THE 80th ANNIVERSARY OF THE E.O. PATON ELECTRIC WELDING INSTITUTE OF THE NAS OF UKRAINE

Academician E.O. Paton

The Institute of Electric Welding was founded as a member of the All-Ukrainian Academy of Sciences by academician Evgeny O. Paton in 1934 on the facility of electric welding laboratory at the Chair of Engineering Constructions of the AUAS and Electric Welding Committee. Formation and all the further activity of the Electric Welding Institute are associated with the name of the outstanding engineer and scientist. He defined the main scientific trends of the Institute in the field of welding technology and welded structures, which are also urgent nowadays.

E.O. Paton could predict the great progress in the development of technology of electric welding of metals. The convinced confirmation of this scientific prediction is the indisputable fact that welding today is the leading technological process of permanent joining of metallic and non-metallic materials. This was due to the great contribution of the Institute staff during 80 years of its activity.

At the first stage the specialists of the Institute proved the feasibility of manufacture of welded structures, being not inferior to riveted ones as to their strength and reliability and by some characteristics even significantly surpassing them. This served a basis for the further mass application of welding. In the 1930s the conception of arc welding as a metallurgical process was scientifically grounded at the Institute and investigations for its automation were carried out under supervision of E.O. Paton. By 1940 the development of high-efficient process of submerged arc welding was finalized and implementation at plants of the country was started. During the World War II the automatic submerged arc welding conquered the decisive importance. Directly in the tank plant shops in the Urals the Institute specialists developed and implemented the technology of automatic welding of armored steel, which made it possible to create the production line for manufacture of welded bodies of tanks T-34 and to mechanize the welding of other military machinery.

Academician B.E. Paton

Pre-war and war stages in the Institute activity were the period of establishment of scientific school, the convinced authority of which was confirmed by awarding the Institute with name of Evgeny O. Paton in 1945.

The solution of main problem, i.e. improvement of efficiency and level of mechanization of welding jobs, required the continuous widening of research works at the Institute for searching new methods and techniques of mechanized welding, naturally, without minimizing of works on increasing the rational fields of application of submerged arc welding. Search for feasibility of submerged arc welding of welds located in various spatial positions was finalized by the development under supervision of E.O. Paton of forced formation of weld to start the mechanization of arc welding of welds in vertical plane.

On August 12, 1953 E.O. Paton, the man added a vivid page to the history of national science and technology, died at the 84th year of his life. Since 1953 until now academician Boris E. Paton, his son, is the Director of the Institute.

One of the most significant achievements of the Institute at the beginning of the 1950s became the development of new technology of fusion melting of thick metal, namely an electroslag welding, which changed radically the technology of manufacture of heavy frameworks, boilers, hydraulic units and other unique rolled-welded and cast-welded structures. Its application allowed producing the high-quality welded joints within the wide range of thicknesses.

Later, the CO_2 welding method with thin wire was developed, finding the wide spreading in industry and providing the significant growth in level of mechanization of welding jobs. The further development of gas electric consumable electrode welding became the development of process and equipment for pulsed-arc welding, welding in mixtures of active and inert gases.

At the end of the 1950s the investigations in the field of electron beam welding actively started at the Institute. The efforts of scientists were directed to investigation of physical-metallurgical processes under the action of powerful (up to 100 kW) sharply-focused beam of electrons to thick-sheet (150–200 mm) structural materials. The problem of a particular importance and successfully solved by the Institute concerned the development of technology of closing the circular welds to prevent the root defects in the form of cavities, pores and discontinuities. Over the recent 10 years more than 60 sets of different types of equipment for EBW, including the installations with a volume of vacuum chambers of up to 100 m^3, were put into industrial operation.

The next stage in development of the beam technology was its application for welding and cutting by a laser. The systematic investigations are carried out in the field of pulsed and continuous laser welding. During recent years the specialists of the Institute have developed the hybrid laser–arc and laser–plasma sources of heating.

Investigations were progressing on all the main trends of pressure welding, such as flash-butt welding and resistance welding, spot welding, friction and diffusion welding.

