ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

Engineering services of the Chemical Technology cluster

ROSATOM

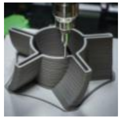
NIIGRAPHITE | GIREDMET | VNIIHT

Chemical Technology cluster provides engineering services in the following areas:

Machines and apparatuses for chemical production (chlorination plants)

Non-standard equipment (growth plants; hot pressing vacuum press)

High-temperature vacuum furnaces and plants (distillation furnaces; ORZM chlorination plant)



Additive equipment (an atomizer for producing titanium alloy powders)

Non-standard quartz glass equipment (quartz reactors, ampoules, vessels, boats, laboratory non-standard equipment, products made of special pure quartz)

High-temperature vacuum furnaces (EVP-750 furnaces; EVP-1900 furnaces; plant for studying the kinetics of metal impregnation; plant for studying the kinetics of wetting and spreading of metals)

Software development (graphical mnemonic circuits for TP monitoring; visualization of SU systems; application software for various equipment; intelligent analysis and systematization systems; automated defect counting system)

Digital products (digital modeling of pilot-scale plants; automation and digitalization of existing plants; modernization of existing technologies)

Electrical equipment (control cabinets; PLC-based control cabinets; automated process control system CD; automated process control system modernization RKD; pre-design inspection of existing control systems)

ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

Rosatom State Corporation, within the framework of the Scientific Division, has formed a Chemical Technology Cluster, which includes three institutes — JSC «Giredmet», JSC «NIIgrafit» and JSC «VNIIHT». It is a system-forming structure that stimulates innovation and supports scientific and technological progress in nuclear, chemical, rare metal, graphite and related industries. Chemical Technology Cluster is an integrator of fundamental scientific research, applied research and industrial production, and provides high synergy between different stages of the scientific and technological cycle. We are developing new technologies, conducting experiments, manufacturing non-standard equipment, and producing low-tonnage of critical materials.

Our advantages:

- projects from technological design to engineering services
- autonomous equipment, as well as fully automated systems or turn-key plants
- Technologies of Chemical Technology cluster are ready to be scaled to industrial schemes of real production
- Our approach to research and development significantly accelerates the search for the optimal solution to achieve commercial targets.

The Chemical Technology cluster structure includes:

- scientific and technical departments with high qualifications and competencies
- a pilot experimental base with modern equipment for research and testing
- a metrological service that ensures the accuracy and reliability of measurements
- pilot production for bringing new technologies to the stage of industrial application

ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

Project management from modernization of plants to turn-key orders:

- collection and analysis of available data;
- laboratory tests;
- technological solutions;
- making calculations;
- digital modeling;
- Technical documentation;
- examination of documentation;
- production/assembly/testing of a prototype;
- putting on production;
- transport logistics;
- installation and adjustment;
- staff training;
- service.

The equipment is made to order according to the agreed technical specifications.

Main competencies:

- scientific and technological reserve of the leading institutes of the materials science profile;
- knowledge of the profile of working with rare chemical elements;
- introduction of promising developments that ensure the technological superiority of enterprises;
- equipping production facilities with customized equipment;
- innovative approaches to technological modernization of existing production facilities;
- creation of new industrial facilities: technological solutions as part of the plant project.

ROSATOM

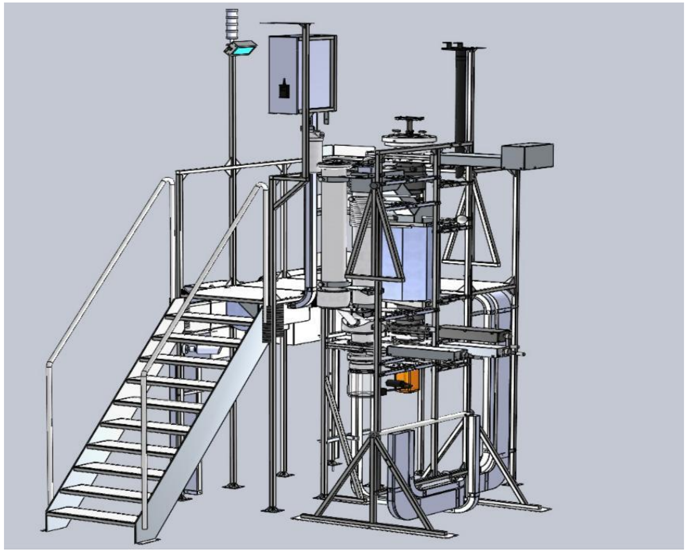
NIIGRAPHITE | GIREDMET | VNIIHT

Application

NIIGRAPHITE | GIREDMET | VNIIHT

Machines and apparatuses for chemical production

Chlorination plants: an example of a hafnium dioxide chlorination plant



The hafnium dioxide chlorination plant is unique in its kind, and there are currently no analogues in the world in terms of the technology that underlies the plant's operation and design solutions. The advantage of the technology is the possibility of continuous production of 99.99% high-purity hafnium tetrachloride with a usable yield above 95%, with near-zero irretrievable losses.

The raw materials for the plant are granular hafnium dioxide with coal.

The raw material is heated to a temperature of about 700-1000 ° C and reacts with chlorine gas. The resulting hafnium tetrachloride is trapped in a quartz crystallizer, and volatile impurities leave the reaction zone, resulting in purification.

