AERO-UA

UKRAINIAN AERONAUTICS

Research and Technology Groups Brochure

Legal Notice

Foreword

Ukraine is one of the few countries possessing the whole cycle of aerospace products design and manufacturing. Research, engineering and production capabilities generated over the decades ensure its strong position in the aeronautics world. Ukrainian aerospace organisations possess unique skills and knowledge that can help Europe to address the challenges and goals identified in the ACARE Strategic Research and Innovation Agenda / Flightpath 2050 Report.

However, awareness of Ukraine's strength in aeronautic research and technology (R&T) is still comparatively low in Europe. Similarly, the number of Ukrainian organisations participating in EU-funded collaborative research is rather low. Consequently, there exists a rich and timely opportunity for key Ukrainian aeronautics players and their R&T activities to be presented collectively.

Today we are happy to welcome you to the Ukrainian Aeronautics Research and Technology Groups Brochure that describes Ukrainian organisations' key achievements and current research in the aeronautics field.

The first issue of this Brochure was prepared under the FP7 AERO-UKRAINE project (www.aero-ukraine.eu), the second one – under the FP7 KhAI-ERA project (http://khai-era.khai.edu). Presented and disseminated at key EU aeronautic events during the 2010-2016 period, this Brochure facilitated EU awareness raising of Ukraine aeronautics R&T expertise and capabilities and resulted in the involvement of several Ukrainian organisations in European collaborative research projects.

Following this successful strategy, an updated and enlarged third issue of the Ukrainian Aeronautics Research and Technology Groups Brochure has been prepared in the frame of Horizon 2020 AERO-UA project (http://www.aero-ua.eu) with the support of the Horizon 2020 National Contact Point for "Smart, Green, and Integrated Transport" in Ukraine (http://ncp.khai.edu). We hope you enjoy reading this brochure and find reliable partners among the presented Ukrainian organizations.

We look forward to Ukraine increasing its aeronautics research and technology collaboration with the European Union in order to tackle the challenges faced by the global aviation industry.

Overview of the Ukrainian Aeronautics Sector

Aeronautics has been long recognized as one of the strongest economic sectors of Ukraine. Since the country became independent in 1991, specific attention has always been paid by the Government to this high-tech sector.

Ukrainian organisations conducting aeronautic research fall into one of three categories: research institutes, higher education establishments, and state-owned or private companies. Together they cover almost all key aeronautics research and technology areas such as materials, structures, manufacturing processes and technologies, numerical simulation and analysis, aerodynamics, propulsion, safety, communications and navigation systems, testing, and aircraft infrastructure.

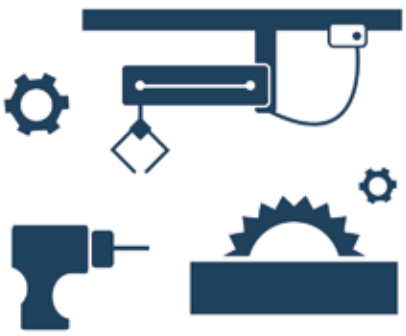
Most of the research institutes of Ukraine are members of the National Academy of Sciences of Ukraine (NASU). It is the largest self-governed research organization, supported by the Ukrainian Government. NASU unites more than 18,000 high-level researchers that work in 168 research institutions, covering a wide range of fundamental and applied research areas. At least 10 institutes are involved in R&D activities related to aeronautics. NASU has an R&D network, which involves pilot-production facilities, design-and-technology bureaus, and engineering centres working on the practical application of fundamental research results. Small businesses and joint ventures operate within NASU that contribute to the commercialization of new developments and innovations.

The Ukrainian Research Institute of Aviation Technology (UkrRIAT) is a major aeronautical research institute which is not governed by NASU. UkrRIAT is a Joint-Stock Company of which 50%+1 shares are the property of the State of Ukraine, and the rest of the shares are the property of legal entities and natural persons. Its main goal is to assist the Ukrainian aeronautics industry with the development of policy-making documentation, new technologies, processes and means of production automation as well as improvement of production processes. UkrRIAT regularly participates in numerous projects in collaboration with Ukrainian and foreign organizations.

The total number of higher education establishments (HEEs) in Ukraine was 657 in 2016, and about half of them have research facilities and conduct research. Among the 70 technical universities spread across the country, 6 deliver aeronautics-related degrees and conduct research related to aviation and aerospace, and 10 others have research teams focused on aeronautics-related issues. Altogether, there are about 30,000 aerospace students.

UKRAINIAN AERONAUTICS ADDED-VALUE CHAIN

Basic and Applied Research → Design and Development → TIERs and Components Manufacturers



Overview of the Ukrainian Aeronautics Sector

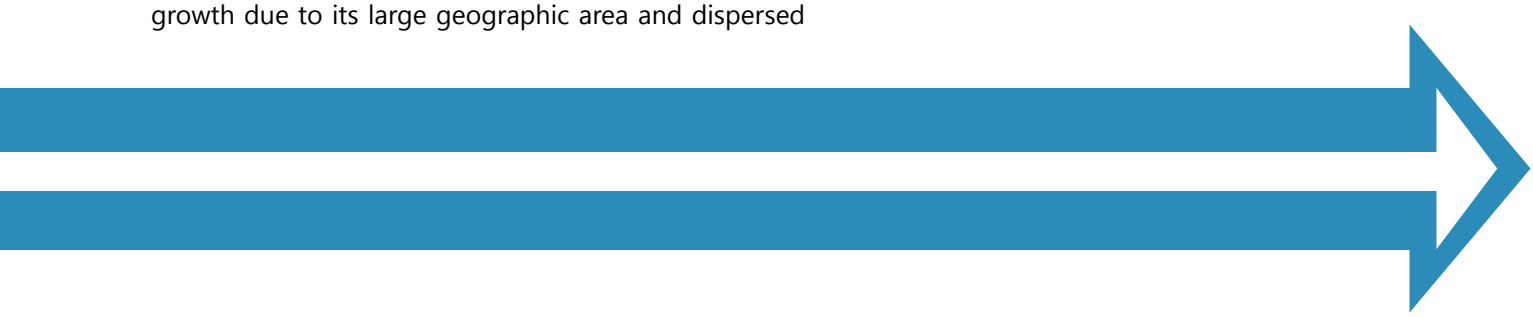
The research activities of the HEEs are funded from the State Budget and are coordinated by the Ministry of Education and Science of Ukraine. It provides financial budget support in the frame of annual open calls, which are in line with the science and technology priorities of the country. In the aerospace field most of the HEEs are active in research cooperation with industry. They provide R&D services and participate in joint internally- and externally-funded projects with Ukrainian industrial entities, as well as with foreign aerospace companies in the frame of EU-funded research programmes and private contracts.

In Ukraine, there are 4 industrial organizations considered as world-class aircraft and components manufacturers – Antonov Company, Motor Sich JSC, SE Ivchenko-Progress, and PJSC FED. Over 25 other enterprises produce aircraft components and equipment or provide aircraft maintenance and repair services. With regard to research and technology, state owned companies rely heavily on the input and support of institutes of the National Academy of Sciences and Universities. Also, there are a range of small-to-medium-enterprises (SMEs) involved in the aerospace sector with a significant number of privately owned ones.

As for air transport, Ukraine has strong potential for growth due to its large geographic area and dispersed population, high level of urbanization and other factors. Today, there are 19 national and international airports in Ukraine that are widely spread across the country. Among them, the international airports "Boryspil", "Kyiv", "Lviv", "Kharkiv" and "Odessa" are the largest ones. In 2016, Ukrainian airports received 133,200 commercial flights, 12.9 millions of passengers and 42,900 tonnes of freight.

Key Ukrainian aeronautics-related companies, research institutions and universities are members of the Innovative Regional Aerospace Cluster "Mechatronics", which was established in 2015 in order to realise the common interests of the Cluster members and to develop an efficient system of interaction and communication between the Ukrainian industry, research and academic institutions. Today, the Cluster includes 30 Ukrainian organizations that have signed the Cluster's Memorandum of Understanding signed by all the Cluster members.

Among others, the Cluster's objectives include stimulating research, production, and financial cooperation within the Cluster, providing broader access to innovations and new technological solutions (including technology transfer), and facilitating the international competitiveness of the Cluster's members through their introduction to global supply chains.



OEMs → Airlines and Infrastructure → MRO Companies

Industry and SMEs

SECTION 1

Industry and SMEs

ANTONOV Company

ANTONOV – unsurpassed capabilities in aircraft creation

Advanced ideas and technologies are especially needed in our dynamic time. Namely such a product ANTONOV Company named after its founder Oleg Antonov, offers for the world market.

ANTONOV Company created more than one hundred types and modifications of passenger, transport and special-purpose aircraft. More than 22,000 ANTONOV airplanes were constructed. Cargo giants "Ruslan" and "Mriya", being a visit card of the Company are the special pride of aviation designers. They set up 270 world records. As a total, ANTONOV aircraft set up more than 500 records. All ANTONOV aircraft.

Our enterprise, existing more than 71 years, is one of several enterprises having the whole cycle of creation of modern aircraft – from pre-project scientific researches to construction, tests, certification, serial production and after-sale maintenance.

Specific of the branch makes special demands on forming personnel and ANTONOV has a right to be proud with its main asset – a high professional staff. About 10,000 people work at the enterprise today. Among them there are representatives of more than 200 professions and specialities, the full staff of designers and scientists working in 40 scientific directions including such rare one as aerodynamics and strengthen of aircraft, mechanics, hydraulics, heat engineering, avionics, material science. Real masters of their work are engaged at all stages of the development of aircraft.

AN-225 Mriya – Super Heavy Transport Aircraft

The main subdivisions of ANTONOV Company are:

- experimental design bureau on projecting, perspective and experimental researches, certification, support of serial production and operation;
- experimental production facilities engaged in manufacturing of experimental aircraft;
- flight test and development base intended to carry out flight tests, development and certification of the aircraft as well as for training of flight and technical personnel;
- divisions of the leading specialists on the programmes.

Besides, ANTONOV Company includes aviation transport subdivision – ANTONOV AIRLINES, national aviation carrier, which delivers different cargoes worldwide and ANTONOV Serial Plant producing serially ANTONOV airplanes.

This complex allows embodying designers' ideas in real aircraft. Thus, competitive production, including designs enters a market. This gives to our partners a possibility to develop and modernize their own aviation production.

We appreciate our cooperation with many partners worldwide and are always glad to have new possibilities for cooperation development.

www.antonov.com

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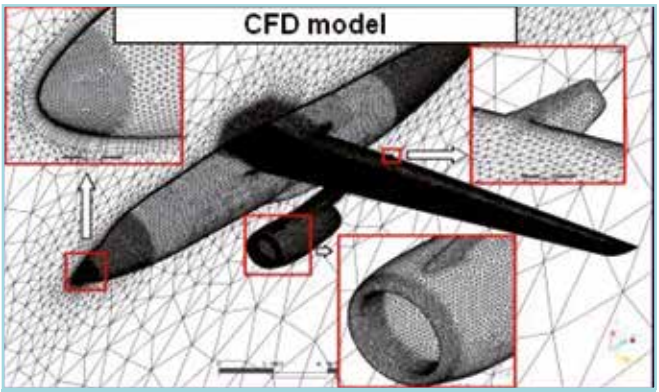
Department of Aerodynamics

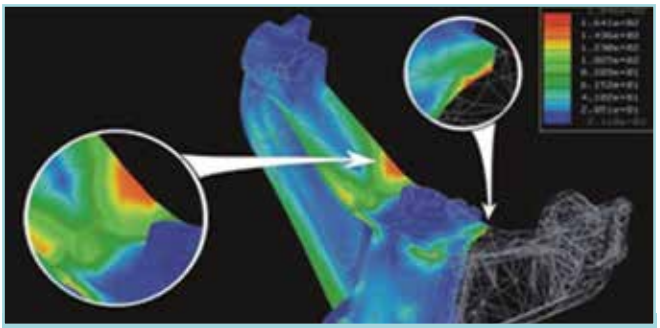
- aerodynamic configurations of new aircraft, new air-foils and wings, wing flaps, slats and other airlift devices;
- use of engine power to obtain high lift of the wing;
- complete cycle of experimental aerodynamic tests;
- simulators of engines;
- computational aerodynamics.



CFD Model for the Antonov An-148

Department of Strength

- Static and fatigue strength tests from separate parts to complete aircraft;
- Development of methods based on IT;
- Research for prolongation of the service life of existing aircraft;
- Simulation of bird strike as a complex dynamic process;
- Development of surface hardening processes;
- Substantiation of structural reliability and durability;
- Methods and tools for inspection of the technical condition of structures.



Landing gear strength analysis

Engine nacelle of Antonov An-148 made of composite material

Department of Material Science

- Constructions development and implementation;
- Nonmetal constructions based on carbon, glass, organic and hybrid fibres;
- Knitted lightning protection nets for polymer compo-sites;
- Application of titanium alloys in aircraft.

Department of Design

Antonov has invested heavily in computer-aided-design equipment and skills to support its aircraft design and development activities.

CAD Model of Antonov An-148

Counter-rotated propellers on the Antonov An-22

Department of Power Plants

Antonov works closely with SE Ivchenko-Progress on the development of aero-engines e.g.:

- Two-row Counter-Rotated Propfans on An-70
- Long-term experience of Counter-Rotated Propellers on An-22

Department of Avionics

Antonov's work over the years on "more electrical aircraft" includes:

- An-124 (1982) - world's first heavy transport airplane with a fly-by-wire control system
- An-70 (1994)– introduction of the electrical flap drive
- An-148 (2004) - world's first transport-category airplane with a 'more electrical' configuration of the control surface drive system achieved through the introduction of electric drives thereby saving 100kg airplane weight

Antonov An-148 has a "more electrical' configuration of the control surface drive system through the use of electric drives

Ivchenko-Progress SE

Ivchenko-Progress SE has been designing a wide range of aero-engines to power aircraft and helicopters since 1945. During the past 70+ years, more than 80,000 of Ivchenko-Progress aviation piston and gas turbine engines, turbine starters, auxiliary power units and industrial application drivers have been manufactured. Aero engines designed by Ivchenko-Progress power 60 types of aircraft in more than 100 countries from Europe, Asia, Africa and America. The total operating time of its gas turbine engines exceeds 300 million hours.

Since the 1990s, the company's design team has been developing gas turbine drivers for industrial applications and special equipment. This line of activity covers 21 types of engines with a power range from 0.5 to 32 MW. Gas turbine drivers from the D-336 family (4 to 10MW) and the AI-2500 (2.5MW) are currently operating in more than 45 compressor and 765 gas-turbine power stations in different countries of the world. The operating time for some driver gearboxes has reached 50,000 hours without the need for repair.

Today, the fields of Ivchenko-Progress activities covers design, manufacturing, testing, development, certification, putting into series production and overhaul of gas turbine engines for aviation and industrial applications. The company has more than 75 design, quality and reliability certificates from international bodies including Bureau Veritas, EASA, Central Civil Aviation Administration of China, IAC AR and DerzhAviaSluzhba of Ukraine.

www.ivchenko-progress.com

National and International Projects

1. International projects:
   - European Commission, 6th Framework Programme project CESAR "Cost-Effective Small Aircraft"
   - European Commission, 7th Framework Programme project ESPOSA "Efficient Systems and Propulsion for Small Aircraft"
   - European Commission, 7th Framework Programme project OXIGEN "Oxide Dispersion Strengthened Materials for the Additive Manufacture of High Temperature Components in Power Generation"
   - European Commission, Horizon 2020 project AERO-UA "Strategic and Targeted support for Europe-Ukraine collaboration in aviation research"

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Design scientific-research complex of Ivchenko-Progress SE

AI-450C turboprop engine for a modification of a single-engine trainer aircraft DART-450

Research and Technology Development Activities

The research and test facilities of Ivchenko-Progress SE are amongst the most advanced in the world. They include 17 test benches and 78 rigs used for solving various problems related to engine testing, component development, certification, reliability and fuel-consumption.

The company's aeronautics R&T priorities are:

- Creation of high-performance aircraft engines of 5th generation (increasing and optimization of thermo-gas-dynamic cycle parameters, increasing of effectiveness of all engine components, decreasing of fuel consumption)
- Increasing of service life and reliability
- Decreasing of weight and DOCs
- Decreasing of harmful emissions and noise
- Development of innovation designs, techniques, materials, design styles, manufacturing and test methods that increase the safety and decrease the environmental hazard and the costs
- Development of activities on the creation of aviation engines for small aircraft.

The experimental-design bureau carries out all production activities related to aircraft engine creation from designing up to certification and service support.

The company follows the policy of continuous transfer to up-to-date technologies, performs the development of in-house technologies and their implementation in production with minimum costs.

The following technologies are developed and/or applied at Ivchenko-Progress SE:

- Technology to optimize rotors assembly
- Technology of advanced brush seals manufacture
- Technology of parts surface strengthening with the help of high-power powerful supersonic waves;
- Laser technology to cut and pierce thin-walled parts
- New technology to cast the blades of up to 170 mm length using high-speed directional crystallization
- A series of machining integrated technologies (e.g. creep feed grinding on 5-axis profile-grinding machine Mägerle)
- Technology of high-speed milling on Starrag machining centers
- Restoration-repair technologies.

Assembly shop of Ivchenko-Progress SE

MOTOR SICH Joint-Stock Company

Motor Sich Joint Stock Company was founded in 1907. The company is engaged in development, production, testing, upgrade, repair and overhaul, and field maintenance of engines for multiple aircraft applications, as well as creation, upgrade and maintenance of helicopters and their components.

Aircraft engines produced by Motor Sich JSC are installed in 88 aircraft types operated in more than 120 countries worldwide.

Quality system relating to development, manufacture, overhaul and maintenance of aircraft engines and their components of gas-turbine installations and mobile power-generating units has been certified by Bureau Veritas Certification company by international certification system for compliance with requirements of ISO 9001, Certificate No. UA226244. Quality system of Motor Sich JSC relating to development, production, overhaul and maintenance of aircraft engines was certified by NATO certification system for compliance with requirements of standard AQAP 2110, Certificate No. HTI/130-009/2010.

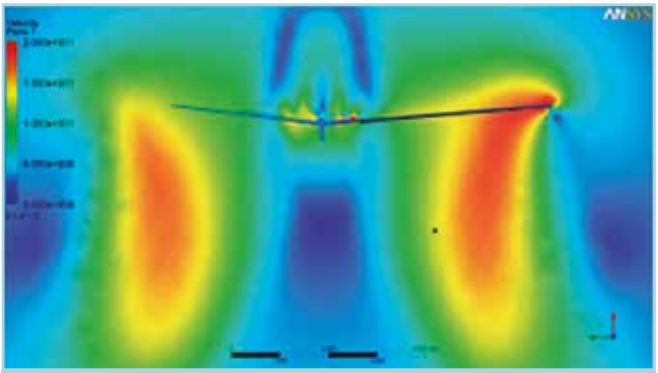
www.motorsich.com

Experimental Design Bureau

Experimental Design Bureau is an association of structural units of Motor Sich JSC founded for development and upgrade of helicopters.

Research and Technology Development Activities:

- Research and calculations in the field of helicopter aerodynamics, dynamics and strength
- Development of aircraft and helicopter fuselage structures made of metallic and composite materials
- Helicopter propulsion system development
- Development of rotorcraft flight structure elements, including composite blades
- Development of mechanical hydraulic and electrical control systems
- Development and incorporation of mission equipment to be used on board of helicopters
- Engineering support for helicopter testing
- Process equipment development for manufacture and testing of aircraft equipment



Helicopter Main Rotor Velocity Field

MSB-2 Helicopter Configuration

National and International Projects

1. National projects:
   - Mi-8MSB multi-purpose helicopter
   - Mi-2 light multi-purpose helicopter powered by AI-450M-B engines
   - MSB-2 light multi-purpose helicopter.
2. International projects:
   - European Commission, 7th Framework Programme project ESPOSA (Efficient Systems and Propulsion for Small Aircraft)

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Chief Metallurgical Engineer Department

Research and Technology Development Activities:

- Production of high purity nickel-based heat resistant superalloys using advanced melt refinement techniques
- Production of turbine blades and vanes using single crystal and directional solidification techniques
- Elimination of internal defects in turbine blades through HIP processing
- PM turbine disk production
- Application of advanced TBC's on aero engine combustors
- Production of turbine blades and vanes by single crystal and directional solidification processes
- Casting of structural parts from special steels and alloys for aero engines
- Casting of structural components from titanium alloys for aero engines
- Casting of large complicated casings from aluminium and magnesium alloys for aero engines
- Vacuum heat treatment
- Application of advanced TBC's and anti-erosion coatings on aero engine flow path components
- PM turbine disk production

Hot Isostatic Press QIH 0,9 x 1,5-2070-1400 MURC (Quintus Technologies AB, Sweden)

Metallurgical furnace FM-1-2-100 (ULVAC, Japan)

National and International Projects

1. National projects:
   - Projects with national scientific and research institutes (Paton Electric Welding Institute, Ukrainian Scientific and Research Institute of Special steels and Alloys) dedicated to aeroengine performance and life cycle enhancement.

2. International projects:
   - European Commission, 7th Framework Programme project ESPOSA (Efficient Systems and Propulsion for Small Aircraft)

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Chief Designer Department

In 2014 Chief Designer Department of Motor Sich JSC celebrated its 90th Anniversary. During all these years many generations of engineers and designers have created engines that made flying dozens of thousands of aircraft.

Today Chief Designer Departments takes part in the following long-term projects:

1. Series production and performance improvement for such engines as D-18T, TV3-117VMA-SBM1, D-36, MS-400, TV3-117V family, D-436TP, D-436-148, AI-450-MS, TV3-117VMA-SBM1V, TV3-117VMA-SBM1V 4E series, AI-222-25.

2. Overhaul for VR-8A, VR-14 and VR-24 main gearboxes for Mi-8, Mi-17 and Mi-24 helicopter families.

3. Pilot and series production development and preparation for:

- TV3-117VMA-SBM1V 1 series turboshaft engine equipped with new digital control system
- TV3-117VMA-SBM1v 5 series turboshaft engine with increased power for helicopters with 15 to 16 tons of takeoff weight
- MS-14 turbopropeller engine for An-2-100 aircraft
- MS-500V and MS-14VP turbo-shaft engine families for ANSAT, W-3A Sokol, etc. type helicopters
- MC-500B-C and AI-450S turbopropeller engine families for general aviation aircraft, trainers and airliners
- AI-450M turboshaft engine family for Mi-2M, MSB-2, etc. helicopters
- VR-442P main gearboxes for MSB-2 helicopter and VR-17MS for Mi-17 type helicopters
- Gas turbine drives for electric power stations and gas pumping units.

