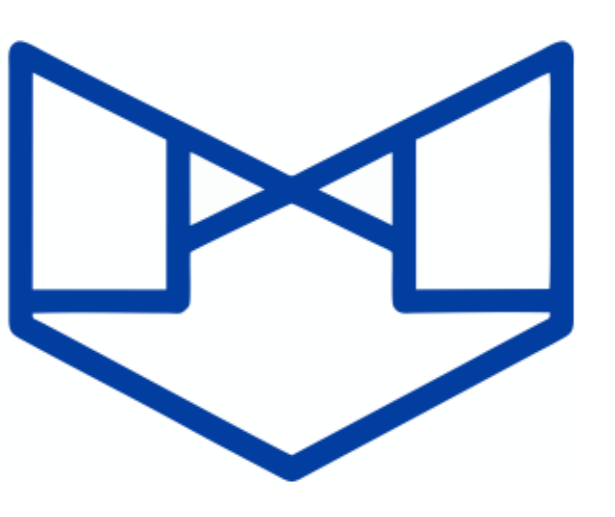
Institute trains highly qualified professionals for the development of new materials (alloys, composite, polymer, ceramic and metal-ceramic materials), high-end technologies for their production, research and management of properties, process automation with the use of modern computer and information technology, technologies for obtaining integral joints and surface engineering.



INFORMATION PACKAGE

YE.O. PATON INSTITUTE OF MATERIAL SCIENCE AND WELDING

Kyiv, 2020

CONTENT

*** ***Information is current as for the 2020/2021 academic year. In the next academic year, there may be minor changes in the list of training specialties and educational programs/specializations.***

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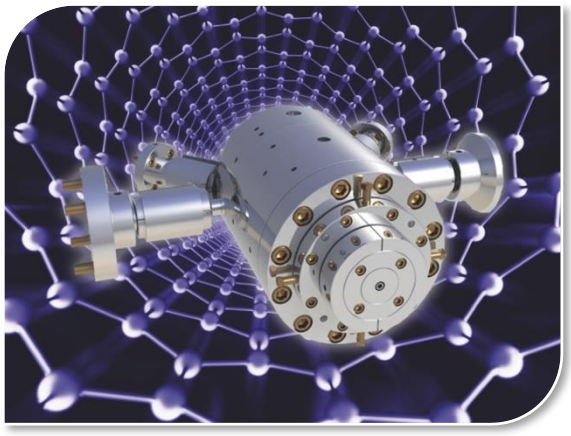
1. COMMON DESCRIPTION. STRUCTURE

Ye.O. Paton Institute of Materials Science and Welding (IMSW) at the Igor Sikorsky KPI was established in 2020 based on the Faculty of Physical Engineering and the Welding Faculty of the University, as well as the Department of Laser Engineering and Physical and Technical Technologies of the Institute of Mechanical Engineering.



The new institute significantly expands the prospects for the implementation of major strategic research and educational projects at the national and international levels, reducing the process of obtaining an innovative competitive product.

Training of metallurgical specialists at the Igor Sikorsky KPI was started since its formation. Faculty of Physical Engineering was allocated as a separate subdivision on 7 October 1944 to train highly skilled engineers – metallurgists and metal scientists for the reconstruction and development of metallurgical and mechanical engineering industries.

Kyiv is the capital of welding. This opinion is widely spread among welders in Ukraine and abroad and reflects the well-known historical events.

Thanks to the outstanding organizational skills and the activity of the scientist, the founder of the national school of welders Eugene Paton, Kyiv became the largest center in the world for welding science. Faculty of Welding (WF) was established in the Kyiv Polytechnic Institute (now Igor Sikorsky KPI) in 1948 and initially was represented by only one department of welding production, the first head of which was Prof. E.O. Paton.

The welding faculty of the Igor Sikorsky KPI is recognized both in Ukraine and abroad center of scientific and methodological work in the training of experts involved in welding. In 2008, the Faculty of Welding was certified as the Training Center of the International Welding Institute for the training of welding coordinators with international qualifications.