The raw material of installations of this type can be almost most of the elements of the periodic table. The output product may be the corresponding chlorides in different phase states.

Characteristics	Indicators
Products	high purity hafnium tetrachloride powder 99.99%
Efficiency	from 10 kg per day
The yield is suitable for hafnium	from 95 %
Raw material	hafnium dioxide with carbon
Working environment	argon, chlorine
Режим работы	twenty-four hours a day.
Chlorination temperature	from 800 °C to 1000 °C
Chlorine supply rate	up to 30 dm^3/min
Weight	1500 kg
Dimensions	5000×3000×3000 mm

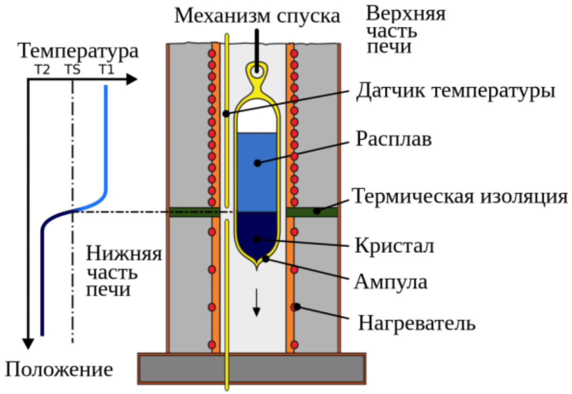
Raw materials – granules of hafnium dioxide

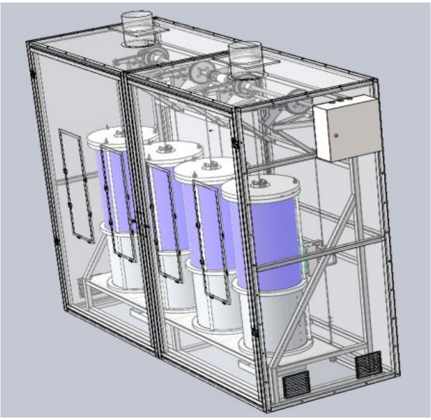
Product - hafnium tetrachloride

NIIGRAPHITE I GIREDMET I VNIIHT

Non-standard equipment

Growth plants: an example of a plant for purification/cultivation of crystals of thallium and silver halides





Advantages:

The simplicity and cost-effectiveness of the crystal growing process, as well as the production of a product with enhanced optical quality.

Universality:

This process makes it possible to reliably obtain monocrystalline ingots of metals, semiconductors, halides of alkali and alkaline earth metals.

Technology:

The Bridgman-Stockbarger method, or directed crystallization method, consists in stretching an ampoule with a material through a furnace with a different temperature gradient along its length (a fixed crucible and a moving furnace element are possible).

Characteristics	Indicators
Number of furnaces in one frame	4
Weight and size characteristics of the grown crystal	diameter from 32 to 80 mm, length from 200 to 300 mm, crystal weight up to 6 kg
The production cycle	1 week
Raw material	different raw materials depending on the type of single crystal being grown
Temperature	upper part up to 500 °C; lower part from 100 to 300 °C
Radial uniformity of temperatures	0,2 °C
Accuracy of temperature changes	0,5 °C
Efficiency	1 crystal per week
Speed (operating)	2 mm per hour

ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

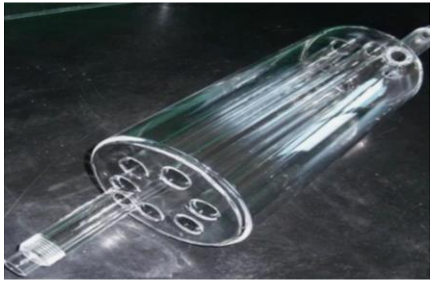
Producing of quartz glass products

Quartz-blowing production: an example of ampoule manufacturing

Uniqueness:
Chemical inertia is a property that allows quartz glass to be used in an aggressive chemical environment. Unique properties include: high uniformity, low light absorption, resistance to high and low temperatures, resistance to high-strength laser radiation, non-conductivity of electric current, as well as resistance to ionizing radiation. Almost all chemical tableware used in laboratories is made of quartz glass.

Technology:
The production technology includes several stages: preparation of raw materials, deposition of a glass block and its further lining, glassblowing, including chemical treatment, annealing.

Characteristics	Indicators
Product	quartz reactors, ampoules, capacitors, laboratory utensils, vessels, boats, components of non-standard laboratory equipment
Additional services	repair and modernization of quartz products
Operating temperature	from 20 to 1400 °C
Coefficient of thermal expansion	$5{,}5*10^{-7}$ cm/cm*°C
Electrical conductivity	$1{,}5*10^{-12}$ С/м
Light transmission coefficient	at least 90%



Non-standard equipment

High-tech technological equipment: an example of a vacuum press for hot pressing

Characteristics	Indicators
Processed material	composite, high-conductivity metal, ceramic materials of carbide, silicon nitride, boron carbide, materials from copper powders, iron, iron-based materials, materials based on copper and iron alloy
Processing temperature	2500 °C
Vacuum	$5*10^{-3}$ Pa
Press pressure	50 tons
Heat-insulating materials	graphite

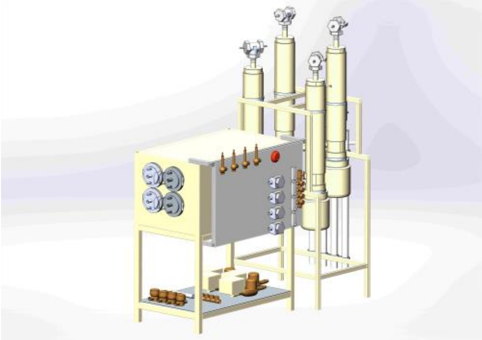
Advantages:

The advantage of hot pressing is the possibility of obtaining materials and products with improved properties (by increasing the density of products). The change in pressure and temperature during pressing is also an additional parameter for regulating the microstructure of products, thereby increasing strength and service life, reducing deformation under load.

