterprises of the machine-building industry.

4.16. Versatile computerized unit for diagnostics of wheeled vehicles





The project won a grant of the Administration of Irkutsk Region.

Advantages of the technology:

- Provides the ability to assess the technical condition of a wheeled vehicle on with high drive-by velocity (40-90 kmh and more).
- Has a low electric power consumption (less than 1 kW/hour).
- Provides the ability to check anti-skid systems of the wheeled vehicle without wheel slip to the support rollers of the unit (vehicle tires do not deteriorate).
- Provides the ability to check the technical condition of automatic transmissions of the wheeled vehicle.
- Provides the ability to check the technical condition of anti-blocking systems of the wheeled vehicle on high initial speeds (40-90 km/h and more).
- Provides the ability to check the technical condition of the chassis of the wheeled vehicle.
- Provides the ability to control the technical condition of braking systems of the wheeled vehicle on high initial speeds (40–90 km/h or more).

Application scope:

- The unit is intended for diagnostics of wheeled vehicles, including for compliance with the requirements of the Technical regulation on the safety of wheeled vehicles.
- Diagnostics and monitoring of the technical condition of modern wheeled vehicles in the conditions of a vehicle fleet operating facility, car repair enterprises, car maintenance stations, brand service centres.
- Diagnosis and monitoring of the technical condition of modern wheeled vehicle at roadside stations and vehicle monitoring centres.
- Quality control of modern vehicle assembly at manufacturing plants.



Testing:

- Technological capabilities of the unit have been tested in INRTU research laboratory.
- The results are positive and meet the requirements of national standards of the Russian Federation.
- Eight Russian patents have been granted for constructive and technological innovations of the unit.

4.17. Methods of coordinate measurement and management of functional elements of assembly tooling when performing assembly and connection works



This development provides a set of methods for automated coordinate measurement of geometric parameters of assembly units and technological equipment in the course of aircraft equipment assembly, as well as management of their spatial position based on the data from digital models of the structure.

Coordinate measurements are carried out by a laser tracker with the use of additional measuring instruments. Movement of structural elements of an assembly tool or



product is carried out using actuated positioners with automated or manual control for compliance to different layout schemes. There are a number of methods of direct, reverse, and combined positioning that ensure the accuracy of assembly of large-sized structures. An experimental testing of the developed methods in laboratory conditions was performed.

Patent "Method to assemble item at several working stages, complex of assembling accessories and portable assembly accessory used in them": patent 2517920 of the Russian Federation No. 2012154849/11; applied on 19.12.2012; published on 07.04.2014, Bulletin № 16. 19 pages.

Used devices and equipment:

- API Tracker 3 40 m laser tracker with a set of spherical reflectors and measuring adapters.
- API SmartTrack six-axis active sensor.
- API IntelliCombo 36 combined device with a laser scanner and a set of measurement probes.
- FESTO automated positioning drives with stepper motors:
 - Carriage-type linear drives: 9 pcs;
 - Rotation drives: 6 pcs.
- Set of FESTO drives for mechanization of assembly equipment:
 - Bayonet-type linear actuators: 2 pcs.
- A set of three compact mechanical 3-axis positioners (manually controlled).
- KUKA KR10 R1100 six industrial robot.
- Laboratory bench imitating assembly tooling and product components during assembly and connection works.

Application feasibility:

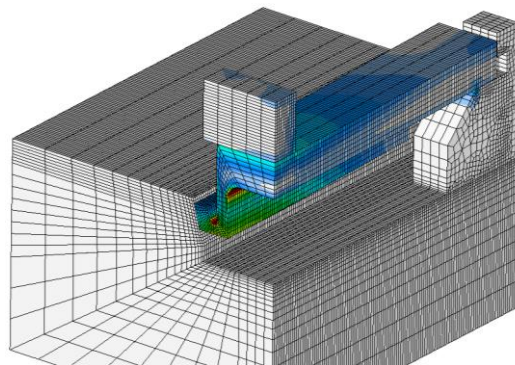
The developed monitoring and control methods can be used in addressing the following engineering problems:

- Measurement of geometric dimensions according to the digital model of the product structure, including for large-sized products (up to 4 m).
- Positioning parts of the product structure (including for large-sized products) according to the digital model, including using automated positioning devices.



- Development of technological positioning systems for assembling sophisticated and large-sized products (for example, aviation equipment, etc.) according to the digital model.

4.18. Technology of strength testing of materials and combined criteria of their strength, taking into account peculiar aspects of components deformation



Summary:

The technology aims to improve the accuracy and reliability of engineering calculations for the strength of structures under combined stress conditions. The calculation is carried out using a simplified computational and experimental method, which takes into account the actual mode of deformation of the structure resulting from application of operational loads. The determination of the structural strength characteristics in the proposed method is achieved through mechanical tests of laboratory samples the operating area of which simulates the peculiar aspects of stress-strain state of this structure in typical test benches.



The research topic was supported by the Innovation Promotion Foundation in 2015 as part of the program "Participant of a Youth Science and Innovation Competition" ("U.M.N.I.K.").

Advantages:

- More precise strength calculation of structures under combined stress conditions by means of experimental determination of their strength characteristics under the conditions of the actual mode of deformation of the structure.
- Option of determining the strength characteristics of the material with combined deformation on standard test equipment.
- Reduction of costs for manufacturing of laboratory samples for mechanical tests with 30 % combined deformation.
- Reducing the cost of the strength test process by eliminating the use of test benches with several separate power drives.

Application scope:

Transport engineering, construction of buildings and structures.

Planned work:

- Formation of a database on the strength characteristics of a wide class of engineering materials under conditions of actual deformation of structures.
- Software implementation of structural strength analysis, taking into account the actual behavior of the deformable object.
- Comparative evaluation of the error of the different combined strength criteria.
- Research of patterns of fatigue fracture and operational life of the material in various modes of deformation present in machine parts and structural elements.



Testing:

The technology was used at Irkutsk Heavy Machine Building Plant (IZTM-Engineering) in the implementation of experimental design development related to the manufacture of a FFCpowered rail carriage with the carrying capacity of 20 tons (order 2014 №22546).

The theoretical provisions of the technology are introduced into INRTU curriculum as part of subjects "Strength of Materials" and "Technical Mechanics", and are also used in the curriculum of Irkutsk State Transport University as part of subjects "Design and Calculation of Railway Cars" and "Railway Car Construction Mechanics".

4.19. Technology for vacuum-plasma processing to improve the technical characteristics of pipe fittings and fasteners

Short description: Technology and vacuum-plasma spraying equipment to increase the sealing, tribological and other surface characteristics of samples of pipe fittings and fasteners. The project is aimed at processing and quality control of modified surfaces by provision of production services to specific consumers.

Advantages: Increased operational, sealing and wear-resistant characteristics of sealing elements, high pressure pipe fittings. The possibility to reuse sealing gaskets in detachable joints increases the economic performance of a consumer. Possibility of operation in an aggressive environment (from -200°C to 450°C).

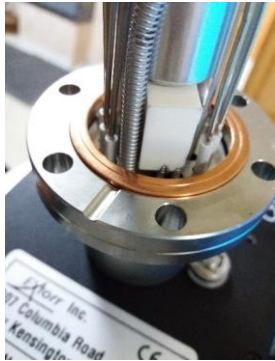


Figure 1 – O-ring in a flange



Figure 2 – Coated O-ring

4.20. Welding complex for automated welding of fixed joints of pipelines

Short description: The welding complex is intended for welding fixed ring welds under constraint conditions, including in non-passing channels. Currently, an application for a patent for an invention has been filed, 3 different prototypes have been manufactured and tested. The optimal kinematic scheme was selected, the operability of this scheme and the ability to weld in impassable channels were proved. The ultimate goal is to sell the technology and intellectual property to a specialized investor.

Advantages: The innovative component of the welding complex is a design of a welding device consisting of rigid links connected in series, rotating around the pipe as well as separation of the device's functionality into separate, articulated links. The separation of functions among the links made it possible to reduce the dimensions of the entire robot in the radial and axial directions compared to the solution when all the functions are concentrated in one welding carriage. Also, such a solution allows placing other functions and facilities to the welding complex. The rotation drive has also changed. In this design, the drive roller is pressed against the outer surface of the steel pipe and has several times larger surface, and the steel-to-steel friction pair is replaced by a silicone-to-steel pair, which has several times greater friction coefficient, which reduces the requirements for



the clamping force and eliminates the slippage of the complex. During welding the whole complex rotates. Counterweights eliminate mass imbalance and the load on the rotation drive is minimized. Rigid links, constant clamping force, bearing on a pair of steel rollers, axial connection of links with each other ensure the rotation of the complex around the axis of a pipe without spiral motion.