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TV3-117VMA-SBM1V Engine

National and International Projects

1. National projects:
   - ANTONOV Company, Kyiv – engines for An-140, An-148, An-158 and An-2-100 aircraft
   - Institute for Problems of Strength, NAS of Ukraine – research in the field of material structural strength
   - National Aerospace University "KhAI" – development of engine life evaluation algorithms, development of engine dynamic simulation models
   - Ivchenko-Progress SE – collaboration on design of TV3-117VMA-SBM1, TV3-117VMA-SBM1V 5 series, D-436T1/TP/148, AI-450, AI-322-25, etc. engines

2. International projects:
   - Collaboration with Central Institute of Aviation Motors (Russia), All-Russian Institute of Aviation Materials (Russia), State Civil Aviation Research Institute (Russia) to ensure engine certification in Aviation Register of Interstate Aviation Committee
   - Design and development of AI-450C engine family for DART-450 trainer manufactured by Diamond Aircraft Industries GmbH (Austria)

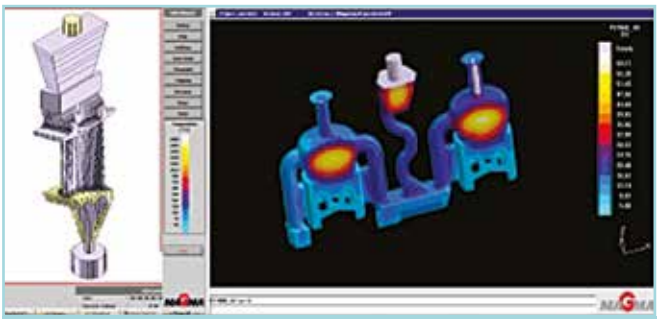
Chief Production Engineer Department

Chief Production Engineer Department is a leading production engineering department ensuring both continuous improvement of already existing production processes and implementation of brand new advanced ones, engineering level and production standards improvement, and production re-equipment.

Main trend for improvement of new product process planning is implementation of computer-aided software for process planning.

Chief Production Engineer Department main activities are:

- Design documentation study for adaptability to manufacturing
- Process flow development and improvement
- Procedure manuals for development of production processes in workshops
- Development of executive programs for CNC machines
- Elaboration of design documentation relating to jigs, fixtures and tools, including metallurgical production
- Research and experimentation aimed to improve and develop brand new production processes
- Development of computer-aided design and drafting software for production process documentation
- Development of computer-aided design software for jigs, tools
- Elaboration of measures relating to product quality improvement
- Development and implementation of computer-aided manufacturing software
- Statistical processing and analysis for stability of parameters obtained during gas turbine engine test.



Casting Research Using Software

Computer models for complex pre-fixtures and die molds for blade manufacturing

National and International Projects

- European Commission, 7th Framework Programme project ESPOSA (Efficient Systems and Propulsion for Small Aircraft)

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Public Joint Stock Company "FED"

The future is in the courage of the first step

PJSC "FED" is a world-known brand name in aerospace industry. PJSC "FED" is a top performer in development, serial production, maintenance, modernization and repair of aircraft and general machinery units not only in Ukraine but far abroad.

Company products are characterized by their innovative design, advanced performances and high quality of production, and are used on many different aircraft and helicopter in more than 60 countries of the world.

PJSC "FED" is a developer of unique technologies and manufacturing processes that are integrated in the world's most successful aeronautic programmes and projects. Serial products of PJSC "FED" is constantly and systematically updated based on operation experience in various regions of the world, new modifications are being developed. This work helps to shape highly competitive aviation industry of international standard, and provides PJSC "FED" with stable position among the world leaders of aircraft engineering.

Highly qualified maintenance and aftersales service is one of the key elements of the Company strategy. In parallel, PJSC "FED" possesses robust R&D facilities.

www.fed.com.ua

Advanced technologies:

1. Precision plasma nitriding nanolayer nanocomposite coating deposition: "NanoTechnology" R&D Center in cooperation with PJSC "FED" specializes in R&D and application of multicomponent coatings (mono- and multilayer, nanostructural, gradient) to enhance operational characteristics of materials and parts, cutting and forming tools
2. High-speed processing of light, heat-resistant and titanium alloys
3. Finishing and super-finishing treatment
4. Honing of holes
5. Finishing of spherical and flat surfaces
6. Diffusion welding of bimetal designs
7. Electron-beam welding in vacuum
8. Galvanic processes on a base of "clean technologies"
9. Test and analytical complex:
   - Chemical-spectrum laboratory;
   - Metallographic laboratory;
   - Mechanical tests laboratory;
   - non-destructive control methods laboratory.

High-precision machine workshop

Equipment for precision plasma nitriding nanolayer nanocomposite coating deposition

National and International Projects

1. National projects:
   - Development and production of aircraft high-lift systems with combined actuators: PJSC "FED", SE "Antonov"
   - AI-222-25F and AI-322 aircraft engine development program: PJSC "Motor Sich", SE "Ivchenko-Progress", PJSC "FED", ST SDB "Polisvit", KhAI

2. International projects:
   - Satellite components development and production programme: Thales Alenia Space (France), PJSC "FED" (Ukraine)

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PrJSC "Volchansk Aggregate Plant"

R&D Department

Volchansk Aggregate Plant is a private company from Ukraine. The company's field of activities includes design, manufacturing, serial production, repair and testing units for aeronautic, industrial gas-turbine and automotive industries.

Volchansk Aggregate Plant is certified to develop aircraft units by the State Aviation Administration of Ukraine. The quality management system corresponds to the requirements of international standard EN 9100 (certification body: TUV Züd), ISO TS 16949 and 9001 (certification body: TUV Hessen).

The Research & Development Department conducts research and development activities for development of hydraulic pumps and motors, oil-fuel units for different aircraft and helicopter engines and actuators for flight control systems, fuel units for industrial gas-turbine engines, and units for automotive hydraulic and pneumatic systems.

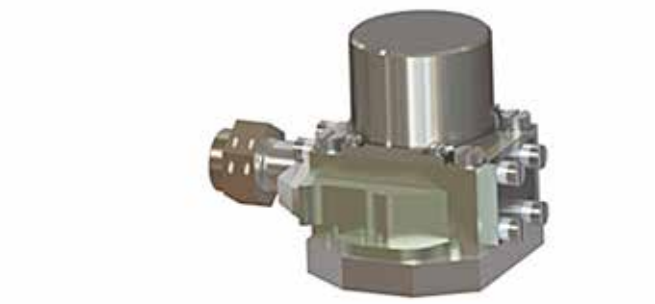
www.vza.com.ua

Research and Technology Development Activities

Design, manufacturing and testing of units for various systems of aircraft and helicopters, units for industrial gas-turbine power plants and automotive industry.

- Scientific research aimed at prediction of unit performances, improvement of functional quality, and meeting environmental requirements.
- Development of innovative design solutions, mastering new technologies and conducting research on efficiency of use of hybrid power plants on the basis of gas-turbine engines of low power.
- Search for innovative solutions on use of hybrid plants in different branches, to provide improvement of efficiency parameters.

1- gas metering device
2- unit of engine control system



Electrohydraulic amplifier

National and International Projects:

1. National projects:
   - ANTONOV Company: units for hydraulic systems of aircraft An-132, An-148, An-124-100, An-178
   - Ivchenko-Progress SE: unit of engine control system D-336
   - National Aerospace University "KhAI": R&D activities focused on effective use of hybrid system

2. International projects:
   - KMPO, Russian Federation: gas metering device for NK16ST engine based on innovative solutions

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State Enterprise “PLANT 410 CA”

SE "Plant 410 CA" was created in 1948. It is the authorized provider of a wide range of aircraft equipment maintenance, repair and overhaul services, particularly AN-24, AN-26, AN-30, AN-32, AN-72, AN-74 aircraft, MI-8MSB helicopters, and D-36 engines.

The plant occupies the territory of 236,000 m^2, including 170,000 m^2 of production facilities. It holds powerful capacities, modern equipment, employs advanced technologies, experienced engineers and technicians and has gained the leading positions in the aviation industry.

SE "Plant 410 CA" has overhauled about 7,000 aircraft and 40,000 engines for domestic and foreign customers from 50 countries since its establishment.

www.arp410.com

SE "Plant 410 CA" provides the following services:

- Complete overhaul of ANTONOV AN-24, -26, -30, -32 aircraft
- Check, refurbish and initial maintenance of MI-8MSB helicopters
- Complete overhaul of D-36 engines for Yak-42, AN-72, -74 aircraft
- Retrofit of RU19A-300, TG-16(M) auxiliary power units
- Aircraft accessories repair
- Aircraft components reconditions
- Inspection and non-destructive tests for aircraft equipment serviceability.

The plant extends the service life of ANTONOV family airplanes, conducts all types of aviation equipment maintenance at the flight test station, performs CRW1, CRW2, CRW3 on AN-74 and CRM on AN-72 aircraft.

Engine repair

Engine repair

National and International Projects

1. National projects:
   - Joint cooperation with ANTONOV Company (Kyiv), Motor Sich JSC (Zaporizhzhia), Ivchenko-Progress SE (Zaporizhzhia) and others
   - Modernization of aircraft and their components

2. International experience:
   - Customized work for Kazakhstan, Bangladesh, Hungary, India, Peru, Romania, Sudan, Sri-Lanka

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Yuzhnoye State Design Office

Yuzhnoye State Design Office is one of the most well-known and recognized scientific and design companies in the world in the field of space technology development. This recognition is based on the exceptional experience in space technology development, gained during more than 60 years of the company's life and reinforced by the capability to grow in modern economic and political environment, while providing flexible response to the needs of the global space launch market.

www.yuzhnoye.com

The main areas of Yuzhnoye SDO activities are aerospace technology development and supervision of operation and manufacturing of aerospace technology (launch vehicle, rocket engines and their components, space systems, spacecraft and their components, ground segment and its components). With its great scientific and technical potential, Yuzhnoye Design Office besides the space rocket hardware develops high technology products for machine-building, power industry, transport, processing industry and other industries.

Yuzhnoye provides the following services:

- Development of design documentation on launch vehicles and satellites, along with their components accordingly
- Development of customized launch complexes and infrastructure
- Development of components and advanced materials for tailored application (metals, composites, honeycomb structures)
- Provision of experimental tests (fire testing, functional testing; strength tests, test of antenna systems, etc.)
- Delivery of services on analytical and design efforts (strength analysis, programming, thermal design, ballistics, air gas dynamic analysis, etc.)

Yuzhnoye is open for cooperation in aerospace field and not only, to meet the most up-to-date market needs and customer requirements by using our best potential.

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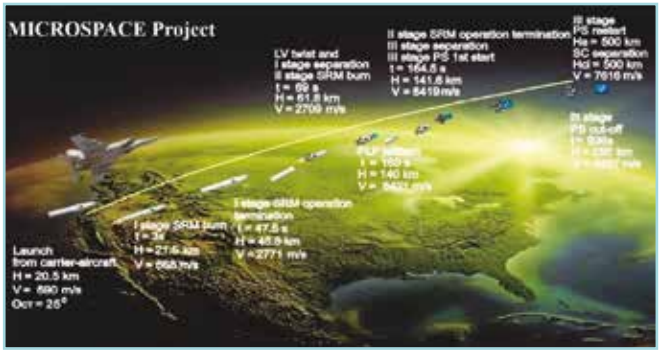
National and International Projects

- Yuzhnoye is a primary contractor for design and development of launch vehicles such as Kosmos, Interkosmos, Cyclone-2, Cyclone-3, Zenit-2, Zenit-3SL, Zenit-2SLБ, Zenit-3SLБ, Zenit-3SLБФ, Dnepr.
- More than 400 spacecraft of 78 types were developed and launched into space (Egyptsat-1; Sich-1, Sich-2; Mikron; Okean-O, etc).
- FP7 and Horizon2020 projects SIDER (2010-2013); ROV-E (2011-2014); LEOSWEEP (2013-2016); NEWSPEC (2013-2017); FIBRALSPEC (2014-2018); LIGHT-TPS (2014-2017); EQUINOX (2016-2019); MODCOMP (2016-2019).

The Purpose of Microspace Project is to use supersonic aircraft as carrier-aircraft of Space Transportation System for microsatellites injection



Joint-Stock Company ELEMENT

JSC ELEMENT is a certified developer and manufacturer of onboard and ground aviation electronics. In 2007 JSC ELEMENT obtained license for development, production, and other types of works in the area of aviation electronics and meteorological equipment.

For more than 10 years JSC ELEMENT is included in Ukrainian State Register of Scientific Organizations. JSC ELEMENT Management System is certified by Bureau Veritas. JSC ELEMENT is the member of Innovative Regional Aerospace Cluster "Mechatronics". JSC ELEMENT employs 40 people.

JSC ELEMENT develops and manufactures the following electronics products:

- Pressure and vibration measurement transducers
- Onboard and ground aviation electronics
- Data collection and data processing systems for tests of gas turbine engines
- Meteorological transducers, weather stations and complexes for industry and military
- Electronics for military and rockets

www.element.od.ua

JSC Element develops avionics systems, specifically

1. Onboard systems:
   - digital control systems for aviation engines type FADEC RDTs-450M, -C,-V
   - exhaust gas temperature regulation units BRT,-01.-02
   - start and generation of the electric power units BZG-450
   - unit for registration of the engine parameters and airplane aggregates parameters
   - pressure measurement system for aviation engines

2. Ground systems:
   - date collection and date processing
   - systems for tests of gas turbine engines (GTE)
   - simulator – stands and software simulators of GTE
   - monitoring-test complexes and equipment for electric cables tests, pressure sensors and transducers.

National and International Projects

- Digital regulator of the engine RDTs-450M-S, start and generation unit BZG-450, control and special test equipment was developed and produced for engines AI-450S of aircraft.
- DA-50-JP7, Austrian company DAIMOND Aircraft. Engines AI-450S was developed and produced by Zaporizhzhia Machine-Building Design Bureau Progress.
- For the Chinese company Skyrizon – the partner of Motor Sich the software and hardware complex for tests of Ai-222 and Ai-322 aviation engines is developed and made.
- Development and delivery the of digital regulators type FADEC for engines of the Ukrainian upgraded helicopters is executed.
- More than 15 years JSC Element is a representative of the Kulite Semiconductor Products Inc, USA in Ukraine. Kulite company is a developer and the manufacturer of pressure transducers certified by FAA.

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Aviation company VECTOR LLC

Aviation company VECTOR LLC is working on development of modern Ukrainian helicopters. The strategic goal of the company is to set up serial production of light multi-purpose helicopters.

Aviation company VECTOR LLC development team has more than 20 years of experience in aeronautics. Many engineers took part in the development of the first Ukrainian helicopter KT-112 "Angel".

The company negotiates with many European companies, is open for knowledge and innovation transfer, and looks for partners in the sphere of production and investment.

The tremendous potential that the employees of the enterprise have will be embodied in new products that will revitalize the aviation industry of Ukraine and enable them to competently perform in the world market of technologies and innovations.

www.ak-vector.com

Research and Technology Development Activities

Key R&D activities of the Aviation company VECTOR LLC company are focused on development of a twin-engine multipurpose helicopter "Bumblebee", which has a wide range of applications:

- Regional and municipal administration;
- Naval Aviation (deck and shore);
- Oil and gas, mining, forestry and water;
- Air ambulances;
- Army, Police, Emergency Service, Border guard;
- Flying schools;
- Agriculture;
- Urban Air Transport:
- Business;
- Private sector.

This category of helicopters is in high demand all over the world. The implementation of the project will provide efficient and reliable transport for various purposes.

The company is open for cooperation in the fields of aircraft engineering, pilot production of helicopters, and testing of equipment.

We are open for cooperation with:

- experienced partners to develop new projects,
- investors to bring projects results to the market.

Medical modification of «Bumblebee» helicopter

Military modification of «Bumblebee» helicopter

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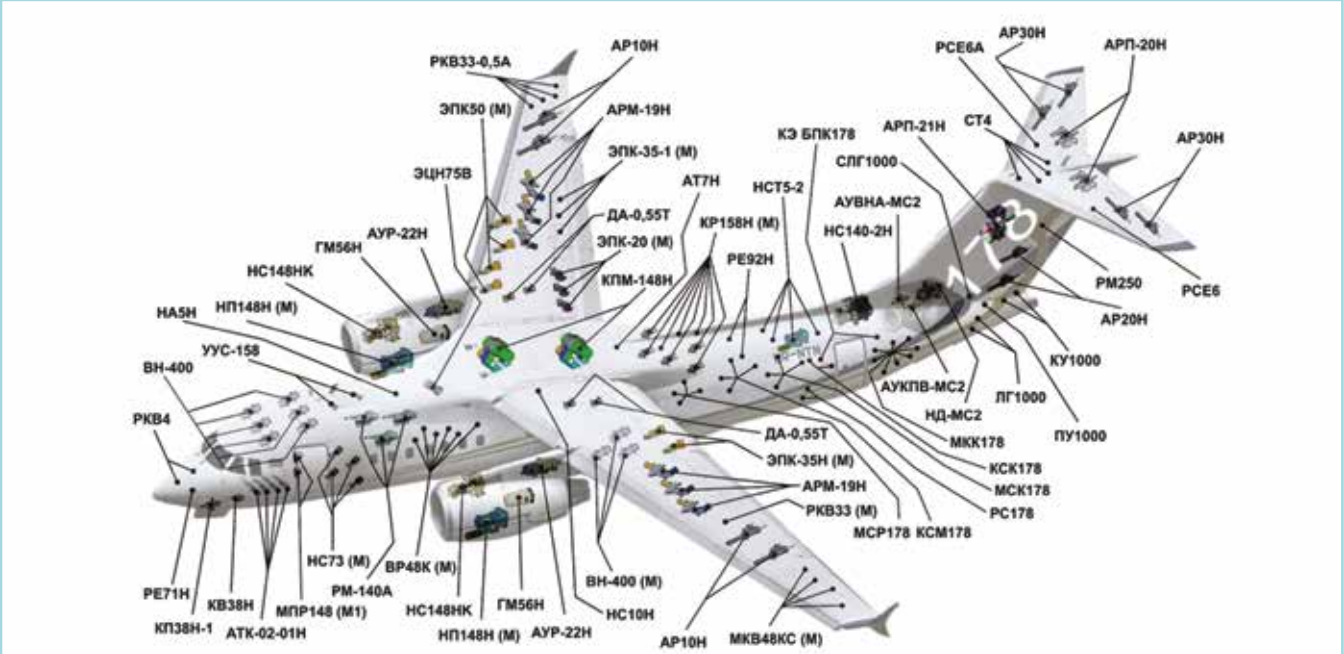
Innovative Regional Aerospace Cluster "MECHATRONICS"

In 2015, Innovative Regional Aerospace Cluster "Mechatronics" was established on the basis of PJSC "FED" in order to realise common interests of the Cluster members and to develop efficient system of interaction and communication between the Ukrainian industry, research and academic institutions. Today, Cluster includes 30 Ukrainian members.

One of the major advantages of the cluster approach is consolidation of R&D, production, financial, labour and other resources at minimum financial expenditures of the Government. The Cluster's members are leading aviation companies, R&D institutions and Universities of Ukraine working in compliance with international standards. It allows major breakthroughs in planning and management of aircraft equipment development and production processes, formation of new industrial practices and standards, getting rid of duplicate structures, gaining efficiency, decreasing time needed for development of new aviation units and systems.

Cluster's major projects:

1. Implementation of AI-222-25F and AI-322 aviation engines programme
2. Development and production of aircraft high-lift systems with combined actuators
3. Development of automatic control systems (ACS) for advanced aircraft
4. Development and production of control systems for guided missiles systems
5. Development and production of control systems for launch vehicles
6. Development and production of inspection equipment:
   - Integrated Modular Airplane Information Management and Control System (AIMCS)
   - Specialized electronic equipment for aircraft functional systems
   - Ultrasonic system for measuring fluid level in hydraulic systems tanks
   - Ground systems (e.g. loading control system for airframe strength and fatigue test rig; flight simulator motion base control system; avionics integration and test system)
7. R&D in the field of ACS for gas turbine engines (GTE) of 5th and 6th generation:
   - Improvement of theory of GTE automatic control
   - Intelligent aircraft GTE
   - GTE mathematical model incorporated into ACS
   - Systems of "electrical" GTE (EGTE)
   - Distributed GTE control system
   - Assurance of GTE ACS durability
8. Improvement of fundamental and applied research in key areas of modern science
9. Facilitation of national aerospace science and engineering, machine-building and machining tool production
10. Organization, coordination and control of innovative projects



An-178 aircraft units developed and produced by the Aerospace Cluster "Mechatronics" members

Innovative Regional Aerospace Cluster "MECHATRONICS"

Cluster's perspective projects:

1. High resolution radar for helicopter flight safety
2. Development and production of light aircraft for general and special purposes
3. Exterior perimeter radioray stand-alone security system

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Key memebers of Innovative Regional Aerospace Cluster "Mechatronics"

Higher Education Establishments

SECTION 2

Higher Education Establishments

National Aerospace University "KhAI"

National Aerospace University "KhAI" (KhAI) is a leading Ukrainian technical University and the only engineering University in Ukraine that provides a full cycle of higher education in the field of aviation and aerospace engineering. Today more than 12 000 students and 160 PhD students are trained at the University. 700 lecturers (incl. more than 100 Professors and Doctors of Sciences, 400 Associate Professors and Candidates of Sciences) and above 2000 teaching staff members are employed at the KhAI. The KhAI is a member of International Association of Universities (IAU/UNESCO), Partnership of a European Group of Aeronautics and Space Universities (PEGASUS), European Aeronautic Science Network (EASN), The Magna Charta of the European Universities (Magna Charta Universitatum), International Association of Technical Universities from CIS Countries, Academic Association of CIS Countries Higher Education Institutions. Being a well-known University, the KhAI is also a globally recognized aerospace research centre. It is focused on innovative research across the aerospace industry, and has worked with AIRBUS, ONERA, Thales Alenia, Boeing, EOARD, IAI, AVIC, etc.

www.khai.edu

Department of Aerodynamics and Fluid Dynamics

The Department of Aerodynamics and Fluid Dynamics was founded together with the KhAI in 1930. The Department trains specialists in aerodynamics and flight dynamics of airborne vehicles of different classes, as well as specialists in aerodynamics of buildings and constructions, surface and waterborne transport.

The Department has the following R&D facilities:

1. Supersonic Aerodynamic Laboratory equipped with supersonic wind tunnel T-6 (Mach number – 0.5÷4; cross section – 0.6x0.6 m; length of working section – 1.3 m)
2. Subsonic Aerodynamics Laboratory equipped with
   - Subsonic wind tunnel T-3 (velocity up to 40 m/s; nozzle diameter 1.5 m; test chamber length 2.0 m; initial degree of turbulence 0.8%)
   - Subsonic wind tunnel T-4 (velocity up to 55 m/s; nozzle diameter 1.5 m; test chamber length 2.05 m; initial degree of turbulence 0.78%)
   - Subsonic wind tunnel T-5, which is used for training purposes (velocity up to 40 m/s; nozzle diameter 0.75 m; test chamber length 1.2 m)
3. Acoustics Laboratory equipped with acoustic chamber (3x3x4.5 m, 125 ÷ 8000 Hz)
4. Hydraulic Laboratory equipped with hydraulic test benches for study and analysis of laws of fluid motion, determination of performances of pipelines, pumps and other devices.

Research and Technology Development Activities

1. **Development of mathematical models, approaches, algorithms and computer codes** for:

- wind tunnel tests of different moving objects in subsonic and supersonic wind tunnels (M=0÷4), including aircraft, helicopters, missiles, cars, submarines, buildings, wind turbines, etc.
- aerodynamic analysis of airborne vehicles (aircraft, missiles, UAVs, helicopters, airships, etc.)
- analysis of airborne vehicles flight dynamics
- analysis of performances of wakes and trailing vortices of different airborne, surface and waterborne vehicles
- analysis of airborne vehicles motion in disturbed atmosphere
- aerodynamic analysis of propellers and rotors
- aerodynamic design of airborne, surface and waterborne vehicles.