Physical and technological peculiarities of new technological processes of flash-butt welding were studied, the systems of automatic control and diagnostics of quality of joints were developed. On the basis of new technologies the manufacture of several generations of specialized and universal machines for flash-butt welding of a large assortment of parts of cross-section area of up to 200,000 mm^2 of low-alloy and high-strength steels, as well as of aluminium, titanium, chromium and copper alloys, was organized and mastered. Machines for welding of rails of various categories under field and stationary conditions, serially manufactured at Kakhovka Plant of Electric Welding Equipment, machines for welding of pipes of diameter from 150 up to 1420 mm in construction of main pipelines, installations for welding of elements of aerospace engineering structures found the widest spreading. Equipment for flash-butt welding of rails is exported to many countries of the world.

Over many years the Institute carries out investigations on space welding. In 1969, V. Kubasov, the pilot-cosmonaut, performed the first in the world unique experiment on the board of spaceship «Soyuz-6» for welding by electron beam, plasma and consumable electrode in the unit «Vulkan», designed and manufactured at the PWI. Thus, the beginning of the space technology was started, having the great importance in the program of space exploration. In 1984 the extremely important experiment, prepared by the PWI, was carried out on the board of orbital station in open space. Cosmonauts S. Savitskaya and V. Dzhanibekov performed for the first time welding, brazing, cutting and spraying in open space by using the hand electron beam tool.

In parallel, such a complex problem was solved at the Institute as mechanization of underwater arc welding, which acquired a great importance in exploration of the World ocean shelf. Specialists of the Institute designed the equipment for mechanized arc welding and cutting by a special flux-cored wire at depths of up to 200 m.

The intensive growth of the advanced engineering is accompanied by a continuous widening of assortment of structural metals and alloys for welded structures. During investigations for study of processes proceeding in the weld the new welding consumables were developed: electrodes, metal and flux-cored wires, fluxes and gas mixtures.

Investigations and research works in the field of strength of welded joints and structures are

the traditional directions in the Institute research area, started by E.O. Paton. Today, these investigations are of an integrated nature, making it possible to develop the new effective methods of improvement of reliability of critical engineering structures at static and cyclic loading. The problem of manufacture of reliable welded structures covers also the problems of selection of materials, rational design solutions, technologies of manufacture and erection, reduction of metal intensity, which are solved successfully by the Institute in collaboration with many industrial organizations and enterprises. During recently, the intensive works are carried out for improvement of reliability, durability and service life of welded structures, as well as development of effective methods of their diagnostics.

At the present time the systems of continuous monitoring, developed at the Institute, are successfully operated at a number of petrochemical enterprises with use of Internet system of communication. This allows developing the monitoring and controlling systems, which give the opportunity to observe the state of structure from a common specialized diagnostic center independently of its location site.

Since the 1950s by the initiative of academician Boris E. Paton the searching investigations and experimental developments were started for revealing the feasibility of applying the welding sources of heating for producing metals and alloys of ultra-high quality and reliability, on the basis of which one more basic scientific direction in the Institute activity was formed — a special electrometallurgy. Efforts and successes of the Institute team in this new field provided the noticeable progress in the development of the advanced quality metallurgy.

The new electrometallurgical processes include, first of all, the electroslag remelting of consumable electrode into a water-cooled mould. Fundamental studies of the electroslag process, its physical-chemical, metallurgical and electrotechnical features provided the advanced positions of the Institute in the development and application of electroslag technology, including remelting, surfacing, casting, hot topping, etc.

During recent years, a complex of research works was carried out at the Institute, serving as a base for the development of new generation of electroslag technologies, based on producing ingots and billets directly from molten metal without remelting of consumable electrodes. These technologies are patented in Ukraine and abroad and realized in industry. In particular, a unique complex for production of bimetal mill rolls was manufactured at Novo-Kramatorsk Machine-Building Works on the basis of these technologies.

Two more electrometallurgical technologies were developed at the Institute: plasma-arc and electron beam. Development of technique and technology of these remelting processes was carried out in parallel with fundamental investigations of physical-metallurgical peculiarities of refining in controllable atmosphere or vacuum and processes of crystallization of steels, complexly-alloyed alloys, non-ferrous and refractory metals.