5. BIOTECHNOLOGY. MEDICINE

5.1. Production of bread supplemented with Iceland moss



START-2011 Competition winning project.

The university has developed a method for producing Iceland moss powder and a technology for the production of bread with this supplement.

The product has functional and preventive properties and is recommended for people working in hazardous and extreme conditions (emergency response workers, military, residents of industrial cities with a high level of pollution, etc.).

The introduction of Iceland moss powder supplement into the bread recipe provides the product with dietary and functional properties, has a significant impact on the human diet, and solves the problem of preventing a number of diseases associated with polysaccharide deficiency. Regular consumption of this bread prevents disorders of the cardiovascular and endocrine systems, gastrointestinal tract, and lung diseases.

Introduction of Icelandic moss powder into bread production accelerates dough maturation by almost 11 percent, and increases bread shelf life by up to 20 percent.

An enterprise "Dobry Khleb" OJSC has been created in partnership with the "Siberian Union of Entrepreneurs".



5.2. Biopectin of Pribaikalie

Short description: Pectin-rich drinks. A method for the production of drinks enriched with pectin based on apple and birch juice has been developed. The production technology provides a high content of pectin, phenolic compounds. Enrichment with dihydroquercetin gives the juice beneficial therapeutic properties. The price is lower than the price of competitors for similar products.

Advantages: Naturalness and absence of preservatives are the main advantages of manufactured products compared to imported ones. The use of local raw materials, open production, implementation of control and safety system eliminate the entry into the market of low-quality and falsified products. Biopectin has the ability for effective complexing with heavy and radioactive metals. The criterion for the effectiveness of the technology is its universality, the possibility of producing a wide range of pectin products; the technology is furthermore environmentally friendly and waste-free.





5.3. Laser for photodynamic cancer therapy



The university developed a unique laser with double frequency conversion, which makes it possible to perform diagnostics and treatment of oncological diseases without serious consequences, without surgery and in a short time.

The treatment is carried out using the method of photodynamic therapy, which has the following advantages:

- diagnostic and therapeutic action at the same time;
- focal action (only the tumor tissue is affected);
- organ-preserving effect;
- ability to remove tumors in hard-to-reach areas;
- cosmetic effect;
- availability of repeated therapeutic procedures;
- lack of severe local and systemic injuries;
- possibility of treating elderly patients or patients with severe comorbidities;
- possibility of treatment in an outpatient setting.

The cost of the developed laser is 1.5–2 times lower compared to similar pulsed equipment produced by international manufacturers.

The laser passed successful clinical trials in Irkutsk Regional Oncology Centre. A certification procedure is currently underway.



5.4. Therapeutic laser



There are experimental models of multi-purpose therapeutic lasers, which, in contrast to equivalents, make it possible to vary the parameters of laser radiation in a wide range in order to obtain the best effect and specificity of the treatment effect.

Lasers make it possible to achieve a unique modulation mode close to the natural biorhythms of human organs, and to ensure the search for active points of treatment on the human body.

These unique laser designs can increase the effectiveness of treatment by 30–40 %. The cost of devices is comparable to commercially available equivalents. As of today, an experimental prototype has been developed.

Expected market demand is 200–300 lasers per year.

An investment of 6 million roubles is needed to kickstart pilot production.



5.5. Technology for improving the internal environment of production premises using methods of phytoergonomics (medical and environmental phytodesign)



It is proposed to improve the quality of the internal environment of production premises using methods of phytoergonomics and phytodesign. Introduction of specially selected plant modules can significantly improve the state of the internal environment of the premises, improve the sanitary condition and aesthetic perception of the human environment.

Advantages of the technology:

- allows to reduce the content of suspended substances in the air;
- moistens the air through the process of transpiration;
- absorbs biogenous elements, some organic substances and metals;
- performs sanitary functions due to isolation of phytoncides and suppression of pathogenic microflora);
- enriches the environment with oxygen;
- recycles excess carbon dioxide;
- improves air ionic composition;
- has a psycho-emotional impact, neutralizes stress;
- low cost.

Application scope: use of plants to improve human performance in various industries.



We offer services on:

- studying qualitative and quantitative composition of indoor air;
- selection of plant modules and plants for vertical gardens;
- development and maintenance of custom projects.

5.6. Functional pastille/marmalade products based on sea buckthorn puree and arabinogalactan



Development of a technological line for the production of functional pastille/marmalade products based on sea buckthorn puree and arabinogalactan produced from Siberian larch wood.

The invention relates to the food industry, in particular to the production of confectionery products for disease preventive nutrition.

Competitive strengths:

- The use of locally available plant raw materials: sea buckthorn sauce, both in the production of jelly/ fruit, and fruit/berry marmalade. While the introduction of non-traditional types of plant raw materials does not pose a problem in the production of jelly/fruit marmalade, this is a technical know-how in the production of fruit/berry marmalade that makes it possible to replace part of apple sauce with sea buckthorn sauce, which does not only deteriorate the product's quality indicators, but on the contrary, provides increased nutritional value to the finished product.



- Introduction of a water-soluble dietary fibre, arabinogalactan (AG) obtained from larch wood, which is a prebiotic and makes it possible to produce functional jelly/fruit and fruit/berry marmalade.
- Modernized technological scheme is versatile and can be further used for production of marmalade, marshmallow, and pastille.

Functional properties

Taken for preventive and to satisfy the increased need in micronutrients:

- boosting immunity in the autumn-winter period;
- chronic fatigue and depression.

Products are intended for people leading an active and healthy lifestyle, seeking to control their weight and improve their physical condition.

5.7 G-flaxes from germinated flax with the addition of natural fruits and berries

Brief description: The invention relates to the food industry and consists in a method of producing crackers based on sprouted flax - G-flax (English: g-flaxes - germinated flaxes). Medical monitoring carried out in Irkutsk Region and aimed at assessing the current consumption of selenium and iodine with basic foods showed insufficient amount of these microelements. In the process of project implementation it is planned to bring innovative food products from plant materials enriched with biological forms of selenium to the market. Currently, there is a growing demand for functional foods with a high content of nutrients of natural origin: vitamins, carbohydrates, amino acids, microelements etc.; this is sports nutrition, confectionery, drinks and others. Such foods can be produced from sprouted or malted grain raw materials. In the process of germination, proteins are transformed into amino acids, fats into fatty acids, starch into natural sugar. The proposed technology provides an integrated approach to the processing of raw materials. Flax seeds will be germinated before food production. Such raw materials are a unique natural product for a healthy diet, more digestible by the body, with a maximum content of nutrients. It has a lot of healing properties that positively affect the body. The products being developed are rich in a large number of vitamins and minerals, a protein that contains various amino acids, as well as soluble substances. It is planned to produce products using patent-



ed technology. Application for the invention "Method for the production of g-flaxes" in Rospatent No.2019118414 of 06.14.2019.

Advantages: Finely dispersed structure and bioavailable components in comparison with analogues; increased nutrient content; suitable for achloride nutrition as they do not contain salt; contain selenium in the form of selenium methionine and selenium cysteine; contain a complex of antioxidants synergistically enhancing each other's action.



5.8. Robotic complex for the rehabilitation of children with motor impairments

Short description: This robotic complex is a board with runners of different sizes, which are installed on the device depending on the individual characteristics of the patients. The complex includes a gyroscope. The training process takes place in a game form when you connect the device to a computer. The sensor on which the game is installed sends a signal to the software module and visualizes it on the monitor. In this case, the gyroscope contains an application where a penguin, wading through trees, must collect the maximum number of fish. The movements of the hero of the game will depend on the direction of the board.

Advantages: The project is the result of collaboration with doctors from the Scientific Center for Family Health and Human Reproduction. It took about a year and a half to create a prototype, then clinical tests have been started. The simulator is primarily designed to improve leg movement and balance in children with cerebral palsy of varying severity. The device itself is as mobile and light as possible, as well as affordable for a wide range of people. Unlike foreign simulators, this development has a low cost for the device, so that it can be purchased for home use. In children with cerebral palsy and intellectual



impairment, the function that controls the position of the body in space has been changed. According to the results of testing, doctors noticed significant changes in the health status of children. They began to walk more freely, the springy ability of the knee joints improved. With the help of such a complex, a child works out a new movement for him/her, which is usual for healthy children. A course of ten procedures helps to improve not only physical but also mental state.



