Institute of Technical Mechanics (ITM), Dnipropetrovsk

Technical Area: Industrial Technologies
Keywords: rocket and space technology

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<th>General Information</th>
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<td>The history of the Institute of Technical Mechanics (ITM) dates back to 1966, when a Sector of Mechanical Engineering Problems was set up within the Dnipropetrovsk branch of the Institute of Mechanics. The sector was later transformed into a division, which became the basis of establishing the Institute under its current name in 1980. Traditionally, the Institute’s structure included a Special Design and Technology Bureau (SKTB) together with the Pilot Production facility for experimental production and prototyping of applied R&amp;D results. Since 1993, ITM has been a lead institute of Ukraine’s aerospace industry involved in solving of a wide range of scientific and engineering problems in the field of rocket and space technology. As a leading Institute of Ukraine's rocket and space industry Institute resolve problems on the development of concepts of government policy in the field of space research and exploration, contributes significantly to the development of projects of Ukraine's National Space Programs, and provides its comprehensive analytical and information support. The Institute performs a wide range of basic and applied research on scientific and methodic support to develop and operate railway and motor vehicles.</td>
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<th>Institute’s Focus</th>
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<td>ITM has unique capabilities in experimental and test equipment (e.g., high-pressure bench for studying various hydrodynamic processes, plasma electrode research facility, vacuum aerodynamic plant), as well as in the development of software and physical and mathematical models of processes associated with rocket and space equipment en route to launch sites, functioning in orbit, and during the atmospheric re-entry to Earth. More specifically, ITM’s core competencies stem from basic and applied investigations in the following fields:</td>
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<td>- Dynamics of mechanical and hydro-mechanical systems, launch vehicle systems, railway and motor transport</td>
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<td>- Aero-thermal gas dynamics of power plants, spacecraft, and their subsystems</td>
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<td>- Strength, reliability and optimization of mechanical systems, launchers, and spacecraft</td>
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<td>- Mechanics of interaction of a rigid body with ionized media and electromagnetic radiation</td>
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<td>- Modeling and simulation of various operating conditions, such as electric and magnetic fields, solar and radar electromagnetic radiation, etc.</td>
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<td>- Systems analysis of rocket and space technology development trends.</td>
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<th>Valuable Technology Offerings</th>
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<td>- New pneumatic systems protecting drivers of various transportation facilities against vibration</td>
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<td>- New effective and environment-friendly technologies and devices for de-scaling carbon stainless-steel parts</td>
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<td>- Technique and device for improving the efficiency of mining by using the method of underground melting (in particular, sulfur melting)</td>
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<td>- Environment-friendly high-efficiency burners for gas and liquid fuel, as well as coal furnaces using a new method of burning</td>
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<td>- Technology for manufacturing antenna and wave-guide devices and concentrating systems</td>
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<td>- Methodology and device for evaluating and monitoring parameters of ionosphere plasma</td>
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<td>- Software for determining projects parameters of products of rocket and space technology in the engine dynamics, aerodynamics, dynamic load and structural strength.</td>
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<th>Scientific Cooperation and Technology Transfer</th>
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<td>The Institute has established scientific collaborative links with its counterparts in the areas of:</td>
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<td>- rocket and space technology development,</td>
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<td>- railway transport,</td>
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<td>- machine-building and</td>
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<td>- heat power engineering.</td>
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<td>Research in these areas was conducted in collaboration with leading organizations of Russia and Ukraine:</td>
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<td>- Yuzhnoye State Design Bureau,</td>
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<td>- “Lutch” Research and Production Association,</td>
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<td>- Antonov ANTK,</td>
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<td>- Zhukovsky TsAGI,</td>
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<td>- the Central Research Machine-Building Institute (TsNIIMash),</td>
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<td>- Baranov Central Institute of Aircraft Engine-Building (CIAM),</td>
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<td>- the Institute of Theoretical and Applied Mechanics of the Siberian Branch of the Russian Academy of Sciences, etc.</td>
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<td>Foreign partners and collaborators include Technical University of Vienna (Austria), University of Bremen (Germany), Medical Records Institute, Newton, MA (USA).</td>
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<td>Industrial cooperation plays an important role in ITM’s applied R&amp;D activity.</td>
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<th>Contact Details</th>
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The Institute of Technical Mechanics of the National Academy of Sciences of Ukraine and the National Space Agency of Ukraine is involved in addressing a wide range of scientific problems regarding the development of launch vehicles and spacecrafts. The Institute has been acting as the leading Institute of Ukrainian aerospace industry since 1995.