2. **Analysis of acoustic performances** of airborne vehicles and aeronautic thrust producers.
3. **Optimization of aerodynamic performances** of any moving objects to maximize their efficiency on the basis of long-term experience accumulated by the Department's staff.

Scale model of aircraft in T-4 subsonic wind tunnel

National and International Projects

The Department actively participates in research projects led by different Ukrainian industrial enterprises such as ANTONOV Company, SE "State Kyiv Design Bureau «LUCH»", Yuzhnoye SDO, SE "MALYSHEV PLANT", JSC "ZAZ", PJSC "AutoKrAZ" as well as Research Institutes "Transprogress and "Morneftegaz".

Also, the Department's staff conducts collaborative research together with colleagues from different international organizations in Europe, Asia, and America.

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CAD/CAM/CAE/PLM Educational and Research Centre

CAD/CAM/CAE/PLM Educational and Research Centre of the National Aerospace University "KhAI" was established in 1993 under the leadership of Professor A. Grebenikov. The Centre yearly provides education and research training for more than 100 students, young specialists, scientists, KhAI employees, production specialists from Ukraine and other countries. Our staff is involved into international collaboration with the colleagues from Russia, USA, Germany, Czech Republic, Canada, Japan, Iran, India, China, and Mexico. To perform research activities the Centre is equipped with modern computer integrated CAD\CAM\CAE\PLM systems: Siemens NX; CATIA, ANSYS, NASTRAN, KOMPAS, etc.

Research and Technology Development Activities

1. Integrated aircraft design: Key area of the Centre's research activity is the development of methodology for airplanes and helicopters integrated design, parametric simulation, engineering analysis and process engineering. Our scientists have developed the concept, principles and methods for integrated design and simulation of long-lifetime aircraft. Also, we have developed the methods of integrated design of airframe structural components and the methods which allow to achieve specified lifetime of zones around riveted and bolted joints. Among the other our activities is the analysis of characteristics of local stress-strain state of zones around holes for fuel overflow and bolted and riveted joints in aircraft primary structural members. Developed approaches include machining process simulation. Proposed methods of integrated design and technological concepts are introduced into the theory and practice of assembly airframes development with the use of CAD/CAM/CAE integrated systems.

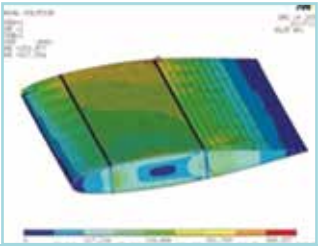
2. Design and manufacturing methods to assure aircraft lifetime: Under the Laboratory there is the research team which activity is focused on the investigation of fatigue lifetime characteristics of aircraft structural components. The Laboratory is equipped with machining facilities for samples manufacturing and machines to conduct tests for the determination of fatigue lifetime characteristics of aircraft structural components. The team investigates efficient design and engineering methods allowing to obtain specified lifetime characteristics of assembly aircraft structural components around the riveted and bolted jointing elements without structural mass increasing.

3. New long-lifetime fasteners: The laboratory staff develops new types of long-lifetime fasteners enabling to ensure specified characteristics of joints static strength, fatigue life, tightness and outer surface quality for transport aircraft air foils. The application of such joining elements will provide the reduced labour intensity for assembly process.

4. Polymer fillers for manufacturing tolerances compensation: The application of polymer fillers when assembling the aircraft structural members allows to compensate manufacturing tolerances and to reduce fretting corrosion intensity on contact surfaces of structural members under operational loads.

5. Performance restoration of thin-wall structures with fatigue cracks: Based on carried out research results the recommendations for load-carrying capacity restoration of aircraft structures with fatigue cracks were formulated. These recommendations and guiding engineering materials based on these recommendations are approved by the leading experts.

Aircraft master geometry model



Central wing box structural analysis model

Central wing box assembly model

National and International Projects

CAD/CAM/CAE/PLM centre has wide experience of managing scientific internship and research projects for foreign students and postgraduates from China, India, Iran, Mexico, Nigeria and CIS countries.

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Interbranch Research Institute of Aircraft Flight Modes Physical Modeling Problems (NII PFM KhAI)

In USSR the Interbranch Research Institute of Aircraft Flight Modes Physical Modeling Problems (NII PFM KhAI) was the parent organization in the field of predictive flight research of advanced aircraft with the use of pilotless dynamically similar subscale models. Since 1976 till 1996 the institute has performed a range of flight tests of models of Su-27 and MiG-29 fighters and their modifications, some aircraft of Myasishchev and Antonov design offices and others. Since 1997 the key Institute's field of activity is development of remotely piloted aircraft for civil and special applications. A great number of different types of remotely piloted aircraft have been developed and tested. Currently, the Institute work is focused on the development and testing of new aerodynamic layouts, avionics, payloads and radio communication systems for aircraft.

Research and Technology Development Activities

1. Predictive flight research with the use of free-flying dynamically similar models: Large-scale free-flying dynamic model (FDM) is the re-usable unmanned research aerial vehicle capable to perform remotely-piloted or automatic pre-programmed flight with the possibility to record in-flight information. FDM is geometrically similar to the investigated aircraft and has the same controls. Its weight, inertia moments, autopilot coefficients and other parameters ensure conformity of FDM flight performance to the full-scale aircraft. When necessary, the pilot actions (including possible pilot errors) are simulated by the model. The major components of FDM structure are made of composites and aluminum alloys. FDM onboard system includes an automatic control system, flight parameters measuring and recording system and recovery system. For FDM development we used the modular approach providing model deep modification during the flight tests. FDM can be applied for: (i) investigation of the most effective aerodynamic layouts with the allowance for fixed and separated external stores effect; (ii) study of critical flight modes related to complicated 3D aircraft movement; (iii) investigation of aeroelasticity phenomena under the energetic maneuvering; (iv) investigation of aircraft invulnerability and reconfigurable automatic control system efficiency.

2. Multi-purpose remotely piloted aircraft systems (RPAS) design and testing: NII PFM conducts research, design, engineering and flight tests of specimens of multipurpose RPAS based on different remotely piloted aircraft (RPA) in consideration of safety flights requirements in the non-segregated aerospace. The modern RPAS based on the "ChiZh-L" small RPA is intended for: (i) real time aerial surveillance of territories, extensive objects and borders; (ii) aerial mapping; (iii) search and mapping of fossil fuel and mineral deposits; (iv) atmospheric investigations; (v) environmental monitoring etc.

Static structural tests of L-410UVP-E fuselage

Static structural tests of L-410UVP-E fuselage

National and International Projects

1. National projects:
   - Yuzhnoye SDO, Dnepr, Ukraine: "ChiZh-L" multipurpose remotely piloted aircraft
   - PJSC "FED", Kharkiv, Ukraine: "Mini-Reis" multifunctional remotely piloted aircraft
   - State Space Agency of Ukraine (SSAU), Kiev, Ukraine: "MARKS" project focused on small aviation-rocket space launch system, funded in the frame of the "National Target Scientific and Technical Space Program of Ukraine for 2018-2022"

2. International projects:
   - "Orbita" Company, People's Republic of China (PRC): "MARKS" project focused on small aviation-rocket space launch system

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"Strength" Research Laboratory

"Strength" Research Laboratory have accumulated more than 50 years of experience in the field of aircraft strength and durability. Our research topics are historically determined by industrial partners. We have performed strength and durability calculations for numerous customers including Beriev, Antonov, Tupolev, Ilyushin and Boeing.

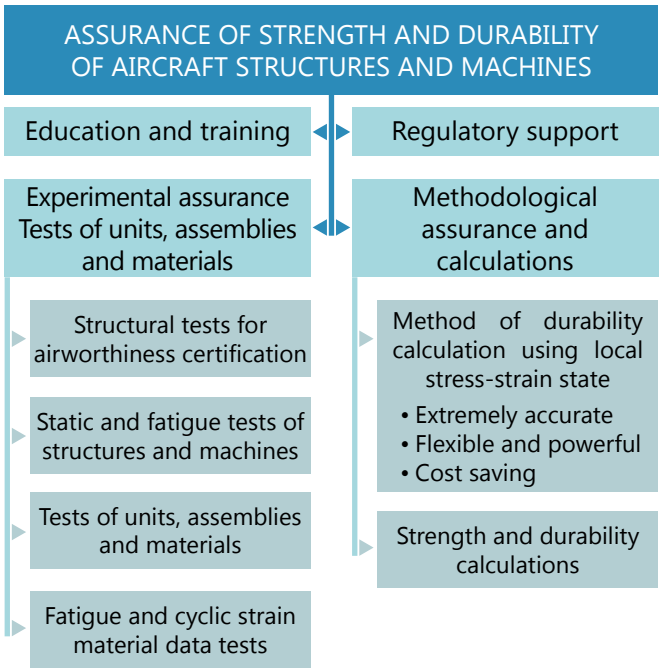
Our Research Laboratory offers a wide range of services related to strength and durability. We have structural tests hall, with the height of 10 m and area of 430 m^2. The laboratory is equipped by hydraulic and electromechanical test machines, both static and fatigue.

Research and Technology Development Activities

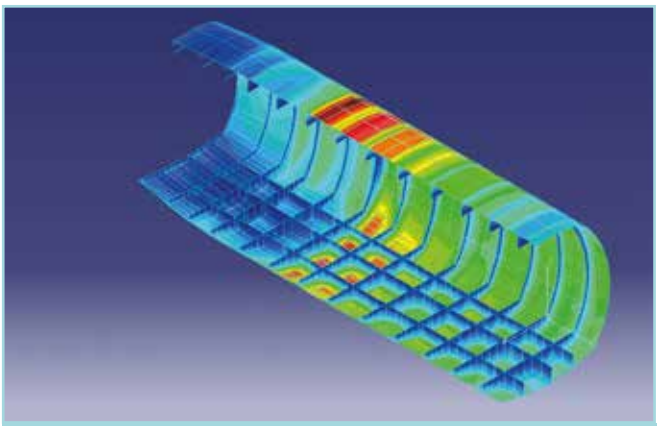
We have developed a new method for aircraft structure durability analysis and calculation. This method is based on energy fracture criterion and uses the local stress-strain state and cyclic strain material data. In contrast to traditionally used methods, no additional testing is required to consider the specific type of loading, operational conditions, flight profiles, or design solution. The application of new material could be studied without fatigue tests of structural elements, with the use of cyclic strain material data tests only.

Our method allows decreasing the required volume of fatigue testing and total costs of aircraft design, testing, modernization and operation.

Our current research activities on aerospace structures strength and durability analysis and testing are the following :



Static structural tests of L-410UVP-E fuselage



Results of 3D FEM strength analysis of L-410UVP-E fuselage

National and International Projects

Among our successful projects are tests of Yak-40, "Shmel" 01-M, "Bekas" X-32, experimental wing box of IL-86, fuselage of L-410 UVP-E, engine pylon of Il-76 and other aircraft.

Also, we have validated and successfully prove the efficiency for described above method for aircraft structure durability analysis for the following aircraft: Boeing 747SR, Boeing 737, Tu-160, Tu-144, Be-200, IL-86, AN-24, etc.

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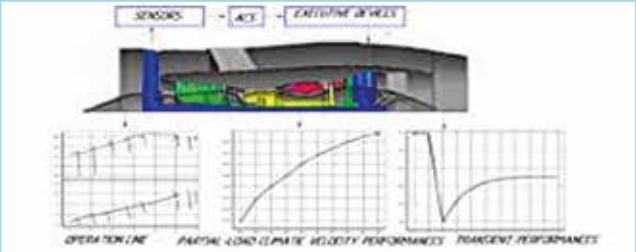
Department of Aircraft Engine Design

The Department of Aircraft Engine Design has 5 Full Doctors of Science, 10 Candidates of Science, who train Bachelor, Mater and PhD students. The Department is well equipped with computer hardware and software and has over 40 years of experience in turbine engine automatic controls, monitoring, diagnostics, numerical modelling and simulation.

The Department's research results have been published in about 200 scientific journals and proceedings in Ukraine and abroad, including Proceedings of ASME Turbo Expo 2007 – 2017.

Research and Technology Development Activities

- Development of fast-response multi-mode dynamic models of turbine engine
- Development of self-turned on-board models of engines
- Engine real-time simulation procedures for semi-natural test-cells and on-design face of electronic control system
- Engine in-flight data (normal and abnormal condition) simulation for debugging and algorithm's checking purposes
- Turbine engine models matching with test data
- Synthesis and analysis of engine automatic control algorithms, incl. adaptive multi-dimensional robust control based on the dynamic model
- Engine parametric diagnostics
- Sensor faults detection procedures using information redundancy and the engine mathematical modelling;
- Lifetime depletion of critical gas turbine engine parts monitoring methods based on the dynamics temperature and stress states identification
- Development of fast calculating monitoring models of temperature and stress state of critical turbine engine parts on steady-state and transient modes based on upper level computer models
- Integration of monitoring models of temperature and stress states into lifetime depletion account systems
- Development of analytical and experimental techniques for modelling of combustion kinetics and related computational fluid dynamics
- Development of technologies for advanced combustor and injector systems with regard to NOx, soot and unburned hydrocarbon
- Stimulation and control of combustion using electric charge
- Flow, heat exchange and thermal state analysis in the engine cowl compartment (engine room for on-ground application).



Turbine engine simulation results

National and International Projects

1. National projects:
   - SE "Ivchenko-Progress", JSC "Motor Sich", JSC "FED": automatic control algorithms implemented in engines AI-322, AI-322F, AI-450MS, MC-14, MS-500, TV3-117VMA-SBM1V, AI9-3B.
   - SE "Ivchenko-Progress": on-ground automated program complex for D-18T engine diagnostics based on the flight information;
   - JSC "Motor Sich": software for life time analysis of the engine main components by flight information;
   - SE "Ivchenko-Progress": dynamic models of different engines;
   - JSC "FED", SE "Polysvit": engine simulation software for automatic control system hardware semi-natural development

2. International projects:
   - University of Sheffield, UK: "Hardware-in-the-Loop Simulation and Testing Technology for Integrated Control-and-Condition-Monitoring Systems of Gas Turbines Using Diagnostic Markov Modelling" (INTAS, GA 05-1000007-421)
   - Compressor Controls Corp., USA: Gas pumping equipment diagnosing software
   - Doosan Heavy Ind.& Constr. Co., Republic of Korea; SEDRY, Shenyang, China: Turbine engine simulation software

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Department of Composite structures and Aviation Material Science

Thanks to 50+ years of experience in aerospace structures design, Department of Composite structures and Aviation Material Science conducts research and provides specialist training in design and manufacturing of polymer composite structures for aerospace, automotive, marine, energy and other applications. The focal point of the Department R&Ds is development and validation of radically new design solutions for complex and integral composite structures with novel type of joints for heavy-loaded composite-to-metal assemblies.

The Department has a specialized Composite Material Laboratory fully equipped with all the necessary facilities to develop manufacture and test composite/ CFRP components and structures (oven, vacuum system, autoclave (up to 5 atmospheres), tensile-testing machine, etc.) Tests are performed in accordance with international standards (ASTM, DIN, GOST, etc.) or proprietary methods and techniques developed by our researchers.

Research and Technology Development Activities

1. Mechanics of Composite Materials: We explore different aspects of composite materials mechanics to apply them effectively for computational and engineering problem solving

2. Optimal Design of Composite Structures: We develop analytical models, optimization algorithms, and tailored software to simplify and speed-up typical structures design (panels, rods, shells, etc.)

3. Innovative Design Solutions for Composites: We create radically new design solutions like hybrid composite-to-metal joints to overcome existing barriers and extend composites application.

4. Efficient Manufacturing of Composite Structures: We improve energy- and cost-efficiency of composites production through the development and application of optimal/tailored curing profile together with specially designed self-heated tooling

5. Rational Maintenance of Composite Structures: We assess influence of typical defects on structural strength to plan efficient maintenance and develop high-quality repair processes with minimal time/costs and influence on repaired structure.

6. Reliable Testing of Composite Structures: We carefully analyse composite structures operation and loading conditions to realize them precisely during testing thanks to the application of specially designed test jigs and accessories.

National and International Projects

1. National projects:
   Fundamental research projects funded by the Ukrainian Government; applied research upon request of Ukrainian and international industrial enterprises Antonov SE, GE "Technology", Russia

2. International projects:
   EOARD project, FP6 SENARIO project "Advanced sensors and novel concepts for intelligent and reliable processing in bonded repairs"; FP6 ALCAS project "Advanced low cost aircraft structures"; FP7 WASIS project "Composite fuselage section Wafer Design Approach for Safety Increasing in Worst Case Situations and Joints Minimizing", FP7 KhAI-ERA Project "Integrating the National Aerospace University ««KhAI»» into ERA", H2020 AERO-UA project "Strategic and Targeted Support for Europe-Ukraine Collaboration in Aviation Research"

Composite panels testing

Innovative Composite Structures Design

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National Aviation University

National Aviation University was established in 1993, and today it is one of the world's most powerful aviation higher educational institutions with more than 50,000 students including 1,200 international students from 49 countries.

The University consists of 15 institutes, 7 colleges, a technical school, 2 high schools, Centre for Air and Space Law, European regional centres of International Civil Aviation Organization (ICAO).

Main research areas are air navigation, air traffic control, avionics, information security, aviation safety, ecology and environmental protection, aircraft flight management, and small unmanned aerial vehicles flight control systems, transport traffic forecasting.

The university launched powerful scientific schools in the fields of management, mechanics, electronics, electrical engineering, materials science and computer technology. Unique devices, control systems of aircraft and space-rocket equipment, advanced technologies, and as a result, high scientific and pedagogical potential of this higher educational establishment have been created at the University.

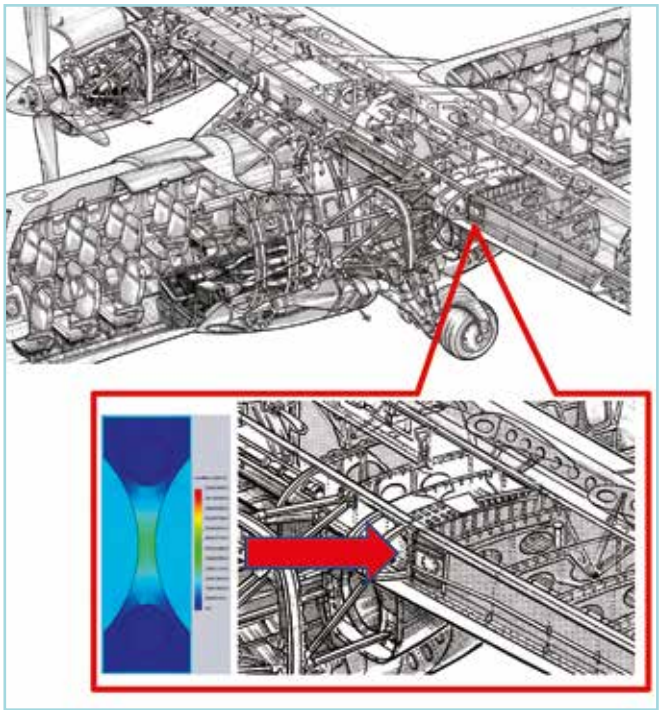
www.nau.edu.ua

Laboratory of aircraft fatigue and fracture

Laboratory conducts fundamental and applied research for aircraft structure strength and operational durability maintenance. Laboratory carries out fatigue tests of aircraft structural components and materials. Standard and original equipment allows testing under wide range of loading conditions (constant amplitude and random load sequences).

Research and Technology Development Activities

- The fatigue sensor based on the idea of possibility to assess accumulated fatigue damage and to predict remaining service life has been developed.
- Numerous tests of sensors attached to the bearing structures of aircraft have been carried out.
- The high accuracy of the fatigue damage assessment is proved.
- The tests were conducted with application of different methods for non-destructive inspection of sensor condition; some of the methods are unique, developed at the Aircraft Design Department of National Aviation University.
- Fundamental knowledge about metal fatigue phenomena have been obtained thanks to the research and development activities implementation.



Area for fatigue sensor installation

National and International Projects

1. National projects:
   - Fundamental and applied projects supported by the Ministry of Education and Science of Ukraine.

2. International projects:
   - INTAS-AIRBUS-1547-99 "Surface relief fatigue sensor". Partners: Airbus Ind., University of Malaga (Spain), Institute of metal physics (Ukraine).

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Nanotribotechnology laboratory

At the laboratory of nanotribotechnology we constantly carry out technological developments and run already manufactured samples of instruments and equipment for industry, in order to increase reliability and lifetime of aircraft and other machinery and mechanisms.

The basis of all developments is our new hypothesis on friction and wear out, which combines the main points of two well-known theories: elastohydrodynamic and adhesion-deformation. We called it the "Compromise Adhesion-Hydrodynamic hypothesis on friction and wear".

Research and Technology Development Activities

1. In our laboratory, new hypothesis "desorption vacuum adhesion wear" has been proven both theoretically and experimentally, devices and methods to explore processes in thin layers of lubricant wear and physics, as well as radically new methods and requirements for structural and greases that have successfully implemented in the aerospace industry and in other fields of engineering were developed.
   Currently, our laboratory, develops and manufactures new instruments and methods of investigation of friction and wear, as well as a number of prototypes for industrial production.
   20 patents were obtained and more than 150 articles were published in peer-reviewed journals in Ukraine, Russia and overseas.
   Nanotribotehnology laboratory has contacts and cooperation with foreign laboratories, centres and universities.

2. Our main technologies and/or services are:
   - Investigation of dynamic processes in the boundary layers in friction in the boundary lubrication conditions, including cavitation processes in conjunction with the adhesive wear tribosystems to improve the efficiency and durability of friction units of aircraft and other equipment.
   - Development of parts manufacturing technologies for ultra-efficient tribosystems based on compression-vacuum theory of friction.
   - Differential-phase laser scanning microscope-profilometer (LDFSMP)
   - Methodology and stands preoperational contactless pulsed magnetic turbulent cleaning ball bearing
   - Implementation of methodology of laboratory tests and tribology lubricants and construction materials to test and analytical measuring complex tribological NAU-01
   - Universal hardware-software complex

National and International Projects

1. National projects:
   - PLC "MAN invest" - Development and creation of layouts of devices and techniques for contactless controlled cleaning of ball bearings by mobile electromagnetic fields.
   - Zaporizhzhia machine-building design bureau "Ivchenko-progress" - General scientific research and implementation of innovative activities.

2. International projects:
   - Dresden University of Technology, Dresden, Germany - Cooperation agreement.
   - National academy of sciences of Belarus V.A. Belyi metal-polymer research institute, Minsk, Belarus- Agreement on scientific and technological cooperation
   - "Institute of welding and protective coatings", Minsk, Belarus - - Agreement on scientific and technological cooperation/

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National Aviation University

Centre of Advanced Technologies

The Head of the Centre of Advanced Technologies has an up-to-date laboratory that includes wind tunnel and equipment to investigate influence of sudden damage during flights on aerodynamic qualities of aircraft. To carry out the research, models of plane wings are created that contain the optimum number of sensors to register moment, degree and location of typical impacts that can be later used in control law.