Due to systematic investigations of high-temperature gas-metal systems the plasma-arc remelting opened up the wide opportunities for production of the new class of structural materials, namely the high-nitrogen steels. Design of powerful plasmatrons for metallurgy allowed the Institute «to enter» the great metallurgy: new designs of units of ladle–furnace type of up to 100 t capacity were developed. The quality of metal, produced in these units, is not inferior to electroslag one.

Using the joint efforts of the Institute scientists, industry research institutes and manufacturers the advanced electron beam equipment was designed, and the technology of electron beam remelting in vacuum became indispensible process for producing the ultra-quality materials in metallurgy and machine building. The works in this direction are concentrated at the RE Center «Titan», established at the Institute.

Investigations of process of evaporation in vacuum of metallic and non-metallic materials and their subsequent condensation as a basis for vapor-phase metallurgy opened up the feasibility of producing coatings of different materials, including heat-resistant, refractory and composite ones with regulation of composition, structure and properties of deposited layers. Thickness of deposited layers is regulated, depending on purpose, from tens of micrometers up to several millimeters.

At the beginning of the 1980s the new scientific direction was formed at the Institute, dealing with the development of new processes and improvement of existing processes of thermal spraying of protective and wear-resistant coatings. At present, the Institute is developing almost all the advanced processes of spraying of protective and strengthening coatings. Technology and equipment have been developed for plasma-arc spraying of wear-resistant coatings, as well as installations for detonation spraying, which can operate with applying different working gases (acetylene, propane, hydrogen).

Result of investigations and developments in the field of building welded structures, made by

the PWI scientists, became the building of famous constructions, among them, first of all, the unique all-welded bridge, named after E.O. Paton, across the Dnieper river. Principles, approaches and design-technological solutions, used in its designing and construction, gave the way to a wide application of welding in bridge construction. This bridge was recognized by the American Welding Society as the outstanding welded structure of the XX century. The experience in construction of E.O. Paton bridge was used in construction of bridges across the Dnieper river in Kiev (Yuzhny, Moskovsky, Gavansky, Podolsko-Voskresensky, road and railway bridges) and bridges in Dnepropetrovsk and Zaporozhie, as well as bridge across the Smotrich river in Kamenetsk-Podolsk. In collaboration with Research Institute «Ukrproektstalkonstruktsiya» the projects and technologies of construction have been worked out, which were realized successfully in construction of unique TV towers in Kiev, St.-Petersburg, Erevan, Tbilisi, Vitebsk, Kharkov. Technologies of welding, developed at the PWI, were applied successfully in construction of huge monument «Motherland», as well as in construction of objects of Euro-2012 in Kiev.

Over the recent years the great attention is paid to the realization of achievements of advanced science and technology in practical medicine. In the 1990s B.E. Paton gave an idea to apply welding for joining of live tissues and organized a creative team of scientists of the PWI, A.A. Shalimov Institute of Surgery and Transplantation, Central Hospital of Security Services of Ukraine and other medical institutions. This cooperation allowed developing the new method of joining (welding) of soft live tissues. At the PWI the advanced equipment of several generations for welding of live tissues has been designed and manufactured already in industry. Method of electric welding of live tissues is applied in more than 50 clinics of Ukraine. Since 2001 more than 100,000 surgical operations of different profiles were made and more than 130 new surgical procedures have been developed and used in practice.

Owing to the combination of purposeful fundamental theoretical investigations with engineering-applied developments, close creative relations with industrial enterprises in realization of technological innovations the Institute transformed for the past 80 years of its activity into the largest center in the field welding and related technologies in the country and world.

Today, the PWI staff is 1560 persons. The scientific potential of the Institute is 440 scientists, among which 8 academicians and 4 corresponding members of the NAS of Ukraine, 72 Dr. of Techn, Sci. and more than 200 Candidates of Techn. Sci.

Results of works of the Institute are confirmed by licensees and received patents, more than 150 licensees have been sold to the USA, Germany, Japan, Russia, Sweden, France, China, etc. About 2600 patents of Ukraine and near and far foreign countries, as well as more than 6500 Author's Certificates were received.