5.9. Highlight of Baikal

Short description: freeze-dried berries and products from them. The technology of vacuum freeze drying or lyophilization of raw berry (honeysuckle) has been developed. It is based on technology that has been successfully used for many years in the food and pharmaceutical industries for the production of heat-sensitive products: pharmaceuticals, food and beverages. The results showed that after processing the berry retained 95% of the content of vitamin C and phenolic components, while the loss of “total antioxidant ability” was less than 10%. Under normal cooling after 7 days of storage, the loss of vitamin C is approximately 20%, and the “total antioxidant ability” is 25%.

Advantages: Technology of vacuum freeze drying is characterized by high speed, oxygen deficiency and low drying temperature, which ensures structural integrity and preservation of most of the initial properties of raw materials - shape, aroma, color, taste, texture, biological activity, nutritional value, vitamins and minerals.



5.10. Baikal energy

Short description: Using molecular cuisine techniques, a method for the production of dessert based on carrot and birch juice has been developed. The product has increased physiological value. Due to birch sap it is enriched with mineral substances and B vitamins. Valuable components of carrots are as follows: β -carotene, B1, PP, C, biotin, folic acid; amino acids; minerals; carbohydrates: sucrose, glucose, fiber and pectin. Cream is a source of protein.

Advantages: Potassium contained in the drink, especially in combination with magnesium, helps to reduce edema, normalize blood pressure and prevents bone destruction. Birch sap has a mild diuretic effect, has a beneficial effect on the activity of the gastrointestinal tract (calorizator). Vitamin A is responsible for normal development, reproductive function, skin and eye health, and maintenance of immunity. B-carotene is a provitamin A and has antioxidant properties. 6 mcg of beta-carotene is equivalent to 1 mcg of vitamin A.



5.11. Universal medical device for the treatment of various diseases by laser and electrotherapy

Short description: The ancient Chinese method of reflexology acupuncture has long been known; it boosts the body's immune system, relieves pain, reduces inflammation etc. Today, in the age of great technical progress, reflexology is undergoing great changes and innovations. No longer needed to prick yourself with a few centimeter needles to get therapeutic effect. The needles were replaced by laser radiation and electric current. Numerous medical studies in this area open new ways to treat various diseases using laser and electrical exposure. Our team can offer a device to the medical market which ideally suits for the treatment of various diseases by laser and electrotherapy. Here is an incomplete list of diseases that can be treated with reflexology: CNS disease (chronic cerebral ischemia; functional tics and hyperkinesis, enuresis, stuttering by children); functional pathology of the autonomic nervous system; borderline psycho-emotional disorders (sleep disturbances, chronic fatigue syndrome, anxiety, fear, obsession, depression, psychogenic sexual disorders); smoking, alcoholism; diseases of the PNS (neuropathy, plexopathy, polyneuropathy); skin diseases (neurodermatitis, psoriasis, eczema); respiratory diseases



(chronic bronchitis, bronchial asthma); diseases of ENT - organs (chronic tonsillitis, pharyngitis, sinusitis, rhinitis, including vasomotor) and many others.

Advantages: Technical novelty of the product as well as competitive advantages consist in creating a three-purpose device for stimulating active points: the search for active points; laser stimulation of active points by radiation of two wavelengths; stimulation of active points by currents of different frequencies and voltages. Typically, dual-purpose devices are used: point search and exposure to active points by currents of different frequencies and voltages, however, laser stimulation has a large positive effect due to a deeper and punctual effect. In the development of the device, a new principle has been applied for transmitting coherent laser radiation to irradiated objects, so that it will become possible to simultaneously act on two points with two laser beams.

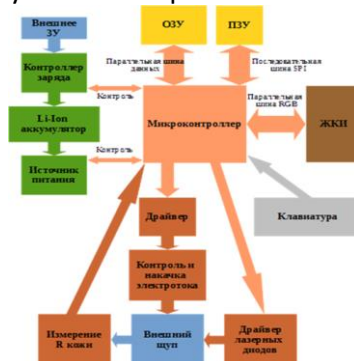


Figure 1 - Block diagram of the interaction of the device modules



Figure 2 - Device

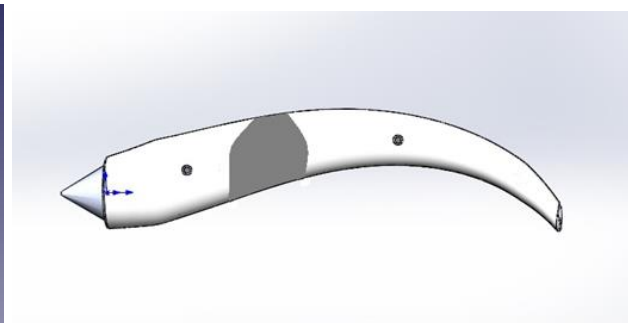


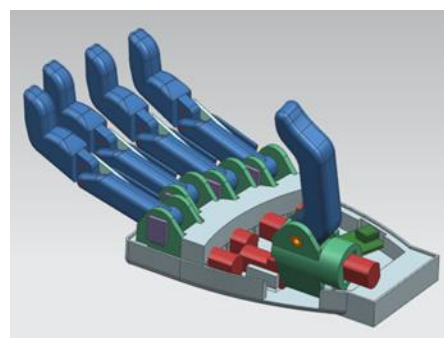
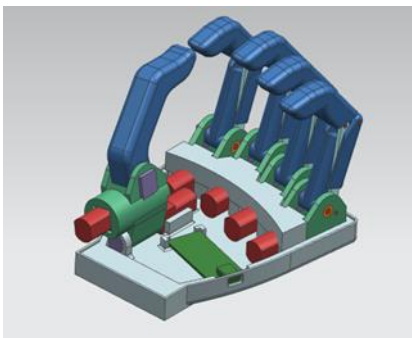
Figure 3 - Active probe

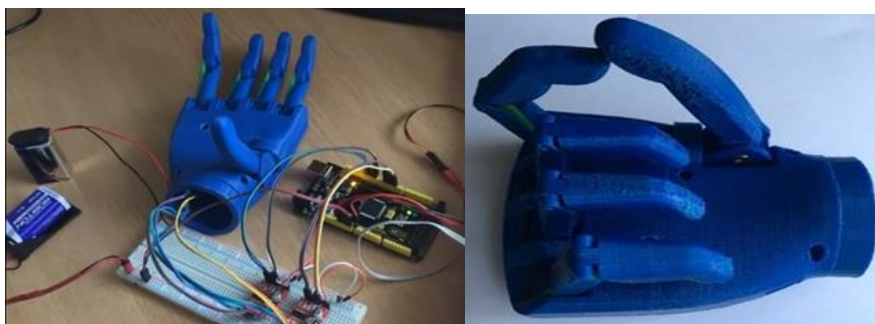


5.12. Development of a bionic prosthesis of a hand for disabled people without a wrist joint

Brief description: The aim of the project is to design the optimal construction of a bionic prosthesis of a hand combining reliability, functional and aesthetic qualities, taking into account production manufacturability. To increase the profitability of using and manufacturing prostheses, the decision was taken to design an optimal prosthetic arm with the possibility of manufacturing using 3D printing technology. Siemens NX10 program was used to design a 3D model as well as to perform a kinematic analysis of the mobility of the main parts of the prosthesis. Such approach allows designing each bionic prosthesis together with its potential user so that the patient receives a functional prosthesis fully suitable to him/her.

Advantages: Most parts of the prosthesis are manufactured using the additive method technology of plastic - FDM. The appearance of the prosthesis will be modeled in accordance with the wishes of each patient while the inner part, the mechanics, will remain unchanged. The design of the prosthesis ensures automatic change of grip. The position of a thumb will be controlled by signals going from user's muscles. Additional options are also envisaged such as highlighting of fingertips to facilitate the prosthesis control in the dark, a display on the forearm, built-in computer control, etc.





5.13. Selenium-enriched malt

Short description: Malt enriched with selenium is used to produce malt flour which is recommended as an effective baking improver. Such an additive accelerates the fermentation process of the dough, increases the volume of baking, improves the porosity and appearance of bread crust. The introduction of 2.5% of selenium-enriched malt flour from the overall prescribed weight of flour is a safe concentration for enriching the product with the microelement and improves the organoleptic characteristics of bread. The consumption of 300 g of fresh bread baked using malt enriched with selenium satisfies from 32% to 60% of the daily human need for selenium.