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The newly established **Institute of Materials Science and Welding (IMSW)** trains highly qualified professionals for the development of new materials (alloys, composite, polymer, ceramic and metal-ceramic materials), high-end technologies for their production, research and management of properties, process automation with the use of modern computer and information technology, technologies for obtaining integral joints and surface engineering.

With years of experience of fruitful cooperation, **IMSW** and the National Academy of Sciences of Ukraine (NASU) formed the educational and scientific association in areas of Material Engineering, Material Engineering and Special Metallurgy, Material Engineering and Metallurgy, which includes the world-famous centers of NASU: Ye.O. Paton Electric Welding Institute, Z.M. Frantsevich Institute of Materials Science., G.V. Kurdyumov Institute for Metal Physics, Physical and Technological Institute of Metals and Alloys, V.M. Bakul Institute for Superhard Materials. This allowed involving the scientific potential of these institutes in the educational process for the training of high-level specialists and masters.

The curricula of the institute provide internships for students both in Ukraine and in leading specialized institutions in the EU and USA for the best of them. Students and graduates have the opportunity to study under the International Welding Engineer (IWE) program or the International Welding Technologist (IWT) with an international diploma. Undergraduate students can study at the Joint Ukrainian-German Faculty of Mechanical Engineering (Igor Sikorsky KPI - Otto-von-Goerike University Magdeburg).

Nowadays more than 700 students study at the **IMSW**. High-quality training in 3 specialties and 8 educational programs is provided by the institute's modern material and technical base, selfless work of academic staff, and support personnel.

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Structure. **IMSW** consists of eight departments:

1. Department of Laser Technology and Material Science trains highly qualified specialists with a degree in "Applied Mechanics" (educational program/specialization "Laser Techniques and Computerized Physical-Technical Materials Processing").

Training opportunities of the department include the modern industrial laser technological complexes, unique equipment for other non-traditional materials processing techniques, as well as various tools for traditional processing technology, well-equipped laboratories for materials science, and classrooms equipped with modern personal computers.

The curriculum provides the opportunity to gain fundamental knowledge in the field of engineering, an organization of production and technology of mechanical engineering with an emphasis on a variety of non-conventional materials processing methods.

2. Department of Welding Production trains professionals with a degree in "Applied Mechanics" (educational program/specialization "Technology and Engineering in Welding").

The curriculum of the Department aims at the training of specialists in the development of welding technology, welding materials with desired properties, mechanical engineering, diagnostics, and forecasting of the reliability and performance of welded structures, certification, and quality control in production.

The perspective of the scientific and pedagogical school caused by direct participation in the training of specialists under the programs of the International Welding Institute (IWI) and the Ye.O. Paton Sino-Ukrainian Welding Institute, in cooperation with the Otto von Guericke University Magdeburg (Germany), Federal University of Uberland (Brazil), Ye.O. Paton Electric Welding Institute of the NASU, opportunities to obtain a diploma of International Welding Engineer (IWE), International Welding Technologist (IWT), International Welding Inspector (IWI).

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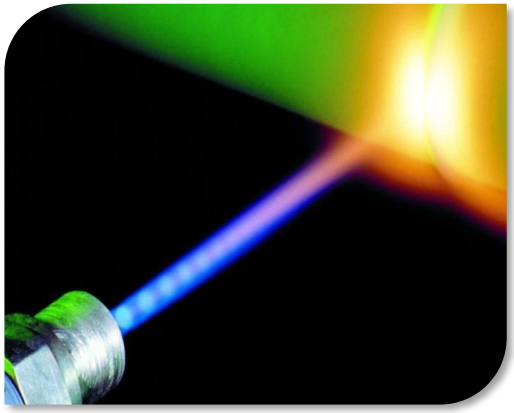
3. Department of Smart Technologies of Joints and Surface Engineering trains specialists with a degree in "Applied Mechanics" (educational program/specialization "Technological Systems of Engineering of Joints and Surfaces"

