INSTITUTE OF TITANIUM — 70 YEARS. HISTORY, PRESENT DAY, AND DEVELOPMENT PROSPECTS

Joint-Stock Company "Institute of Titanium" (JSC "Institute of Titanium") is the only comprehensive institution of its kind in Europe, comprising a research division (Research Institute of Titanium, NDITitan) and a design division (TITANProject), the Zaporizhzhia Metallurgical Pilot Plant, and the Centre for Certification Testing and Metrological Support of Analytical Control for Non-Ferrous Metallurgy Productions in Ukraine. This structure ensures a comprehensive approach to project execution — from the development of cutting-edge technical solutions to the mastering and implementation of highly efficient technologies and equipment on a turnkey basis; addressing complex production challenges, including environmental issues, and manufacturing of world-class products.

JSC "Institute of Titanium" is a nationally and internationally recognised centre of excellence in the development and industrial implementation of solutions for the production of titanium and magnesium, titanium alloys, powders of titanium, zirconium and intermetallic powder compositions — including those suitable for the manufacture of parts by additive manufacturing methods — as well as for the production of rare and rare-earth metals (gallium, germanium, zirconium, hafnium, vanadium, tantalum, niobium, and others).

The majority of research works performed, and technologies, and technological processes developed by our Institute have been implemented in production or are being prepared for implementation.

Using its own technological developments, JSC "Institute of Titanium" undertakes design work and production commissioning in various countries worldwide. Industrial enterprises have been built and are operating successfully on the basis of the developed technologies.

HISTORICAL BACKGROUND. ACHIEVEMENTS. SCIENTIFIC SCHOOLS

On 7 August 1956, a branch of the State Special Design Institute (SSDI) was established in Zaporizhzhia, tasked with providing design and engineering documentation for the first facility of the Soviet titanium industry — the Dnipro Titanium-Magnesium Plant.

This date became the founding day of JSC "Institute of Titanium".

In 1958, the branch was reorganised into the Ukrainian Design Institute of Non-Ferrous Metallurgy "Ukrdniprokolormet".

While carrying out the primary work on the development of titanium production in Zaporizhzhia, the Institute also conducted general design activities for other non-ferrous metallurgy facilities in Ukraine.

By the early 1960s, a creative team of designers and researchers had formed, the Institute's material and technical base was strengthened, and a research division was established within its structure. Laboratory studies were conducted to improve the production of titanium, aluminium, organosilicon compounds, and refractories; new analytical methods were developed; and physicochemical research was carried out.

During the 1960s and 1980s, a number of large-scale projects and engineering developments were completed for the Zaporizhzhia Titanium-Magnesium Combine. Research activities were broadly expanded to include the development of closed-type submerged arc furnaces and the technology for smelting titanium slags in them, the creation of high-productivity chlorinators, efficient condensation systems, and large-capacity reduction and separation units for sponge titanium production. A comprehensive body of work was also carried out to improve the quality of sponge titanium.

An enormous volume of work on the design of enterprises, development of equipment for scientific research, and mastering of the technology and equipment was carried out by JSC "Institute of Titanium" during the construction and reconstruction of all three titanium-magnesium plants of the former USSR — those in Zaporizhzhia, Berezniki, and Ust-Kamenogorsk. In 1965, the Institute was designated the leading sectoral institute for the titanium-magnesium industry and renamed the All-Union Research and Design Institute of Titanium.

The 1970s and 1980s were also characterised by a continuous growth in the volume and quality of research work performed, and by the strengthening of creative collaboration with specialists from industrial enterprises and co-executing institutes. At the Zaporizhzhia Titanium-Magnesium Combine, particular mention should be made of the large and highly significant body of work carried out during this period on the design and establishment of semiconductor complex productions of germanium and especially high-purity silicon. Simultaneously, important work was carried out at other industrial enterprises: the Solikamsk Magnesium Plant, the Transcarpathian Research Plant, the Dnipro Aluminium Plant, the Kalush

Magnesium Plant, the Dnipro Electrode Plant, Vuhlekompozyt, Kremniypolimer, and others.

