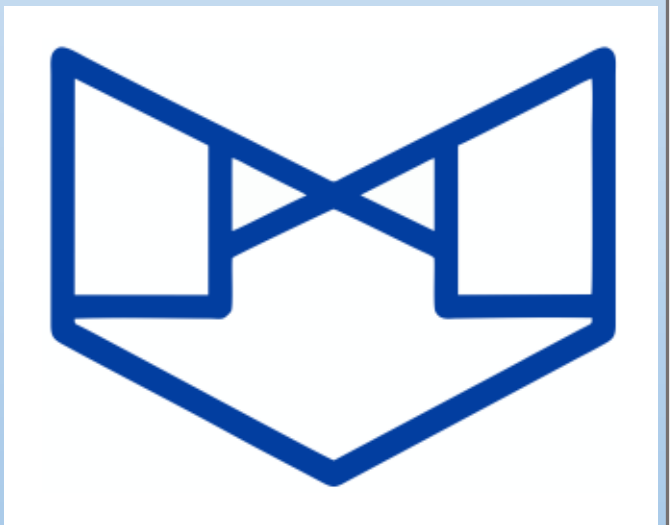
Institute trains highly qualified professionals for the development of new materials (alloys, composite, polymer, ceramic, and metal-ceramic materials), high-end technologies for their production, research and management of properties, process automation with the use of modern computer and information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



INFORMATION PACKAGE

E.O. PATON EDUCATIONAL AND RESEARCH INSTITUTE OF MATERIALS SCIENCE AND WELDING

Kyiv, 2022

CONTENT

*** ***Information is current as for the 2022/2023 academic year. Next academic year, there may be minor changes in the list of training specialties and educational programs.***

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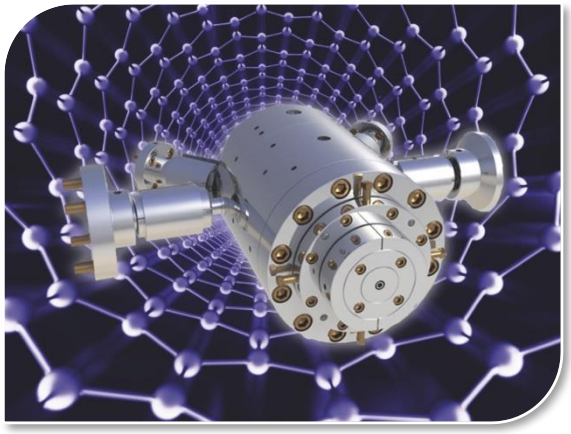
1. COMMON DESCRIPTION OF THE INSTITUTE

E.O. Paton Educational and Research 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.

The training of metallurgical specialists at the Igor Sikorsky KPI was started almost from the day of its foundation. 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 statement, widespread among welders in Ukraine and abroad, reflects 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 as a 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.

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 the 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.

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

2. STRUCTURE

The Institute of Materials Science and Welding consists of six departments:

1. **Department of Laser Systems and Physical Technology;**
2. **Department of Welding Technology;**
3. **Department of Physical Materials Science and Heat Treatment;**
4. **Department of High Temperature Materials and Powder Metallurgy;**
5. **Department of Foundry Production,**

as well as

- **Center for Collective Use of Scientific Equipment "Materials Science of Refractory Compounds and Composites";**
- **<u>Educational and scientific laboratories</u>:**
  - **Laboratory of Electron and Optical Spectroscopy**
  - **Laboratory of Structure Diffraction Analysis “RIGAKU” and Mass Spectroscopy;**
  - **Laboratory of Electron-Beam, Plasma and Spark-Plasma Technologies;**
  - **Laboratory of Computer 3D-modeling and 3D-analysis;**
  - **Laboratory of Mechanical Tests;**
- **Center of Energy of the Future;**
- **Personnel Training Center of the International Welding Institute;**
- **Educational and Research Laboratory of Nanostructured Materials;**
- **Educational and Research Laboratory of Materials Science and New Technologies "TOPAZ-TECHNOLOGIES";**
- **Educational and Research Laboratory of Plasma and Hybrid Welding and Additive Arc Technologies.**

3. EDUCATIONAL PROGRAMS

Levels of higher education. Training of students at the **IMSW** is carried out at three levels of higher education.