Machines and apparatuses for chemical production

NIIGRAPHITE I GIREDMET I VNIIHT

Chlorination plants: an example of a REE oxide chlorination plant with ammonium chloride



Uniqueness:
The furnace uses special structural materials that don't corrode in the environment of ammonium chloride, which makes it possible to obtain high-purity anhydrous REM chlorides. Thanks to automation, the process can be carried out around the clock with minimal staff involvement. A single production of this type of equipment is also an advantage.

Universality:
The plant is universal for different rare earth oxides due to the ability to determine key process parameters. The output product may be the corresponding chlorides. Ammonium chloride is a convenient, cheap and safe chlorinating agent, and the chlorination process takes place at relatively low temperatures.

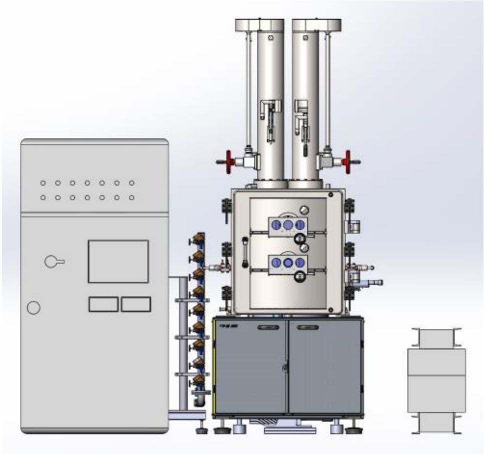
Technology:
A mixture consisting of REM oxides and ammonium chloride (NH4Cl) is used for the chlorination process. Chlorination is carried out in an oven at a temperature of 200-400 ° C. During the chlorination process, water and ammonia are formed, which are removed from the volume of the device.After the chlorination process, the temperature is raised to 400-600 °C to remove excess NH4Cl from the reaction zone.

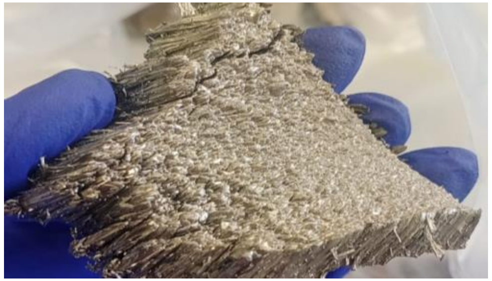
Characteristics	Indicators
Quantity	up to 1 l
Pressure	up to 200 bar
Temperature	up to 600 °C
Twisting moment	up to 100 H*cm
Agitator type	magnetic / overhead drive
Measuring instrument	manometer
Pressure relief valve	yes
Heating element	yes
Weight	Up to 5 kg
Dimensions	400×200×200 mm

High-temperature vacuum furnaces

NIIGRAPHITE | GIREDMET | VNIIHT

High-temperature vacuum furnaces: an example of distillation furnaces





Высокочистый дистиллированный скандий

Uniqueness:

The innovation of the technology is achieved through the use of composite heaters in the furnace design. The technology implies the need to measure changes in the mass of raw materials and products during the process.

Universality:

The distillation method is used to purify most REM to a level of at least 99.99%. This method is effective for purification of metals of the yttrium subgroup, yttrium and scandium. The input product is "rough" metals (with impurities), the output product is high purity metal (distillate).

Technology:

The distillation of REM is carried out in a high vacuum with resistive heating. Fractional separation of the main product and volatile impurities takes place in the furnace, and volatile impurities are not sublimated. Due to high vacuum, it is possible to purify the product from gas impurities – oxygen, nitrogen, etc.

Characteristics	Indicators
Products:	distillate of REM to t of 99.99%
Efficiency:	at least 500 g per
Yield:	at least 90%
Raw materials:	roughed-up REM (s metal with impuri
Vacuum:	10^{-6} mm hg.
Heating:	resistive
The production cycle:	24 hours
Operating mode:	periodic
Process temperature:	up to 2000 °C
Heating speed:	up to 20 °C/mi
Management:	according to progran manual mode
Sound and light indication/alarm	yes
Weight	2100 kg
Dimensions	3000×4000×3000

ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

High-temperature vacuum furnaces

High-temperature vacuum furnaces: an example of a plant for growing single crystals by the Chokhralsky method

Advantages:
Production of practically dislocation-free single crystals having a dislocation density of less than 200 cm-2 and a uniform distribution of alloying impurities in the volume. The grown single crystals maintain a constant ingot diameter and have a more even cylindrical side surface, which is an important parameter in terms of subsequent calibration, processing and cutting of ingots. Suitable for producing semiconductor ultrathin wafers with a diameter of at least 100 mm and a thickness of less than 160 microns.