**PRIMARY SCIENTIFIC DIRECTIONS**

- software, physical and mathematical modelling for investigations of hydrodynamic processes in the feed systems of rocket propulsion
- thermo-gas-dynamic and heat-and-mass exchange processes in power plants
- vehicles in-flight conditions simulation at high, medium and low altitudes, for strength and vibration tests
- technological processes for manufacturing radio-engineering devices elements
- solar power concentrators by the electroforming method

**DISTINCTIVE COMPETENCIES**

The Institute has developed experimental and test equipment possessing unique capabilities;

The plasma electrodynamic facility is one of the best plasma-gas-dynamic tunnels in Europe. Systems and technical characteristics of the facility make it possible to model and simulate many effects like high-energy electrons, Earth’s radiation belts and auroral plasma in the ionosphere; solar ultraviolet radiation; thermal cycling in vacuum; supersonic flows of atomic oxygen; gas and plasma jets of spacecraft electrical-jet engines; supersonic fluxes of a “cold” ionospheric plasma, magneto-hydrodynamic control in heat exchange and deceleration of magnetized bodies.

Vacuum aerodynamic plant with cryogenic discharge system is used to investigate parameters of interaction of:

- rarefied gases supersonic flows with design materials of spacecraft external coating
- spacecraft components and structures thermal state
- lighting situation in spacecraft neighborhood
- effective cross-sections of atoms and molecules dispersion
- working efficiency of on-board measuring equipment and its calibration
- dynamics of pressure reduction in untight containers.

It is possible to conduct full-scale aero-dynamical experiments using passive standard artificial satellites.

At the Institute wide-scale investigations are carried out in the field of cavitation self-excited oscillations in hydraulic systems, which in their content and novelty of the results obtained have no analogues in the world. Scientific and engineering fundamentals of a new original scientific trend are founded in the areas of liquid-propellant rocket propulsion and liquid-propellant launch vehicles.
Fundamental research is carried out for the inert and chemically reacting liquids and gases injection into supersonic high-enthalpy gas flow. The obtained results on supersonic flow excitement on jet engine nozzles allow to develop effective methods of supersonic flow processes control. It allows for the first time in rocket-manufacturing practice to develop new highly-efficient "servoelements" for the rocket flight control system.

Heat-resistant coating on calorific intensive surfaces of liquid propellant rocket engine combustion chambers are developed at the institute. Complicated problems on deformation, strength and load-carrying capacity of non-homogeneous structures of rocket and space and aircraft technologies, power and transport engineering industries operating under intensive effects of different physical nature, including local loads and contact interactions, are solved.

PARTNERING OPPORTUNITIES

The Institute’s scientists collaborate with many international societies and organizations including

- the Tsiolkovsky Russian Academy of Cosmonautics
- the American Society of Mechanical Engineers
- the Pugwash Movement National Committee
- the International Society for Ramjet Engines
- the German Society of Applied Mathematics and Mechanics
- the International Committee on Machines and Mechanisms Reliability
- the International Assistance Association for Cooperation with scientists of the Independent States of the former Soviet Union
- the International Engineering Academy

the Ukrainian Automatic Control Association of the International Automatic Control Federation, etc.

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a) The rocket flight control system
b) The plasma electrodynamic facility
c) Mikrosputnik spacecraft
d) Vacuum aerodynamic plant with cryogenic discharge system
BASIC R&D LINES

- dynamics of hydromechanical systems;
- aerospace power plant thermogas dynamics;
- aerogasdynamics;
- rarefied gas dynamics;
- ionized medium dynamics;
- dynamics of multidimensional mechanical systems;
- statistical dynamics of mechanical systems;
- vibration protection systems;
- dynamics and control of mechanical systems;
- structure strength, dynamics, and manufacturing technology;
- system reliability and longevity;
- efficiency of engineering systems;
- system analysis and control problems;
- functional elements of control systems.
SERVICE IN THE AREA OF ROCKET AND SPACE ENGINEERING

Purpose
- Scientific and technological assistance of launchers and spacecraft development
- Theoretical and experimental research of processes in rocket and space objects elements
- Development of software for research and design work
- Development and investigations of samples of rocket and space objects components
- Scientific and technological assistance of requirement specifications, projects, production and operation for rocket and space objects

Services
- Mathematical modeling of liquefied launchers longitudinal vibrations with taking into account cavitational phenomena in liquid propellant rocket engine pumps
- Mathematical modeling of liquid propellant rocket engines injection
- Investigation of “liquid propellant rocket engine launcher airframe” system dynamic stability
- Development of mainly new means to ensure liquefied launchers longitudinal stability
- Analysis of dynamic compatibility of the liquid propellant rocket engine with the launcher design
- Prediction of dynamic response (longitudinal accelerations) of spacecraft during injection and flight of the liquefied launcher
- Use of plasma electrodynamic facility to simulate operational conditions, motion and flow regimes, spacecraft and Solar system planets interaction with interplanetary medium (solar wind), cold and hot plasma, charged particles flows, electric and magnetic fields, solar spectrum and radar waveband electric and magnetic radiation in the Earth ionosphere and magnetosphere at elliptical, geostationary and geopolar orbits at heights of 150 – 40000 km
Services