Ground selenium-enriched malt is used as a baking improver in the concentration 2.5% from total flour weight. Grounded malt is used to enrich beer or kvass with selenium when it is added in the concentration up to 1.5% of the total weight of grain during mash preparation.

Advantages: Selenium-enriched malt has great antioxidant properties and is longer stored compared to plain malt. Organic forms of selenium in malt are less toxic to the body than inorganic ones (selenites and selenates).





6. TECHNOLOGIES OF BROAD APPLICABILITY

6.1. Development of an integrated resource-saving technology and high-tech production of carbon-based nanostructures and silicon dioxide to improve properties of building and construction materials



The project is the winner of the 6th stage of the competition held under Decree No. 218 of the Government of the Russian Federation (2015):

Industrial Partner: UC RUSAL Engineering and Technology Centre LLC (Krasnoyarsk)
Investment amount: 364 million roubles.

Project objective: production of concentrates of nanoparticles of various chemical composition and functionality, addition of which makes it possible to radically improve the properties of structural and building materials.



Targets: development of hardware and process schemes for efficient extraction of nanoparticles, together with by-production of useful materials that are returned to the main production, and production of a line of nanoparticle containing products to improve properties of rubber, concrete, asphalt, ferrous metals.

Economic effect: with the production of 100,000 tons of nano-modifiers per year, the volume of new tax revenue in the economy of Irkutsk region will increase by 50 million roubles per year.

6.2. Archaeological and ethnological research



INRTU's Research laboratory of archaeology, paleoecology and systems of life of the nations of Northern Asia performs the following types of research:

- Archaeological and ethnological assessment of the territory and justification of allocation of zones with special conditions of use.
- Collecting information on cultural heritage objects (literary, archival, folklore materials).
- Survey of territories in order to identify objects of archaeological and ethnological value, their recording; determining the object area and making reference to paper and digital topography.
- Conducting archaeological excavations, including of saving type.



- Processing, conservation and interpretation of archaeological and ethnological materials; creation of databases based on 3D models.
- Creating high-quality photos and 3D models of any items.
- Studies of traditional cultures and social life of the peoples of North Asia.

- Analysis of the economic activities of Siberian peoples and their effectiveness, shares of traditional and borrowed elements of culture and their interaction.
- Assessment of the adaptation of human groups to the environment; the impact of globalization and industrial development of Siberia on its inhabitants.

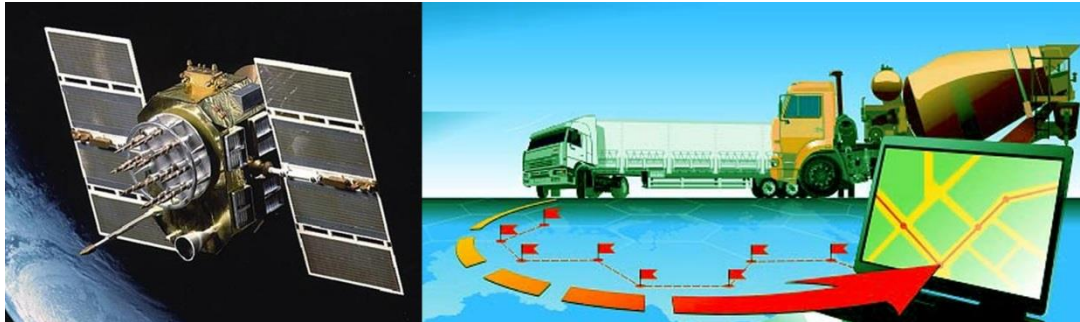
The unique character of the laboratory in the combination of high-class specialists and modern equipment, which makes it possible to solve problems of reconstruction of various aspects of life of ancient and modern peoples of Northern Asia: identify the features of territorial mobility and intercultural communication; to determine the causes and consequences of migration of these peoples, to carry out reconstruction and investigate origins of the technologies of ancient industries.

The laboratory team includes practitioners with licenses for various types of archaeological activities and many years of experience in both research and reconstruction. The geography of their research includes the territory of Eastern Siberia, Mongolia, China, Japan and the United States.

Vast experience of cooperation with leading Russian companies in road construction, pipeline, electric wire, housing, tourism and other industries has helped the laboratory to establish mutually beneficial relations between business and science and form the positive image of INRTU's Research laboratory of archaeology, paleoecology and systems of life of the nations of Northern Asia IRNITU as a reliable partner.



6.3. System for moving object monitoring



This system applies GLONASS/GPS technology to monitor parameters of the use of vehicles (cash transit vehicles, special-purpose vehicles, logging trucks, public transport, etc.).

System features:

- positioning and tracking of the object;
- receiving reports of data on the movement and operation of objects and information from sensors;
- displaying the object path with breakdown by speed;
- option of displaying overlaying paths of simultaneous movement of different objects;
- option to specify the route of the object with the deviation monitoring, obtaining data on the number of travels;
- fuel monitoring: defueling, refueling, remaining fuel;
- creation of specific layers of production facilities to monitor the movement of process transport;
- Continuous recording of data into the memory of the device every second, if the navigation device is outside cell communication zone. On entering the next cell communication zone, all recorded information is automatically transferred to the server;
- use of this system in automated production management systems of enterprises.

Benefits from the system implementation:

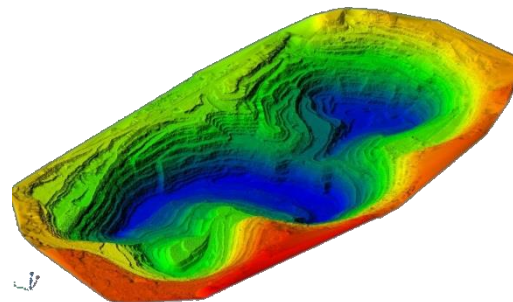
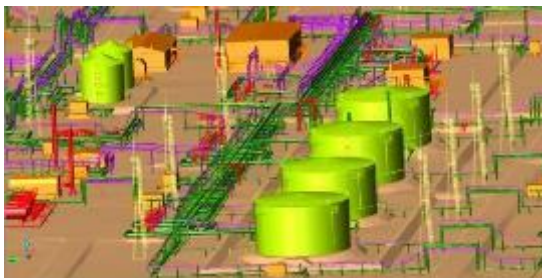
- real-time monitoring of plan implementation;



- fuel saving (about 30% per month);
- service life saving (reducing the number of repairs);
- prevention of inappropriate use of process transport;
- Opportunity for the dispatch operator to track the deviation of the vehicle movement from the planned route and the difference between the actual movement of the vehicle and the planned one;
- For cash transit vehicles: option of installation of an alarm button. On triggering, the alarm signal is transmitted to the closest police rapid response team.

The cost of installing the system starts from 80 thousand roubles (depending on the number of necessary devices), monthly fee 500 roubles for one navigation device.

6.4. Post-construction survey of complex engineering structures and quarries, creation of 3D models



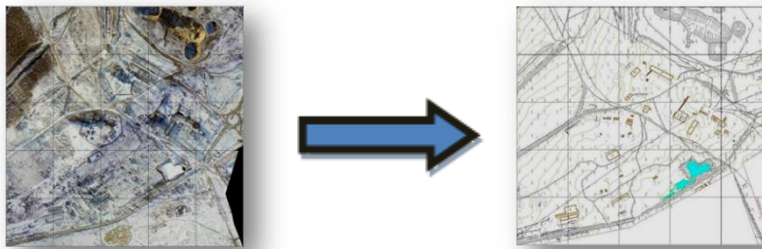
To determine the accuracy of the actual as-built structure positioning and identify any deviations occurring during the construction period, to obtain the coordinates and heights of the constructed structures and other data necessary for drawing up the as-built plans, a postconstruction survey is carried out using the technology of ground-based laser scanning. The technology does not require preparation of a geodetic control. In the process of scanning, we obtain hundreds of millions of points of an object with real three-dimensional coordinates, which makes it possible for us to create 3D models of objects of complex geometric shapes, drawings, sections, and volumes with the highest detail, accuracy and speed.



The geometry of the modeled object does not differ from the real one. Remote method of collecting information makes it possible to significantly speed up work performance time. The quality of the survey complies with all requirements of regulatory and technical documentation. Scanning speed up to 1 million points per second, highest density up to 1000 points per 1 m². As a result, a highly detailed model of the entire structure or ground form is obtained.