Technology:
Single crystals are grown in large-diameter quartz crucibles by pulling up the single crystal from the melt. At the beginning of the process, an oriented seed is introduced into contact with the melt, from which the gradual growth of the crystal begins.

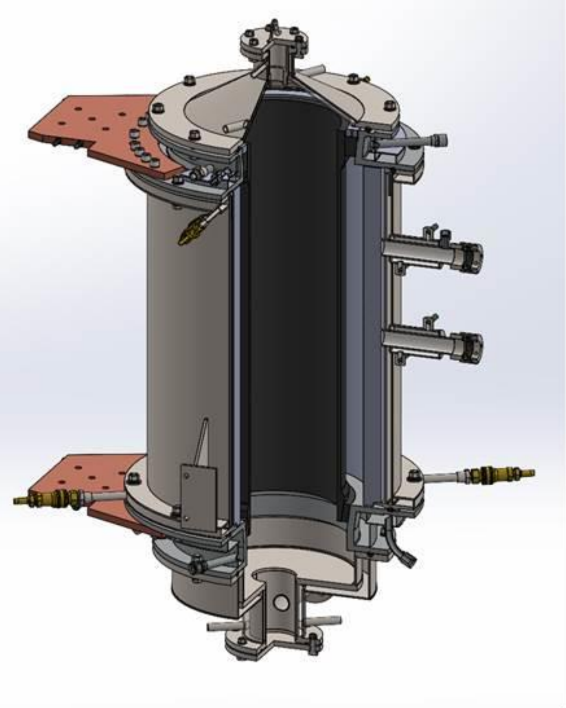
The special feature of the technology is the selection of thermal growth conditions with high accuracy of heating the initial product. A complex of rotational and translational displacements under vacuum ensures growth in the required crystallographic direction. The furnace has the additional possibility of carrying out processes in an inert gas atmosphere, as well as a closed circuit of cooling water. The control system displays graphs of all process parameters online.

Characteristics	Indicators
Product:	distillate of REM to the level of 99.99%
Efficiency:	at least 500 r per day
Yield:	at least 90%
Raw materials:	roughed-up REM (spongy metal with impurities)
Vacuum:	10^{-6} mm hg
Heating:	resistive
The production cycle:	24 hours
Operating mode:	periodic
Process temperature:	up to 2000 °C
Heating speed:	up to 20 °C/min
Management:	according to program and in manual mode
Sound and light indication/alarm	yes
Weight	2100 kg
Dimensions	3000×4000×3000 mm

High-temperature vacuum furnaces

NIIGRAPHITE I GIREDMET I VNIIHT

<u>High-temperature vacuum furnaces: an example of the furnace EVP - 750</u>



Universality:

Furnaces of this type are used for processing carbon materials. The functional capabilities of the units allow for the processes of firing and impregnation with metals, including silicification.

Technology:

The principle of operation is to impregnate carbon blanks with silicon, for which a high temperature and vacuum are created in the furnace volume. The vacuum system protects the work area from various impurities contained in the air, and also eliminates oxygen to eliminate the combustion process of graphite materials.Gorenje When high temperatures are reached, the material is impregnated with silicon and silicified.

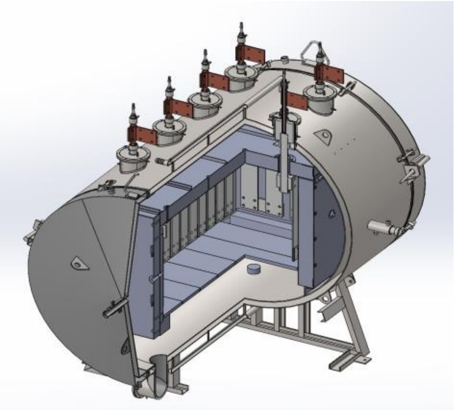
Characteristics	Indicators
Raw materials	graphite and silicon
Product	silicified graphite
Volume	120 l
Vacuum	10^{-3} mm hg
Process temperature	up to 2000 °C
Heating	resistive
The production cycle	24 hours
Operating mode	periodic
Management	according to program and in manual mode
Thermal insulation	carbon thermal insulation material
Heating element	graphite
Weight	1000 kg
Dimensions	1725×1225×800 mm

ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

High-temperature vacuum furnaces

High-temperature vacuum furnaces: an example of the furnance EVP - 1900



Uniqueness:

In addition to high-temperature processing of carbon-carbon composite materials, the EVP-1900 furnace is capable of pyrolytic sealing operations, which makes it possible to create new products and materials with improved performance and thermal strength characteristics (increased density, reduced porosity, increased corrosion resistance, etc.).