The Centre has 3 Doctors of Science, 10 Candidates of Science and 5 PhD students involved in research. The department has published two monographs and over 120 articles on its research.

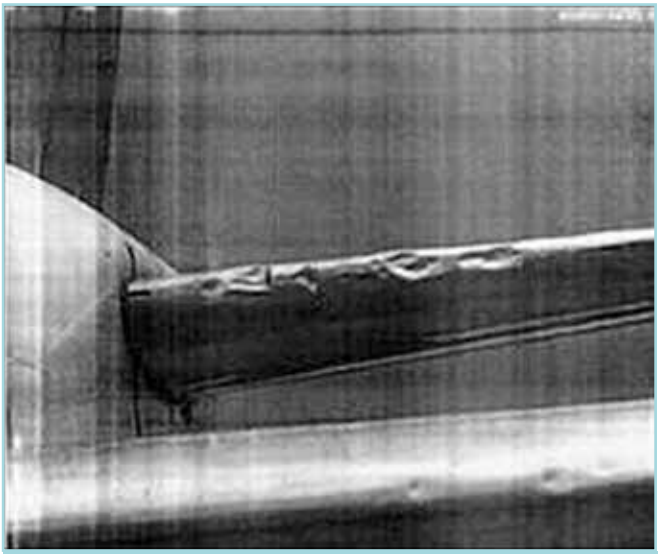
Research and Technology Development Activities

Our research focuses on system methods for aircraft conservation, operation and contingency during exceptional circumstances. This includes:

- Diagnostic techniques for aircraft external contour as well as method of control reorganization during sudden damage to airplane
- Development of system method of conservation of controllability for aircraft in exceptional circumstances and contingency during the flight
- Method of preparation of rule base forming and development of decision-making techniques and support for crew in existing flight situations
- Development of operation algorithms and structure for on-board intelligence system to prevent existing contingency during the flight from resulting in catastrophe.

The main technologies and services we offer include:

- Optimal placement of sensors to register moment, degree and location of typical damages impacts during flights
- Creation of rule base based on past positive crew actions in similar situations to prevent emergency during the flight
- Implementation of scale-down experiments to prove method efficiency for aircraft external contour during flight.



Typical plane damage

National and International Projects

We work extensively with Ukrainian industrial enterprises including JSC Ukrtransgas, Aviant, Artem and Antonov. Also, we implement projects on behalf of the Ministry of Science and Education of Ukraine such as "Theory, methods and principles of diagnosis of aerodynamic condition of aircraft external contours during flight".

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Centre of Environmental Problems of Airports

The Centre of Environmental Problems of Airports (CEPA), which includes the Acoustic Laboratory and several specialised groups, was established in NAU for solving particular tasks of Environment Protection in and around the airports. The main purpose of the CEPA is to define the protection zones around airports and aerodromes of civil aviation for the dominant environmental factors: aircraft noise, air pollution, electromagnetic fields and third-party risk. The work is done in accordance with existing national rules (Civil Aviation Authority, Ministry of Environment Protection and Ministry of Health Protection of Ukraine), which were developed with leading participation of the NAU (CEPA) in accordance with ICAO recommendations.

Research and Technology Development Activities

The centre's research is concerned with operational procedures and airport measures for noise and air pollution impact reduction:

- Aircraft Noise Models and Sound Propagation Models (Air Absorption, Directivity Patterns, Lateral Attenuation, Acoustic Screen Effects)
- Models of Exhausted Jets Based on Semi-Empirical Theory of Turbulent Jets
- Models of Aircraft Engine Emission
- Aircraft Crash Location Model and Aircraft Crash Consequences Model
- Optimal aircraft flight profiles (take-off and approach flight stages) for minimum noise and air pollution around airports
- Noise and vibration performances measurements in acoustic chambers, recommendations for their minimization.

The main technologies and services:

1. Semi-empirical methods for assessment of Aircraft Noise Levels and Noise Exposure around Airports
2. Methods for assessment of Air Pollution Concentrations around Airports
3. Methods for assessment of Third Party Risk around Airports
4. Numerical Methods for Optimization of Aircraft Trajectories and Flight Scenario for Minimum Noise and Air Pollution Impact around Airports
5. Software design for acoustic signal analysis and synthesis in aircraft cabins.

Sound transmission/absorption testing for new aircraft cabin structures and materials

International Projects

1. NATO project: "Prediction of noise from aircraft" with University of Hull, UK, 1998.
2. European Commission projects:
   - FP5 SILENCE(R) ("Improving prediction models for noise footprint calculations in a part of sound propagation and installation effects in operating conditions", G4RD-CT-2001-OQ500);
   - FP5 X2-NOISE (G4RD-CT-2002-05102);
   - FP6 X3-NOISE ("Aircraft External Noise Research Network and Co-ordination", ACA5-CT-2006-030840);
   - FP7 X-NOISE EV ("Aviation Noise Research Network and Coordination", ACA5-CT-2010-265943);
   - FP7 TEAM-Play ("Tool Suite for Environmental and Economic Aviation Modelling for Policy Analysis", EC № ACPO-GA-2010-266465-TEAM-Play);
   - FP7 TURBOGAS (CS-GA-2009-255674 TURBOGAS);
   - Development of a Public European Model Suite for Aviation (H-2020-MOVE/C2/SER/2014-269/SI2.706115)
   - Feasibility study on the integration of third party risk near airports into "IMPACT" (Integrated Aircraft Noise and Emissions Modelling Platform)

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Electronics Department

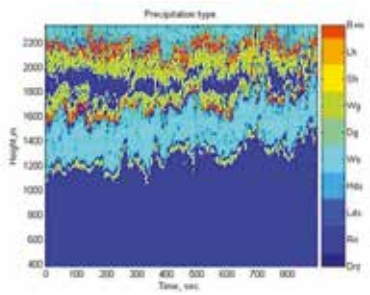
The Electronics Department of the National Aviation University conducts research and provides specialist training (BSc, MSc, and PhD) in the field of electronics including electronic systems, IoT electronic technologies and micro- and nanosystems technologies.

The scientific and academic staff includes 10 Professors, DSc, PhD; 9 Associate Professors, PhD; 5 Assistant Professors and Engineers, MS. Permanently, the department has 15 PhD students.

Research and Technology Development Activities

The main research and technologies development activities of our Department include:

- Mathematical modelling of Doppler-polarimetric scattering on arbitrary hydrometeors, computer simulation of Doppler-polarimetric signals and images
- Radar polarimetry. Radar pattern recognition. Radar signal processing (including statistical synthesis of algorithms)
- Mathematical modelling and computer simulation of processes and systems, application of mathematic tools of probability theory, statistical and imitation simulation, theory and practice of signal processing
- Modelling of secondary radar environment and multilateration systems
- Microwave remote sensing of clouds and precipitation with microwave radar and noisy acoustic radar (sodar)
- Multi-parametric signal processing. Combining of passive and active methods
- Measuring of physical quantities. Adaptive methods of measuring under the condition of severe external action
- Development of applied software tools for remote sensing data and signal analysis
- Experimental remote sensing with Doppler-polarimetric radar and prototype of noisy atmospheric sodar
- Fuzzy logic and neural network algorithms for signal processing and pattern recognition
- Signal processing in real time and processing of raw data of the remote sensing previously written digital carrier.
- The main technology we are proposing is the weather radar mesh (WRM) of compact-size low-power low-cost smart nodes with improved resolution capabilities. This approach has a number of advantages comparatively with the traditional large-size long-range and expensive radar systems, such as the fabrication and maintenance simplicity, coverage homogeneity and quality, etc. It can be the only case to use for the regions with local shading, for example, in mountains. The WRM integration with the mobile base stations could be the possible way to further decreasing its deployment cost.



Radar hydrometeor type recognition

National and International Projects

More than 70 projects. Among them:

1. Mobile system for acoustic spatial localization of movable objects with application of intellectual technologies, Project #1053-DB16, 2016-2017, NAU, Ukraine.
2. UWB RADAR: Behind-Wall Detection and Identification of Alive People for Security, Industrial and Civilian Applications, Joint project of D.P. Electronic Systems Ltd., Israel and ConfService, 2016-2017, Kyiv, Ukraine.
3. Development of a new model for retrieving information about turbulence intensity from radar signal. Joint project with TU-Delft, 2015, The Netherlands.
4. Development of experimental plants for studying the characteristics of digital image signal receivers, Project # 964-X14, 2014, Teleoptic, Ukraine.
5. Justification of methodology and techniques for innovative development of Ukraine enterprises on the profile of medical electronics. Project # №881-X13, Teleoptic, 2013.
6. Theoretical and experimental substantiation of extending functionality of weather radar and efficiency of detecting dangerous weather phenomena using the polarization properties of sounding waveforms and reflected signals. Project # 685-DB10, 2010-2012, HAY, Ukraine.
7. Doppler-Polarimetric Radar Measurements of Turbulence in Rain, Joint project, Rep. IRCTR-S-006-03, TU-Delft, The Netherlands, 2003.

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National Technical University "Kharkiv Polytechnic Institute"

National Technical University "Kharkiv Polytechnic Institute" was founded in 1885. Today more than 18,000 Bachelor and Master students study at 24 Departments and 95 Chairs being trained for 107 specialties. The University works on 25 international educational projects. The double degree curricula worked out in cooperation with the Universities worldwide.

40 well-known scientific schools work fruitfully in Ukraine and abroad. The scientific potential is also defined by the Research Institutes "Molniia" and "Ionosphere" and the Research Centre for Gas Dynamic and Thermal Physics Processes in Turbine Machines.

According to the rating data of the International British Company QS the University is among 701+ best universities of the world.

www.kpi.kharkov.ua

Research and Design Institute "Molniia"

R&D institute "Molniia" dates back to 1954 when the Laboratory for Mechanical Rectifiers (headed by S. M. Fertik) was set up.

Throughout the period of its existence the Institute became widely known not only in Ukraine but also abroad. Some test units of the Institute were entered the IEC 61000-4-32 compendium. The Institute is the basic organization of the Engineering Committee of Ukraine in the field of the electromagnetic compatibility of engineering facilities (TK 22) and in fact it has a direct influence on standardization processes in this area.

Research and Technology Development Activities

The Institute studies the generation processes of powerful electromagnetic phenomena including those that accompany the lightning. The Institute investigates the processes of interaction of pulsed electromagnetic fields, currents and voltages with the aircraft of a different design.

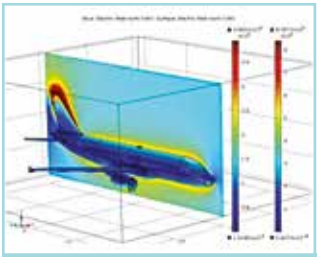
The Institute has its own Test Laboratory. This Test Laboratory has the trial and test field that is the facility of national patrimony of Ukraine in the field of science and engineering. The Test Laboratory was accredited with the National Accreditation Agency of Ukraine to comply with the ISO/IEC 17025 Standard. The Accreditation Certificate No2H484 is valid until 15.09. 2019. The laboratory runs tests of the airborne equipment to comply with the DO-160G Standard. Currently it works towards the realization of tests in compliance with the USA military standard MIL STD 461G and the NATO Standard AECTP 500 E. The institute is involved in the mathematical simulation of different electromagnetic compatibility processes, including definition of the structure of electromagnetic field that penetrates the aircraft body in the case of nearby lightning stroke. The scientists investigate thermal stability of aircraft envelope elements exposed to direct lightning stroke with the ultimate parameters (current intensity up to 200kA).

National and International Projects

1. National projects:
R&D Institute "Molniia" carries out tests for all key Ukrainian aircraft and airborne equipment manufacturers, including ANTONOV Company, Yuzhnoye SDO, State Company "POLYSVIT", State Company "Aircraft Design Bureau" and the private company AVIACONTROL.

2. International projects:
In cooperation with ANTONOV Company and Frantsevich Institute for Material Science Problems we carried out tests of new special-purpose structural materials for BOEING.

Antenna after the lightning test



Slice: Electric Field norm at the A320 surface

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National Technical University "Kharkiv Polytechnic Institute"

Turbine Machine Building Department

Turbine Machine Building Department of National Technical University "Kharkiv Polytechnical Institute" was founded in 1930 for training of engineers according to industrial needs particularly for Kharkiv Turbine Plant. Turbine Machine Building Department is a large educational and research University subdivision. The Department successfully carries out both advanced research and fulfils the orders of manufacturing plants manufacturing steam and gas turbines. Currently 7 Doctors of Science and 7 Candidates of Science works at the Department.

The Department has (i) Aerodynamic test benches: test bench for determining losses in line cascades; circular large-scale static bench for investigation of steam turbine and outlet manifold operation; (ii) Turbine-1: Large-scale stage models with short blades of steam-and-gas turbines; (iii) Turbine-2: Stage Models with long blades; (iv) Double-stage Turbine: Bench of centrifugal fan for determining external characteristics and flow structure, which can be used for compressor stage investigation.

Research and Technology Development Activities

- The principal method is the detail study of flow characteristics by means of measuring with the help of oriented gas-dynamical probes. The most frequently used probe is the five-tube one having the receipt part in the form of truncated five-sided pyramid, with the axis normal to probe axis of rotation. It allows to determine pressure and three velocity projections in any flow points. The probe moves along the radius and rotates about its axis by means of coordination mechanism. The pressure in probe inlets is registered by water manometers. In some cases, four and three-channel cylindrical probes are used which have large gradient parameters – separate single- and double-tube probes.
- During the tests of the stages coordinate mechanisms are fixed to the turbine case and step parameter irregularity behind nozzle cascade and turbine rotor blades are determined by rotating the nozzle cascade inside the case. Large-scale peripheral irregularity caused by the outlet manifold presence behind the turbine or by working medium rejection between stages was usually determined by placement of some probes into the transverse sections. Large-scale irregularity of cases was defined by means of a single probe by placing it on a part which can be rotated about its axis of symmetry.
- Gas Turbine Secondary Air System Analysis.

Turbine-2

Compressors plant for tests

National and International Projects

1. Joint project of NTU «KhPI» and PJSC «TURBOATOM» (Ukraine): «Development and Aerodynamic Investigations of Nozzle and Rotor Blade Cascades for Heat and Nuclear Power Plant Turbines» (2008-2013).

2. Joint projects of NTU «KhPI» and SAMSUNG AEROSPACE CO. LTD. (Republic of Korea):
- «Aerodynamic Investigations of the Transitional Manifold used for industrial Samsung Aerospace Gas Turbine»
- «Aerodynamic Investigations of Swirl Angle Effect on the Gas Turbine Transition Duct»
- «Aerodynamic Investigations of Gas Turbine Exhaust Nozzle Model in a Wide Range of Operation Modes»
- «Investigations of Turbulent Effect on the Aerodynamic Characteristics of Gas Turbine Transition Duct».

3. Joint project of NTU «KhPI» and TechnoSolution (Republic of Korea): «Design, Manufacturing and Calibration of Pressure and Temperature Probes» (2001).

4. Joint project of NTU «KhPI» and SAMSUNG TECHWIN CO. LTD. (Republic of Korea): «Performance Test of High Pressure Turbine and Transition Duct» (2002-2004).

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Department of Material Science

Department of Material Science was founded in 1932. The Department carries out research work in the following areas:

- Chemical-thermal laser processing of structural and tool materials to improve their performances
- Development of technologies for production of foils and protecting films by vacuum condensation and microarc oxidation of ion-plasma combustion to increase the properties of machine parts
- Development of new alloys and composites based on metals in the form of foils, obtained by vacuum crystallization for electronics and precision instrumentation
- Development of nanostructured materials.

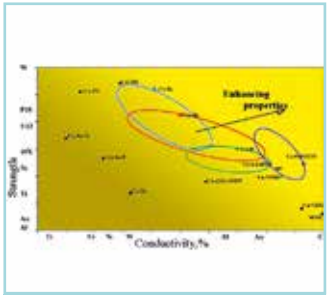
Research & Technology Development activities

Technology of microarc oxidation on parts made of Al and Ti-alloys provides the formation of solid (microhardness up to 24000 MPa), wear-resistant (ih ~ 10-10-10-12), anticorrosion, antifriction (f<0.01), heat-resistant (up to 1200 °C), electrical insulating (up to 600 V) of a ceramic layer with a thickness of up to ~ 0.3 mm. The ceramic layer has an ideal adhesion to the base material; it is possible to form a ceramic layer of equal or variable thickness on the outer surfaces of parts of virtually any configuration. The technology is environmentally friendly and improves the durability of the product. It can be applied to machine parts, aircraft and shipbuilding, engine building, defence industry, space technology. There are five patents based on the results of the developments.

Creation of a new class of nanocomposite coatings of solid solutions with enhanced mechanical properties at high temperatures, such as composite materials, films, foils, coatings based on copper of different functional purposes which are obtained by Physical Vapor Deposition (PVD).

- The technological parameters required to obtain films and coatings based on copper with specified characteristics are determined. For example, developed copper-based alloys can have the strength of about 1000 MPa with electrical conductivity which is 30 % of pure copper.
- These characteristics are preserved after heating to 700 °C for one hour.
- Developed materials have a record combination of strength, electrical conductivity and thermal stability of the original structure and properties.
- These coatings can be used as different elements of electronic engineering and aerospace devices.

Surface after microarc oxidation and parts, after treatment with MDO



Pseudoalloys. High strength at high electrical conductivity

National and International Projects

1. National projects:
   - Ministry of Education and Science of Ukraine: Development of material science foundations of composite materials with high physical and mechanical properties
   - Ministry of Education and Science of Ukraine: Methods for creating nanocomposite coatings and modified surface layers with increased high-temperature functional properties
   - Ministry of Education and Science of Ukraine: Development of physical basis synthesis technology of nanostructural dispersion hardened metal-metal type composites based on copper

2. Internetional Projects:
   - European Office of Aerospace Research and Development, UK: Multifunctional ceramic nanostructured coatings
   - The US Air Force Research Laboratory, Materials and Manufacturing Directorate, USA: New high-temperature materials based on the multicomponent (high entropy) alloys with controlled nanoclustered structure
   - Brookhaven National Laboratory, USA: Radiation Modified Ion-Implanted Materials

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http://www.kpi.kharkov.ua/wp-content/uploads/2016/11/Department-of-Materials-Science.pdf

National Technical University "Kharkiv Polytechnic Institute"

Department of Physical Chemistry

Laboratory of Electrochemical Design for Functional Materials and Coatings of Physical Chemistry Department over the past 30 years has been developing and implementing modern trends of electrochemical technology for metal surface treatment.

Research results in this field are protected by more than 90 Patents of the former USSR and Ukraine.

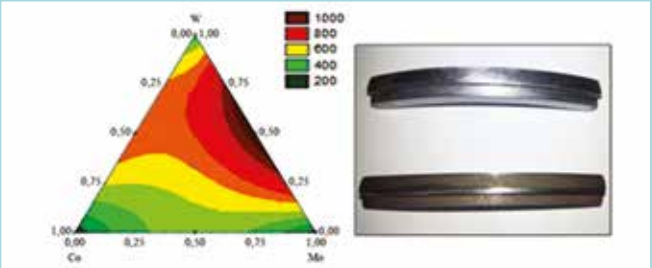
Research & Technology Development Activities

1. Electrochemical Design of Functional Materials and Coatings:
   - Plasma electrolytic oxidation (PEO) of Aluminium and Titanium alloys for mixed oxide coatings synthesis
   - Electrochemical synthesis of composite coatings based on metallic matrix reinforced by nanoscale oxides (Al2O3, ZrO2, TiO2)
   - Electrodeposition of multicomponent alloy coatings
   - Smart materials synthesis strategy by plasma electrolytic oxidation and electrophoretic deposition integration
   - Corrosion monitoring and prediction of protective coatings service life under operating conditions
   - Nonchromate treatment of Aluminium alloys for protective coatings synthesis

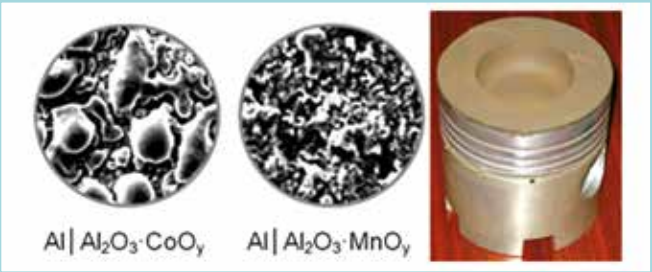
2. PEO of aluminium and titanium alloys for one step synthesis mixed oxide coatings containing p,d-elements (Co, Mn, Fe, Ni, Zn, Sn), refractory and rare metals (W, Mo, Zr, V) with wide range of functional properties – high corrosion resistance and chemical stability, high wear resistance, low coefficient of friction, heat resistance, catalytic activity in combustion and wastes purification processes, adjustable porosity, biocompatibility

3. Results of mechanical tests of Composite coatings reinforced by nanoscale Al2O3 oxides indicate increased ductility, strength and other physical-mechanical properties of the synthesized composite materials. Inclusion in the basic matrix of Cu and Ni nanosized particles of aluminium oxide leads to grain size decreasing.

4. Electrodeposition (pulse and stationary) of binary and multicomponent coatings based on iron family metals (Fe, Co, Ni) alloying by refractory (Mo, W, V) and rare (Ti, Zr) metals with wide range functional properties: high corrosion resistance and chemical stability, microhardness, low coefficient of friction, catalytic activity in electrochemical hydrogen evolution process, organic substances oxidation, wastes purification.



Microhardness (MN/m2) of Co-Mo-W coatings for surface restoration



Catalytic oxide coatings for internal combustion piston

National and International Projects

1. National projects:
Projects funded by the Ministry of Education and Science of Ukraine:
   - "Development of novel technologies of functional nanomaterials for increasing of service life, corrosion and mechanical resistance and metal restoration"
   - "High-efficiency development of physical and chemical nanostructural materials creation methods for energy and rendering accumulation systems and technogenic contaminations", etc.

2. International projects:
   - STCU project No 3268 "Development of new sensors for monitoring of gas environments" (2005–2007)
   - INTAS project 04-80-7219 "Holistic Strategies for Chromate-Free Surface Treatment of Aluminium" (2007–2009)

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Zaporizhzhya National Technical University

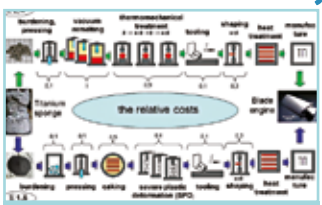
Zaporizhzhya National Technical University consists of 7 institutes, 13 faculties, 61 departments (incl. military training department), more than 11,000 students including 8,000 full-time students; bachelors and masters are trained in 49 specialities, 9 teaching and laboratory buildings with the newest equipment, 4 hostels for 2,200 students, health and recreation centers on the Dniper River and the Azov Sea sports and nutrition facilities; robust administrative services.