- Vacuum-arch techniques for plasma condensate coating high-heat surfaces of liquid propellant rocket engine combustion chambers
- Heat-resistant coatings for liquid propellant rocket engine combustion chambers; corrosion-resistant and barrier coatings for composite materials units (copper-carbon, copper-tungsten)
- Dynamic design of highly maneuverable controlled objects with a simultaneous selection of their basic design and operating parameters
- Determination of characteristics of spacecraft gas-liquid systems, operating in conditions of weightlessness and alternating loading

- Optimization of superlight space rocket design parameters and motion control software
- Hydrogasdynamics and unsteady heat-and-mass transfer in jet engines
- Supersonic and subsonic gas flow control
- Gasdynamic control of rocket engine thrust vector
- Evaluation of dynamic response of rocket-space technology elements at various kinds of starting

- Evaluation of characteristics of spacecraft opening process and elements stress-strain-state
- Space debris population dynamics analysis. Theoretical and experimental studies of means for the prevention of near-Earth space pollution from operating and used launch vehicles and spacecraft
Services

- Strength and carrying capacity of shell-and-rod structure of spacecraft under extremal conditions
- Reliability and durability of space and rocket technology products
- Models of damage accumulation;
- Load regimes equivalent to operational ones

- Engineering diagnostics of the state of the structure elements based on application of the physical phenomena within materials
- Evaluation of residual life
- Development of improvements in the functional properties of structural materials

- Aerogasdynamics of rocket and space technology objects, computational aerothermogasdynamics of launch vehicles, re-entry spacecraft, passages of hypersonic ramjet engines and control jet thrusters;
- Theoretical and experimental studies on jet flows, launch vehicles start gasdynamics and thermostatic parameters of launch vehicles sections and technological devices
- Calculations of supersonic flows around launch vehicles

- Determination of parameters of controlling two component liquid propellant rocket engine of small thrust
- Study of spacecraft vibration loading at transportation
Services

- Determination of parameters of launch vehicles trajectories and spacecraft orbits by measuring data of navigation satellites and earth stations
- Space and rocket objects control
- Systems analysis of space activities
- Analysis of perspective space systems
- Simulation of space cable system motion
- Methods to study dynamics of perspective spacecraft
- Study of aerodynamic, thermal, photometric characteristics and processes of mass transfer in the region of orbital and re-entry spacecraft
- Laboratory flight simulation, experimental investigations of features of the rarefied gas supersonic neutral flow/streamlined surface interaction
- Concepts development, formulation and realization of space scientific and applied experiments
- Experimental studies and aerogasdynamic maintenance of space projects

Expert examination

- Preparation of a performance/requirements specification (requirements specification) for space equipment object development
- Design (pilot project, draft design, detail design) examination
- Space equipment object experimental development package plan examination
- Consideration of the results of work on the space equipment object development and manufacturing
- Space equipment object flight test preparedness substantiation
- Analysis of the subcontractors’ normative documents employed in the space equipment object components development and manufacturing

Preparation of expert’s conclusions on space equipment object designs includes

- Performance/requirements specification (requirements specification) compliance analysis
- Comparative analysis of the proposed engineering solutions and basic performance characteristics of the space equipment object under development as against its best domestic and foreign counterparts
- Assessment of the expected space equipment object efficiency
- Assessment of the space equipment object competitive ability in the world market of space services
- Normative requirements compliance assessment
- Preparation of recommendations on the introduction of the obtained achievements into other industries

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RADICALLY NEW BIOENERGOINFORMATIONAL MEDICAL TECHNOLOGY WITH THE USE OF ELECTROMAGNETIC WAVES

Purpose
The integrated noninvasive medical technology is intended for the early detection and correction of functional disorders in organs and tissue systems of the human body.

Advantages
Diagnosis: noninvasivity, informativity (preclinical disease detection), high sensitivity (disease prediction), the accuracy and reproducibility of results.
Therapy: noninvasivity, harmlessness, a sublow-energy intensity and a high accuracy of action on organs (systems) of the human body with millimeter-wave signals, the possibility of acting on the vegetative nervous system to restore the innervation of organs and tissue systems.