For the years of the PWI activity more than 60 most outstanding developments, fulfilled and implemented in national economy by the Institute specialists in collaboration with industrial teams, were awarded by the Lenin and State Prizes, and also by various Prizes of Ukraine.

The Institute supports international relations with leading welding centers in Europe, USA, Asia and is the member of the International Institute of Welding and European Federation of Welding.

Results of investigations of scientists of the Institute are published in journals «Avtomaticheskaya Svarka», «Tekhnicheskaya Diagnostika i Nerazrushayushchy Kontrol», «Sovremennaya Elektrometallurgiya», «The Paton Welding Journal», which have a wide reading audience. Monographs, subject collections, proceedings of the conferences, handbooks and other book products are also published at the Institute. Specialized councils are working at the PWI for defending the theses for degrees of Dr. or Candidate of Techn. Sci. The associates of the Institute defended more than 139 theses for Dr. of Techn. Sci. and about 720 theses for Candidate of Techn. Sci. The Institute organizes different conferences, seminars, exhibitions and takes part in the national and international exhibitions.

Due to implementation of the PWI developments in industry, the production of welding consumables and equipment has been created in Ukraine, that allows recognizing the welding as one of the few branches of economy having a stable positive foreign trade balance.

Over 80 years the Institute team has passed a glorious path. Today, this is a team of confederates, increasing the achievements of the Paton scientific school, which has the world recognition. All the activity is directed for the further progress of welding and related processes, as well for the solution of basic problems of industrial production.

The 55th Anniversary of the Experimental Design Technological Bureau of the E.O. Paton Electric Welding Institute

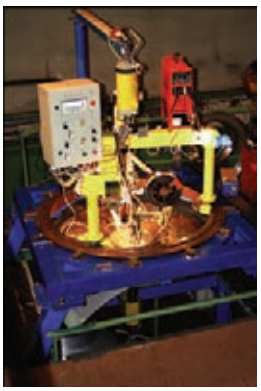
In May, 1959 the Experimental Design Bureau (currently the State Enterprise «The Experimental Design Technological Bureau of the E.O. Paton Electric Welding Institute» — PWI EDTB) was founded with the purpose of development of new welding equipment and technologies, design-technological provision of research works and acceleration of implementation of scientific and technical developments into the national economy. EDTB was founded on the basis of developments of the design department of the Institute in prewar, further war and postwar times. The principle «laboratory–design bureau–pilot production» established by Evgeny O. Paton during foundation of the Institute, was fully realized. This close relation with practice, production, readiness to solve any tasks, put forward by the national economy, allowed EDTB to participate efficiently in creation of reliable welded structures and implementation of mechanized and automated welding processes.

Within close cooperation with the PWI scientists and specialists, branch institutes and other leading enterprises during 55 years EDTB has been designing equipment for different mechanized welding methods, testing of equipment and technology of welding, implementing the completed research developments of the Institute into industry. The main attention is paid to the complex mechanization of welding production, creation of highly-efficient machines and automated production lines.

The welding machines, developed by the EDTB designers and produced in tens of thousands by many plants, were used in such branches as construction, machine and ship building, production of pipes for main pipelines, nuclear power engineering, etc.

In different periods five Doctors and more than forty Candidates of Techn. Sci. were working at EDTB. Twenty six works, in which together with the scientists of the Institute the EDTB colleagues were participating, were awarded with two Lenin Prizes, eight USSR State Prizes, nine Prizes of the Council of Ministers of the USSR and six Prizes of the Council of Ministers of the Ukrainian SSR. 29 specialists of EDTB have a title of laureates of these prizes. Many colleagues of the EDTB were also awarded with other state prizes.

EDTB during its 55 years of activity was headed by the following members: Dr. P.I. Sevbo, a team-mate of E.O. Paton; Profs A.I. Chvertko, V.F. Moshkin, as well as S.I. Pritula and V.S. Romanyuk. During many years Dr. Vladimir E. Paton talented designer, worked as the chief of the department and later as the



EDTB Deputy Chief. At the present time EDTB is headed by G.V. Zhuk.