Since 2000, specialist training has been provided about technology for aviation engine production. Modern technologies, licensed commercial programmer packages and special software are used in the educational process. Close working and education relations exist with factories in Zaporizhzhya.

http://www.zntu.edu.ua/

Machine Building Institute / Aircraft Technology Engines Department

We have been involved in the development of new technologies for the production of aircraft engine parts. We develop technologies of severe plastic deformation of different alloys for aviation and space technology. We also develop environmentally friendly production of parts from powders. The basic scientific field of our investigations is "Scientific and technological support of manufactures of the aircrafts engines parts from titanium alloys based on severe plastic deformation methods."
We also deal with the technology of the high-speed milling of non-rigid aircrafts engines parts. We have developed the new coating for turbines and the technology for its manufacturing.
We are successful in development of technologies for producing billets from alloys based on the titanium aluminides. We have developed the technology for machining and hardening of surface layers of parts from the titanium aluminides and powders alloys, and some alloys in the submicrocrystalline condition. Also, we have developed a technology of repair and maintenance for aircraft engines.



New technology of blades production

Equipment for hardening of bling blades

We offer the following technologies:

- Technology of severe plastic deformation for different alloys (nickel-base superalloys, titanium, aluminum alloys, and alloys from powders)
- Technology of powder metallurgy
- Additive technologies.

We offer the following services:

- Optimization of manufacturing techniques for the basic details of aircraft engines
- Optimization of modes of high-speed milling of blades for compressors
- Optimization of modes of surface layers hardening;
- Calculation of the intense-deformed condition of details of aircraft engines
- Tests for wear of samples and natural details of aircraft engines at working temperatures
- Formation of sub-microcrystalline condition in preparation of details of aircraft engines.

National and International Projects

1. National projects:
   Ministry of Education and Science of Ukraine projects:
   - Technology design for nanostructures formation in a surface layer of aircraft engines parts for maintenance of their reliability and resource
   - Design and investigation of titanic alloys in nanostructured condition for aeronautical engineering

   Motor Sich JSC projects:
   - Research and development of integrated manufacturing techniques for compressor bling for the high pressure turbojet engine D-27
   - Research of influence of technology twist extrusion on constructional durability of titanic alloys for working blades of compressors
2. International **ERASMUS+** projects:
   - Interregional Network for Innovative Development of Ecosystems Technosphere Based on Micro- and Nanoobject Technologies
   - Internet of Things: Emerging Curriculum for Industry and Human Applications

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Odessa National Polytechnic University

Institute of Radioelectronics and Telecommunications, "Diagnostics" Laboratory

The scientific and research laboratory "Diagnostics" has been carrying out – over the past 20 years – development and implementation of modern methods of control of different types of power equipment (turbines, aero engines and rocket-powered engines and the plants on their basis). PhDs and Doctors of technical science work at the laboratory.

Objective of our work is development of generalized structural model which describes the signal monitoring systems and the development of a methodology for diagnostics of the technical condition of power plants.

Method of investigation is formulation and analysis of mathematical models that describe the characteristics of power equipment, and experimental studies of the parameters of the power equipment by analyzing records of tests of power equipment, as well as participation in pilot studies on test stands.

In case of need, devices requiring atypical data processing methods can be developed and used for the design of control, diagnostics and emergency protection systems of power equipment. The results of the work repeatedly reported at international conferences and published in professional journals. Many of the Laboratory's innovations are protected by patents in Russia and Ukraine.

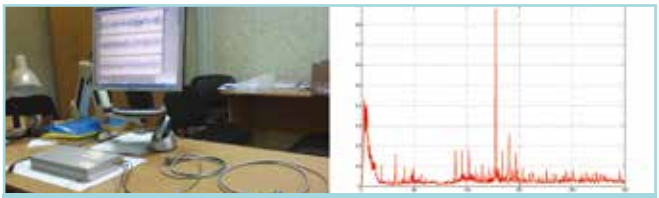
Research and Technology Development Activities

Analysis of mathematical models that describe the characteristics of rotating machinery, experimental investigations of their parameters through analysis of records of tests, as well as participate in a pilot study on the test stands and in operating conditions.

The model, describing the nature of the manifestation of the dynamics in measured vibro-acoustic parameters of the engine, is being proposed. the types of relationship between the regime parameters of machines and the parameters of the model that allows to offer a model of diagnostics of the technical condition of the engine in real time and monitor the incidence of new mechanisms of dynamics, is being established.

Specific methods of diagnosing the technical condition, taking into account the structural properties of signals and their relationship with the regime parameters of machines, are formed as the result of experimental studies using the specific examples of the techniques. During these researches, the proposed methods of diagnosing are tested and the requirements for the methods of rec-ords processing are clarified. In case of necessary, the devices that use the atypical methods of data processing are developed.

The results of the work are used to develop and to design the control systems, diagnostics and emergency protection of engines.



Portable apparatus for rotary machines monitoring

Manifestation of the fractional harmonics of the rotor frequency in the presence of a defect

National and International Projects

1. Contractual works with SPA "Energy" (Moscow), "MRKS" (Moscow), Tokmak (Ukraine), "SPA Promavtomatica" (Krasnodar), "PA Engineering" Ltd. (Sarov), SDPS (Zaporozhye), Lvov (ZETC), Odessa aircraft plant.

2. INTERCOSMOS programme: Venus (3 – 9), Mars (2 – 7), Space (series), Intercosmos (2 – 9), Vertical (9 – 10), VEGA (1 – 2), Phobos (1 – 2), Prognoz (9 – 10), Interball, Horizon (series), Gamma, Georgiaspurt, Intercosmos Bulgaria 1300, MP-12-(series), Soyuz-Apollo, Salyut-7, Agat.

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Research Institutes

SECTION 3

Research Institutes

Ukrainian Research Institute of Aviation Technology

UkrRIAT was established in June 1964, during the period of Soviet aircraft industryrapid development. The purpose of the Branch was to assist Ukrainian plants introducing new technologies and developing mass production of new types of aircraft with following main activities:

- Development of policy-making technology and process documentation
- Engineering and technical assistance to aircraft factories in development of new technologies serial production
- Evaluation of manufacturability of product designs (TKI) and development of recommendations to improve TKI
- Development and implementation of technological processes and means of mechanization for high-life-time and high-loaded joints
- Automation of production based on the use of CNC machines (CAM / CAE)
- Creation of structures made of composite materials
- Improvement of production processes

UkrRIAT is a Joint-Stock Company of which 50%+1 shares are the property of the State of Ukraine, and the rest of shares are the property of legal entities and natural persons.

Key activities in accordance with the Statute are as follows:

- Research and development, prototyping and manufacturing processes development, engineering and consulting services in the field of technology and production engineering, repair, modernization, utilization of aircraft and aviation equipment and aviation material science
- Examination/evaluation of production of aviation and other high-tech industries

www.ukrniat.com

Research & Technology Development Activities

- Development of programmes and forecast-analytical materials in the area of aircraft industry and other Hi-Tech industries
- Development of normative documentation in the field of aircraft industry, other Hi-Tech branches covering the whole life cycle of the item
- Technological design of the aircraft and aircraft manufacturing capacities
- Forecasting, estimating and determining labour and material costs for aircraft production
- Development of efficient manufacturing processes, methods and means for manufacturing of high-loaded joints of airframe components including metal-composite ones

Examples of UkrRIAT up-to-date technologies

- Impact of structural and technological parameters on strength of type components of helicopter airframe structures
- Fuel overflow hole strengthening method impact on wing panel strength
- Stress-strain behaviour of composite structures in joint area
- Manufacturing process for adhesive-riveted joints for helicopter airframe assembling
- High-load-transfer joining for outer and central wing butt
- Bolt-riveted joining with elastic-plastic fit
- Proposals on aircraft manufacturing facilities set-up in countries of Asian region

National and International Projects

1. National projects (ANTONOV, Motor Sich):
   - High-load-transfer joining for helicopter airframe assembling
   - Impact of technological parameters on strength of metal-composite airframe structures
2. International projects (Airbus, Evektor Aerotechnic, ANTONOV Company, Beijing A-star Holding Co):
   - Riveting by method of pressure with rolling out for composite structure assembling
   - Assembly method for aircraft airframe using assembly holes
   - Provision of the advisory services for the project development of serial production of the civil medium transport aircraft and its engine in PRC

Manufacturing Processes for Assembly and Tools

Tools for airframe components assembly

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E.O. Paton Electric Welding Institute (PEWI)

E.O. Paton Electric Welding Institute (PEWI) of the National Academy of Sciences of Ukraine is a multidisciplinary research institute, which realizes fundamental and applied research works, develops technologies, materials, equipment and control systems, rational welded structures, methods and equipment for diagnostics and non-destructive testing and control.

www.paton.kiev.ua

Department of Technical Diagnostics of Welded Structures

Department of Technical Diagnostics of Welded Structures performs research and development in the field of "Technical diagnostics and prediction of residual life of welded joints, materials, coatings and structures in operation". The objective of the research is to develop theory, methods and means to ensure safe operation of structures. Developments are based on acoustic emission (AE) method.

Department developed new modern technology and equipment of EMA family, which provide evaluation and prediction of industrial structure condition and safety. Systems of EMA family are applicable for periodic testing or continuous monitoring of technical condition of critical industrial facilities in operation.

Systems consist of AE transducers, equipment for AE signal pre-processing and amplification, personal computers with specialized software, communication and auxiliary devices. Systems configuration is individual and depends on geometry and working conditions of the structure and level of conclusions on its efficiency.

Testing technology is based on recognition of destruction processes by AE data.

AE testing technology, AE transducers and high-level software for EMA family systems were developed at PEWI and acoustic devices and appropriate low-level software were developed in Hungary.

EMA systems determine the degree of danger of object condition with localization of possible destruction areas, predict destructive loading under operating conditions, and evaluate residual life of structures. This reduces the costs of scheduled maintenance or elimination of consequences of possible accidents. EMA systems have no analogues worldwide.

EMA systems were implemented during continuous AE monitoring of four biggest in Europe ammonia storages ST (120 000 m3); pipelines and installations for ammonia production at Odessa Port Plant; ammonia transportation pipelines on the bridge over Dnieper river; pipelines, boilers and units of thermal power plants in Kyiv and short-time AE monitoring of thousands of other industrial objects.

EMA-4 devices based on the 4-channel and 16-channel modules

National and International Projects

1. National projects:
   - Testing of wing elements at ANTONOV Company.
   - Acoustic emission testing of fuel storage tank made of AMg6 alloy with spherical and conical bottoms at YUZHNOYE State Design Office.
   - RESOURCE and RESOURCE-2 research programmes of the National Academy of Sciences of Ukraine.

2. International projects:
   - Testing of 6+22 alloy 2219-E87 specimens for AEROSPATIALE (France) through the IAW. Prediction of destructive loading during gas vessel test in Hungary. The International Work Group of experts from Austria, Hungary and Ukraine conducted tests of pressure vessels. Technology of destructive loading prediction has been tested. Long before the failure, destructive loading prediction of 31.71-38.05 bar was obtained. The real destructive loading amounted to 36.54 bar. Real error of the issued prediction is less than 5%.

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G.S. Pisarenko Institute for Problems of Strength

G.S. Pisarenko Institute for Problems of Strength was founded in 1966 by G. S. Pisarenko, an outstanding scientist and Academician of the NAS of Ukraine. At present, it is the unique special-oriented scientific institution that deals with the problems of strength and lifetime of existing and new materials as well as structural elements considering the factors peculiar to actual operating conditions.

Currently the Institute is involved in the development of fundamental and applied investigations in the field of experimental mechanics and strength of materials as well as structural elements, namely:

- Limiting state and strength criteria for materials and structures
- Calculated and experimental methods of the stress-strain state investigation
- Fracture mechanics and structural survivability
- Nonconservative mechanical systems vibrations.

The Institute team constantly develops new methods of experimental investigations and creates test machines as well as test benches (more than 150 items) to conduct the investigations on processes of deformation, damage and fracture of modern metallic and non-metallic structural materials. It has a fruitful cooperation with such high-technology enterprises as Yuzhnoye State Design Office, Antonov, Ivchenko-Progress, Zorya-Mashproekt, Motor Sich, etc.

The Institute is the main institution of the Academic Council on Mechanics of a Deformed Body and renowned in both European and world scientific communities.

Since 1969 the Institute has issued the journal "Problemy Mitsnosti", which is translated into English and published by Springer as "Strength of Materials".

www.ipp.kiev.ua

National and International Projects

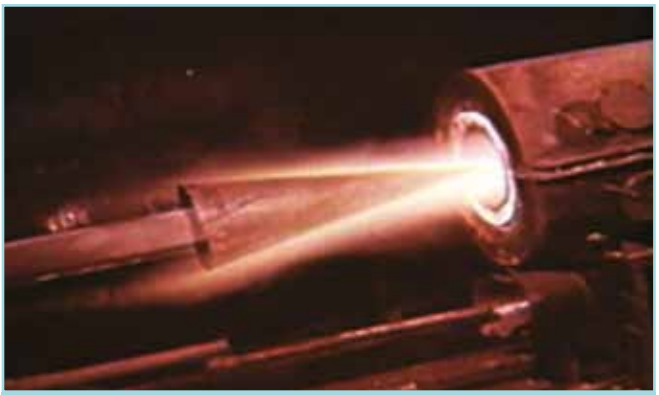
1. National projects:
   - Custom-made scientific and research activities are performed within the bilateral cooperation with the leading Ukrainian enterprises such as Antonov, Ivchenko-Progress, Zorya-Mashproekt, Motor Sich, etc.

   - International scientific conferences on Problems of Dynamics and Strength in Turbomachinebuilding are occasionally held at the Institute.

2. International projects:
   In 2011-2016 the Institute participated in two Czech-Ukrainian projects.

   Currently the Institute is involved in the implementation of H2020 AERO-UA project.

   The Institute is highly interested in extending its involvement in the international research and educational projects funded from private or EU national funds (e.g. Horizon 2020, Erasmus Plus, etc.) From cooperation in the field of aeronautical engineering we expect the following results: adoption and implementation of the best practices at the Institute laboratories, enhancement of cooperation with scientific and research institutions and business structures in this field with additional funding as well as the increase of the number of applied investigations within the general scope of scientific and research activities at the Institute.



Testing of thermal shielding model on gas-dynamic bench

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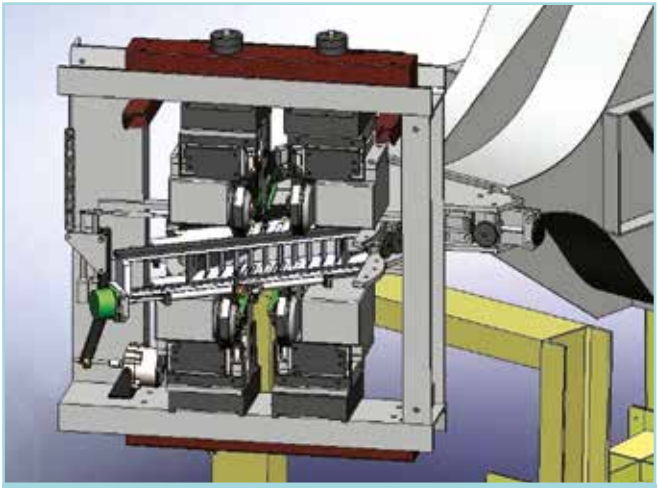
G.S. Pisarenko Institute for Problems of Strength

Research and Technology Development Activities

Main research activities of the Institute are aimed at the development of methods and means of enhancement of reliability and lifetime of elements and structural assemblies of aeronautical engineering, namely:

- Development of calculation and experimental methods and means of determination of dissipative properties of aircraft materials and structures, including in the field of centrifugal forces and action of streaming flow, as well as the methods of determination of vibration characteristics of structural elements and their systems, namely blade assembly, considering structural-technological and operational factors.
- Development of procedures and implementation of experimental investigations on prediction of characteristics of creep, long-term strength and residual lifetime of aircraft materials belonging to various classes.
- Development of methods and facilities for lifetime testing of aircraft structural elements, including composite structures as well as with thermal barrier and other coatings, in gas flows and field of centrifugal forces together with their load-carrying ability under extreme operational conditions.
- Elaboration of theory of metal fatigue damage accumulation considering its cycle inelasticity and development of methods for determination of fatigue limiting state of aircraft materials belonging to various classes under low- and high-cycle loading.
- Development of methodologies and accomplishment of qualification investigations of modern aircraft materials, including composites, with determination of their mechanical properties considering specific technologies of manufacturing in a wide range of loading and temperature conditions using the results of tensile, creep, long-term strength, low- and high-cycle fatigue testing, as well as the fatigue crack growth determination.



Test bench for experimental determination of unsteady aerodynamic loads

Technologies and services

1. Ultimate state criteria of materials and procedures of strength and life assessment for structural elements under extreme thermomechanical loading for aircraft and spacecraft structures, nuclear power engineering and other high-tech industrial fields based on complex experimental investigations of deformation and fracture of materials considering structural and technological factors, stress state type and actual loading modes within a wide range of temperatures. The theory of fatigue failure of metals, which is based on the deformation-energy approaches and accounts for the interrelation between the fatigue damage accumulation in metals and the cyclic inelasticity is proposed. Given this, the models of transition from fatigue to brittle fracture have been justified.

2. Procedures of calculation and experimental investigation of vibrations of structural elements such as turbo machine blades and their systems (assemblies and sets), as well as reduction of their vibration stress level at resonance operation modes through the increasing of damping capacity considering the possible operational damages and influence of centrifugal forces and temperature.

3. Methods of diagnostics of fatigue cracks and other damages to aircraft structural elements at their forced vibrations.

4. Experimental and calculation complex aimed at prediction of stability against subsonic flutter of compressor blade assemblies, which allows to accurately determine the aerodynamic loads (forces and moments) acting in a flow on rotor blades, and based on this to predict the stability against subsonic flutter of assemblies in a wide range of their mechanical parameters and flow characteristics.

5. Surface hardening techniques for aeronautical engineering components, which make it possible to significantly enhance the lifetime of assemblies and mechanisms and to reduce the duration of machining of components (three times), cause the decrease of power intensity of surface treatment.

6. A database of mechanical characteristics of a wide class of new aircraft materials, including composites, considering the specific techniques of their manufacturing and treatment, as well as temperature and types of operational loading. Experimental and calculated procedures of lifetime increasing for highly-loaded structural elements are developed.

Frantsevich Institute for Problems of Materials Science

Frantsevich Institute for Problems of Materials Science (IPMS) of the National Academy of Sciences of Ukraine is a leading centre in the field of development of materials with the special service properties for machine building, nuclear energy, aviation (in particular details of frames and parts of high efficiency engines), space, chemical, transport and agricultural machine building, direct transformation of chemical energy into electrical one and other technical applications. IPMS provides advanced scientific and engineering consultancy as well as contract research and development services.

IPMS was set up in 1955 on the base of the laboratory for special alloys of the Ukrainian Academy of Sciences. Since then it has progressively widened its fields of research and customer base. IPMS' activities in new material development and commercial application are supported by a large pool of researchers in solid-state physics and chemistry, inorganic physical chemistry, and mechanics of deformable media.

IPMS employs about 1200 people, including 4 academicians and 7 corresponding members of NASU, more than 70 doctors and more than 345 PhD

www.ipms.kiev.ua

Department of Composite Materials

The Department of Composite Materials is currently studying wire knitted meshes and nanostructured carbon fillers for lighting protection and repair of carbon reinforced plastics. The aim is to develop a production technology for elements of polymer based composites with a surface reinforced by flexible copper meshes, consisting of thin wires, covered with low-melting solder.

The copper meshes can dissipate the energy of a thunderbolt through the effective power- and heat sink from the zone of lighting strike. In the global aircraft construction (Boeing, Airbus and others), the problem of lighting protection of carbon-plastics is very actual. Generally, it has been solved by the use of stretchable perforated copper foil.

The important advantages of the IPMS approach are that the knitted copper meshes have i) a low weight (up to 40% compared with tensile foils) and ii) an enhanced ability to dissipate energy due to the unsoldering of flexible loops, evaporation of solder from wires surface and relaxation of mechanical stresses in the surface layers of composites.

Also, it has been established that the conductivity of polymer composite surface layers have been significantly enhanced by means of nanostructured carbon fillers. Discharge test of experimental panels showed that both meshes and fillers contribute to the improvement of lighting durability of elements of aviation structures.

After soldering | *After knitting* | *Loop cell*

Wire knitted meshes fillers for lighting protection and repair of carbon plastics

National and International Projects

Department of Composite Materials is working with:

- ANTONOV Company during more than 20 years to develop knitted lightning protection meshes for their using in carbon plastics details of aircrafts.
- Yuzhnoye SDO for development and production of multifunctional carbon plastics reinforced by carbon fibers and weft-knitted fabrics with enhanced service parameters

Department of Composite materials is a beneficiary of FP7 FIBRALSPEC project (2014-2017)

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Department of Physics of High-Strength and Metastable Alloys

Lab-scale technologies for materials and coatings manufacturing:

1. High-strength wrought Al-Sc alloys.
   - Alloys 5*** type: YS=480 MPa, UTS=550 MPa, δ=8 %, σ_{-1}=220 MPa. These alloys can be used for fuselage and other aircraft components.
   - Alloys of 7*** type: YS=750 MPa, UTS=810 MPa, δ=8 %, σ_{-1}=280 MPa. These alloys can be used as strengthening ribs for aircraft and other vehicles.

2. High-strength cast aluminium alloys.

Alloy	Mechanical properties			Melting interval, °C
	UTS, MPa	YS, MPa	δ, %	
Alloys for operation up to 150 °C Al-Mg-Si-Zn-Cu-TM*	540...660	490...620	1...2	590...620
Alloys for high-temperature application Al-Mg-Si-Sc-TM*	310...501	300...460	1...2	575...590

*TM – transition metals

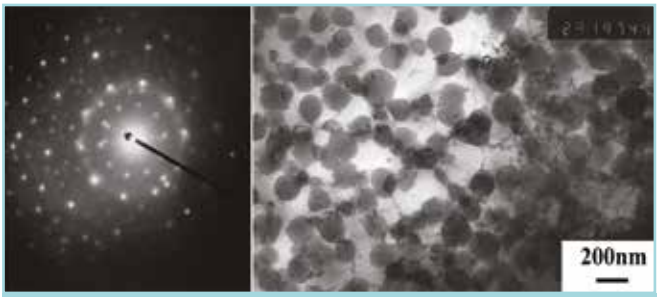
3. High-strength aluminium alloys hardened by nano-quasicrystalline particles, for elevated temperature up to 300 °C. Can be used in aviation to replace titanium alloys.

Alloy	Mechanical properties								
	20 °C			190 °C			300 °C		
	UTS, MPa	YS, MPa	δ, %	UTS, MPa	YS, MPa	δ, %	UTS, MPa	YS, MPa	δ, %
Al-Fe-Cr	542	485	7.0	413	388	3.44	297	283	3.5
Al-Fe-Cr-Ti	585	546	8.4	458	425	4.47	345	328	3.9
Al-Fe-Cr-Ti-Zr	677	648	7.0	511	464	2.63	351	331	1.8

4. Quasicrystalline heat protective and corrosion resisting thick coatings based on Al-Cu-Fe system.
Water-atomization method for production of quasicrystalline powders and new high-speed spraying method were developed in IPMS which makes possible to obtain quasicrystalline thick coatings with the following properties:

- Thermal conductivity coefficient of Al-Cu-Fe coatings is very small: 2.42 $Wm^{-1}K^{-1}$ (close to the thermal conductivity of oxide ceramics ZrO_2). Thickness of coatings up to 1 mm.
- Hardness reaches 7 Gaps, friction coefficient is about 0.09 in optimum conditions.
- Thermal expansion coefficient is about (14.5–18.5) $x10^{-6}$ K^{-1} at 100 – 700 oC (close to the thermal expansion coefficient for most of structural metals (Fe, Al, etc.)
- Quasicrystalline coatings porosity is lower than 5 %.
- Quasicrystalline coatings have high adhesion strength.