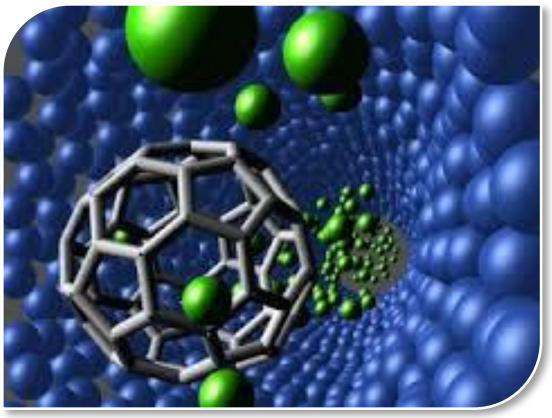


Surface engineering combines methods of targeted changes in the physicochemical properties of the surface layers of materials by deformation, modification, filmings, coatings, and application of protective layers by various combined methods.

Students have the opportunity to participate in international double degree programs with leading universities in Brazil and Germany, to be trained in the programs of the international system of personnel training in the field of welding – International Welding Engineer (IWE), International Welding Technologist (IWT), International Welding Inspector (IWI).

4. Department of Metal Physics trains specialists with a degree in "Material Science" (educational program/specialization "Metallophysical Processes and Their Computer Simulation").

Department graduates are generalists in the field of modern technologies at the intersection of material engineering, management, computer science, medicine, and biology.



The purpose of the specialty is computer design and experimental study of nanomaterials, development of nanotechnology for biomedical engineering, energy-saving environmental systems, micro- and nano-electronics, aerospace and military equipment, robotics, criminalistics.

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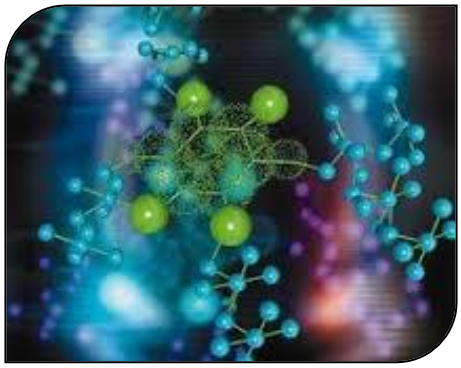
5. Department of Metallurgy and Heat Treatment trains specialists with a degree in "Material Science" (educational program/specialization "Metallurgy and Computer Simulation of Thermal Processing".



Graduates work in enterprises and organizations of the automobile production and instrument making, aerospace and electronic engineering, microelectronics, in the leading research institutes of the National Academy of Sciences of Ukraine, as a high academic staff, public sector worker, innovation sector and international institutions.

Active cooperation with well-known centers of NASU allows using advanced laboratories of these institutions in teaching, as well as to involve both the known scientists in the educational process and students in performing the investigations of the most urgent problems of modern material engineering.

6. Department of High-Temperature Materials and Powder Metallurgy trains specialists with a degree in "Material Science" (educational program/specialization "Nanotechnology and Computer Design of Materials")

Department trains specialists in the development of new materials and resource-saving technologies for almost all branches of science and engineering from medicine and microelectronics to aerospace engineering.

Today, the department is a leading institution in Ukraine that trains specialists in the development and use of composite and powder materials, special materials for coating, highly emissive materials, structural ceramics, etc.

7. Department of Physical and Chemical Fundamentals of Metal Technology trains specialists with a degree in "Metallurgy" (educational program/specialization "Special Metallurgy").