3D modeling makes it possible to perform a comprehensive assessment of the state of the object, serves as the basis for further design. In addition, 3D models are the best way to visualize data.

6.5. Topographical surveys using ground and aerial scanning systems



As of today, laser scanning is one of the most effective and promising methods for collecting spatial data for large-scale mapping.

The unique capabilities of the laser-location system make it possible to achieve the following: actual terrain (even when covered by forest canopy, achieved with air laser scanning) without any loss of accuracy; 3D models of industrial sites and pipelines, buildings and structures, topographic plans and maps in a featureless area (tundra, desert, sandy beaches) with accuracy and detail unattainable by any other methods.

Laser scanning method-based topographical survey means:

- topographical survey in scales 1: 500, 1: 1,000, 1: 2,000, 1: 5,000 for construction and reconstruction of civil and industrial objects;



- special detailed survey of underground and overland lines of communication, facilities and industrial equipment installation;
- pre-construction surveys of construction objects;
- geodesic works in calculation of earth quantities.

Examples of successfully implemented projects with the participation of Mine Surveying and Geodesy Department's staff:

- Complex engineering surveys on the object: Ugahan Mining and Processing Plant for needs of Vysochaishiy PJSC in Bodaybinsky district. Works were conducted in different periods of time since 2013 till 2017, total area of survey is more than 30 sq. m. M 1 : 2 000.
- Aerial communication line and aerial photography of prospective areas for needs of JSC Gold Mining Company Lenzoloto in Bodaybinsky district. The works were carried out in 2016, total area of the survey 220 km² M 1 : 2 000.
- Making up of digital 3D model of terrain relief and situation to perform mine surveying works using unmanned aerial vehicle at deposits Cehtovo Koryto and Zapadnoe for needs of the companies JSC Pervenets and JSC Tonoda, included in the group of companies of OJSC Polus Zoloto in Bodaybinsky district. The works were carried out in 2016-2017, total area of the survey 72 км² M 1 : 1 000.

6.6. Survey from unmanned aerial vehicles





The most technological type of survey of large areas is rightfully considered aerial laser location. A complex of innovative equipment which includes laser scanner, multi-spectral and photo cameras, satellite navigators and inertial systems since recently can be allocated in the unmanned aerial vehicle (helicopter or aircraft).

This type of survey is currently available since the University possesses state-of-the-art unmanned aerial vehicle Aeroscout B1-100. It is possible to perform geological survey using it for purposes of 3D modelling and making digital location maps with high productivity – up to 10 km² a day!

RIEGL LMS-Q160 laser scanner is used for purposes of aerial laser scanning.

Advantages of aerial laser scanning from a light UAV:

- there is no need in an assigned flight strip;
- obtaining of true relief even under top of trees;
- determination of location and object shape of complex structure;
- high accuracy and details of obtaining digital data.

Light air vehicles are also available for:

- aerial photography;
- thermal-imaging survey;
- multispectral survey.

For purpose of aerial photography the University applies GeoScan 101 aerial photography complex which is designed for prompt production of orthophotomaps, altitude matrixes and 3D models of location and individual objects.



6.7. Remote monitoring technologies of hazardous facilities



Remote probing technology allows getting with high accuracy geospatial data about the object located at any distance and it doesn't require presence of the specialists in the danger area.

Monitoring tasks of hazardous industrial objects and their components are solved in high technological and safe manner (open pit borders, different technological installations, main structural bearing elements, utility poles, power plants etc.). The works are carried out with non-stop of manufacturing process.

The University has all licenses for performance of works, RF certificates for used equipment and software, qualified personnel.

The University develops and implements specialised software products and techniques for surface and aerial laser scanning technologies («LENTA», «MapsModel» etc.).

Over the last 5 years works on industrial areas modelling (including buildings, constructions and communications models) of processing shops of Ust-Ilimsk pulp mill, Sorskiy Ferromolybdenum Mining and Processing Plant, VCHNG, Tugnuysko – surface mine, Krasnoyarskiy Hydroelectric power plant, Nevskoe Gold Recovery Plant, Tyretskiy salt mine and many others were performed.



6.8. Development and implementation of algorithms for self-starting of electric drives of "responsible" devices



The developed algorithms allow reducing the technological equipment downtime by more than 30 % due to short-term breakdown in the power supply system.

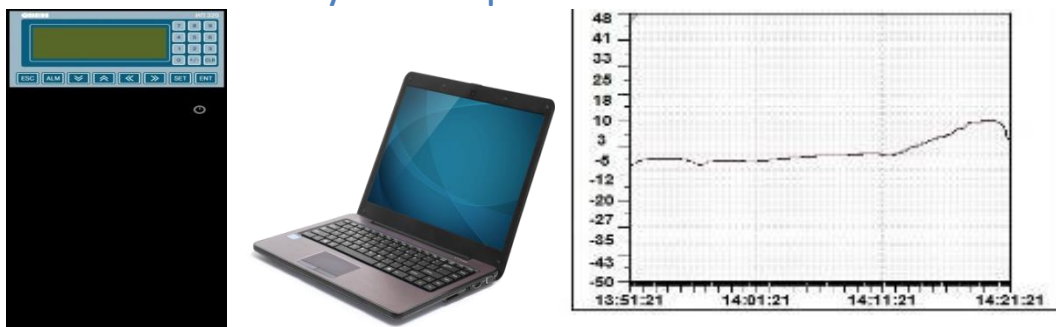
For the last 5 years the results of INRTU developments were implemented on 247 electric drives of Angara Petrochemical Company OJSC plants.

Economic benefit makes up more than 10 mln rub per year (reduction of additional material costs and electric resources at forced restart of the plants).

The developed algorithms can be used at all enterprises with continuous-cycle fabrication (chemical and oil-refining industry, minerals processing, metallurgy, thermal power etc.).



6.9. Online analyser of specific surface of bulk materials



One RF patent has been granted.

Metrological characteristics: measurement range 0.1–2000 m²/g, fractional error $\Delta = \pm 2-5 \%$, productivity 1 sample/hour.

It has an internal instrument interface, control system and specific surface calculation (OVEN controller of PLC 154 with information output to the operator panel OVEN IP-320, laptop).

Application scope: plant laboratories in production of cement, alumina for aluminium, powder metallurgy, catalysts and pigments, technical carbon, weighting agents for oil and gas extraction drilling agents; gold recovery sorption technology; research and educational laboratories.

Competitive strengths:

- reduction of measurement time by three times as compared with analogues;
- refuse to use expensive inert gases and hazardous liquid gas as a coolant;
- temperature control and calculation process automation;
- production costs of measurement is lower 2–3 times as compared with analogues;
- RF patent protected.



6.10. Modified range of multi-purpose fire-fighting hoses



Performance characteristics:

- manufactured in transportable, portable and fixed version;
- for hose operation one can use: water, conventional foam, quick-hardening foam and other fire extinguishing agents with improving additives.

Competitive strengths:

- hose capacity with water from 20 to 100 l/s;
- capacity improvement with foam in 2.5 times;
- increase of long range of foam spray in 1.7 times (supply of fire extinguishing agents up to 75 m);
- increase of foam expansion more than in 2.0 times.

Scope of application: in hazardous locations of forest, oil refining, chemical and transport industry.

In 2011 tests based on the Ministry of Emergency Situations (Russia) of Irkutsk region.

Nowadays universal fire-fighting hoses undergo experimental performance in Irkutsknefteproduct OOO and Buryatnefteproduct OOO.



6.11. Interregional center of forensic inquiries and certification



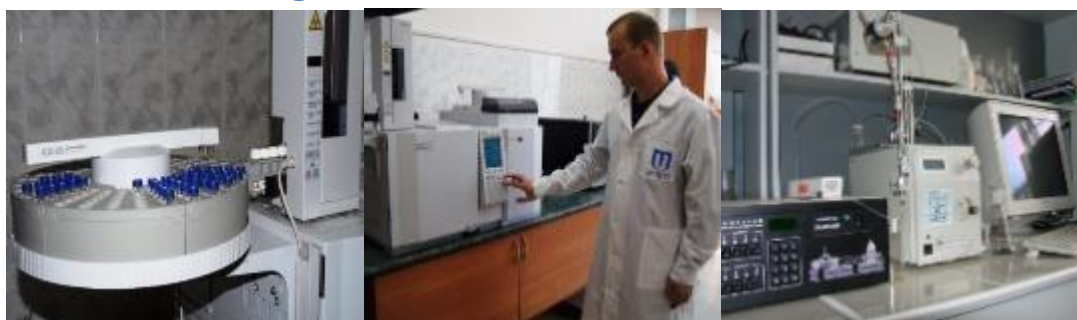
Interregional centre of forensic inquiries and certification performs pre-trial and forensic inquiries and examinations in the following fields:

- highway investigation;
- motor vehicles investigation;
- computer-based investigation;
- linguistic investigation;
- expert evaluation;
- fire investigation;
- handwriting examination;
- psychological expertise;
- construction and technical expertise;
- chemical expertise;
- ecological expertise;
- documents requisites expertise.