The Department has equipment for melting of high quality ingots up to 20 kg from aluminium alloys, equipment for mechanical testing and investigation of structures.



TEM investigation of Al-Fe-Cr alloy structure. Nanograins of Al matrix and nanoquasicrystalline particles

National and International Projects

1. National Projects:
   - Topic No III-7-16 of the Ministry of Education and Science of Ukraine "Methods of control of structure and properties of deformed, cast and foamed alloys of aluminium and development of new alloys on this basis with higher level of service characteristics" (2016–2018)

2. International Projects:
   - COST 532 project: ES5 (M4) "Elaboration of novel eutectic alloys based on Al-Mg-Si system for tribotechnical application in cylinder-piston groups at elevated temperatures" (2003-2007)
   - STCU project No 3605 "New light-weight composites based on cubic aluminium intermetallides L12 with enhanced heat resistance" (2006-2008)
   - STCU project No P061 "Structure and properties of high-strength alloys of aluminium" (2000-2003)
   - STCU project No 4450 "Development and synthesis of nanostructure 3D-form products and coatings using the integrated nanotechnological scheme" (2010-2012).

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Frantsevich Institute for Problems of Materials Science

Department of Physics of High-Strength and Metastable Alloys

The Department of Physics of High Strength and Metastable Alloys has several know how in the field of creation of new cast aluminium alloys which, according to their physical and mechanical properties, exceed modern cast high strength aluminium alloys.

The main scientific areas of department are the following:

- Developing of new high-strength aluminum alloys doped with scandium, high-strength casting aluminum alloys, high-temperature alloys based on aluminum intermetallides, powder aluminum alloys and foam aluminum with special properties;
- Creation of detonation coatings based on titanium aluminide alloys and aluminium titanate ceramic sprayed from mechanically alloyed powders Ti-Al;
- Investigating dispersion- and eutectic-strengthened structural materials (metallic, ceramics, ceramic metals).
- Creation of detonation coatings based on titanium aluminide alloys and aluminium titanate ceramic sprayed from mechanically alloyed powders Ti-Al.

Capabilities of the Department allow to conduct the following tests:

1. Mechanical test in a temperature interval from 196 to 1400 °C;
2. Indentation testing from 196 to 1000 °C;
3. TEM, SEM, Auger spectroscopy, light microscopy;
4. High-temperature (up to 2200 °C) DTA unit;
5. Units for investigation of tribological characteristics.

Department has an experience in production of aluminium sandwich panels with dense metal coatings and foamed aluminium granules with density less that 1 g per cubic cm (lighter that water). It allows essentially decrease the weight of separate articles using in aircraft.

Al sandwich panels and foamed granules with density less that the density of water

National and International Projects

1. Project III-17-05 of the Ministry of Education and Science of Ukraine "Development of deforming and cast aluminum alloys with enhanced level of mechanical properties";

2. Project III-7-16 of the Ministry of Education and Science of Ukraine "Methods of controlling the structure and properties of deformed, cast and foamed aluminum alloys and the development on this basis of new alloys with an increased level of performance characteristics"

3. STCU project No 3605 "New light-weight composites on the base of cubic aluminium intermetallides L12 with enhanced heat resistance", 2006-2008;

4. STCU project No 4450 "Development and synthesis of nanostructured 3D products using the integration nanotechnology scheme", 2010-2012.

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Frantsevich Institute for Problems of Materials Science

Department of Materials Strength and Plasticity

The main scientific areas of the Department of materials strength and plasticity are the followings:

- Investigating of dispersion- and eutectic-strengthened structural materials (metallic, ceramics, ceramic metals) aimed at study of relation of material structural parameters with mechanical properties;
- Creating a scientific basis for elaborating silicon-boride-strengthened Ti-based materials possessing increased values of Young modulus and high-temperature strength;
- Studying effects of alloying, solidification rate, ther-momechanical processing and boron addition technique on structure and mechanical properties of Ti-Si-X, Ti-B-X, Ti-B-Si-X (X = Al, Zr, Sn) alloys;
- Studying phase equilibria in the Ti-Si-X, Ti-B-X, Ti-B-Si-X systems including detailed investigation of "titanium corners" of the diagrams aimed at an increase of both heat resistance and plasticity;
- Studying effect of solidification processing rate at cooling rate 102 - 107 degrees/s on formation of boride phase and its eutectic constituents, their morphology and geometrical parameters in alloys of Ti-Si-X, Ti-B-X and Ti-B-Si-X systems, using different technological procedures of alloy crystallization.

The Department offers the following services:

1. Production of rapidly solidified powders, their com-pacting and thermo-mechanical processing;
2. Elaboration of silicon-strengthened titanium “steels” possessing increased high-temperature strength, oxi-dation resistance and ductility;
3. Elaboration of advanced in situ reinforced Ti-matrix composites

Transmission components made from novel tita-nium composites (tribotic)

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National and International Projects

- Ukrainian Ministry of Education and Science of Ukraine “Development and manufacturing titanium based femoral heads for hip joints” (N 0106U006699)
- STCU project P-1847 “Structure and properties of eutectically reinforced materials based on titanium intermetallics and silicides” (IMAP, USA)
- STCU project P-060 “The study of structure formation and mechanical behaviour of heat-resistant titanium alloys with eutectic strengthening” (EOARD, Air Force Research Laboratory, USA)

Frantsevich Institute for Problems of Materials Science

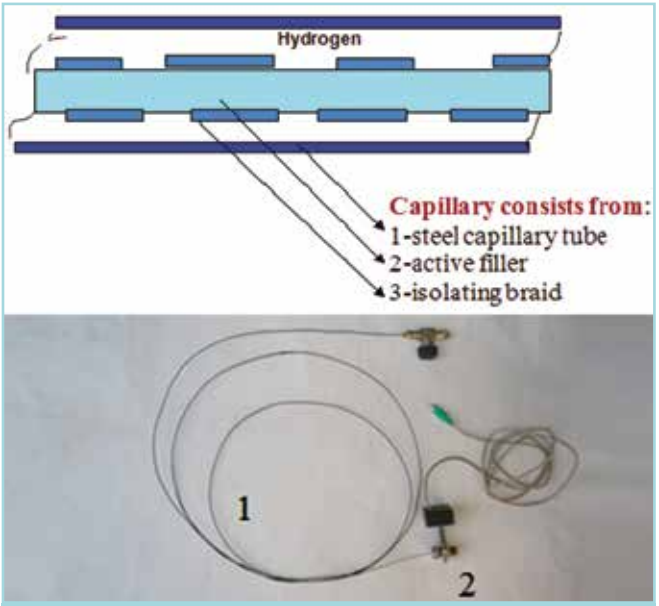
Department of Structural Chemistry of Solids

The main scientific interests of the Department of structural chemistry of solids are the followings:

- Development of physicochemical bases for the creation of highly effective materials with increased hydrogen-sorption and electrochemical properties for use in chemical sources of current and some kind of sensors.
- Development of physicochemical principles for the formation of unusual properties of a new generation of materials based on carbides, nitrides and oxides in a nonequilibrium structural state using information on the features of their atomic-crystal and electronic structure.
- Study of the process of obtaining and investigating the properties of coatings and fibers by the method of gas-phase chemical deposition and the development of fiber composite materials with polymer and metal matrices reinforced with continuous fibers of silicon carbide.
- Physicochemical features of the processes of synthesis and quality of microhomogeneous powders of refractory compounds.

Practical using of hydride peculiarities – developed layout of linear pneumatic fire / overheat alarm sensor for aircraft fire protection system. Device performance is based upon the increasing of gas pressure in sensible element due to hydride decomposition during temperature increasing.

Technical characteristics fire alarm sensors	
Overheat signal	165-185° C
Fire signal	> 54° C
Operation time	5 seconds
Time of restoring at 250°C	45 seconds
Size of heated zone	300 mm



Layout and common view of linear pneumatic fire / overheat alarm sensor for aircraft fire protection system: 1-steel hermetic capillary and 2-pressure sensor

National and International Projects

- Project III-4-11 of the Ministry of Education and Science of Ukraine "Synthesis and study of the features of the electronic structure of nanosized carbide, nitride, oxide phases, as well as high porous carbon materials".
- Project III-5-11 of the Ministry of Education and Science of Ukraine "The development of environmentally friendly, energy-saving hydrophobic and photocatalytic materials based on alloys and compounds of Mg, transitional and rare-earth elements for their use in hydrogen power and chemical current sources".
- Project STCU No. 5363 "Recovery and accumulation of "solar" hydrogen in a photoelectrochemical system with high efficiency".

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Department of Materials Dispergation and Plastic Deformation by Rolling Method

The main scientific areas of the Department of Materials Dispergation and Plastic Deformation by Rolling Method are the followings:

- Development of new technological processes of materials treatments by pressure;
- Creation of the production technology for high quality ferrous alloys (steels and cast iron) by casting and powder metallurgy methods including jet forming.
- Development the technology of the production of wear resistant powder tool steels using Special Time-Temperature Treatment (STTT).
- Creation of a technology for manufacturing of high wear resistant powder tool steels with special treatment of metal melt before spraying.
- Development of high wear resistant powder tool steels for processing of titanium alloys.
- Development of energy saving production technology for high quality rolling using the method of asymmetric rolling of the powders.

Development of production tool technology from the powders of high speed steels sprayed by inert gas. Using of this technology allows to reach the value of the coefficient of metal using of 0,8-0,85 and wear resistance of two times higher than corresponding value for analogous steel trademarks produced by traditional methods.

The impact strength of such steels is 1.4-1.5 times higher in comparison with similar ones produced by traditional method. The wear resistance of tools made from powder high-speed steels obtained using of a special temperature-time treatment of the melt during processing of titanium alloys is 1.5 to 2 times higher than corresponding values for tools produced from conventional powders of similar steel grades.

Developed metal cutting tools with enhanced service parameters are very actual for aviation for mechanical treatment of hard-to-work alloys.

Tools made from steel R9M4K8-MP produced from powder using of STTT

National and International Projects

- STCU project No. P315 "Development of tools for cutting Ti 5553 alloy". In cooperation with Boeing Company.
- STCU project No. 1554 "Development of new cold-resistant and corrosion-resistant steels and alloys through the control of grain sizes and grain boundary purity for using in offshore rigs and in main gas and oil pipelines".

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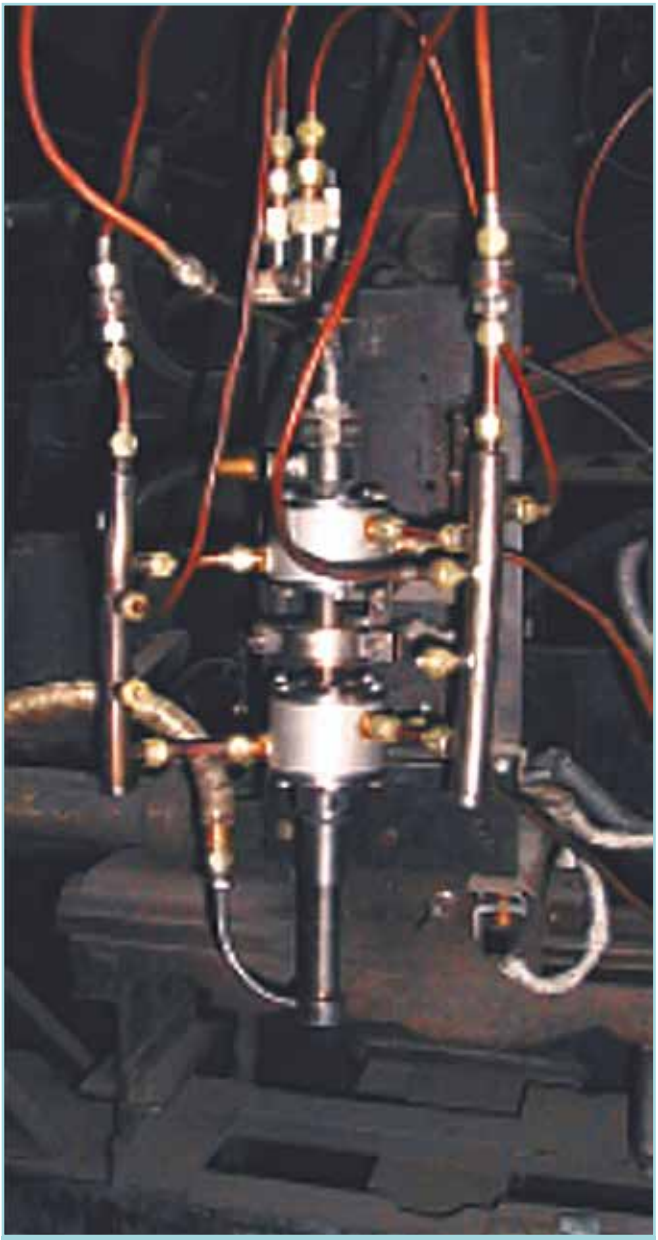
Frantsevich Institute for Problems of Materials Science

Department of Rocket and Space Materials Development and Certification

The main scientific areas of the Department of rocket and space materials development and certification are the followings:

- Investigation and production of various materials and coatings using radiation heating;
- Study of heat-protective and thermophysical characteristics of materials via modeling of radiation convective heating under conditions of orbital flights or aerocapture of descending vehicles and space planes (Discovery Diploma RAEN №298 from 15.12. 2005);
- Life tests and determination of heat conductivity of heat-protecting materials;
- Development of equipment and technologies for deposition of high-temperature corrosion-resistant coatings using high-speed gas-flame spraying.
- The Department's main technologies and services are the followings:
- Solar stations with a mirror of 1 to 5 m diameter and radiation heating units on the basis of xenon lamps with a heat flow density of to 15 000 kWt/m2;
- Burners with control of flow characteristics for high-rate gas-flame deposition of coatings;
- Plasmatrons and gas generators for investigation of heat protecting materials;
- Computerized installation for measuring of heat conduc-tivity of low-heat-conductivity materials and honey-comb construction of spaceships equipment.



Two-chamber burner with control of flow characteristics for high-rate gas-flame deposition of coatings

National and International Projects

- During last 10 years joint cooperation in the framework the Program of Scientific and Technical cooperation of National Academy of Sciences of Ukraine and SDO Yuzhnoye.
- "LIGHT TPS" FP7 project «Super light-weight thermal protection system for space application» (2014-2017)

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Physico-Technological Institute of Metals and Alloys

Physico-Technological Institute of Metals and Alloys of the National Academy of Sciences of Ukraine (PTIMA NASU) conducts research in the field of hydrodynamics, heat and mass transfer and crystallization processes at preparation, processing and solidification alloys with physical and chemical actions to obtain novel cast metallic materials or final products and develops equipment and technologies for their manufacturing.

The institute cooperates with a number of Ukrainian enterprises including Antonov SE, JSC Motor Sich. The institute's staff of 400 employees includes 2 Members of NAS of Ukraine, 25 doctors, 44 candidates of sciences, and more than 50 young researchers and post-graduate students.

www.ptima.kiev.ua

Department of Alloys Refining

Investigations carried out at PTIMA NASU covers electron beam melting and refining of high-temperature alloys based on Ti, Zr, etc. High temperature processes in molten metal in electron beam spot, including heat and mass transfer, physical and chemical processes are being studied.

PTIMA NASU is engaged in the research on titanium waste refining with production of items with mechanical properties that doesn't yield the properties of initial alloy. This problem nowadays seems very important since solves the task of waste recovery. Refining the titanium wastes is realized in electron-beam casting installation in skull crucible with electromagnetic stirring of melt and casting parts in chill moulds. In the case of ingots production, ingots may be cast into water cooled copper mould with electromagnetic influence on metal during crystallization.

The important reasons of doing such work are as follows: nowadays the electron-beam (EB) technology is the most effective method of refining; the EB skull procedure with electromagnetic stirring of melt solves the problem of chemical composition correction, that may be necessary in the case of multicomponent alloy's waste refining; casting ingots with electromagnetic influence on metal during its crystallization may improve the metal structure and properties.

Lids and frames of solid flight recorder of sound information produced by casting technology with the use of titanium waste

National and International Projects

Numerous Grants and Projects of National Academy of Sciences of Ukraine

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Physico-Technological Institute of Metals and Alloys

Magnetohydrodynamics Laboratory

Research in the field of magnetohydrodynamics carried out at PTIMA NASU covers physical and chemical processes taking place under influence of electro-magnetic forces to molten Al-based alloys as well as during melt crystallization.

Manufacturing of Al alloys of high quality, which are widely used in aircraft and spacecraft design, is solved at PTIMA NASU by application of novel Complex of vacuum magneto-dynamic melting furnace equipped with the machine for semi-continuous casting alloys. The latest includes crystallizer with sublimating coating and heated thermal nozzle.

Alloy preparation includes melting charge materials, refining and modifying the alloy with alloying elements under vacuum and filtration with porous ceramic filter. Semi-continuous casting ingots are created under protective argon atmosphere.

Characteristics of such Complex are as follows:

- Crucible useful capacity – 600 kg
- Metal maximum temperature – 750 °C
- Operated vacuum – up to 0.133 (1) kPa (Hg, mm)
- Ingot diameter – up to 500 mm.
- Ingot length – up to 4000 mm.

The elaborated Complex enables to manufacture ingots of high-strength aluminium alloys based on Al-Mg of the 5556 type, Al-Mg-Zn of the 7046 type, Al-Mg-Zn-Cu of the 7075 type, Al-Li-Mg-Cu of the 8090 type, as well as new alloys modified with Sc.

Mechanical properties of pressed semi-products from these alloys after heat treatment can reach the following values: UTS–700–750 MPa, δ – 8–12 %.

Complex of metallurgical equipment for semi continuous casting of high-quality ingots from wrought aluminium alloys

Cylindrical ingots of high strength Al alloy

National and International Projects

Numerous Grants and Projects of the National Academy of Sciences of Ukraine

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Physico-Technological Institute of Metals and Alloys

Department of Magnetohydrodynamics of Liquid Metals and Alloys

Research in the field of magnetohydrodynamics carried out at PTIMA NASU covers heat and mass transfer, hydrodynamics, physical and chemical processes taking place under influence of electro-magnetic forces to molten metal/alloys (Fe-based, Al etc.) as well as during melt crystallization.

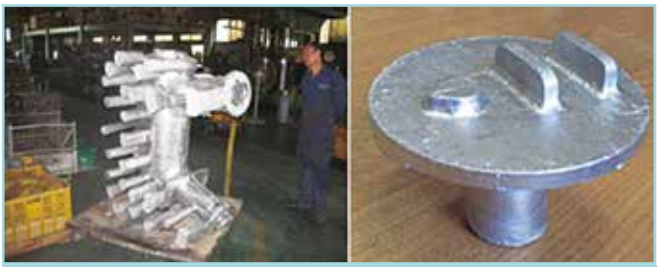
Unique multifunctional electrotechnological MHD-equipment is developed, as well as new technologies for processing of liquid aluminium alloys applied in aircraft and spacecraft design that provides:

- intensification of dissolution of components in melt and high homogeneity of chemical composition and temperature
- promotion of the destruction of microinhomogeneities and reduction of size of clusters in melt (physical modifying)
- Degasification of aluminium melts by argon blowing to hydrogen content ca. 0.05 cm3/100 g
- Removal of up to 80% of nonmetallics at multiple filtering of current-carrying melt through foam ceramic filters.

For cast hypoeutectic Al-Si aluminium alloy (A356) it is allowed to obtain highly refined macro- and microstructure and provide elongation of samples in 4-6 times higher than the standardized one. When Al-5% Zr master alloy was created, thermal & forced processing allowed to decrease the particles of the Zr-containing phase in aluminium matrix to 5 μm and obtain their spherical shape. In high-strength Al-Cu alloy similar to A201, such effects have provided the transformation of branched dendritic structure into compact one with maintaining high strength and ductility.

Application of complex MHD & plasma technology provides synthesis essentially new composite materials, including aluminium based, with high level of properties for Hi-Tech.

Technology of casting under low controlled electromagnetic pressure (LEMD-process) has significantly improved the quality of aluminium ingots obtained into die-press moulds.



Castings for machine-building (including aircraft) manufactured using developed MHD-equipment and technologies

National and International Projects

1. National projects
   Numerous Grants and Projects of the National Academy of Sciences of Ukraine; Projects "Resource" of NAS of Ukraine; "Nanotechnology and Nanomaterials" Projects of NAS of Ukraine

2. International projects
   STCU Project on electromagnetic processing of metallic melts.

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G.V. Kurdyumov Institute for Metal Physics

G. V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine was founded in 1945 and remains as one of the leading research centres in the fields of metal physics and physical metallurgy in Ukraine and Europe. Fundamental research is carried out along four main directions: Atomic Structure of Metals and Heterophase Metallic Systems, Physics of Strength and Plasticity of Metals and Alloys, Electronic Structure and Electronic Properties of Metallic Alloys and Intermetallic Compounds, Nanoscale systems.

Institute maintains strong international cooperation around the world and exhibits scientific achievements at the top international level. These results lead to the solid R&D capabilities, which are being used by Ukrainian aerospace enterprises ('Antonov', 'Motor Sich' JSC, Ivchenko-Progress SE) and by a number of foreign companies.

Aerospace R&D outcome includes structural materials (high-strength aluminium alloys, wear-resistant superalloys for gas-turbine engines), functional materials (shape memory alloys), certain technologies (electro-thermal treatment of titanium alloys, powder metallurgy titanium components manufacturing and ultrasonic treatment of aerospace metallic materials) etc.

Institute employs 431 people, including 123 PhDs and 63 Dr. hab.

Institute employs 431 people, including 123 PhDs and 63 Dr. hab.

www.imp.kiev.ua

Department of Physics of Strength and Ductility of Inhomogeneous Alloys

Gas turbine fan blade subjected to local RHT

During the last decade, the high strength titanium alloy production technology has been under development, as well as the cost-effective production of titanium components that uses innovative powder metallurgy approach.

First research direction is based upon employment of special Rapid Heat integrated production Treatment (RHT), which has been incorporated into technology of beta-titanium alloy parts characterized by extremely high strength (UTS ≥ 1500 MPa) whilst keeping reasonable level of ductility (El ≥ 8%). This technology has been successfully used to produce high-strength titanium springs and fasteners for a new ANTONOV aircrafts as well as for gas turbine fan blades.

Another new cost-efficient production technology is based on blended elemental powder metallurgy (BEPM) method in its simplest press-and-sinter approach, without application of pressure or deformation during or after sintering.

A distinctive feature of technology is the employment of hydrogenated titanium powder instead of traditional titanium powder. Hydrogen has a major effect on synthesis improvement, providing production of alloys having 98.5-99.5% density, desired microstructure and chemical homogeneity, low impurity content and high mechanical properties. Also, it should be mentioned that now research team of the department is working on studies aimed at combining the positive effects of RHT and BEPM approaches.