Department is the only one in Ukraine, provides training in Special Metallurgy at all educational levels. Students get basic training in the theory and practice of metallurgy, casting, and others, as well as acquire in-depth knowledge in the field of production

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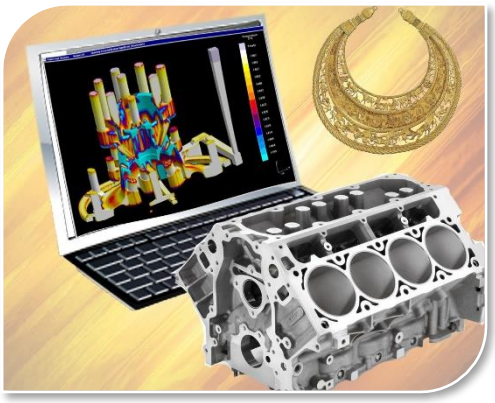
of high-quality metals and alloys using the modern special methods: electroslag, vacuum, plasma and electron beam technology, electromagnetic treatment of alloys in the liquid state, and under crystallization.

Upon completion of training, graduates obtain a Europe-recognized Government-issued degree, which provides employment opportunities in the specialty in any domestic or foreign companies

8. Department of Foundry of Ferrous and Non-ferrous Metals provides training specialists with a degree in "Metallurgy" (educational program/specialization "Computerized Casting Processes").



Department trains specialists in the development of new materials, high-end technologies for its production and formation, determining the properties of materials and assess the quality of the finished product, process automation with the use of modern computer technology and information technology, CAD/CAM systems, including AutoCAD, CATIA, Pro CAST, LVMFlow, MagmaSoft.

The best students have the opportunity to complete their studies in Germany and receive a double degree. The acquired knowledge and skills will help them to establish their own business.

Graduates of the institute work in research centers and institutes of the National Academy of Sciences of Ukraine, branch research and design institutes, industrial enterprises in almost all industries that produce parts and functional elements for devices, machines, and mechanisms from composite materials, metals, and alloys.

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2. EDUCATIONAL PROGRAMS

Levels of higher education. Training of students at the **IMSW** is carried out at three levels of higher education. The first (Bachelor's course, I-IV academic years) – the students acquire fundamental knowledge in physics, mathematics, mechanics, computing, informatics, and special disciplines. During the fourth year, they defend the bachelor's thesis and acquire a bachelor's degree.

At the second level, (Master's course, I-II academic years) students acquire relevant professional skills including laboratory practice. Applicants defend a master's theses and acquire a master degree

The third educational-scientific level – postgraduate studies, I-IV academic years). Applicants defend their dissertations; they are awarded the educational qualification of Doctor of Philosophy (Ph.D.).

Terms of training: Bachelor – 4 years; Master (education-professional program) – 1.5 years; Master (education-scientific program) – 2 years: Ph.D. – 4 years; Doctorate – 2 years.

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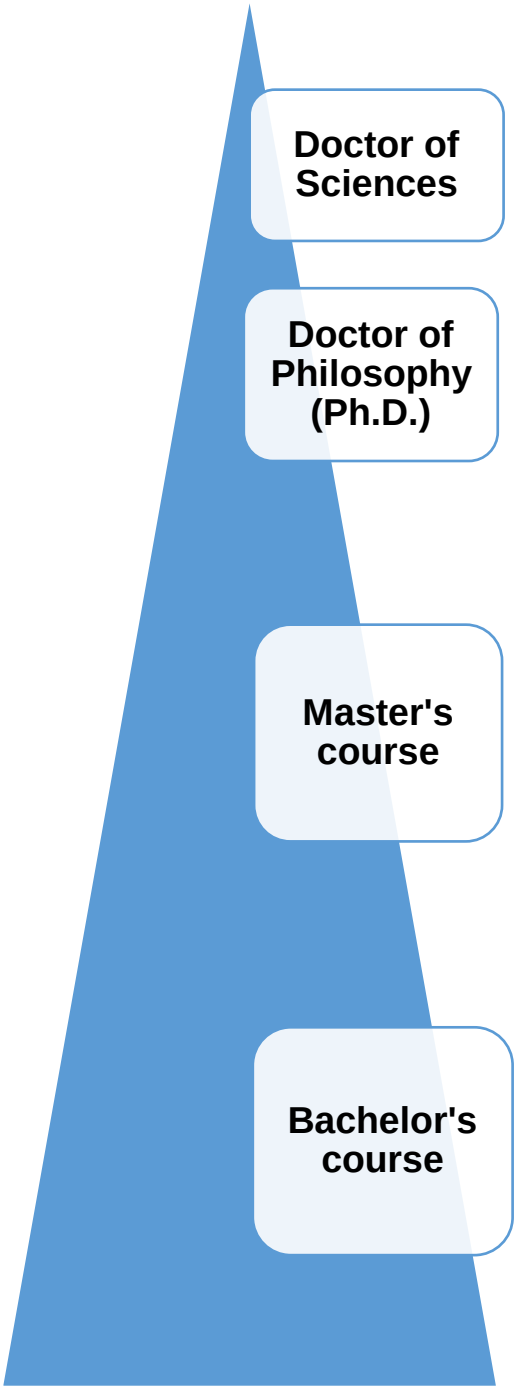
Specialties and educational programs/specializations:



Applied Mechanics

Material Science

Metallurgy

Applied Mechanics:

- Laser Techniques and Computerized Physical-Technical Materials Processing
- Technology and Engineering in Welding
- Technological Systems of Engineering of Joints and Surfaces

Material Science:

- Metallophysical Processes and Their Computer Simulation
- Metallurgy and Computer Simulation of Thermal Processing
- Nanotechnology and Computer Design of Materials

Metallurgy:

- Special Metallurgy
- Computerized Casting Processes

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3. TRAINING AND LABORATORY BASE

The Institute has a modern technical training base: research and training centers, laboratories, equipped with modern technics and special training and demonstration systems.

Centers:

Center for X-ray Structure Analysis Rigaku. Center is intended to performing fundamental and applied experimental research, solving technical and scientific tasks in the field of materials engineering using modern techniques for record and processing of X-ray diffraction data with the use of diffractometer Ultima IV – direct, accurate, reliable, and versatile information on the phase composition and structure of materials as the base of it physicochemical and mechanical properties control.

Center for Electron Microscopy for fundamental and applied research on the structure and chemical composition of materials, a solution of technical and research tasks in the field of materials engineering.

Laboratories:

- Laboratory of Computer 3d Modeling and Analysis (Educational program TEMPUS "MMATENG");
- Laboratory of Micromechanical Testing;
- Laboratory of Optical Microscopy;
- Laboratory of Single Crystals Growing;
- Laboratory of Electron Beam Technology;
- Laboratory of Mass Spectrometry;
- Laboratory of Nanotechnologies and Nanomaterials;
- Laboratory of Dispersed Ceramic Materials;

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- Laboratory for Preparation of Section Metallographic Specimens (sample preparation);
- Laboratory of Foundry of Ferrous and Nonferrous Metals;
- Laboratory of Powder Metallurgy Technology;
- Laboratory of Coating Technology;
- Laboratory of Vacuum Technology;
- Laboratory of Refractory Compounds Technology;
- Laboratory of Thermal Analysis;
- X-ray Laboratory;
- Electron Microscopy Laboratory;
- Laboratory for Obtaining Powders by Dispersing Melts;
- Laboratory of Physical Research Methods.

Department of Welding Production has the following laboratories:

- Paton Laboratory of Automatic Welding was established in 1978. Modern equipment allows training on fusion welding;
- Laboratory of Stress and Deformation in Welding, which allows students to explore the thermal deformation processes and study mechanisms of residual stresses and strains in models of welded joints
- Design Laboratory of Welded Structures, where students perform laboratory work to assess the state of stress of welded structures under load.
- Laboratory of Metal Science and Heat Treatment of Welded Joints, which provides equipment to study the effect of different types of heat treatment on the structure of welded joints Laboratory of the Theory of Welding Processes, which offers the equipment to perform training on a cycle of disciplines of theoretical fundamentals of welded joints formation.
- Laboratory of Production Tooling intended to design and build models of assembly and welding equipment and diploma projects fulfillment.
- "Plasma, Hybrid and Additive Technologies", intended for Laboratory of Electron Microscopy and Metal Soldering, where students perform research structures of welded and brazed joints. The laboratory is equipped with modern equipment to carry out research and training tasks related to the study of a certain way of surfacing;