EDTB carries out works on the following main directions:

- technology and equipment for arc and resistance welding;
- materials, technology and equipment for mechanized surfacing and thermal spraying of wear-resistant materials;
- mechanization and automation of assembly-welding works;
- technology and equipment for welding in building and bridge construction;
- development and manufacture of automated systems for ultrasonic and eddy-current control;
- working out of design documentation and manufacture of non-standard equipment for welding production;
- complex mechanization and auxiliary equipment;
- development and manufacture of control systems for welding and surfacing equipment.

Today the welding equipment, created by the EDTB designers and technologists, is operating in on-land and underground conditions, in space and under water. This equipment is used to perform most of the technologies in welding, surfacing and spraying of different steels, cast iron, nonferrous metals, which are known to the modern science.

In close cooperation with the PWI research departments and PWI Pilot Plant of Welding Equipment, the EDTB designers and technologists in the period of 2000–2013 designed, manufactured and implemented the equipment for welding and surfacing of wide range of metals and alloys. These works were performed on the orders of enterprises and organizations of Ukraine, the countries of near and far abroad and also order of the NAS of Ukraine and «Gosinformnauka».

EDTB during many years has been closely cooperating with many educational establishments of Ukraine, including NTTU «Kiev Polytechnic Institute». The EDTB specialists deliver lectures on welding equipment, conduct practical classes, supervise industrial and pre-graduation practice of students, head the State examination boards on defense of diploma projects.

In most cases in welding equipment, designed by EDTB, the modern design and technological solutions are applied, which allowed authors to receive hundreds of author certificates, dozens of patents and awards for the participation in national and international exhibitions. The EDTB specialists published the results of their work in hundreds of information letters and articles in the journal «Avtomaticheskaya Svarka» and other leading technical journals and, finally, the catalogue-guidebook «Welding equipment» in eleven volumes, created at EDTB, the first volume of which was published in 1968.

From the day of its foundation up to the present time the EDTB staff has always been feeling and still feels the continuous and active support of Prof. Boris E. Paton, Director of the Institute, the President of the National Academy of Sciences of Ukraine, who made great contribution to the foundation of EDTB, its formation and development.

Today EDTB is a mobile friendly team, where immense experience of veterans gained during decades, maturity of high-skilled specialists of middle-aged generation and thirst for knowledge of talented youth are closely combined.

G.V. Zhuk, PWI EDTB

Paton Turbine Technologies — new name of a well-known company

History of emergence of Paton Turbine Technologies Company, which before April 2014 operated under the name of Pratt&Whitney-Paton, dates back to the beginning of 1993. This is exactly when the E.O. Paton Electric Welding Institute (PWI) of the NAS of Ukraine and Pratt&Whitney — Division of United Technologies Corporation (UTC), USA, one of the leading world manufacturers of aircraft engines, signed an Agreement on establishing in Kiev a joint venture, which has been successfully operating for more than 20 years in the world market.

This resulted in formation of a modern high-technology company, involved both in deposition of protective coatings on blades for aviation and industrial gas turbines, and manufacturing of commercial EB-PVD equipment, evaporation materials, as well as repair of blades and other parts of various purpose turbines.

Intensive activities of the staff, as well as long-term joint work with our US partners allowed the company reaching world-class level of production, which has been evaluated as «Silver» in ACE system of UTC competitiveness assessment that is a quite high mark.

With support and very direct involvement of Pratt&Whitney, the JV has been certified to all the necessary international standards, that allowed it to successfully operate in the world markets of aviation and power gas turbine construction.

Company customers include such well-known names as Pratt&Whitney (USA), Siemens (Sweden), Honeywell (USA), Rolls Royce (UK), Turbine Overhaul Services (Singapore), Kawasaki Heavy Industries (Japan), Permsksie Motory (Russia), Mayer Tools (USA), Glen Group (USA) etc., as well as Ukrainian enterprises operating in the field of gas turbine construction, aircraft repair and gas transportation.