Technology

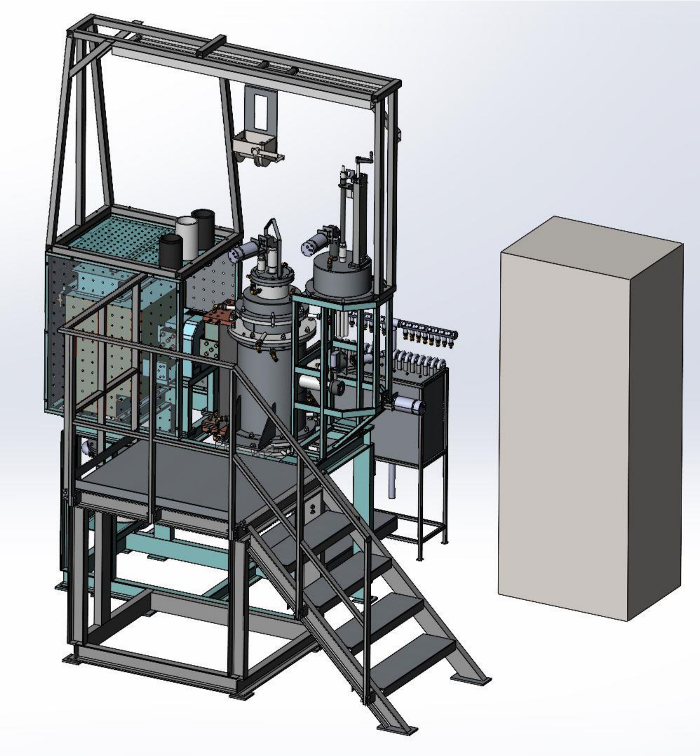
1) The process involves impregnation of a porous carbon semi-finished product with pitch and carbonation. It is produced to create a denser and less porous structure..

2) In volumetric pyroclassification, the process consists in the deposition of pyrolytic carbon, which forms during the pyrolysis of natural gas in the volume of carbon material.

Characteristics	Indicators
Raw materials	special carbon workpiece , pitch, natural gas / argon / nitrogen
Product	carbon carbon composite
Volume	7000 l
Vacuum	10^{-3} mm hg
Process temperature	up to 2200 °C
Heating	resistive
The production cycle	from 3 days
Operating mode	periodic
Management	according to program and in manual mode
Thermal insulation	carbon thermal insulation material
Heating element	graphite
Weight	4000 kg
Dimensions	2500×3800×2500 mm

High temperature vacuum plants

High-temperature vacuum installations: using the example of plant for studying the kinetics of impregnation



Uniqueness:
The plant of silicification and studies of the kinetics of impregnation with metals and alloys of porous carbon bases and allows for unique research to create materials with new or specified properties. The special design of the vacuum linear displacement input unit allows experiments to be carried out even at high temperatures.
A single production of this type of equipment is also an advantage.

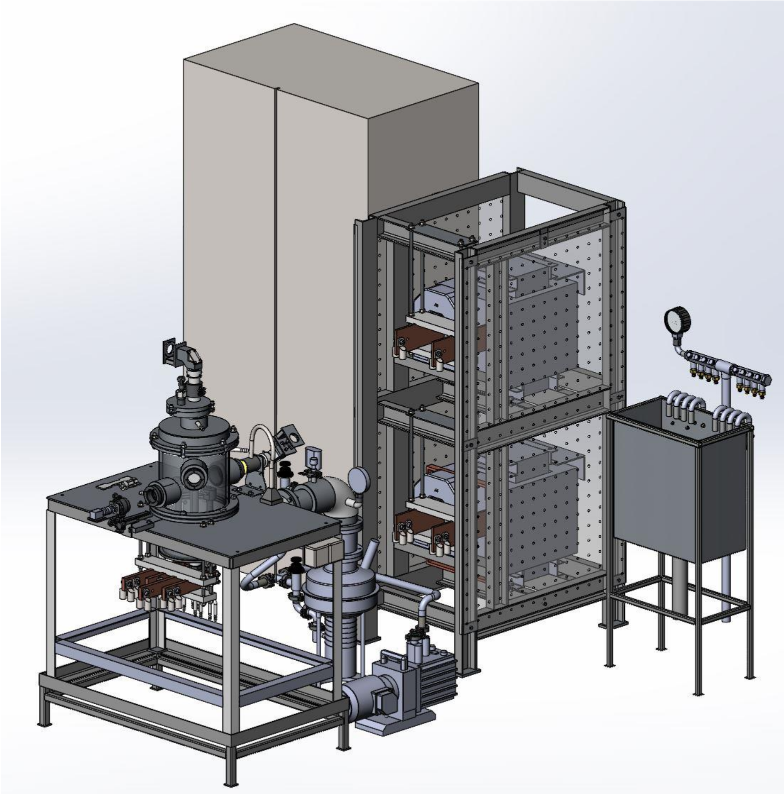
Characteristics	Indicators
Raw materials	graphite and silicon
Product	kinetics of interaction of the studied materials
Volume	100 l
Vacuum	10^{-2} mm hg
Process temperature	up to 2100 °C
Heating	resistive
The production cycle	24 hours
Operating mode	periodic
Management	manual
Thermal insulation	carbon thermal insulation material
Heating element	graphite
Weight	270 kg
Dimensions	1400×800×700 mm

ROSATOM

NIIGRAPHITE I GIREDMET I VNIIHT

High temperature vacuum plants

High-temperature vacuum installations: using the example of a wetting and spreading kinetics research facility



Uniqueness:

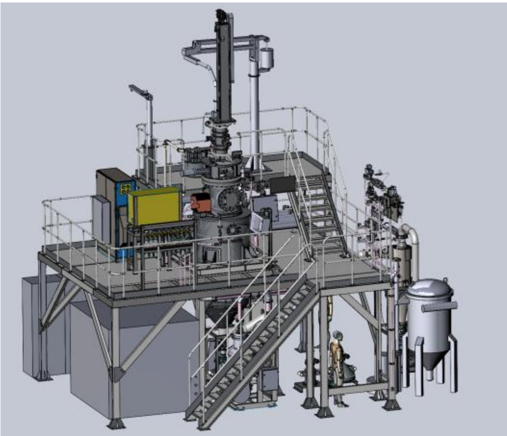
The plant for studying the kinetics of wetting and spreading of metals over porous carbon bases is unique and allows for unique research to create materials with new or specified properties. The special design of the heating element, combined with high vacuum conditions, allows for high-speed recording of experiments even at extremely high temperatures. A single production of this type of equipment is also an advantage.