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- Laboratory of Stress and Deformation in Welding, which allows students to explore the thermal deformation processes and study mechanisms of residual stresses and strains in models of welded joints;
- Design Laboratory of Welded Structures, where students perform laboratory work to assess the state of stress of welded structures under load.
- Laboratory of Metal Science and Heat Treatment of Welded Joints, which provides equipment to study the effect of different types of heat treatment on the structure of welded joints.
- Laboratory of the Theory of Welding Processes, which offers the equipment to perform training on a cycle of disciplines of theoretical fundamentals of welded joints formation.
- Laboratory of Production Tooling intended to design and build models of assembly and welding equipment and diploma projects fulfillment.
- "Plasma, Hybrid and Additive Technologies", intended for research.

Experimental research of the ***Department of Smart Joints Technologies and Surface Engineering*** is conducted in laboratories specialized in research areas and used in parallel as classrooms, where laboratory work with students is carried out:

- Laboratory of vacuum-condensation spraying and mechanical tests;
- Surfacing and spraying laboratory;
- Plasma spraying laboratory;
- Laboratory of welding processes automation;
- Pressure welding laboratory;
- Microwelding laboratory
- Power supply laboratory;
- Laboratory of plasma-ion technologies.

4. RESEARCH ACTIVITY

The main scientific directions of the institute's work on the departments:

Department of Laser Engineering and Physical and Technical Technologies

- Laser welding
- Laser hardening
- Laser cutting
- Development of lasers and laser technology
- Plasma treatment
- The use of lasers in medicine

Department of Welding Production

1. Technology and metallurgical processes in welding:

- Creation of theoretical models for calculating the composition of the gas phase, the influence of welding materials on the composition of the weld metal, the content of gases and non-metallic inclusions in arc welding based on physical and thermodynamic simulation;
- Research of metallurgical processes during welding and development of new fused, agglomerated fluxes and flux-cored wires for welding and surfacing;
- Study of the tendency of the weld metal to form cracks based on technological tests;
- Research of arc discharge during welding and its technological characteristics based on complex coefficients of stability and transients using synergistic power supplies;
- Research and simulation of the peculiarities of pore formation during welding;
- Simulation of thermal processes during welding;
- Study of the influence of thermodeformation welding cycles on the phase composition and metal structure of the welded joint;
- Technological features of modulated current welding with synergistic arc regulation;
- Creation of mathematical models of melting of the base and electrode metal in arc fusion welding and optimization on their basis welding processes in shielding gases.

2. Stress and strain during welding:

- Simulation and calculation by the method of finite elements of welding stresses, deformations, and displacements of elements of welded structures based on modern computer technologies;
- Research of influence of technological schemes of welding on residual movements of a longitudinal axis of welded designs and development of an optimum technological sequence of their welding;
- Simulation of stress-strain state of welded structures for beam and arc welding methods.

3. Diffusion welding and soldering of metals, alloys, and composite materials:

- Mathematical simulation of thermodeformation processes during diffusion welding and soldering;
- Development of diffusion welding and soldering technologies with the controlled stress-strain state;
- Study of the effect of surface modification by highly concentrated energy flows on the properties of diffusion-welded and soldered joints;
- Creation of new materials for obtaining diffusion welded and soldered joints.

The scientific school "Physico-chemical and thermodeformation fundamentals of welding and related processes" successfully work at the department.