Essence of the technology
Diagnosis: assessment of the functional condition of all organs and tissue systems on the same scale by measuring the admittance of the bioenergy channels of the human body. Comparison of the measured energoinformational matrix with nosode-type reference ones. Making liquid-based and solid-based matrices (an energoinformational “disease imprint”) for diagnosis and therapy. Making electronic autonosodes with the use of GaAs crystals for informotherapy.
Therapy: sublow-energy targeted actions on organs (systems) of the human body via its bioenergy channels (up to 12 at a time) with millimeter-wave electromagnetic radiation with consideration for its resonance interaction with cell membranes. The energoinformational spectrum of the radiated signal can be controlled by modulating it with a specially formed signal or a signal from a nosode-type reference pharmaceutical matrix or an autonosode.

Practicl implementation
Municipal Hospital No 7, Sevastopol, Ukraine
Center for Human Body Functionality Correction, V.I. Vernadsky Tavria National University, Simferopol, Ukraine
Biomed Treatment-and Diagnosis Center, Alchevsk, Ukraine

Approbation
The clinical testing of the medical technology was conducted at:
- Institute of Pediatrics, Obstetrics and Gynecology, Academy of Medical Sciences of Ukraine (Kyiv);
- Institute of Nephrology, Academy of Medical Sciences of Ukraine (Kyiv);
- Institute of Gerontology, Academy of Medical Sciences of Ukraine (Kyiv);
- State Medical Academy (Dnepropetrovsk).

Based on the results of the clinical testing, State Registration Certificate No 8501/2009 was issued (Order No 141 of the Ukrainian Ministry of Public Health dated February 5, 2009).

Punctural electrographic instant diagnosis of the functional condition of the human body
The essence of the new approach to the diagnosis problem consists in obtaining, by appropriate measurements involving biologically active points (BAPs), radically new reliable biophysical parameters that characterize human body processes not only on the level of the intercellular (humoral) medium, but on the cellular lever as well. This, in its turn, offers not only an objective assessment of the energoinformational status of the human body (energoinformational homeostasis), but also a comprehensive picture of the functional condition of the organs and tissue systems of the human body.
BIORESONANT INFORMATION-PUNCTURAL THERAPY WITH THE USE OF ELECTROMAGNETIC WAVES

The essence of the new approach to the problems of prevention and treatment of various diseases consists in purposeful action on BAPs of the acupuncture system of the human body with low-intensity millimeter-wave electromagnetic radiation to restore the unbalanced energoinformational homeostasis and enhance the compensatory and adaptive capabilities of the human body by restoring the damaged structure of the information signals generated in cells, organs, tissue systems and the human body as a whole. The purposeful introduction of significant information into the human body via its acupuncture system with the aim to enhance its compensatory and adaptive capabilities is the main objective of the proposed medical technology.

Punctural electrographic instant diagnosis and bioresonant information-punctural therapy are based on the latest advances in modern fundamental natural science in the field of the bioelectrical and functional activity of the organs, tissues and systems of the human body, on its compensatory and adaptive capabilities, and on the millenaries-old experience of Oriental medicine. It is this fact that gives a hope for the reality of the expected radical changes in the diagnosis, prevention and treatment of various diseases with the help of the bioenergoinformational medical technology.

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TECHNOLOGY OF COMPUTATIONAL SUBSTANTIATION OF THE DESIGN PARAMETERS OF COMPLEX HYDRAULIC SYSTEMS

Essence of the technology
Computer simulation of fast hydro- and gas-dynamic processes in complex hydraulic systems, which include manifolds, pilot-controlled valves, tanks, throttle valves, dead legs, etc., for the choice and substantiation of the design and operating parameters of specific engineering systems.

Advantages

- Accounting for: the design features of hydraulic lines (pipe diameters, wall thickness, material); the physical and chemical liquid/gas properties; the hydraulic resistance of feed pipelines and control valves; the degree of gas saturation, gas release and discontinuity of flows; the propagation of wave processes in the system elements; the dynamics of electrically or pneumatically controlled valves; thermogas dynamic processes at the system outlets;
- Unified method for the representation of a branched hydraulic system and its operating conditions.

Hydraulic schematic of the feed system of Liquid-propellant thrusters
O – oxidizer tank; F – fuel tank; 1, 2 – thrusters

Overall view of a thruster
**Approbation**

As applied to the feed system of two-component liquid-propellant spacecraft flight control thrusters (the number of 30 to 100 N thrusters is 8 to 20 inits, and the number of simultaneously operating inits is 2 to 8). The characteristic times of operating mode switching (100 to 200 ms), propellant valve response (30 to 40 ms) and wave process propagation (5 to 20 ms) are comparable with one another.