In March, 2014 United Technologies Corporation, one of the founders, left Pratt&Whitney-Paton JV, in connection with global change of its business strategy, which was followed by the

Protective coating shop

Paton Turbine Technologies Certificates ISO 9001:2008 and AS 9100C-JISQ 9100:2009

Company changing its name to Paton Turbine Technologies (PTT). Company sphere of activity, standards and management system, including quality management system, and customers, remained the same.

Quality management system (QMS) is based on the requirements of international general technical standard ISO 9001, as well as international aerospace standard AS9100, which is harmonized with EN 9100 and JIS Q 9100 standards. The Company is certified as overseas repair station for compliance with US Federal Aviation Regulations CFR FAR145. Availability of such a certificate allows performance of work on maintenance of aviation equipment, registered in the USA. Starting from 2006 the Company takes part in the US National Program on accreditation and qualification of processes in the defense and aerospace industries — Nadcap. In July 2014, PTT successfully passed the regular audit on this Program, that once more confirmed the high international technical level of organization of production in the Company.

Company personnel are highly-qualified workers, engineers, researchers and office workers, who continuously improve their skills and performance through various courses and training programs. Program of personnel training in keep-

Designed and manufactured at Pratt&Whitney-Paton EB unit for deposition of protective coatings on aircraft gas turbine blades at customer facility

ing with the requirements of US Federal Aviation Agency has been introduced and is running in the Company.

PTT now manufactures products and provides services with optimum price-quality ratio in the following business segments:

- EB deposition of metal and ceramic coatings on blades of various-purpose gas turbines;
- design, manufacture and servicing of EB equipment for coating deposition;
- production of consumable materials (ceramic and metal ingots) for deposition of EB coatings;
- comprehensive reconditioning of gas turbine engine components with application of classical (welding, brazing, microplasma) and original (EB PVD) repair technologies;
- engineering of processes, materials and equipment.

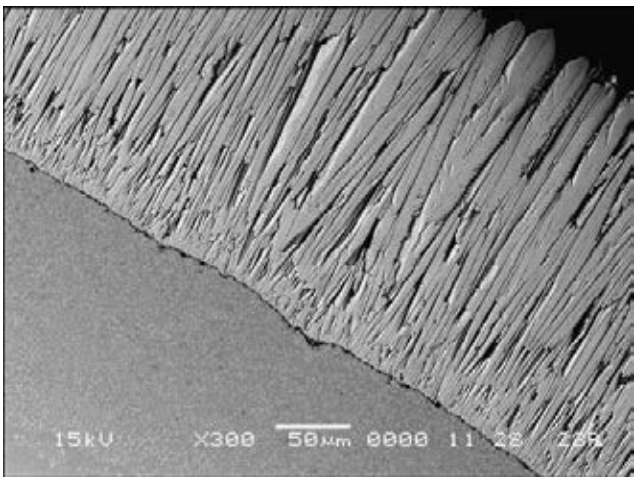
Thermal barrier coatings of up to 200 μm thickness proposed to customers by PTT are applied by EB PVD of ceramic ingots, mainly of zirconium dioxide. Coatings have columnar structure with specified thickness distribution over the cross-section, that ensures excellent performance of coatings on turbine parts exposed to both mechanical and temperature cyclic loads.

It should be noted that achieving the specified distribution of coating thickness on turbine blades is a complex engineering problem that is successfully solved due to many years of experience of our staff.

The Company developed technology of deposition of coatings based also on other oxides that appears to be promising for protection of aircraft turbine parts with increased working temperatures.

Application of protective ceramic coating requires presence of a bond coat on the part surface that ensures both adhesion of thermal barrier ceramic layer to part surface, and its protection from the impact of turbine aggressive working environment. Technologies developed in the Company (surface preparation, heat treatment, EB deposition, etc.) allow deposition of both only the ceramic coating on parts, which already have a bond coat, and of two-layer coating (metal + ceramic). The most wide-spread combinations are bond coat from nickel aluminide (or platinum), as well as nickel, cobalt and chromium alloys, doped by aluminium and yttrium (MCrAlY). Deposition of purely metal protective coatings of various composition is also performed.

Procedures of deposition of structural coatings, for instance from titanium alloys, to restore the shape of worn fan blades have been mastered.