Department of Smart Joints Technologies and Surface Engineering

- Forecasting the quality of welded joints based on artificial intelligence methods;
- Quality control of welded joints by electromagnetic influence on the processes of metal transfer and crystallization of the welding bath;
- Research of processes of phase-structure formation and physical-mechanical properties of polyfunctional nanostructured coatings;
- Study of physicochemical processes in plasma spraying and contact shock interaction with the surface of the base of the particles of coatings formed by complex multicomponent mixtures based on powder
- study of mechanisms of influence of the structure and phase composition of plasma coatings on the adhesive-cohesive, physical and mechanical (strength)

properties, crack growth resistance of compositions based on the developed experimental and computational methodology for assessing the nature of the deformation and failure mechanism of the system "basis - coating";

- creation of functional surfaces by welding deposition with the introduction of nanostructured components into the newly created layer;
- development and research of plasma devices on complex plasma-forming mixtures and technologies with their use, settings management, and spatial position of the plasma flow in the processes of surface engineering.

Department of Metal Physics provides investigations on the following topics:

- Formation of nanoscale magnetic solid FePt films, doped with Ag, Au, Cu, to increase the density of magnetic recording and storage of information
- Creating functional and biocompatible composite coatings on titanium alloys and iron, reinforced with carbon nanotubes and the elements of the implementation, in conditions of extreme energy impacts
- Initiative work “Computer Methods of material “designing”
- Formation of gradient states in nanolayer metal film compositions through processes on the outer surface;
- Physicochemical fundamentals of strengthening the light structural alloys by ultrasonic shock treatment in different environments.

The activities of the ***Department of Metallurgy and Heat Treatment*** is integrated into the framework of the scientific school of "Control and management of metals and alloys quality by the surface, thermal, chemical-thermal treatment, the impact of liquid and crystallization processes":

- Protective coatings on steel and hard alloys
- Development of active methods for monitoring and quality control of liquid metals and alloys
- Study of optimal methods of material processing for cathodes of lithium current sources.

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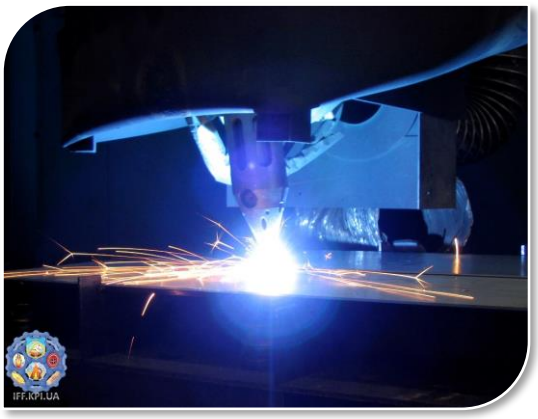
Department of High-Temperature Materials and Powder Metallurgy

- Material science of refractory compounds and composite materials, development of directionally and volume-reinforced composite materials based on metals, alloys, and refractory compounds;
- Physics of high-speed electron beam sintering of homogeneous and heterogeneous high-temperature materials;
- Development of composite materials based on high-entropy alloys;



- Physical fundamentals of powder compaction control during injection molding of parts for extreme operating conditions;
- Physico-chemical fundamentals of production spherical powders of metals, alloys, and refractory compounds for 3D printing and MIM technologies;
- Development of theoretical fundamentals of the process of growing large, structurally and chemically perfect single crystals of refractory borides with a given crystallographic orientation;
- Study of superfast cooling of eutectic alloys of quasi-binary systems, the influence of fields of mechanical oscillations, with simultaneous transmission of current on phase transformations, consolidation, and formation of the microstructure of capillary-porous bodies in the conditions of a heavy temperature gradient;
- Study of the processes of wetting the surface of refractory compounds with melts of metals and alloys and their interaction;
- Phase equilibria and phase transformations in thermodynamic systems with microheterogeneous liquid phase;
- Research of regularities of influence of high pressure, intensive deformation, the temperature on features of diffusion, phase transformations, the evolution of structure and mechanical properties of materials;
- Research of mechanisms of powders compaction;
- Development and production of highly porous nanocomposites based on metal oxide powders.