**Purpose**

The choice, substantiation and optimization of the design parameters of complex branched hydraulic systems of airborne and space vehicles, rocket and internal-combustion engine fuel supply systems, urban water distribution systems, etc. operating in transient conditions (start-up and shutdown transients, hydraulic shock, manifold restructuring, gas release, discontinuities).

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**Time history of the pressure in the combustors of thrusters 1, 2, and 3 when the thrusters are started sequentially**

1a – thruster 1 thrust reduction due to the start-up of thrusters 2 and 3;
2a – thruster 2 thrust reduction due to the start-up of thruster 3

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**Effect of the propellant ignition delay time τ₁, the electric-valve armature breakaway delay time τ₂, and the valve opening time on the thruster start-up**

1 – momentary valve opening; 2 – with taking into account the valve response time
TECHNOLOGY OF DEVELOPMENT OF INDUSTRIAL APPARATUS
FLOW SYSTEMS

Purpose
The choice and development of the design of the hydraulic flow systems of industrial apparatuses in different industries (the chemical industry, the power industry, metallurgy, etc.) to increase the efficiency of the production processes in the working area of the apparatus.

Essence of the technology
Combined use of computational methods and experimental modeling of gas-dynamic processes with model plants of different scale (including full-scale ones).

Advantages
The technology is implemented using inexpensive model equipment and shortens (or fully eliminates) the stage of flow system tryout with the use of pilot and industrial plants.

Approbation
In the development of chemical apparatuses and space vehicle ground temperature control systems:

Development of the design of the gas distributor of an industrial ammonia conversion apparatus
The gas input is of the jet type. Inlet pipe diameter – 500 mm. Maximum diameter of the apparatus – 4,000 mm. Gas distributor diameter – 4,000 mm. Distance between the inlet and the gas distributor – 1,750 mm.

Full-scale plant (overall view)
Gas distributor in the form of a thick-walled perforated grid with a radially variable flow section
Velocity distribution downstream of a grid with a constant (1) and a variable (2) flow section
Development of the flow system of an industrial spouted-bed apparatus to coat granulated ammonium nitrate

Spouted bed structure (semicircular version of the plant, 1:6 scale)

Overall view of a full-scale plant with a full-scale industrial discharge assembly

Volume gas distributor of diameter 950 mm

The try-out of spouting processes using plants of different scale allows one to reveal scale effects that take place when going from model small-scale plants to full-scale industrial apparatuses.

Development of the general and the local ground temperature control system of the spacecraft housing of the Zenit launch vehicle

Overall view of a full scale model of a part of a spacecraft housing 2,500 mm in diameter

The objective of the development is the choice of the design of temperature-controlling air input and distribution devices to provide the required heat removal from the spacecraft instruments at the minimum air speed during the prelaunch preparation on the launching site.

Services
Gas-dynamic analysis of the apparatus flows, recommendations on improvement of the original design, and its choice and experimental development with consideration for its manufacturability.

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TECHNOLOGY OF VORTEX SEPARATION OF FINE DUST FROM A GAS FLOW

**Essence of the technology**
The use of the energy of coaxial vortex counter flows for the separation of dust particles from dust-laden flows and the development of efficient fine-dust-trapping plants on this basis. Depending on the dust type, different methods are used to control the aerodynamic activity of the vortex flows.

**Current status of the technology**
A laboratory vortex dust-trapping plant, on which a technique of choice of the design and operating parameters that maximize the efficiency of fine dust separation has been tried out.

Schematic and overall view of laboratory vortex dust-trapping plant
Purpose
To increase the efficiency of fine dust separation using vortex dust-trapping plants in place of filters, multicyclones or scrubbers employed in different industries to remove harmful dust components from air.

Field of application
The chemical industry, the woodworking industry, the iron-and-steel and the nonferrous-metals industry, the building metals industry, and the power industry.

Patent protection
Ukrainian Patent for Invention No 71057, in which a pre-increase in the dust concentration in the peripheral part of the inlet pipe by the mounting of a shaped central cowlling upstream of the swirler is proposed. The central, less concentrated part of the dust-laden flow is directed through slot nozzles in the side surface of the hollow director cone to the peripheral part of the vortex chamber. The joint action of these improvements enhances the efficiency of the dust-trapping plant operation.

Advantages
- increased dust separation efficiency for small-fraction micron particles;
- separation of dusts smaller than 5 micrometers with an efficiency up to 97 to 98 percent for some dust classes;
- lower power consumption in comparison with filters and scrubbers;
- higher recovery of dust materials;
- lower environmental impact.

Services
Computational and experimental substantiation of the design and operating parameters of dust-trapping plants for specific dust types; supervision of the operational development of vortex dust-trapping plants.