Department is also involved in the development of the biocompatible (Ti-Zr) alloys for cardiology.

High-strength (UTS >1500MPa, El > 8%) titanium springs made of Ti15-3-3-3 alloy

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G.V. Kurdyumov Institute for Metal Physics

National and International Projects

1. National:
   - "Optimization of technology of D18T aircraft engine fan blades optimization", funded by Motor-Sich JSC
   - "Development of technology for high-strength titanium springs and fasteners", funded by ANTONOV SE
2. International:
   - "Nature of titanium martensite" funded by INTAS, Brussels
   - "Development of Rapid Heat Treatment technology forming high-strength conditions in commercial titanium alloys", funded by Wright-Patterson Air Force Research Laboratory, OH, USA
   - "Application of cost-efficient powder metallurgy technology for production of titanium parts", funded by Pacific North-West National Laboratory, WS, USA
   - "Tailoring of microstructure and properties of titanium parts with local rapid heat treatment", funded by Air Force Office of Scientific Research (AFOSR) and AFOSR European Office of Aerospace Research and Development (AFOSR/EOARD), London
   - Current project "Titanium Armour with Gradient Structure: Advanced Technology for Fabrication", funded by NATO program "Science for Peace and Security", Brussels.

Department of Structure and Properties of Solid Solutions

Department of Structure and Properties of Solid Solutions was founded in 1975 on the basis of the laboratory of crystal structure investigation by Professor K.V. Chuistov. The basic research direction has been formulated as investigation of the heterogeneous solid solutions formed as a result of various phase and structural transformations and clarification of correlation between the structural and physical and mechanical properties of metallic alloys. Department is able to perform:

- Investigation of the phase and structural changing during decomposition of solid solutions
- Study of the nature of thermal and deformative stability of metastable structures in decomposed solid solutions
- Investigation of intercommunication between the crystalline and phase changing, on the one hand and mechanical properties – on the other one, as the result of precipitation during the decomposition of solid solutions
- Investigation of physical causes and mechanisms the thermal stabilization of structural conditions of aluminium alloys that will allow to improve structure and properties of available commercial alloys and to propose new compositions
- Search of effective alloying elements to ensure improved mechanical and technological properties of aluminium alloys
- Investigation of structure condition and physical-chemical properties of low-dimensional metallic and carbon nanomaterials - nanosized powders, amorphous and quasicrystal materials, fullerenes, carbon nanotubes, etc. with the aim to develop new generation of supercapacitors, electrical accumulators, pollution-free hydrogen energy sources
- Investigation of structures and properties of materials being formed under the metal vapour condensation onto substrates at different temperatures (EB-PVD coatings).

The following equipment is available at the Department: X-ray diffractometers, including the texture diffractometer, diffractometer equipped with high-temperature chamber and small-angle diffractometer; metallographic and electron microscopes, instruments for magnetic and electrical resistance measurement; setup for examination of dissipative properties of flat specimens and coatings on flat substrates; setup for examination of fatigue properties of materials on repeated loading in bending.

R&D direction that highlights the department's capabilities related to aerospace industry is the development of high-strength cast and wrought aluminium-based alloys. In the frame of this research the Department successfully completed several state-funded national projects, including some with Antonov SE.

Novel AlMgSiCu alloy vs. ASTM 2024 and 6013

Alloy	Density, Mg/m3	$\sigma_{0,2}$ MPa	$\sigma_{\delta\tau}$ MPa	δ, %
ASTM 2024	2.78	435	320	19
ASTM 6013	2.71	430	380	13
AlMgSiCu	2.66	450	360	20

National and International Projects

- STCU Project № 1976 (2002-2004) "Controlling the cast Al-Mg alloys atomic structure through microalloying for stabilization of their operational properties";
- AIRBUS SAS AI/ AE-1&AI/ET 435/0324/ 98 (1999 – 2000) "Improvement of aluminium cast alloys through scandium enhancement"
- AIRBUS SAS AI/AE-2&AI/ET 435.0325/98 (2003-2006) "Development of aluminium high-strength casting alloys".

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G. V. Kurdyumov Institute for Metal Physics

Department of Crystallization

The Department of Crystallization, which was founded in 1945 by Academician Prof. V.I. Danilov, provides systematic studies of atomic structure of metallic melts and physical nature of their transition processes into solid state.

Main research areas of the Department include investigation of physical principles and mechanisms of formation, growth and morphology of crystals; determination of the effect of melt mixing and vibration convection on crystallization patterns of bulk transparent metal-like substances; crystallization of melts in microgravity conditions.

Investigation of processes of high-speed (40-300 K/s) and ultra-fast (up to million K/s) cooling of the melts (melt-spinning technique) of metal alloys, studying their structure and properties takes an important place amongst Department's research topics.

The corresponding equipment has been developed; the relationship between the conditions of obtaining and the structural state in a wide range of rapidly heated micro-, nanocrystalline and amorphous ribbons has been studied, and technological solutions protected by patents that provide their high level and reproducible of their physical and chemical properties were provided.

R&D in the field of ultrafast quenching of the melt have allowed to create a number of new compositions of amorphous, micro and nanocrystalline alloys with a special combination of magnetic, electrical, corrosion, mechanical and other properties which are already used in various fields of modern technology and technology, in particular, for aerospace applications. The Department is able to perform:

- Manufacturing of precision alloys (induction melting in a vacuum and a protective atmosphere)
- Thermal, thermo-magnetic and thermo-mechanical treatment of amorphous and nanocrystalline alloys
- Investigation of structure and phase transformations of melts, amorphous ribbon and bulk samples, nano-phase compositions (differential scanning calorimetry - Netzsch DSC 404 F1 Pegasus); X-ray diffraction analysis and optical microscopy
- Investigation of physical properties (thermal stability, microhardness, magnetic and electrical properties).

Turbine working blade with wear-resistant soldering for D-18T turbojet bypass engine

Melt-spinning equipment for amorphous and nano-crystalline soft-magnetic ribbons production

Annual capacity - 5 tons

National and International Projects

- STCU project No 124 «Development of new soft magnetic amorphous and nanocrystalline alloys with high magnetic permeability and of the technology for their preparation by rapid melt quenching»
- STCU project No 2047 «Correlation of physical and mechanical properties of amorphous alloys of various chemical compositions with their structure state caused by melt heat-time treatment»
- STCU project No 3520 «Bulk metallic glasses precursors of the multi-component shape memory alloys»
- STCU project P280 «Development of new high strength bulk structural aluminium alloys with nanocomposite structure»

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G. V. Kurdyumov Institute for Metal Physics

Department of Phase Transformations

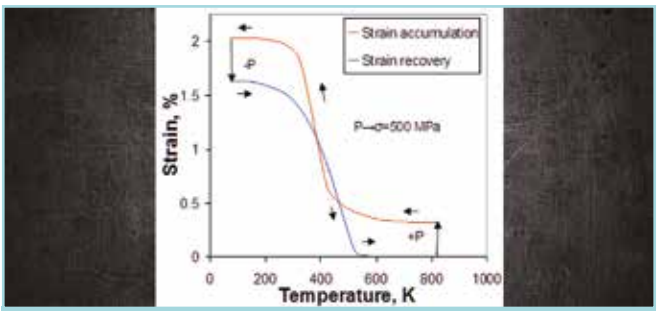
The Department deals with physical nature of phase transformations in metals and alloys through the study of their mechanisms, thermodynamics and kinetics under certain external influences.

Since the foundation of the Institute by Georgiy Kurdyumov, who was leading the Department at a time, the Department's main aim was shaped into the development of physical principles for functional materials design (shape memory alloys (SMA), in particular).

Department is able to perform:

- Alloys production (arc- and induction melting) and has free direct access to X-ray spectral composition analysis at the Institute; thermal-mechanical treatment of alloys
- Crystal structure studies (powder X-ray diffraction, optical metallography, TEM)
- Crystal (Rietveld refinement) and electronic structure modelling in close collaboration with other Departments through free direct access to Institute's computer cluster facilities (16 nodes, 64 cores; ab initio - Wien2k, Quantum-ESPRESSO etc.)
- Investigation of physical properties vs. temperature (electrical resistivity (up to 200 K/sec), dilatometry; 77-1100 K) with free direct access to calorimetric measurements at the Institute (Netzsch DSC 404 F1 Pegasus)
- Investigation of functional properties (own-produced shape memory testing device in 3 and 4-point bending under static stress; 77-1100 K)
- Investigation of mechanical properties (Vickers hardness (HV30), "Micron-Gamma" device equipped with Berkovich indenter (ISO 14577-1:2002(E))) and has free direct access to INSTRON 8802 at the Institute.

Recently, three R&D directions are followed in the frame of a number of national and international projects: i) industrial shape memory alloys improvement (mostly biomedical), ii) magnetic shape memory materials, iii) high entropy shape memory alloys (HESMA). The latter area is expected to be directly related to aerospace applications, as these novel high entropy alloys due to their advanced lifetime, high work output, superior shape memory performance over a wide temperature range, excellent mechanical properties allow their application in aerospace morphing structures, vibration isolation systems, jet engines, sensors and actuators.



Typical HESMA shape memory behaviour

Polycrystalline NiTi SMA vs. HESMA

Properties	NiTi	HESMA
Temperature range, K	77-390	77-900
Young's modulus, GPa	45	70-80
Yield strength, MPa	70-600	≈1200
Shape recovery strain degradation, %	8 → 1	stable 3
Work output, J/cm3	10-20	5-10

National and International Projects

Amongst 8 international projects successfully carried out at the Department are the following:

- INCO-Copernicus ERBIC-CT96-0704 "Development of non-conventional shape memory alloys production technologies: high temperature Cu-based and NiTi-based alloys"
- Project of the Science & Technology Centre in Ukraine (www.stcu.int) STCU No 3520 "Bulk metallic glasses precursors of multi-component shape memory alloys"
- CNRS project P.I.C.S. 3717 "Functional alloys for high temperature applications: comparative study of alloys prepared from precursors obtained by non-conventional powder production routes"

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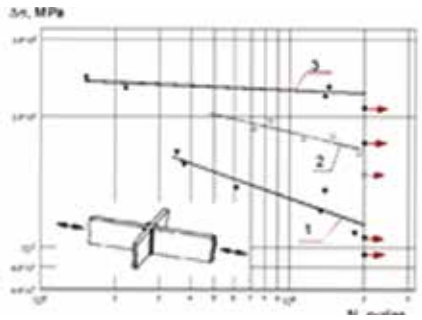
G. V. Kurdyumov Institute for Metal Physics

Department of Physical Fundamentals of Surface Engineering

One of the main areas of research activity of the Department relates to the studies of strain-induced structural and phase formations in surface layers of metallic materials under the influence of severe plastic deformation induced by ultrasonically assisted multiple impact loads. During the last decade, the possibilities and outcomes of ultrasonic impact/finishing treatments combined with other surface modification methods, such as laser treatment, electric discharge surface alloying, metallization, nitridation/carburization etc., were comprehensively investigated. Essential part of activity has been spent on the development of novel portable ultrasonic equipment and advanced ultrasonic technologies for the processing of construction materials and enhancement of their properties. The 'structure-properties' relationships are mainly under consideration, which allows finding optimal regimes of ultrasonic impact treatment and surface finishing.

Considering the capability to produce ultrafine-grained and nano-crystalline microstructure in the topmost surface layers, the ultrasonic impact treatment is considered as a basis for the development of new complex technologies capable of producing modern construction and functional materials with enhanced fatigue durability and improved wear and corrosion resistance, from raw materials (steels, titanium, aluminium, zirconium alloys etc.) of different strengths, phase compositions, and structures.

Ultrasonic Impact Treatment (UIT)



Change in carbon steel welding joint fatigue behaviour (1 - initial, 2 - UIT, 3 - repeated UIT)

UIT of welded crack (1 m) in Podil railway bridge (Kyiv, Ukraine; without stopping of on-going traffic)

National and International Projects

1. INCO-Copernicus IC15-CT96-0740 "The development of new ultrasonic assisted processes in metallurgy and machinery"

2. Projects of the Science & Technology Centre in Ukraine (www.stcu.int)
   - STCU NN32 "Development of new method for materials processing using ultrasonic field in microgravity" funded by NASA (USA) and State Space Agency (Ukraine)
   - STCU P024 "The development of improved technology and equipment for ultrasonic impact treatment of welded joints and constructions"
   - STCU 2354 "Development of ultrasonic technologies for manufacturing of the new composite materials with adjustable coefficient of thermal expansion" funded by MEMRY Europe (EU)
   - STCU P210 "Development of equipment for ultrasonic impact treatment of metals and studies of the equipment efficiency" funded by Surtek Inc. (Canada).

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O. Ya. Usikov Institute for Radiophysics and Electronics

O. Ya. Usikov Institute of Radio Physics and Electronics of the National Academy of Sciences of Ukraine (IRE NASU) was established in 1955 based on the former Departments of Electromagnetic Oscillations and Radio Wave Propagation of the Kharkiv Institute of Physics and Technology of NASU. Since its establishment, the Institute has gained a status of widely-known scientific centre, whose achievements determine the level of the national science.

Institute conducts research on generation and amplification of electromagnetic MW-band oscillations, mm- and submm- wavelengths, their canalization, radiation, propagation, reception and processing; radio wave propagation in different frequency ranges under natural conditions, namely, in the atmosphere, over the land and sea surface; remote sensing of the Earth's environment from space-borne carriers; interaction of electromagnetic radio waves with solids (metals, semiconductors, dielectrics) and biological objects. The institute cooperates with a number of Ukrainian enterprises including Yuzhnoye State Design Office. The institute's staff of 490 employees includes 41 doctors, 125 candidates of sciences, and more than 100 young researchers and post-graduate students.

http://ire.kharkov.ua/

Quasioptics Department

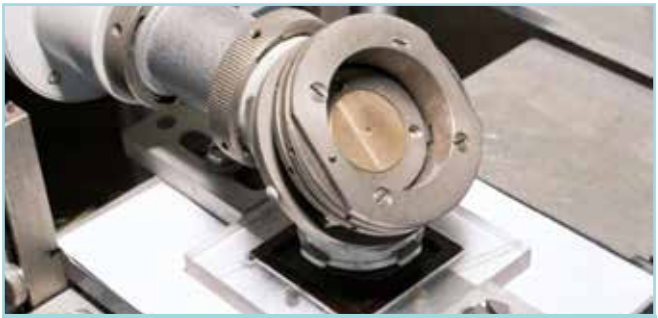
The main research area of the department is development of quasioptical principles and techniques using the sub-THz and THz electromagnetic waves. The application area involves material research relevant to aeronautics, radar, spectroscopy, non-destructive testing, ellipsometry, plasma diagnostics, etc.

Recent department activity has been dedicated to non-destructive testing of composite bonds which are used as light-weight aircraft structures. Nowadays, composite structures are often used in the manufacturing of structural components in aeronautics industry. However, optimal ways of joining the light-weight composite structures are still in the agenda and should be found. The performance of adhesive bonds depends on the physical and chemical properties of both adhered surfaces and adhesives. Therefore, a set of quasioptical non-destructive testing techniques has been developed and applied to the characterization of composite bonded structures and the state of adhered surfaces before bonding.

National and International Projects

- STCU project P-278. "Stand for quasi-optical researches SQR-110/1". Funded by Center for Biomolecular Magnetic Resonance (BMRZ), J.W.Goethe University (Germany, Hessen, Frankfurt am Main), 2006-2010.
- STCU project P-398. "Stand for quasi-optical researches BCA-Compass". Funded by Institute of Plasma Physics Czech Academy of Sciences, 2011.
- FP7 project ENCOMB. "Extended Non-Destructive Testing of Composite Bonds". Funded by European Commission. 2010-2014.
- STCU & NASU Targeted Research & Development Initiatives. Project 5958. "Novel all-dielectric functional metamaterials for terahertz applications". Finded by European Communities and National Academy of Sciences of Ukraine. 2014-2016.

Some wideband THz components, developed in quasioptics department



Sub-THz Non-Destructive Testing of CFRP samples for Airbus Aeronautic Industry

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O. Ya. Usikov Institute for Radiophysics and Electronics

Department of Statistical Radiophysics

Department of statistical radiophysics conducts research on:

- Statistical characteristics of the electromagnetic field of microwave and mm-wave ranges interacting with the propagation media, interfaces, and complicated-shape scatterers
- Time-spatial, spectral and polarization features of Earth surface at low grazing angles, scattered by the medium inhomogeneities, sea and land and by the radar targets
- Physical and simulation models and methods for calculating the field characteristics in the radio-systems due to the atmospheric effects and interaction between the waves and the real media boundaries.

O. Ya. Usikov Institute for Radiophysics and Electronics of the National Academy of Sciences of Ukraine developed a "Millimetre Wave Coherent Semiconductor Radar for Airport Surface Movement Monitoring and Control". The radar is intended for advanced surface movement guidance and control systems (A-SMGCS) that are necessary for determination of aircraft position and for monitoring (detection, tracking and identification) of other objects in the airport area.

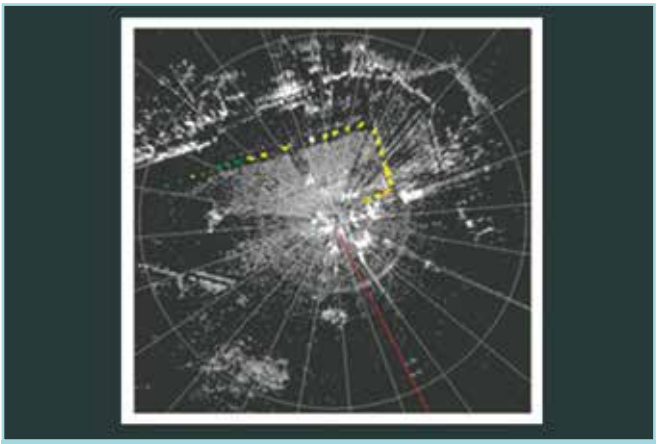
The basic radar characteristics are:

1. Detection of the objects being of a 1 m2 radar cross-section, which corresponds to a man or a big animal with probability 0.9 at probability of a false alarm 10-6 up to distances not less than:
   - In conditions of clear weather - 5 km
   - In rain intensity of 16 mm / hour - 3 km
2. Angular resolution on azimuth - not less than 0.250;
3. Resolution on range - not less than 15 m;
4. Coverage area in horizontal plane when the aerial is 5-10 m above the ground: on range - 90÷5000 m; on azimuth - 3600.
5. Time of the review (the period of information update) - 4 s.

National and International Projects

1. National projects
   Competitive research work of the Ministry of Education and Science of Ukraine and innovative project of the National Academy of Sciences of Ukraine "New Radar System of Millimetre Range for monitoring objects and their movement at airports to ensure control and security functions".

General view of radar sensor



Radar image of some airport area with an "Antonov-140" aircraft moving along taxiway and runway

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Institute of Macromolecular Chemistry

Institute of Macromolecular Chemistry of the National Academy of Sciences of Ukraine (IMC NASU) is a leading scientific centre of Ukraine for development and investigation of different polymers, composites and related materials. It was founded in 1958 (before 1964 was named as Institute of Chemistry of Polymers and Monomers).

The Institute employs about 230 workers, including 1 Fellow and 1 Corresponding Members of National Academy of Sciences, 9 Professors, 16 Doctors of Sciences (DSc) and more than 70 Candidates of sciences (Ph.D.). More than 50 young scientists and PhD students work in the Institute. 3 of the young specialists currently have joint supervision of the Ukrainian and European leading scientists.

http://ihvs.kiev.ua/en/

Department of Polymer Composites

1. Synthesis of novel polymers for different applications
2. Elaboration and testing of polymer composites
3. Polymer for medical applications
4. Multipurpose polymer coating
5. Special polymeric binders
6. Polymer adhesives and sealants
7. Polymer based sorbents
8. Photoactive polymeric materials
9. Bulletproof glasses

Experimental sample of intraocular lenses

Technology Development Activities

1. Photopolymer adhesives:
   Photopolymer adhesives for binding silicate and organic glasses, metals, ceramics, cement, wood, plastics etc. "Absolute adhesion" technology. Enhanced flexibility, strength (up to 40 MPa) and water-resistant properties. Applicable for large surfaces. Exploitation temperatures–40 to +100 °C.

2. Low temperature flexible epoxy adhesives:
   Low temperature epoxy adhesives and binders for large scale and thermally unstable materials. Provide high adhesion bonding strength (over 15 MPa) and enhanced flexibility of adhesive layer. Moderate viscosity of initial compositions. Applicable for different materials.

National and International Projects

1. National projects
   - Innovation NASU project "Compositions for flexible intraocular lenses"
   - IMC NASU and Yuzhnoye SDO project "Oligomeric epoxy-urethane binders for special purposes"
   - NASU Project "Titanosilicate heterogeneous catalysts for synthesis of glycidol"
   - NASU Project "Low temperature oligomeric epoxy binders for different uses"
   - IMC NASU and Yuzhnoye SDO project "Oligomeric binders for multilayer aircraft construction materials"

2. International projects
   - STCU project "Polymeric sensor membrane for aflatoxine determination"

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Institute of Macromolecular Chemistry

Department of Chemistry of Heterochain Polymers and Interpenetrating Polymer Networks

Institute has long-term experience in elaborating of polymer materials for protecting personnel and structural elements of aircraft against microorganisms' attack throughout long-term operation.

Novel polyurethanes (PUs) and elastic polyurethane foams (PUFs) stable to biocorrosion, induced by pathogenic microorganisms (fungi) were created (The inhibition of the growth of microorganisms (MOs) by the developed PU materials is presented in Fig. 1, 2, 3). The polymers possess fungicidal/fungistatic and bactericidal/ bacteriostatic activity. It was shown that after the biological tests on mold fungi and yeasts, polymers totally keep their main exploitation characteristics [Acta Astronautica. 2009, V.64, N1, 36-40].

Life-firmness investigation of the most aggressive extremophiles: mold fungi Aspergillus and Penicillium on the PUs surfaces showed that for some samples it made up from 3 to 10 days. Biological activity of the polymer matrices allows to obtain PUs, PUFs and PUFs/activated carbon sorbic composites and avoid infecting and biodegradation of the composite sorbic materials during both the application and long storage. Obtained results are the base of a technological scheme of assured human protection against microorganisms' attack in specific condition of his existence.

The ideology of these investigations consists of not as much in development of materials stable to biocorrosion and/or possessed antimycotic properties, as in complex approach to working out of the basis of the system of guarantee human and environmental protection against the destructive attack of fungi.

Biologically active materials have been developed as i) multipurpose protective coatings, ii) structural elements (elastic gasket materials), components of seats in the cabin and cockpit of aircraft, etc.), iii) composite materials for the air-condition systems, etc.

Fig. 1

Fig. 2

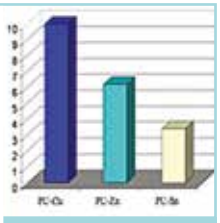

Fig. 3

Fig.1 Inhibition of the growth of microorganisms (MOs) by the PU; **Fig.2** Inhibition of the growth of microorganisms (MOs) by the PUF; **Fig.3** Viability of spores on the film surface of PU.