Investigations are performed using modern equipment of laboratories and scientific research centres of INRTU.



6.12. Operational control and labour conditions monitoring



Purpose of operational control is to ensure safe and (or) harmless adverse effect of the industrial objects to human and his environment by duly fulfilment of sanitary regulations, sanitary and disease control (preventative) measures, arrangement and performance of control over compliance with them.

Industrial control objects are industrial, public premises, buildings, structures, health protection areas, sanitary protective zones, equipment, transport, technological equipment, processes, workplaces used for works performance, service delivery, as well as raw materials, semi-finished products, finished products, production and consumption wastes.

Our services on arrangement and conduct of industrial control:

- development of industrial control program;
- performance of laboratory and instrumental investigations (performed by properly accredited laboratory);
- accounting and reporting forms maintenance established by the current legislation on issues related to the implementation of production control;
- monitoring of officially published sanitary rules, methods and principles of industrial control objects supervision in accordance with performed activity.



Our customers: large enterprises of Irkutsk city and region, republic of Buryatia, Republic of Sakha (Yakutia), Moscow city, Khabarovsk and Krasnoyarsk, municipal and commercial organizations, individual entrepreneurs.

6.13. Work safety outsourcing



Industrial ecology and life safety department provides services of work safety outsourcing.

Work safety outsourcing means performance of functions of work safety service or work safety officer of the employer.

The main benefit of work safety outsourcing is an ability to use someone else's highly professional experience gained in solving similar tasks, and a constant access to new technologies and knowledge. The department, preparing specialists in work safety, focuses on development of technologies and method of task solving, permanently engaged in personnel development. Focused specialization in the subject area allows to ensure reliable and proper performance of the functions given to it for outsourcing.

Outsourcing allows reducing staff costs and settle issues of resources economy in the enterprise.

Advantages:

Before outsourcing: schedule overrun, late performance of given tasks; incompetence, lack of knowledge, lack of confidence of staff members; costs for paying taxes, sick leaves, motivation and equipment; necessity of constant control, loss of valuable time of managers; low responsibility, combination of tasks; risk of fines and prescriptions in the case of inspection by regulatory authorities.



After outsourcing: operational efficiency and promptness; work only with a team of professionals and experienced specialists of wide profile; cost control and absence of hidden costs, payment only for result; control only over result, more time for strategic tasks solving; responsibility for quality of works performance.

Application scope:

Performance of work safety service functions for companies with 50 employees, namely:

- arrangement and coordination of work safety activity;
- control over compliance with work safety requirements by the company's employees;
- work on prevention of workplace injuries and illnesses, organization of training and testing of knowledge on work safety, providing workers with individual protective equipment, health care and sanitation and housekeeping support;
- work safety document management, making up of local regulations and standards on work safety (preparation of orders, provisions, standards, instructions on work safety), organization of information support of the company's employees and work safety promotion;
- investigation and registration of accidents and occupational diseases;
- interaction with regulatory authorities.

6.14. Special evaluation of work conditions





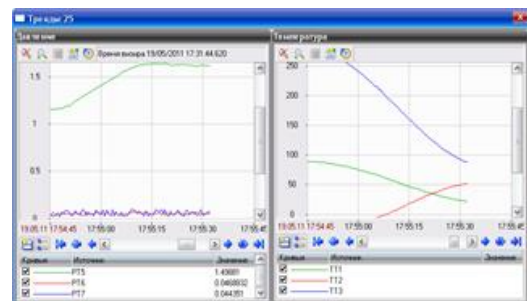
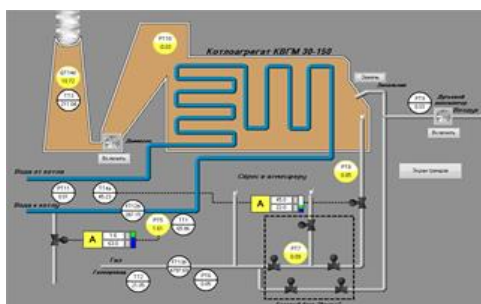
Technosfernaya Bezopasnost' Innovation Centre, accredited by the ministry of Labour and Social Development (accreditation certificate) provides services on special evaluation of work conditions (SEWC):

- according to the results of SEWC, it is possible to lower the class of harmfulness or remove this class, and thus you will receive a possibility to deduct a smaller amount of the additional tariff or not to pay it at all;
- declared workplaces according to the results of SEWC are excused from check-up by the state inspection for the period of 5 years and can be prolonged in case of absence of accidents and professional diseases in the company;
- according to the results of SEWC the employer can be exempt from all costs connected with harmful working conditions.

Our advantages:

- we provide legal support of the results of our activity during 5 years;
- carry out urgent works on SEWC performance;
- in case of change of conditions in the workplace we make beneficial reassessment;
- provide a possibility of a partial execution of works;
- experience in evaluation of working conditions for over 18 years;
- availability of five experts in the company working under a labour contract and having a certificate of expert giving a right to perform works, under special evaluation of work conditions (Expert No. in the register: 798; 767; 799; 756; 790).

6.15. Development of training systems for production processes and units





Personnel learning to work with new production for the first time or already working at industrial facilities (factories, plants, process lines, etc.) should undergo regular training. Currently, one of the most effective training methods for acquiring practical skills of safe work, preventing accidents and eliminating their consequences on process objects is the use of trainer simulators.

Computer-based simulators contain dynamic models of processes, as close as possible to real ones, and real controls (functional keyboards, graphic displays).

Training and obtaining practical skills on computer simulators makes it possible to ensure mastering of knowledge about the basic operations of the production process and the control system, including start-up, planned and emergency stops in general and specific emergency situations, accidents and decision-making.

Programs for practicing skills of start-up, normal operation, planned and emergency shutdown of production (facility) are created using process regulations for production and other process standards, including ECLPs (emergency containment and liquidation plans).

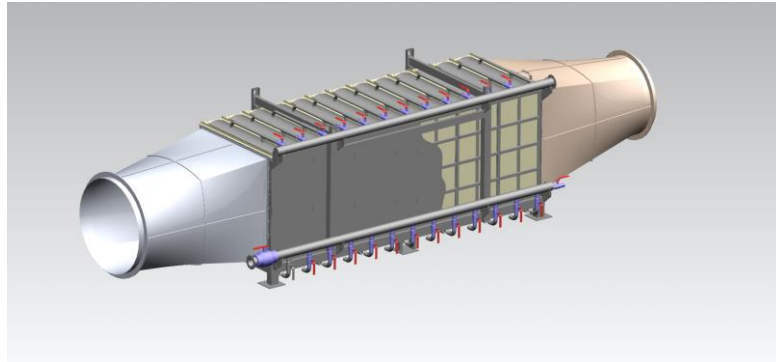
The main use of training systems is the opportunity to conduct training of process and technical personnel on simulation models of a production process or unit with automated control functions, mastering their skills in different production situations.

Advantages:

- training and retraining of operating personnel to work on process equipment;
- creation of a simulation model of production prior to actual commissioning to master process operations;
- individual development of a simulation model of production or a process unit together with the customer;
- preparation of an accurate mathematical model;
- development of tasks for the training system according to individual requirements;
- development of unique control algorithms;
- development of an automated control system.



6.16. Shell and tube heat exchanger



The project was completed following Decree No. 218 “Development of high-power, energy-efficient technology RA-550 for producing aluminium” of the Government of the Russian Federation and on commission from UC RUSAL.

Strengths of technology:

- Improving energy efficiency of the production facility;
- Decrease in physical volumes of gases;
- Decrease in the temperature of gases;
- Heat recovery.