At the first level (Bachelor's course, I–IV academic years) the students acquire fundamental knowledge in physics, mathematics, mechanics, computer engineering, and special disciplines During the fourth year, they prepare and 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 prepare and defend a master's theses and acquire a master's degree

The third educational-scientific level – postgraduate studies, I-IV academic years. Applicants defend their dissertations and 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.

1. Department of Laser Systems and Physical Technology provides training under the following Educational Programs:

Specialty	Educational Program	Levels of higher education		
		First	Second	Third
131 Applied Mechanics	Engineering of Welding, Laser and Related Technologies	Bachelor *EPP*	Master *EPP*	–
	Applied Mechanics	–	Master *ESP*	Ph.D. *ESP*

Comment: EPP – Educational-Professional Program
ESP – Educational-Scientific Program

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 Technology provides training under the following Educational Programs:

Specialty	Educational Program	Levels of higher education		
		First	Second	Third
131 Applied Mechanics	Applied Mechanics	–	Master *ESP*	Ph.D. *ESP*

Comment: EPP – Educational-Professional Program
ESP – Educational-Scientific Program

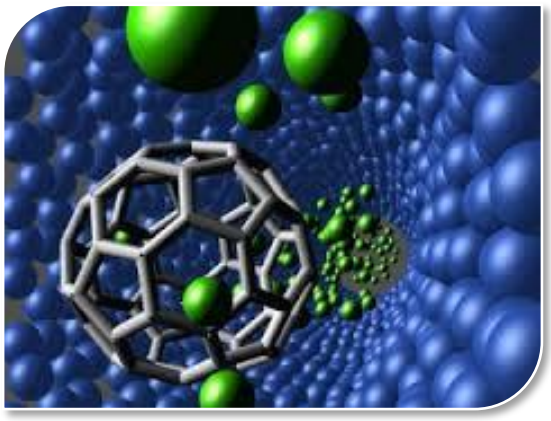
The curriculum of the Department aims the training specialists in the development of welding technology, welding materials with desired properties, mechanical engineering, diagnostics, forecasting of the reliability and performance of welded structures, certification, and quality control in production.

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 E.O. Paton Sino-Ukrainian Welding Institute, in cooperation with the Otto von Guericke University Magdeburg (Germany,) Federal University of Uberland (Brazil), E.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).

3. Department of Physical Materials Science and Heat Treatment provides training under the following Educational Programs:

Specialty	Educational Program	Levels of higher education		
		First	Second	Third
132 Materials Science	Engineering and Computer Simulation in Materials Science	Bachelor *EPP*	Master *EPP*	–
	Materials Science	–	Master *ESP*	Ph.D. *ESP*

Comment: EPP – Educational-Professional Program
ESP – Educational-Scientific Program



Graduates of the department are specialists of a wide profile in the field of modern technologies at the intersection of materials science, 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 nanoelectronics, aerospace and military equipment, robotics, and criminalistics.

Graduates work in enterprises and organizations in automobile production and instrument making, aerospace and electronic engineering, and 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 materials engineering.

4. Department of High-Temperature Materials and Powder Metallurgy provides training under the following Educational Programs:

Specialty	Educational Program	Levels of higher education		
		First	Second	Third
132 Materials Science	Nanotechnologies and Computer-Aided Materials Design	Bachelor *EPP*	Master *EPP*	–
	Materials Science	–	Master *ESP*	Ph.D. *ESP*
136 Metallurgy	Metallurgy	–	–	Ph.D. *ESP*

Comment: EPP – Educational-Professional Program
ESP – Educational-Scientific Program

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

Today the department is a leading institution in Ukraine for training specialists in the development and use of composite and powder materials, special materials for coating, high-performance emission materials, and structural ceramic materials.