National and International Projects

1. National projects
   - National Space Agency of Ukraine «Development of new polymers stable to biocorrosion in conditions of long-term space flight» (2002-2012)
2. International projects
   - INTAS 93-3379-ext (NTU of Athens, Greece)
   - INTAS 1997-1936 (NTU of Athens, Greece)
   - NATO RESEARCH FELLOWSHIPS, 1999 (NTU of Athens, Greece)
   - STCU 375 (1997-1999) "Investigation in the field of application components of missile fuel for the national economy necessity" (USA financing party)
   - STCU U071 (2003-2005) "Investigations in the field of a new crown compounds and polymer based on its" (USA financing party)
   - NATO Science for Peace Program SfP 977995 / "Novel Combined Adsorption-Filtering Materials for Individual Protective Systems" (2003-2006)
   - Program cooperation between NASU and AS of Czech Republic "Development of Polyurethane Foams and based materials for multi-vectorial application for human and environmental protection" (2008-2010)
   - Program cooperation between NASU and TUBITAC (Turkey); "Development of the novel nanostructured hybrid silica-organic systems based on functional polyurethane(urea)s" (2009-2011)
   - 7th Framework Programme / Marie Curie Actions / Intern. Research Staff Exchange Scheme "COMPOSITUM"
   - "Hybrid nanocomposites and their applications" (2009-2012);
   - Program cooperation between NASU and AS of Romania "Development of multifunctional organic and organic-inorganic polymeric materials on the base of components with different chemical nature" (2012-2016)
   - Program cooperation between NASU and AS of Poland ("Development of newest polymer nanocomposites with high performance using the perspective carbon filler - anthracite as an analogue of graphene" (2015-2017).

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Department of Chemistry of Heterochain Polymers and Interpenetrating Polymer Networks

Chemistry, physical chemistry and technology of functional polymers and based composites

Theoretical principles of modification of polymers and composites thereof by small-scale chemistry products

Theoretical principles of fabrication of polymers for medical applications

Institute has long-term experience in elaborating of:

- Polyurethanes and related polymers
- Organic-inorganic hybrid polymer materials
- Nanostructured multi-component polymer systems
- Preventive coatings stable to action the biotic, abiotic and technogenic factors
- Optically transparent polymer materials for different purposes (photocuring coatings, UV-glues, adhesives, hybrid binders)
- Multi-purpose glue compounds and glue compositions
- Electric conductive adhesives
- Adhesive polymer materials for oil and gas industry, ship repairing, mineral resources mining, house- and industrial building
- Liquid rubbers with functional terminated groups for antirusting protection, casting compositions, coatings
- Polymers for medical application
- Ecologically-friendly multi-purpose water based ionomer polyurethane dispersion
- Environmentally degradable polymers based on renewable resources
- High performance polymer binders for high temperature resistant composites and nanocomposites, adhesives, coatings, potting resins, membranes for aerospace application
- Polymer recycling

High performance polymer matrices for composites and nanocomposites

National and International Projects

1. National projects
   - Development of nanotechnology of producing hybrid organic-inorganic composite nanomaterials of high thermal stability, adhesion strength and low dielectric loss for elements used in aerospace and electronics. State Target R&D Program "Nanotechnologies and nanomaterials", Ukraine (2010-2014).

2. International projects
   - Matériaux Composites Nanostructurés Intelligents (2006-2007), ECONET Project (Egide, France). Partners: Rouen University, Ingénierie des Polymères, Lyon I, University of Lorient (France), Technical University of Lodz (Poland).

   - Nanoporous Thermostable Polymer Materials (2017-2021). Franco (CNRS) – Ukrainian (NASU) Project: International Associated Laboratory (LIA). Partners: Institut de Chimie et des Matériaux Paris-Est (ICMPE), Ingénierie des Polymères, Lyon I, France, Institute of Nuclear Research of NASU, Ukraine.

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V.M. Glushkov Institute of Cybernetics

V.M. Glushkov Institute of Cybernetics of the National Academy of Sciences of Ukraine (GIC-NASU) conducts research on computational methods of optimization, mathematical theory of control and dynamic games, numerical methods of solution of distributed parameter and fractional derivative systems, stochastic systems, reliability theory and data protection, theory of parallel computing, methods of the theory of decision making. The institute provides high-performance supercomputing resources for institutes of National Academy of Science and serves Ukrainian National Grid as a National Resource Centre. The hybrid supercomputer "SCIT-4" developed in GIC-NASU is currently the top performance and the "greenest" high-performance computing system of Ukraine. The institute cooperates with a number of Ukrainian enterprises including ANTONOV State Enterprise. The institute's staff of 540 employees includes 40 doctors, 132 candidates of sciences, and more than 90 young researchers and post-graduate students.

http://www.incyb.kiev.ua/

Department of Numerical Methods and Computer Simulation

1. GIC-NASU is leading HPC R&D institution in National Academy of Sciences of Ukraine. Being both the biggest computer centre of the Academy and the main resource centre of Ukrainian National Grid (the Ukrainian branch of EGI), GIC-NASU provides researchers and engineers from the Academy, Ukrainian Universities and high-tech enterprises with its supercomputer resources, cloud services and software applications. Among them 'Supercomputer Aero & Hydrodynamic Virtual Lab' is developed for industrial users from aircraft design agencies, engine building, shipbuilding design institutes, power engineering, chemical industry and other organizations involved in development of modern machinery. The virtual lab aims at complex simulation, examination and optimization of future properties of the products under design. To meet the goal the virtual lab integrates multiple parallel software packages such as Flowvision, ANSYS, OpenFoam, Nastran together with GIC-NASU proprietary programs for evaluation of the structural integrity of constructions, simulation of hydro-mechanical and thermo-mechanical processes, solving optimization problems of big dimension. GIC-NASU conducts research in the field of flexible wing aerodynamics modelling. A hang glider wing CAD model is built, the finite element method together with the successive approximation method is used to determine a loaded wing shape and airflow.

2. GIC-NASU carried out adaptation of supercomputers of the family "SCIT" for the computational tasks of the ANTONOV State Enterprise in the framework of the project on development of software and hardware complexes for parallel computations based on cluster architecture computers. A software and hardware complex developed at GIC-NASU based on clusters and Nastran MSC, Marc MSC Software have been introduced into computational process in ANTONOV SE within the network environment. This complex made it possible to significantly reduce the time required for the solving of computational problems in ANTONOV SE as well as to significantly increase the dimensions of problems being solved. In 2005-2016 Institute of Cybernetics together with State Enterprise Elektronmash have created a family of intelligent computers Inparcom. In contrast to traditional ones the intelligent computers implement an innovative function of automatic adaptive adjustment algorithm, program and computer's architecture according to characteristics of the problem being solved. Intelligent computers have been used during the calculation of aero-dynamic characteristics of AN-148 plane (ANTONOV SE), during the studies of dynamics of aircraft and industrial gas turbines (JSC "Motor Sich").

AN-148 lift computed at GIC-NASU 'Supercomputer Aero & Hydrodynamic Virtual Lab' for ANTONOV Company

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National and International Projects

1. National projects
   National Academy of Sciences of Ukraine and ANTONOV Company joint project "Creation and development of software and hardware complexes

for parallel computing based on computers of cluster architecture of the Institute of Cybernetics and their adaptation to Antonov ASTC computational problems" (2008).

2. International projects
Program of cooperation between the Governments of Ukraine and the Federal Republic of Germany, Project ISKON ("Intelligent Software for the Untersuchung und Loesung von Aufgaben zur Analyse der Festigkeit von Konstruktionen", 1999-2002).

Department of Optimization of Controlled Processes

1) General method to solve the problems of control in condition of conflict and uncertainty is developed – the method of resolving functions (MRF), based on application of the inverse Minkovski functionals and special set-valued mappings. These are the problems with many participants and those under state constraints, problems of the pursuit in turn under condition of conflict. MRF justifies the classic rule of parallel pursuit, well known to engineers engaged in design of rocket and airspace technology. The positional method of pursuit, associated with the time of first absorption, is elaborated, which justifies pursuit along the 'line of sight'. The Krasovskii rule of extremal targeting is extended to the cases of group pursuit, integral and mixed constraints on controls, delay of information, systems of variable structure, impulse controls, and state constraints. It is laid a foundation of the nonlinear theory of collision avoidance. The methods of evasion along a direction and of variable directions, method of invariant subspaces and recursive method are proposed. The conditions of first and higher order are studied. Sufficient conditions for escape a group of pursuers as well as conditions of evasion under the moving objects groups' counteraction are derived. A cell markovian model is proposed to analyse game problems with incomplete information (so called search problems) in which the probability of detection or the mean time of detection plays the role of performance criterion.

2) Simulators for training pilots are created to minimize risks during the aircraft take-off and landing in extreme conditions (lateral wind, rain, ice covering of the landing strip etc.), to prevent accidents and emergences; model of soft landing (coincidence of geometric coordinates and velocities) of an airplane on an aircraft carrier is built, where the ocean surface plays the role of phase constraints; by way of illustration, the software is developed simulating the process of soft landing in the case of second-order dynamics under friction, the work is performed in cooperation with NIST (National Institute of Standards and Technology, USA); game models of search for mobile and stationary objects, carried out by heterogeneous facilities (aircrafts, helicopters, airborne ships), are created, the methodology can be applied for the search of crashed objects in difficult for access regions and for search of fish shoals and sunken ships; methods of the moving objects collision avoidance in condition of conflict are elaborated, that can be used in planning of dispatching services for safe traffic at airports and seaports in the period of maximum congestion; methods for optimization of the interaction of the space based object groups, moving along circular or elliptic orbits, are worked out

National and International Projects

1. National experience
   - NASU projects 0112U000748 "Development of methods for managing dynamic processes under uncertainty and gaming interaction" (2012-2016)
   - NASU project 0112U002716 "Development of methods and means of decision-making support for managing mobile objects under uncertainty" (2012-2016).

2. International projects
   - STCU projects No 5240 (2011 - 2013) "New methods for remote sounding of chemical and biological components using optical instruments"
   - STCU projects No 1746 (2002 - 2004) "Analysis of dynamics and development of optimal algorithms for charged particle transport in plasma media"
   - Russian-Ukrainian Scientific Projects No 03-01-14 (2014 – 2015) "Game problems of dynamics under information uncertainty"; No F53.1/006 (2013–2014) "Problems of group control under uncertainty, with elements of routing", No F40.1/021 (2011–2012) "Game problems of control, routing and tasks allocation in group of objects".

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Institute for Information Recording

Institute for Information Recording of the National Academy of Sciences of Ukraine (IIR-NASU) conducts research on physical fundamentals, principles, methods and systems of recording and transformation of information, theoretical foundations and applied methods for creating computer information-analytical systems, investigation and development of information protection methods in computer systems and networks, theoretical basis and applied methods of computer simulation, creation of automated monitoring systems of plurality moving objects in real time. The institute cooperates with the Yuzhnoye State Design Bureau "The institute's staff consists of 172 employees, including 83 scientific workers, including 9 doctors, 24 candidates of sciences.

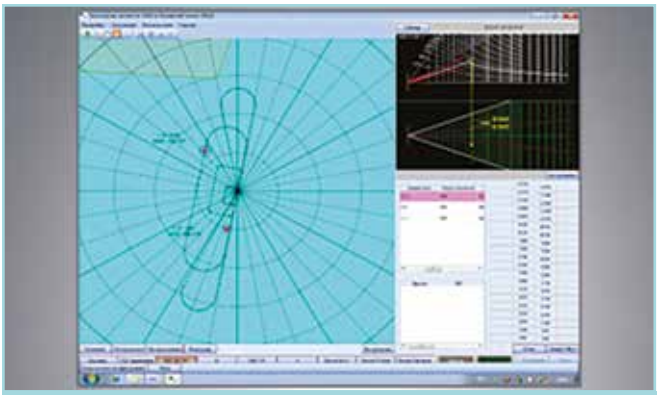
http://www.ipri.kiev.ua

Department of Digital Modelling Systems

1) The Department of Digital Modelling Systems of the Institute for Information Recording of the National Academy of Sciences of Ukraine for more than 30 years has been working on the study of complex control systems and creation of information and computer systems, simulation of complexes, automated control systems, including automated control systems for the training and use of forces and assets of aviation units at various levels of command and control of the Armed Forces. One of the priority activities of the Department is research in the area of survivability and information security of complex control systems for critical objects.

2) Specialists of the department developed a methodology for creation of computer modelling complexes that provide modelling of automated control systems tasks, organizational and staff structure of management, development of software and hardware, survivability mechanisms, training of officials, testing of new functional modules. The construction of computer modelling complexes is based on the modular principle, which allows to configure a flexible structure for specific tasks.

A technology has been developed to ensure the survivability of automated systems of organizational control in the face of destructive influences. The technology allows the system to adapt to new, changed and, as a rule, unforeseen situations, to resist unfavourable influences and to fulfil its objective function at the expense of appropriate changes in the structure and behaviour of the system. The technology of survivability is developed on the basis of recognition, localization, countermeasures, restoration, adaptation, and special mechanisms for ensuring survivability - reconstruction, reconfiguration and reorganization.



Automated workstation of the Head of Near Zone in the mode of solving the task «Control of flights of aircraft in the near zone»

National and International Projects

National projects

1. Cabinet of Ministers of Ukraine:
   - Governmental Information and Analytical System for Emergency Situations.
2. Ministry of Defence:
   - Information and Computing System for Control of Equipment and Armament in engineering and aviation support of combat and daily aviation activities of the Armed Forces of the USSR.
   - Informational and Computing Control System for the Engineering and Aviation Support of combat operations and combat training of the aviation group of the aircraft carrier.
3. Yu. A. Gagarin Research&Test Cosmonaut Training Centre:
   - Automated Control System for Training Modelling Complex of the Gagarin Research & Test Cosmonaut Training Centre.

International projects

The Department has completed several international projects on the creation of computer modelling complexes of automated systems of organizational control.

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Institute of Technical Mechanics

The Institute of Technical Mechanics of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine provides scientific and technical support to the execution of the projects of the National Space Programs of Ukraine and coordinates R&Ds in space engineering under the supervision of the State Space Agency of Ukraine.

Currently, fundamental and applied research is conducted at the institute in the following areas:

- Dynamics of mechanical and hydromechanical systems, of launch vehicle systems, and of rail and motor transport
- Aero-thermo and gas dynamics of power plants, aircraft and spacecraft , and their subsystems
- Strength, reliability, and optimization of mechanical systems, launch vehicles, and spacecraft
- Mechanics of interaction of a solid with ionized media and electromagnetic radiation
- Systems analysis of trends and prospects in space engineering.

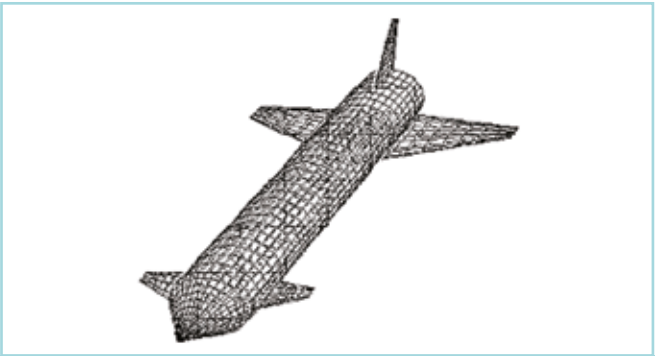
www.itm.dp.ua

Department of Aerogasdynamics and Dynamics of Technical Systems

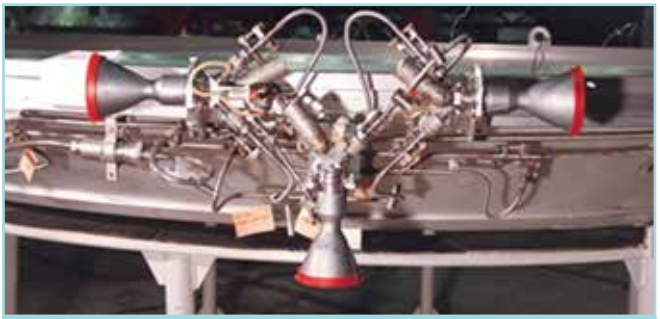
The Department's research priorities are to formulate mathematical models, to develop algorithms and software for determining the parameters of thermal and gas dynamic processes associated with operation of individual elements of aerospace systems.

This software can be used to study:

- Total and disturbed aerogasdynamic parameters of winged rockets with aerodynamic controls and carrying surfaces in supersonic portion of the flight considering interactions between flow fields over the rocket body, controls, stabilizing surfaces, and wings, regardless of their numbers and positions on the rocket body.
- Ramjet vehicles (RV): rational mathematical models, algorithms of their numerical realization and relevant software for flow simulation through the ramjet air intake are formulated; processes in ramjet combustion chamber; flow in ramjet combustion chamber; determination of thermal and gas dynamic parameters in the vehicle integrated with an air-breathing engine.
- two-phase non-isobaric supersonic jets of combustion products of the rocket propellants in supplying water in the jet body: major features of the effects of water supplying, vaporizing, mixing, and burning the combustion products in atmospheric oxygen on the flow structure and gas dynamic and thermo-physic parameters of the jet;
- recommendations for the selection and validation of the project parameters of complex branched hydraulic fuel systems for jet engines are made considering the design features of hydraulic passages, hydraulic valves of supply tubes, control valves and regulating valves;
- a level of gas saturation of propellant components, the dynamics of electric and pneumatic valves, thermal and gas dynamic processes at the system outlet.



Svityaz rocket



Control units

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The research results have been used at leading design aerospace organizations. The software proposed is being employed to develop and update rockets (in particular, at Yuzhnoye SDO during governmental and commercial projects), during individual projects and preparation of expertise associated with some projects of National and State Target-Oriented Research Space Programs of Ukraine.

Certain of the research results have been used for the Suprovodzhennya project of the State Space Program of Ukraine to evaluate the status of the development of liquid jet systems for the Cyclone -4 rocket complex third stage from developmental testing. The research results were repeatedly reported at ISABE Conferences. Supervisor of studies V. I. Tymoshenko represents ISABE in Ukraine.

Department of Hydromechanical and Vibration Protection Systems Dynamics

The challenge of aerodynamic design quality improvement of aviation gas turbine engines elements (GTE) is relevant both for Ukraine and other countries which develop aviation technologies. The main way to solve this problem is the use of modern, efficient research. In this regard, unique scientific and methodological support to meet the challenges of improving the aerodynamic shape blade rows of GTE compressors in two-dimensional and three-dimensional productions has been developed.

A theory of low-frequency (4 to 50 Hz) cavitation self-oscillations in pump feed systems of liquid-propellant rocket propulsion systems (LPRPSs) has been developed. Based on the theory, efficient methods and means for the suppression of cavitation self-oscillations in LPRPS pump systems have been developed. The problem issues of LPRPS dynamics involving mathematical simulation of engine starting process and LPRPS transients in emergencies with consideration for cavitation in the centrifugal pumps with an inducer have been resolved.

The cavitation self-oscillation theory made it possible to tackle issues of linear and nonlinear LPRE dynamics (calculation of the frequency characteristics and the engine starting process) and rocket dynamics as a whole (pogo stability analysis, rocket body pogo oscillation amplitude assessment) at a qualitatively new level. A set of mathematical models of low-frequency dynamics of modern (250-ton thrust) staged LPRE taking into account pumps cavitation, vaporizing and condensation in of the engine were designed to put to the orbits the promising launch vehicles. A mathematical simulation of the start-up of the liquid rocket engine is performed.

National and International Projects

A linear theory of liquid-propellant LV pogo stability has been developed, first by taking into account cavitation phenomena in the LPRE pumps in the mathematical models of dynamics of the "LPRPS LV body" system. This approach of inclusion of cavitation phenomena is unique for both in Ukraine and abroad and allows to make sufficiently reliable theoretical predictions of liquid-propellant LV pogo stability. Nonlinear theory of liquid rocket LV pogo stability was developed.

For the first time in the world's practice in the field of heavy and superheavy liquid-propellant launch vehicles a fundamentally new and promising class of small dampers of pogo oscillations was created which hydrodynamic and thermodynamic efficiency is significantly higher than those of gas-liquid ones. In the hydrodynamic damper the supercavitation phenomenon is used to obtain high ductility necessary for the pogo stability of LV, while thermodynamic damper uses thermodynamic effects in two-phase vapor-liquid media near the saturation line. The hydrodynamic damper passed a full cycle of experimental testing and was installed on the "Zenit" LV and provided its pogo stability.

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International Scientific and Educational Center of Informational Technologies and Systems

International Scientific and Educational Center of Informational Technologies and Systems of NSA of Ukraine and MES of Ukraine (International Center) providing development of the artificial intelligence, novel informational and communicational technologies and systems, automatization problems, informational society creation in Ukraine and his interaction with world informational space. International Center successfully performs one of the critical informatics problem – new generation of high knowledge-intensive informational technologies creation – intellectual informational technologies, which are able to reproduce some elements of human's intellect. Main scientific directions and topics of International Center are being appreciated in Ukraine and abroad. Institute stuff consists of 350 workers, including 30 Doctors of Science, 70 Candidates of Science and also around 100 young researchers and postgraduates.

www.irtc.org.ua

Department «Intellectual control»

1) International Scientific and Educational Center of Informational Technologies and Systems of NSA of Ukraine and MES of Ukraine is involved into development of aircraft collision warning method, which synthesizing recommendations in evident conflict conditions presence and provide, in general, spacious turning manoeuvre to avoid possible dangerous plane approaching and after solution of conflict it provides plane returning to the planned trajectory and it's further holding. Whilst, in recommendations for manoeuvre performing synthesis process, taking into account optimal criteria, that are, accordingly to past simulation, provide time and recourses economy for manoeuvre's performing more than by 30% by contrast with acting methods. Using of the set method in air traffic control will provide insure safety level in flights with spontaneous routes, which is predicted to nearest years.

The theoretical foundation of researches being conducted in the Department, is the theory of ergatic systems, based on which the methodology for analysis and synthesis of complex ergatic dynamic systems was created. The methodology allows to develop reliable and efficient control systems of complex distributed objects and processes. Research of essential principles of data processing and decision making of ergatic systems operating in conflict environment is based on this methodology. The systems which were created based on these principles are applied in different control systems of high-speed loops of distributed engineering processes. This ensures functional and temporal combination of internal resources of network-centric distributed control systems with objects and technological processes based on compatible use of accelerated time-scale dynamics models, into a single space-time network-centric complex.

In the 2010-2017 years the department has been performing tasks within the following research programs: "Development of integrated ergatic dynamic objects control complexes in conditions of limited time and information for decision-making", "Development of methods, models and intelligent control information technologies for complex human-machine systems", "Creating the theoretical foundations of the global computer and communication networks of intelligent control of complex distributed stringent dynamic processes", "Development of models and methods for solving severe conflict situations".

Department research strategy is based on holistic examination of control processes in man-machine systems related with the tasks. Based on a holistic examination of control processes the formalized images of the object control and control environment are created, control algorithms that take into account features of the human operator control participation, are being developed.

Control units

Control units

National and International Projects

- National Aviation University: "Development of models and methods of solving severe conflict situations"
- Scientific and methodological centre of process analysis: "Creating the theoretical foundations of the global computer and communication networks of intelligent control of complex distributed stringent dynamic processes".

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