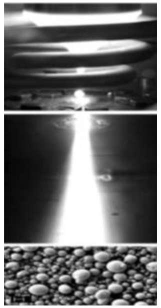
Characteristics	Indicators
Raw materials	Graphite, silicon etc.
Product	kinetics of interaction of the studied materials
Volume	22 l
Vacuum	5*10-7 mm hg
Process temperature	up to 1900 °C
Heating	resistive
The production cycle	24 hours
Operating mode	periodic
Management	manual
Thermal insulation	carbon thermal insulation material
Heating element	graphite
Weight	70 kg
Dimensions	1000×500×350 mm

Additive equipment

NIIGRAPHITE | GIREDMET | VNIIHT

Powder production plants for additive technologies: an example of an Atomizer for producing titanium alloy powders





Uniqueness:
The installation for studying the kinetics of wetting and spreading of metals over porous carbon bases is unique and allows for unique research to create materials with new or specified properties. The special design of the heating element, combined with high vacuum conditions, allows for high-speed recording of experiments even at extremely high temperatures. A single production of this type of equipment is also an advantage.

Technology:
The installation operates using both induction electrode melting technology with melt spraying by a free-fall nozzle, and advanced (material-efficient) technology with the formation of an overheated melt jet accelerated to high speeds. The Atomizer unit is used to produce a fine fraction of titanium alloys, which are later used as a printing material in 3D printers for the manufacture of precision products of complex configuration.
For example:
- fractions: 10-63, 20-45, 10-50, 20-63 microns are used in selective laser melting;
- fractions: 40-150, 50-100, 20-120 microns are used in direct laser cultivation;
- fractions: 40-80, 50-80, 40-100 microns are used in laser surfacing.

Characteristics	Indicators
Raw materials	spray workpiece (diameter up to 120 mm, length up to 750 mm)
Working environment	argon
Gas consumption	40 nm^3/kg
Product	powders for additive and MIM technologies (VT6, VT6C, Vt6, VT1-0, VT1-00)
Average particle size	50-70 microns
Fraction from 20 to 80 microns	at least 50% of the total powder weight
Content of oxygen	700-2000 ppm
Efficiency	up to 50 tons per year
Dimensions	7000×7000×8500 mm

Electrical equipment

<u>Electrical equipment by example: development of circuit solutions and cabinet designs for control systems for non-standard technological equipment</u>

The control cabinet of the electric vacuum furnace is based on a temperature PID controller. Electrical panel devices (current, voltage, pressure, temperature indication) and a digital recorder are provided in the cabinet for displaying and recording electrical and technological parameters.

The cabinet has controls for the installation's actuators, as well as an emergency shutdown button. The automatic and manual mode of technological process management is implemented. In case of emergency situations, equipment operating limits, as well as when a backup power source is turned on, a light and sound alarm is activated. The control and power cables are inserted into the control cabinet through sealed membrane channels, which provides IP54 shell protection.

Electrical equipment

<u>Electrical equipment for example: vacuum distillation furnaces of rare earth metals based on a programmable logic controller</u>

The control cabinet of the vacuum distillation furnace is based on a programmable logic controller. A panel programmable logistics controller (PLC) with a 15" touch screen is used to display and register electrical and technological parameters, control the plant's actuators, conduct the technological process, display graphs of technological and electrical quantities, and log accidents and events. A light and sound column is provided on the cabinet, signaling emergency situations, situations requiring operator attention and normal operation.

In order to separate the power circuits and PLC control cabinet, the control panel is designed for two-way maintenance. On one side there is a compartment for the controller and input/output circuits, on the other side there is a power compartment for the thyristor power regulator and the power circuits of the actuators.

When the main circuit voltage is not removed, the door of the power compartment is locked in the cabinet. When the doors of any of the compartments of the control cabinet are open, the operation of the installation as a whole is blocked. An emergency shutdown button is provided for the emergency shutdown of the installation.

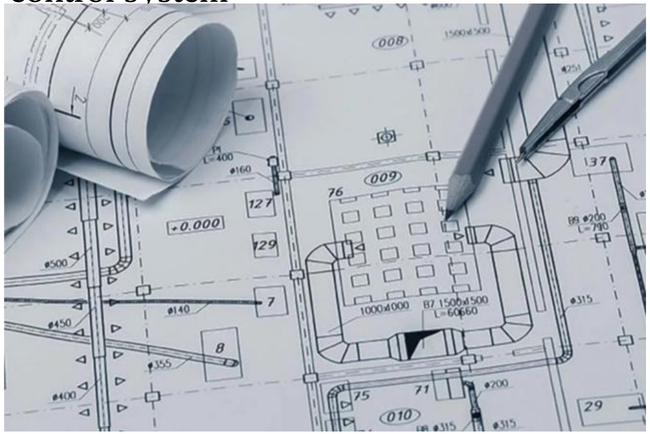
Fans and thermostats are provided in the cabinet to control and maintain the required temperature, as well as temperature monitoring sensors (with readings displayed on the controller panel) in each compartment of the cabinet. The control and power cables are inserted into the cabinet through hermetic seals, which ensures the degree of protection of the cabinet shell IP54.

ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

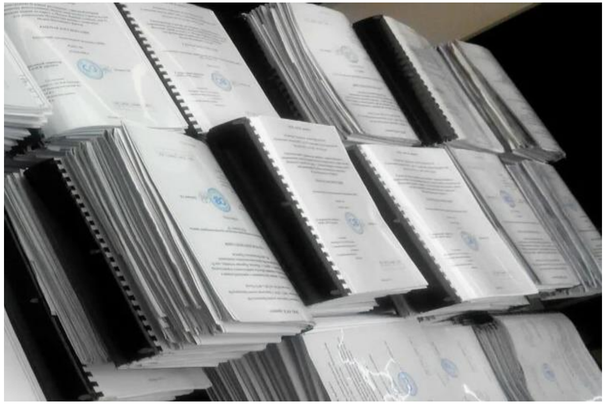
Electrical equipment

Electrotechnical services: an example of the development of an automated process control system



Development of design documentation for the automation of existing plants and technological sites in terms of automated process control systems according to the ESCD based on the technology provided.

Electrical engineering services: an example of the development of an АСУ ТП



Development of working design documentation for the modernization of existing technological processes and installations in terms of ESCD and АСУ ТП.

Electrical engineering services: an example of a pre-design survey of existing technological processes

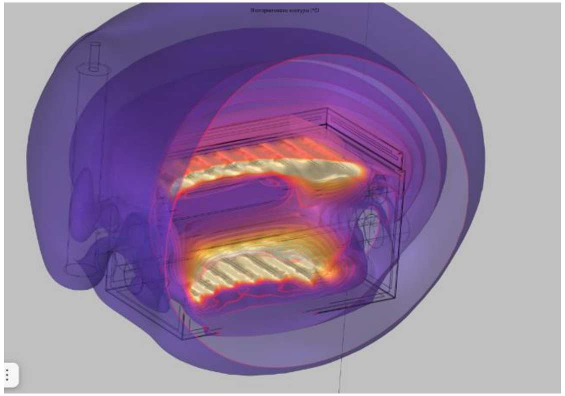
Pre-design inspection of existing technological sites, installations and their modernization in terms of АСУ ТП: replacement of outdated or failed actuators, control equipment, replacement of relay-contact logic with microprocessor logic with information output to the operator panel, development of cabinet designs and control panels on the required element base.

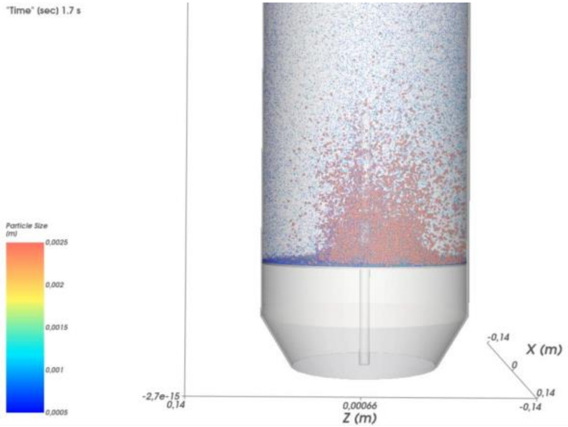
Digital products

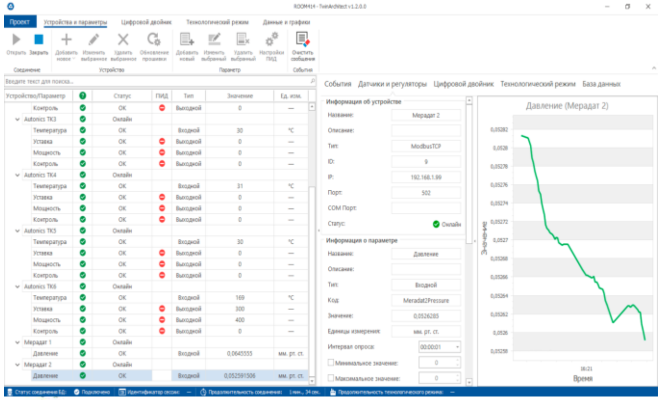
<u>Digitalization by example: technology development and obtaining initial data for the design of pilot plants and technological sites using CAD/CAE systems for the chlorination of hafnium dioxide</u>

Digital modeling makes it possible to identify technological and design flaws at the test stage in a virtual environment, which reduces defects during actual production and reduces development time. The chemical technology cluster has a specially developed system for managing digital models of chemical technology plants, which is aimed at building digital counterparts of production plants, solving problems of optimal control of the chemical process with a variable number of elementary stages.

All information, from drawings and production technology to maintenance and disposal regulations, will be digitized and readable by devices and people. The digital twin provides real-time management of all factors affecting the cost and quality of a product even before its production begins.