Typical microstructure of thermal barrier coating

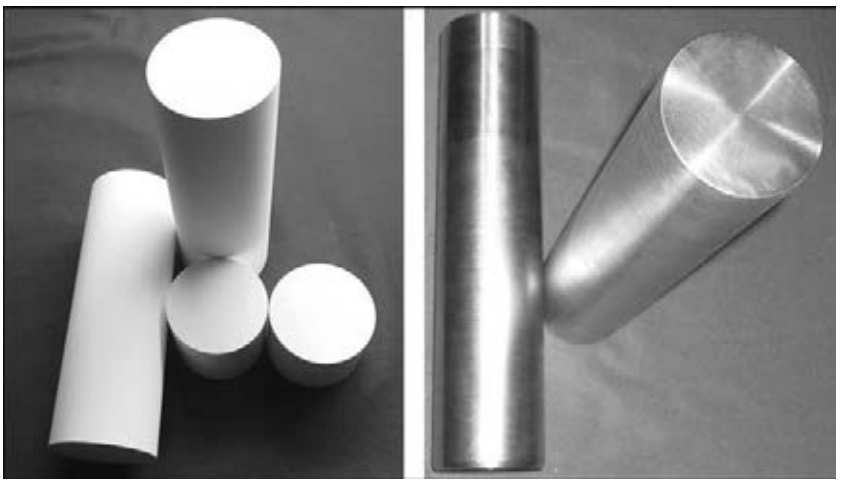
In this case, EB PVD technology with ionization of evaporation metal can be applied that allows an abrupt increase of coating adhesion to the base of the parts being reconditioned.

Over many years of working in the market, the Company has acquired experience of coating deposition on parts of various types of gas turbines, including their aircraft, land and navy variants. Here are some of them: PW4000, JT9D-7Q, JT9D-7R4, PW4090, CF6-80C2, G61, CFM56-5B, CFM56-7B, GTX100, PS90A, PS90GP, V84.3A2, V94.3A2, etc.

PTT Company can rightfully be regarded as one of the reliable producers of world-class commercial EB PVD equipment for deposition of ceramic and metal coatings. Our equipment is running successfully in the US and Singapore. We provide servicing of our equipment and supply spares and consumables.

As was noted above, PTT produces high-quality ceramic and metal ingots, which are both used

Commercial gas turbine blade with thermal barrier coating



Ceramic (*left*) and metal (*right*) ingots

in its own production, and are supplied to customers as a separate product.

Ceramic ingots are made by special methods of compacting oxide powders of the required composition with subsequent high-temperature sintering. The most widely accepted type of materials is zirconium dioxide, partially stabilized by yttrium oxide (ZrO_2–6–8 % Y_2O_3). Manufacturing technology ensures ingot density on the level of 3.6–4.2 g/cm^3.

Metal ingots are made by vacuum-induction melting with double EB remelting that provides high quality of billets for subsequent evaporation in vacuum. Ingot manufacturing to customer specification is possible.

The Company has been developing technology and performing repair of components of aircraft and land gas turbine engines stating from 2001. Many years of practical experience of operation and high professional level of personnel, application of high technologies and unique specialized equipment, high quality standards and efficient management system allow the Company to satisfy customer requirements to the maximum both in terms of quality, and in terms of economic efficiency (terms, volume, price). Nowadays customers are offered a complete range of repair operations, including those with application of EB technology of deposition of high-temperature MeCrAlY and thermal barrier ZrO_2–7 % Y_2O_3 coatings.

Availability of an up-to-date laboratory of metallographic examination, directly integrated into the technological process, equipment and instruments applied for nondestructive and destructive testing, in addition to highly qualified personnel, enables PTT maintaining and developing reliable manufacturing with invariably high product quality. Company laboratory has been certified in the LCS system, applied at UTC, and has confirmed its compliance to the requirements of Nadcap Program.

One can see from the above-said that Paton Turbine Technologies Company is a reliable partner, which successfully operates in Ukraine in compliance with the best world business practices.

Prof. G.S. Marinsky,
Director of PTT Company
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