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Research work at the **Department of Physical and Chemical Fundamentals of Metal Technology** is conducted on the following topics:

- Refining, modifying, and microalloying of melts (development of new progressive ways to improve the physical, mechanical, and performance properties of ferrous and non-ferrous alloys);
- Special metallurgical technology (research processes and parameters of electroslag, vacuum, plasma, and electron beam technologies and electromagnetic processing of metals and alloys in a liquid state and under crystallization);
- Special casting agents (the study of the processes and parameters of electro-chill and centrifugal casting, shell casting, etc.);
- Special metallurgy process automation;
- Obtaining the cast composite materials;
- Process development for production and research of the shape memory effect;
- Development of high-quality technologies for remelting of ferrous and non-ferrous metal wastes, refining of melts from harmful substances, and so on.

Research work at the ***Department of Foundry of Ferrous and Nonferrous Metals*** is performed on the following topics:

- technological features for predicting the properties of melts and the metal structure of castings for use in extreme conditions
- development of the methodology of forecasting the structure and properties of the metal in the casting of iron-based alloys with high chromium content.
- theoretical and technological principles of the development of new alloys with specific properties for the production of casting units
- theoretical and technological principles of special properties control of superalloys cast components for particularly critical applications.
- theoretical and technological principles of structure control of the modified micro-alloyed castings.

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- theoretical and technological fundamentals of properties differentiation of the composite molding methods.

Faculty elaborations, recommended implementation into production:

- production processes of high-quality castings of ductile iron by the intermolding modification.
- heat-resistant chrome-aluminum steels and technology of manufacturing of its castings for use in corrosive environments at temperatures up to 1300 °C.
- new nickel-free abrasion-resistant iron and technology of production its castings, which work under intensive abrasive and hydroabrasive wear.
- technological processes of modifiers production containing dispersed refractory particles for producing aluminum alloys.
- liquid ester class hardeners for rare-glass chemical technological systems
- molding and core mixtures of different composition and destination.
- parting highly thermostable coatings for molds and cores
- methods for determining the properties of the molding sand, forms, and nonstick coatings.

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5. INTERNATIONAL PROJECTS AND COLLABORATION

1. ***Joint Ukrainian-German Faculty of Engineering Igor Sikorsky KPI and the Otto von Guericke Magdeburg University (Germany).***

The purpose of the joint faculty is to improve the specialists training to meet the needs of enterprises of Ukraine and the joint Ukrainian-European, including Ukrainian-German enterprises. Graduates of the Joint Faculty are skilled in modern technics, knowledge-intensive technologies, European standards, the German language, the ability to create scientific and technical documentation in the German language and work with it. After training completing, graduates obtain a German Master of Science degree and a Ukrainian Master's degree, which makes it possible to find a highly qualified job in any company or firm both in Ukraine and in the European Community.

2. ***The Project of cooperation with the European Union "TEMPUS MMATENG"***

The purpose of the Tempus project is a modernization of curricula of the two-level training program (Bachelor/Master) in Material Engineering on the competency-based approach and the best practices of implementation of the Bologna Process.

Project objectives:

- Develop and implement the modernized curricula in Material Engineering with integrated infrastructure support;
- Improve the skills of teachers, to create service-officers for Engineering Materials (Material Engineering Service Office, MESO);
- To create educational and scientific laboratories of information technology in Material Engineering.

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Members of the welding staff of **IMSW** are the active members of the International Institute of Welding, the European Welding Federation, and the International Union of experts on quality and other professional societies. The Faculty has the license for the training program of the International Institute of Welding. According to this program, senior students of the faculty are trained annually.

Institute involved in the scientific and technical projects in the framework of agreements with foreign partners, among which:

- Federal University of Uberlandia (Brazil);
- Otto-von-Guericke University Magdeburg (Germany);
- Guangdong General Research Institute of Industrial Technology (China).

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