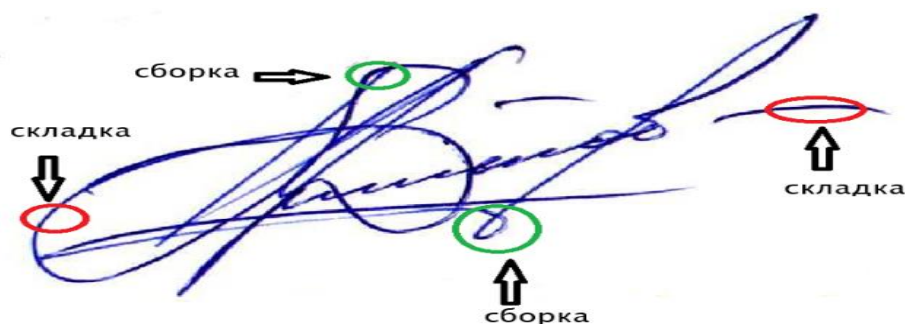
Application scope:

- Metallurgical industry;
- Chemical industry;
- Oil and gas production;
- Industrial power systems.

Testing: Pilot tests are underway at RUSAL Sayano-Gorsk JSC.



6.17. Digital Graphology



The purpose of the Digital Graphology software is to determine the authenticity of the author's signature. The software analyzes signature microfragments that contain persistent characteristics of fine motor skills of the person signing the document. The algorithm of digital graphology takes into account the individual signature variability and is based on the physical laws of the theory of chaos.

The program performs recognition of copyright signatures not only on paper in the existing document flow, but also provides establishing the authenticity of an electronic signature on digital media. Through the use of this software, it will be possible to create electronic databases of copyright signatures that can be used in the banking sector, in HR departments of enterprises, etc. The software requires only a fraction of a second to determine the authenticity of the signature (today, to conduct such a study, a graphanalysis expert needs more than a week). The developed algorithm is able to recognize not only Cyrillic symbols, but other alphabets, including Chinese script.

The Digital Graphology software is an innovative technology in handwriting and graphanalysis in general. In addition to the ability to create electronic client databases of copyright signatures, digital graphology will undoubtedly contribute to effective work of law enforcement agencies in crime investigating and solving.



Further development of the method will make it possible to determine the individual characteristics of the fine motor skills of a person and, further, to assess the psychological characteristics of the signing person in fractions of a second.

In the future, based on the assessment of psychomotor data, using the methods of neuropsychological diagnostics, the use of the software will enable the following:

- assess the functional and psycho-emotional states of the individual;
- present an individual psychological profile of an individual as a subject of activity in a structured fashion;

The Digital Graphology software relates to the broader field of computer recognition, focused on the detection and classification of objects.

6.18. Technology for production of aluminum composites modified with carbon nanostructures

Development of composite materials consisting of a metal matrix and reinforcing elements distributed inside it is one of the top priority directions of modern metallurgy and material science and engineering. In most cases, only composite materials are able to meet the requirements of modern engineering technology which is characterized by heavier operating conditions (increased loads, speeds, temperatures, media aggressiveness, weight reduction). Currently, among the majority of the known metal matrix composites, the most widely used are the. The reason is that aluminum composite materials have high strength, low specific gravity, as well as a favorable combination of a number of mechanical and operational properties. The principle of the technology is to obtain composite aluminum and carbon nanostructure materials with improved physical and mechanical properties produced by hot pressing.

The project won BP Exploration Operating Company Limited grant competition in 2016-2017.

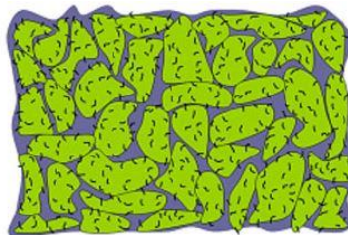
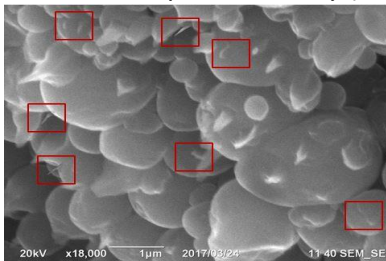


Advantages:

- ability to create uniform modifier additive distribution in the metal matrix due to the use of hot pressing technology for aluminum powders and alloys;
- increased hardness and strength of composites compared to the source metal;
- possibility of using carbon nanostructures obtained from silicon production waste (dust from gas cleaning systems of electrothermic furnaces) as modifier, which may be a basis for reduction of the resulting composites cost.

Application:

- automotive industry (wheel rims, gears, piston rings, brake shoes, cylinder liners);
- aerospace industry (structural radiators and high gain antenna systems);
- oil and gas industry (pump-compression and casing pipes);
- sports industry (bicycles, badminton and tennis rackets, ski poles, golf clubs).



6.19. Diamond detector

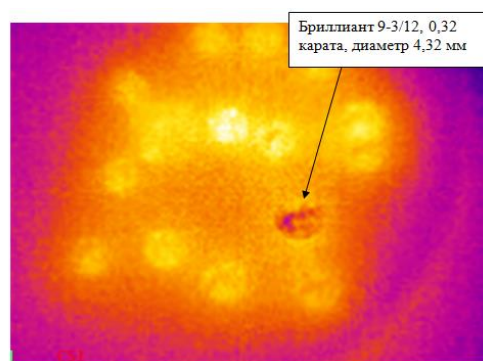
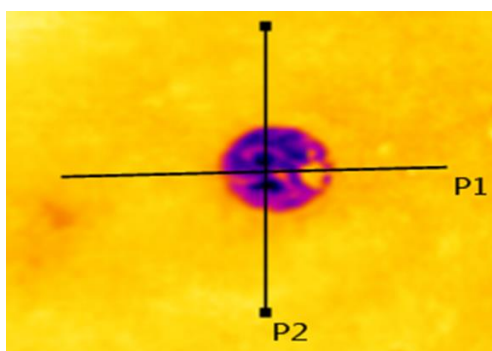
Short Description: Intelligent automated system for diamond searching and quality assessment. The diamond detector is an application for thermal imagers as well as devices containing a thermal imaging module (smartphones, attachments etc). The application allows quick evaluation of valuable components (diamonds as well as gold and silver). Recognition technology is made over the entire range of valuable components' characteristics and ensures distinct separation of diamonds from any fakes. The main method is the recognition by images (video) of valuable ore components via mathematical and software processing of a large database of graphic data (Big Data) in real time.



Advantages: The developed technology (Diamond Detector) allows as follows:

- find large diamonds during the opening of a deposit (in a quarry, drift, on the field of a placer deposit, in a factory before crushing and grinding);
- replace the X-ray fluorescence separation by separation without the use of X-rays and without loss of those diamonds that do not shine under the X-ray (it is possible to recognize almost all diamonds, even slightly dirty (dusty, covered with small mineral particles));
- conduct an express assessment of diamonds (within 1 minute) comparable with the expertise of gemological laboratories by its accuracy;
- find, in addition to diamonds, other valuable components (gold, silver, etc).

The scientific novelty of the project consists in the creation of an image of a recognizable mineral particle in a wide range of electromagnetic waves without use of X-rays taking into account a wide range of particle properties (geometric, physical, chemical etc), i.e. diamonds and other valuable ore components are recognized at a distance (without contact) by a large set of characteristics (color, shape, characteristic chips, optical parameters, physical and chemical properties, and other parameters). A large database (Big Data) of particle images can be created, which is processed almost instantly in order to identify a valuable component (diamond). Compared to the known X-ray fluorescence separation method, the Diamond Detector detects all diamonds without loss.