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ION-PLASMA PROCESS EQUIPMENT
AND TECHNOLOGY OF APPLICATION OF FUNCTIONAL COATINGS
ONTO HARD-TO-REACH INNER SURFACES

Brief description
Ion-plasma process equipment has been developed to apply functional coatings onto hard-to-reach inner axisymmetric surfaces of parts. The technology that uses the equipment makes it possible to apply coatings of different compositions and purposes and is environmentally appropriate.

Purpose
Extension of the service life of friction pairs in critical machine assemblies that are subject to increased corrosive and mechanical wear.

Fields of application:
in landing gear;

![AN225 airplane landing gear](image1)
![Typical landing gear assembly](image2)
![AN148 airplane landing gear](image3)

In aircraft hydraulic units;

![In aircraft hydraulic units](image4)

In versatile machines, in mining and drilling equipment

![In versatile machines, in mining and drilling equipment](image5)
Chief advantages

- The coating roughness corresponds to the substrate roughness;
- Single-layer, multilayer, nanostructured and nanocomposite coatings of different compositions and purposes;
- The minimum dimension of the surface to be coated is 25 mm. No limitations on the coating length;
- Single-layer coating thickness up to 100 m;
- The surface temperature during coating deposition is 200 – 400°C;
- Environmentally appropriate alternative to galvanic and chemical inner-surface coating application processes.

Stage of development

- Pilot plasma process apparatuses and an industrial prototype plant have been developed and made to coat the working surfaces of friction pairs of the cylinder-piston type made of VT22 high-strength titanium alloy.
- The development is covered by a Ukrainian patent.

Approbation

The technology and process equipment developed were used for the application of a Cr-based protective coating onto the inner working surface of the AN148 airplane (inner diameter of the working surface – 32 mm; length 250 mm; coating thickness – 30 m; coating microhardness – 12 GPa; coating roughness parameter – 0.2 m). The coated part was put to a comprehensive life test in the amount of 74,500 simulated flights. After the test the functionality of the coated working surface was fully retained.

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TECHNOLOGIES FOR THE MANUFACTURING OF ANTENNA/WAVEGUIDE DEVICES AND SOLAR CONCENTRATORS

**Purpose**
Manufacturing of thin-walled antenna/waveguide devices and solar concentrating systems, creation of optimum antenna/waveguide structures and minimum-weight solar concentrating systems.

**Essence of the technology**
Multipurpose use of electroforming (current-induced crystallization of a metal from a supersaturated near-cathode electrolyte layer). The surface of the electrodeposit is a precise replica of that of the matrix cathode, and a large number of identical products with a high-quality reflective surface can be made.

**Advantages**
High manufacturing accuracy, small mass, controlled uniformity of the material distribution in the electrodeposit (structural homogeneity of the material). Possibility of making complex-structure antenna/waveguide devices and solar concentrating systems, which cannot be made by other technologies. Assurance of the required strength, stiffness and longevity. The technologies fall into wasteless and energy-saving ones.

**Approbation**
In the development of space antenna/waveguide devices, radio astronomy devices and solar plants.

**Parabolic mirror antennas and solar concentrators**
Diameter 0.5 – 1.6 m, variable thickness 0.2 – 0.5 mm

Parabolic solar concentrator or mirror antenna (variable thickness $(2.5 – 4)\times10^{-4}$ m, diameter 1.6 m, mass 8 kg) and the apparatus to make them

Solar concentrator (made at the Institute of Technical Mechanics of the National Academy of Sciences of Ukraine and the National Space Agency of Ukraine) at the Heliocenter of the Institute for Problems in Materials Science of the National Academy of Sciences of Ukraine (Katsiveli, the Crimea, Ukraine)
Parabolic mirror antenna made up of antenna sections manufactured by the proposed technology for comprehensive characterization of spaceborne antenna systems. The mirror measuring 5x6 m contains 70 trapezoidal two-layer (a reflective metal surface and its reinforcing layer) sections.

Waveguides of different types

Waveguides with lengthwise variable cross-section. Apparatus to make them.

Cone and pyramid antennas

Cone antennas with beam-shaping ribs made by the proposed technology.

Apparatus to make pyramid antennas. Antennas made by the proposed technology.

Small parabolic concentrators and the apparatus to make them

Small parabolic concentrators for solar plants and the apparatus to make them. Dimensions: height $(3 – 5)10^{-2}$ m, the smaller base is a circle of diameter $(6 – 18)10^{-3}$ m, the larger base is a hexagon or a circle, mass $4.5 – 6$ g.