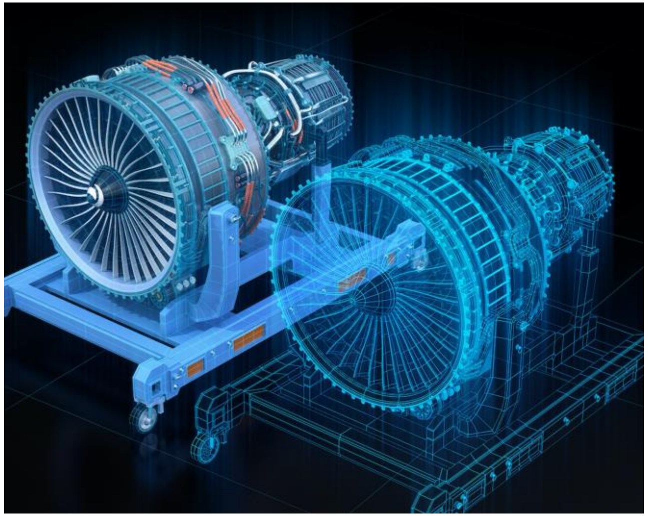
ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

Digital products

Digitalization by example: automation and digitalization of existing installations and technological sites

Digital twins are a powerful tool for real—time data analysis. They help to optimize technological processes, which, in turn, reduces operating costs. Digital counterparts of automated equipment protect it from emergency situations, extending its service life until major repairs. Moreover, they predict the wear of components and allow you to plan diagnostic maintenance in advance, which, in turn, reduces depreciation charges.



Digitalization by example: modernization of existing and technological processes

Examination of existing technological sites, installations and their modernization in order to increase productivity. Substantiation of the results by mathematical modeling data.

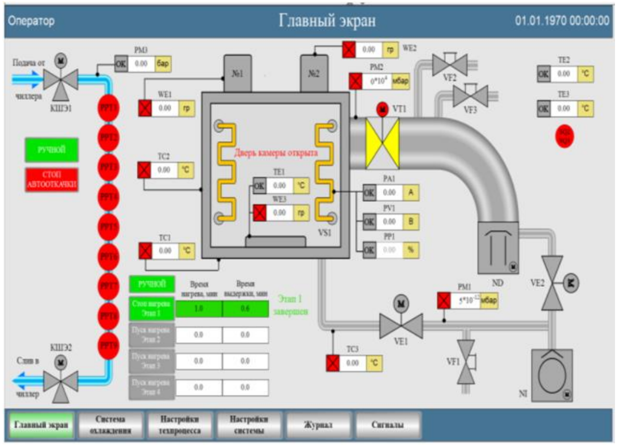
ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

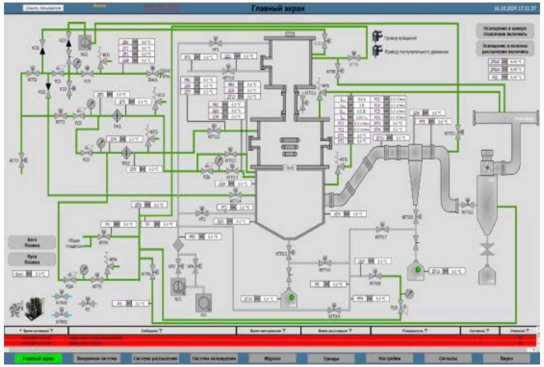
Software development

The chemical technology cluster has competencies in software design and development, ranging from the idea and wishes of the Customer to direct implementation into the production process of the enterprise. The software tools being developed are characterized by an applied nature and are aimed at solving problems that arise in technological processes and directly affect their economic and time efficiency. We are ready to offer the development and modernization of automatic control systems (ACS) of installations of any complexity, according to your technical specification or a technical specification developed jointly with our company's specialists. Our specialists also develop АСУ ТП.

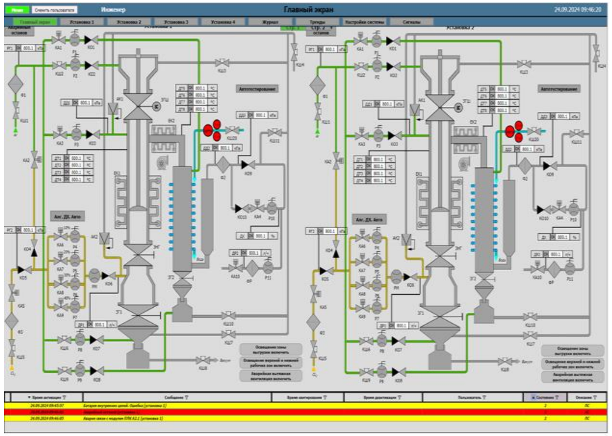
Software as an example: mnemonic circuits of the Rzmz vacuum distillation furnace



Software for example: visualization of the control system of an installation for the production of spherical titanium alloy powders by gas spraying of a rod



Software for example: development of application software for a hafnium dioxide chlorination plant



ROSATOM

NIIGRAPHITE | GIREDMET | VNIIHT

Thank you for attention!

Head of the Engineering Department
Anton Smykalo

anysmykalo@rosatom.ru

Deputy Director for Engineering and Non-standard Equipment
Mikhail Gorshenkov
miagorshekov@rosatom.ru

Chief Designer
Sergey Verba

svverba@rosatom.ru

www.giredmet.ru - the official website of JSC Giredmet
www.niigrafit.ru - the official website of JSC NIIgrafit