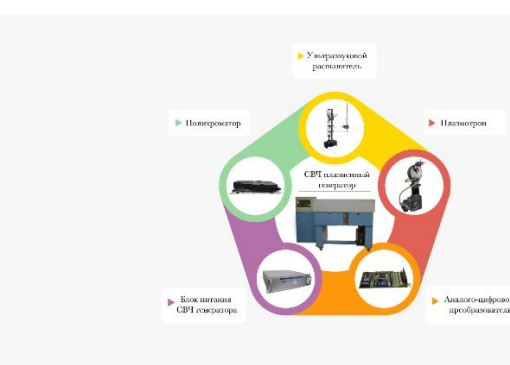


6.20. Development and creation of a software and hardware microwave plasma complex for monitoring, control and safe operation of the oil system of ground and air engines

Scope of application: Engine building

Expected effect: on the basis of the created mobile software and hardware microwave plasma complex, unique diagnostic technologies (with a reliability of at least 90%) of engine friction units are being developed to predict the technical condition of the lubrication system regardless the types of developing defects. The development of such equipment and technologies makes it possible to obtain a comprehensive effect as follows:

- monitoring of the technical condition of the lubrication system by the construction of promising engines of the 5th and subsequent generations;
- prediction of safe behavior of friction units when using the latest (nanocomposite) materials in the construction of assemblies, machines and mechanisms;
- introduction to the world market of microwave plasma systems - analytical equipment, which ensures global excellence and leadership in tribodiagnostics for 7 - 9 years, including through the use of exclusive intellectual law;
- the maximum increase of the safe operating life of engines due to the transition from the resource with assigned intervals to the resources set in accordance with technical condition;
- obtaining a multiplicative effect by the development of diagnostic technologies not only for friction units of the engine lubrication system, but also for other systems and industries, for example, for the aircraft hydrocomplex, for the mining industry, for research in analytical chemistry. Moreover, these technologies can be developed without considerable alteration of the microwave plasma complex.



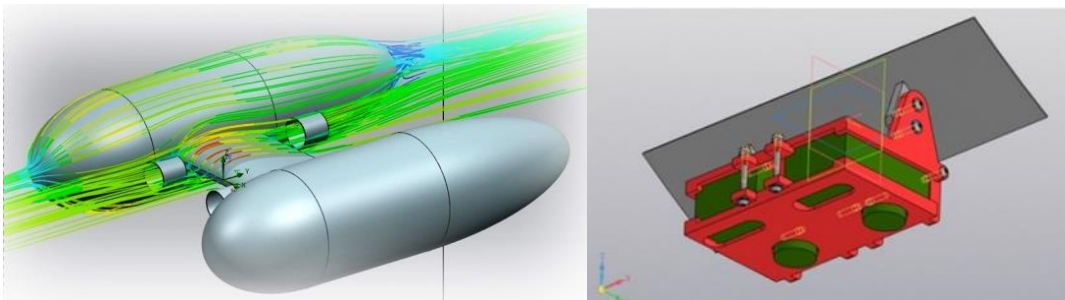
6.21. Universal ultralight air transport platform “Dronozhabl”

Short description: The project of a universal ultralight air transport platform is aims to develop and introduce on the market a product meeting the following requirements: vertical take-off / landing; flight time at least 2 hours; flight speed up to 60 km/h; target load weight up to 8 kg; device weight not more than 30 kg (super-light). Functions: monitoring and research missions, advertising campaigns, broadcasting of cultural events. The scalability of the project involves the development and introduction on the market of a line of platforms differing in weight and size as well as load-bearing parameters to ensure freight traffic.

Advantages: The original design in combination with the modularity ensures that the above-mentioned features are available “all at once” rather than “either one or another”; the latter is typical for almost all devices (for example, a copter can stay in the air for up to 1 hour but only when replacing the entire target load with additional batteries).



The design providing the declared performance characteristics implements a positive mutual influence of key elements of heterogeneous systems, is an own development of the University team and is in the patenting stage.



6.22. Technology for the production of heating elements from carbon paste for various fields of application

Short description: The technology is designed to organize the production of heating elements with a maximum operating temperature of up to 150° C on a dielectric surface. For example: fiberglass, ceramics, lavsan, etc. Heating elements can be used in various industries: medicine, mechanical engineering, instrument making, construction. The heating elements are made using the technology of "screen printing" by applying carbon paste to a dielectric surface followed by polymerization in a conveyor furnace. The technology is delivered in accordance with the requirements specification. Stages of technology delivery: development of requirements specification; preparation of design estimates; production launch.

Advantages: It takes 3 months to organize the production for small and medium-sized business including the release of an experimental batch and product certification. Heating elements are more efficient compared to the closest analogues due to the use of the technology "distributed heating layer", the entire component base is located in the



Russian Federation, the cost is much lower compared to analogues due to the high productivity and low cost of components. The universality of the technology allows switching between production of different types of heating elements within the short period of time.

Basic equipment, samples



Products produced with developed carbon paste



6.23. Dynamic chess

Short description: The main difference from the classical chess format is the idea of using chess pieces and fields of various size and weight to adjust the load and contribute to the physical development of players. Dynamic Chess is an educational, interactive platform for outdoor and indoor use, which is of interest to both players and a large number of spectators. The enlarged format of Dynamic Chess turns them into a team game. The age and social status of consumers of Dynamic Chess is practically unlimited.



Advantages: The positive effect of using this development consists in increased stagginess, additional interest to the game, creation of a moderate load on various muscle groups, improved blood supply, fat burning and the fight against hypodynamia.



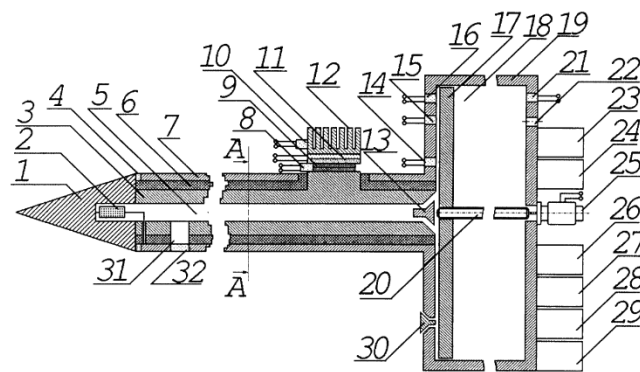
6.24. Specialized detector for prevention spontaneous combustion of coal

Short description: The device is a multicriteria detector of aspiration type and is designed to identify fires in bulk combustible substances (coal, peat, grain etc). A feature of this device is that the measurement of main parameters (temperature, smoke particles presence, gas composition) is carried out directly in the mass of a combustible substance. An intake pipe is immersed into the substance, gas-air mixture goes to an outer measuring chamber through the pipe by means of a piston with electric drive. The device is powered by Peltier-based thermoelectric generator, alarm messages are transmitted via radio channel.

Advantages: Measurements are taken directly at places of the most likely occurrence of spontaneous combustion; due to its multicriterion character, operation algorithm of the device allows detecting spontaneous combustion even at the stage of coal self-heating; device operation is ensured by one of the monitored parameters of the medium -



increased temperature; the device does not have external cables, easy to use and requires minimal maintenance.



ФИГ. 1

1 - tip; 2 - temperature sensor; 3 - intake pipe; 4 - electrical insulation; 5 - air channel; 6 - thermal insulation; 7 - casing of the intake pipe; 8 - protection device sensor; 9 - bimetallic safety plate; 10 - ambient temperature sensor; 11 - Peltier element; 12 - radiator; 13 - inlet valve; 14 - sensor of piston initial position; 15 - gas analyzer; 16 - smoke detector; 17 - piston; 18 - measuring chamber; 19 - measuring chamber case; 20 - threaded shaft; 21 - sensor of piston final position; 22 - compensation hole; 23 - display unit; 24 - alarm generator; 25 - electric motor; 26 - logical unit; 27 - control unit; 28 - signal processing unit; 29 - reference voltage generator; 30 - exhaust valve; 31 - intake hole; 32 - air filter.

Существующие технологии



Предлагаемая методика





6.25. Production technology of new aluminum master alloys

Short description: The problem of improving the mechanical and operational properties of cast aluminum alloy products is extremely urgent for foundry. The most effective solution to this problem is to maintain a constant chemical composition of heavy metals (the sum of V, Ti, Cr and Mn should not exceed 0.01%) as well as modifying (grinding) of aluminum structure and its alloys. To fulfill these conditions, master alloys are used in the aluminum industry.

Currently, various types of master alloys are used to modify and refine aluminum and its alloys. The uniqueness of Al-B master alloy is that it can be used both for refining and modifying aluminum and its alloys.

The proposed master alloy is intended for aluminum industry enterprises aiming:

- to produce high-quality castings from aluminum and its alloys with specific properties;
- to produce cheaper and higher-quality aluminum products competitive in the world market;
- to reduce energy costs for production cycle;
- to abandon the costly method of removing crusts from mixer surface.

Advantages:

- combining two fundamentally important operations to obtain high-quality aluminum castings;
- preventing the formation of hard-to-remove crusts on mixer walls and bottom;
- reduction of cost for crusts removing and mixers repairing;



- use of less energy-intensive technology for producing small-crystalline Al-B master alloy, which allows controlling the process of structure formation, i.e. affect the morphology, size, quantity and distribution pattern of nucleating particles.