Services

Transfer of documentation for methods of manufacturing of antenna/waveguide devices and solar concentrating systems including (a) flowcharts specifying the operation sequence and operating conditions (temperature, electrolyte composition, etc.); (b) design and production documentation for products and equipment. Development of processes for the manufacturing of new complex products (seamless pipes, diaphragms, bellows, floats for oil storage metering systems).

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FREIGHT-CAR TRUCK RETROFIT

**Purpose**
Extended service life of trucks and improved dynamic performance of freight cars.

**Essence of the technology**
Replacing standard friction assemblies with new, more durable ones and introducing new devices into the construction to improve dynamic car performance.

**Advantages**
Truck retrofit is possible both for cars in service and for new cars. On retrofit, the car cost increases by 3 to 4 percent only while the service life of the major-wear parts shows a several-fold increase (a ten-fold increase for some parts).

**Approbation**
Operational and dynamic tests of cars together with their in-service inspection have confirmed and in some cases surpassed the predicted efficiency of the proposed retrofit.

A project of complex retrofit of freight-car trucks, S03.04, has been developed and introduced. The retrofit uses three elements of the A.Stucki Co. (USA) and the ITM-73 wear-resistant wheel profile (Ukraine). The retrofit is in progress at all the Ukrainian car-repair plants and ten Ukrainian car shops. A system of repair and maintenance of retrofitted cars has been set up. Patents have been issued for: the ITM-73 wear-resistant wheel profile, which halves wheel flange wear; resilient roller side bearings, which offer a higher critical car speed, and friction wedges, which extend the service life of the wedge damping system by a factor of more than ten.
<table>
<thead>
<tr>
<th>Major characteristic</th>
<th>Retrofit by Project S03.04 (Ukraine)</th>
<th>Retrofit by Project M1698 (Russia)</th>
<th>UVZ truck (Russia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life, km x 1000:&lt;br&gt; - wheel flange (machining life),&lt;br&gt; - wedge damping system,&lt;br&gt; - center plate arrangement</td>
<td>300 – 400&lt;br&gt; 1000 – 1200&lt;br&gt; 700</td>
<td>100 – 150&lt;br&gt; 160 – 210&lt;br&gt; 160 – 210</td>
<td>100 – 150&lt;br&gt; 160&lt;br&gt; N/A</td>
</tr>
<tr>
<td>Critical speed of empty cars with medium–worn wheels, km/h</td>
<td>120</td>
<td>60 – 80</td>
<td>110 – 120</td>
</tr>
<tr>
<td>Repairability:&lt;br&gt; - Truck part reclamation during shop repairs&lt;br&gt; - No need for power-intensive repair work</td>
<td>Truck part reclamation during shop repairs&lt;br&gt; No need for power-intensive repair work</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Cost, USD:&lt;br&gt; - Repair work&lt;br&gt; - Pay–back period, years</td>
<td>2000 – 2500&lt;br&gt; 1,8 – 2,3</td>
<td>450 – 550&lt;br&gt; no less than 5</td>
<td>N/A</td>
</tr>
</tbody>
</table>

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TECHNOLOGY AND MEANS FOR HYDRODYNAMIC OIL-WELL STIMULATION

Purpose
New advanced technology of cavitation pulse stimulation of oil wells 3 to 4 km in depth for well yield increase and well recovery.

The essence of the technology
The technology is based on generating high-frequency hydraulic pressure pulses in the well at the productive stratum level. The hydraulic pressure pulses have a frequency of 1,000 to 6,000 Hz and an amplitude up to 60 MPa. The hydraulic pressure pulses are generated at the outlet of the hydrodynamic device inserted into the well.

Advantages
The new, unique distinction from world analogs is the use of a proprietary high-frequency pressure pulse generator without any moving or rotating parts. The high-frequency, high-amplitude pressure pulses are generated in the well using the stream energy of the fluid fed to the generator. The technology will offer a 3- to 5-fold increase in well yield.

Approbation
Pressure pulse treatment of oil wells has been conducted. The results have shown that relatively short stratum stimulation times (60 to 120 min) suffice to obtain a 3.0- to 3.5-fold increase in well yield.

Possible users
Service and drilling companies in different countries.
Equipment layout and schematic of the action of the pressure pulses at the outlet of the high-frequency pulse generator on the well walls at the productive stratum level

1 – productive stratum; 2 – high-frequency pressure pulse generator; 3 – drilling string; 4 – casing pipe; 5 – mud pump; 6 – derrick

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TECHNOLOGY OF VIBRATORY-ROTARY DRILLING WITH THE USE OF DRILLING ASSEMBLIES WITH HIGH-FREQUENCY CAVITATION HYDROVIBRATOR

**Purpose**
Enhanced efficiency of the rotary drilling of holes 36 mm to 250 mm in diameter through various rocks.

**Essence of the technology**
The imposition of high-frequency, high-amplitude vibrations on the rock-cutting tool and the generation of a pulsating drilling mud flow.