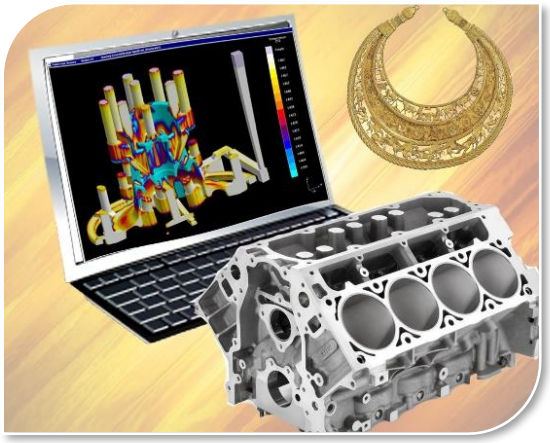
5. Department of Foundry Production provides training under the following Educational Programs:

Specialty	Educational Program	Levels of higher education		
		First	Second	Third
136 Metallurgy	Computerized Casting Processes	Bachelor *EPP*	Master *EPP*	–
	Metallurgy	–	–	Ph.D. *ESP*

Comment: EPP – Educational-Professional Program
ESP – Educational-Scientific Program

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 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

Department trains specialists in the development of new materials, high-end technologies for its production and formation, determining the properties of materials and assessing 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.

4. 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. The following educational and scientific laboratories have been created in **IMSW**:

Laboratory of Structure Diffraction Analysis "RIGAKU" and Mass Spectroscopy is intended to perform 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. This instrument allows getting direct, accurate, reliable, and versatile information on the phase composition and structure of materials as the base for control of materials' physicochemical and mechanical properties.

Laboratory of Electron-Beam, Plasma and Spark-Plasma Technologies designed for fundamental and applied research on the structure and chemical composition of materials, a solution to technical and research tasks in the field of materials engineering.

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Laboratory of Computer 3D Modeling and 3D Analysis;

Mechanical Testing Laboratory;

Training and scientific laboratory of nanostructured materials;

Training and scientific laboratory of materials science and the latest technologies "TOPAZ-TECHNOLOGIES";

Educational and scientific laboratory for plasma and hybrid welding and additive arc technologies.

The Department of Welding Technology 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 the Theory of Welding Processes,** the equipment of which allows conducting classes in a cycle of disciplines on the theoretical foundations of the formation of welded joints.
- **Laboratory of Production Tooling** intended to design and build models of assembly and welding equipment and diploma projects fulfillment.
- **Laboratory of Plasma, Hybrid and Additive Technologies.**
- **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.**

The Department of High-Temperature Materials and Powder Metallurgy has the following laboratories:

- **Laboratory of electron beam technology;**
- **Laboratory of physical and chemical foundations of powder metallurgy;**
- **Powder metallurgy technology laboratory;**
- **Laboratory of coating technology;**
- **Laboratory of dispersed ceramic materials;**
- **Laboratory of vacuum technology;**
- **Laboratory of technology of refractory compounds;**
- **Thermal analysis laboratory;**
- **X-ray research laboratory;**
- **Laboratory of electron microscopy;**
- **Laboratory of optical microscopy;**
- **Sample preparation laboratory;**
- **Laboratory for obtaining powders by dispersing melts;**
- **Laboratory of physical research methods.**

5. RESEARCH ACTIVITY

The main scientific directions of the institute:

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 Technology

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, and 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.
- 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.

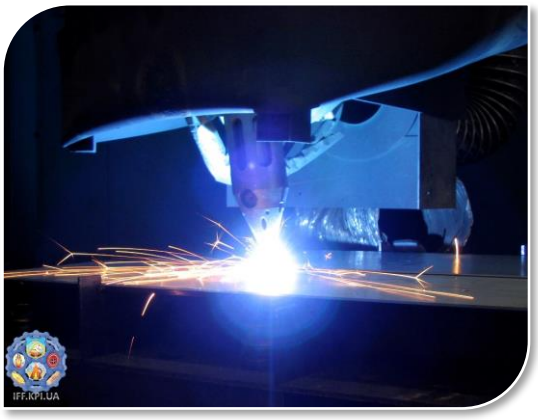
Department of Physical Materials Science and Heat Treatment provides investigations on the following topics:

- 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.

- 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.

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.

Research work at the ***Department of Foundry Production*** is conducted 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.
- theoretical and technological fundamentals of properties differentiation of the composite molding methods.
- 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 ferrous and non-ferrous metal wastes, refining melts from harmful substances, and so on.

Developments of the *Department of Foundry Production* recommended for implementation in 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 of 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 compositions and destinations.
- parting highly thermostable coatings for molds and cores
- methods for determining the properties of the molding sand, forms, and nonstick coatings.

6. 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, and 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.

Members of the welding staff of **IMSW** are active members of the International Institute of Welding, the European Welding Federation, 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).

7. CONTACT INFORMATION

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