**Advantages**
The freedom from springs and moving parts, the enhanced reliability of the drilling assembly, and the moderate overall dimensions make it possible to drill deep holes using vibratory-rotary drilling. The cavitation hydrovibrator offers freedom of depth control. The cavitation hydrovibrator imparts to the rock-cutting tool longitudinal vibration accelerations of peak-to-peak amplitude 50g to 15,000g in the frequency range 100 to 10,000 Hz. The cavitation hydrovibrator (Fig. 1) is mounted in the drilling string ahead of the rock-cutting tool or over the core barrel.

**Approbation**
Testing on an experimental drilling ground has shown that the cavitation hydrovibrator offers a 60 to 70 percent increase in penetration speed, a more than twofold increase in rock-cutting tool durability, and a higher recovery of core in drilling through fissured rocks.

**Possible users**
Drilling companies in different countries and drilling equipment makers.

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Time history of the pressure and vibration accelerations during the operation of the high-frequency oscillation generator.

- $P_2$ – pressure at the generator outlet;
- $a_2$ – vibration acceleration on the hydrovibrator body;
- $a_3$ – vibration acceleration on the rock-cutting tool

![High-frequency cavitation hydrovibrator](image-url)
Fig. 2. Schematic of drilling with the high-frequency cavitation hydrovibrator

Drilling hydrovibrator with roller bit

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CAVITATION PULSE TECHNOLOGY FOR THE PREPARATION OF FINE-PARTICLE COAL-WATER FUEL

Purpose
Coal-water fuel is a new,far more environmentally appropriate kind of power-plant fuel, which can be used at thermal power plants now in operation in place of gas or black oil.

The essence of the technology
Consists in the use of periodically detached cavitation in the flow of a coal-water slurry for dispersing and homogenizing the slurry to obtain fine-particle coal-water fuel, which can be burned as it is in boiler furnaces.

Advantages
• direct burning in boilers without need for preliminary drying or dewatering;
• far lower power consumption per product unit (by a factor of 4 to 6);
• no moving parts or automatic control elements in the cavitation pulse disperser, simple plant design;
• high production capacity;
• wide range of control of the cumulative effect of cavitation.

Approbation
The technology for the preparation of fine-particle coal-water slurries has been tried out at the Hydraulic Laboratory of the Institute of Technical Mechanics using various coal ranks and slurry concentrates. As a result, a fine-particle coal-water fuel with a coal content of 60% and a particle size of 40 μm has been obtained.

Possible users
Power engineering industry, heat and power plants, public boiler plants.

Cavitation pulse plant for the preparation of fine-particle coal-water fuel

T – trapping filter; P – pump; M – motor; F – filter
Time history of cavitation pulse disperser operation on coal-water slurry

Prototype cavitation pulse plant to try out the operating conditions for different coal ranks and slurry concentrates

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SELF-CONTAINED PNEUMATIC SYSTEMS FOR DRIVER SEAT VIBRATION PROTECTION IN VEHICLES OF DIFFERENT TYPES

Purpose
Use in driver seat suspensions for a significant reduction of the vertical vibrational loads acting on the driver.

Essence of the technology
Based on theoretical and experimental studies, a radically new pneumatic vibration protection system with an elastic rubber-cord shell, which features a quasi-zero stiffness and a gradual increase in stiffness in compression and rebound, has been developed. Setting up nonequilibrium working processes in the air spaces of the vibration protection modules dispenses with hydraulic shock absorbers.

Advantages
- simple seat suspension design;
- a seat natural frequency less than 1.2 Hz and a gain factor no greater than 1.2 are provided;
- no hydraulic shock absorbers are needed;
- a driver seat with a pneumatic vibration protection module offers a significant decrease in the level of vibrations acting on the driver.

Approbation

The key design solutions are protected by Ukrainian patents No 64036, No 74313 and No76685

Possible users
Automobile and tractor plants and vehicle-operating companies when upgrading series-produced tractors, buses, and agricultural machines with the aim to improve the driver’s work environment.

Driver seat suspension with self-contained pneumatic vibration protection module (overall view)
Vibration loads acting on the driver versus forcing frequency for seat vibration protection systems with conventional metal springing elements (1) and with proprietary pneumatic vibration protection modules (2).

Embodiments of driver seats with self-contained pneumatic vibration protection modules

Driver seat of Belarus tractors with pneumatic vibration protection module

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