Within a short period, through the combined efforts of researchers, designers, and production specialists, powerful high-efficiency units were created and full reconstruction was carried out at all enterprises.

The significant contribution of JSC "Institute of Titanium" to the development of non-ferrous metallurgy in the USSR was recognised in 1972 by the USSR State Prize (awarded collectively).

A special focus of the Institute's work was the search for areas of rational application of titanium and its alloys in civilian industries. One of the most important and promising areas pursued by the Institute was the development of technology for producing titanium powders. The theoretical foundations of powder production by electrolysis were developed, and pilot-scale electrolysers were created. The collective's efforts resulted in the development of technology and equipment for the production of powders and powder-derived products, which was mastered at the pilot workshop of the Zaporizhzhia Titanium-Magnesium Combine and subsequently at the Zaporizhzhia Metallurgical Pilot Plant of the Institute of Titanium (ZMPP). This technology was also implemented at the Transcarpathian Research Plant of the Institute of Titanium.

In 1993, the Institute was designated the leading organisation for carrying out research and engineering work and designing enterprises of the non-ferrous metallurgy of Ukraine. This necessitated restructuring of operations, identification of new major clients, and securing reliable funding for the ongoing work. Under these conditions, the decision was made to direct primary efforts towards expanding international contracts and identifying and contracting new clients abroad.

At this time, the conclusion of a major contract for the design and construction of a magnesium plant in Israel (city of Sdom, on the shore of the Dead Sea) played an enormous role in ensuring the continued existence and development of the Institute. As a result of this contract, a plant incorporating the most advanced technical solutions for electrolytic magnesium production by a continuous process was built, and its designed capacities were rapidly achieved and exceeded.

This work enabled the Institute to retain its core specialists, acquire the necessary experience of executing projects for foreign facilities, equip the Institute divisions with modern computing and other equipment, and transition to computer-aided design. In subsequent years, JSC "Institute of Titanium" actively developed international cooperation. Its business partners have included the People's Republic of China, India, Australia, Egypt, Brazil, Israel, Canada, and other countries.

Of particular note is the work performed for the People's Republic of China. For example, in recent years, more than 40 industrial facilities have been realised in China, which were designed, tested, and commissioned in the following areas: production of titanium slags, titanium tetrachloride, sponge titanium, magnesium and magnesium alloys, desulphurisation of pig iron using granulated magnesium, and production of stainless steel by the argon-oxygen decarburisation (AOD) method.

Simultaneously, a large volume of research and design work was carried out in Ukraine. First and foremost, mention should be made of work on the restoration and development of Ukraine's titanium industry. In 1993–1994, jointly with specialists of the E.O. Paton Electric Welding Institute of the National Academy of Sciences of Ukraine, the Zaporizhzhia Titanium-Magnesium Combine, and other organisations, the State Programme for the Development of Ukraine's Titanium Industry was developed and approved. Within the framework of this Programme, a major body of work was carried out, most notably including the restoration in 1998 of sponge titanium production at the Zaporizhzhia Titanium-Magnesium Combine.

In 2005, the contribution of JSC "Institute of Titanium" to the development of the domestic titanium sector was recognised by the State Prize of Ukraine in Science and Technology (awarded collectively).

Dozens of specialists have defended doctoral and candidate dissertations. Scientists and specialists of the Institute have authored and published dozens of books, hundreds of scientific papers, and have obtained hundreds of authors' certificates and patents. A large group of employees has been awarded orders, medals, and other state honours.

The following scientific schools were established and successfully developed at JSC "Institute of Titanium":

- Processing of titanium-bearing raw materials and production of titanium slags, led by Cand. of Tech. Sci. Degree V.P. Pechonkin;
- Production of sponge titanium by the metallothermic reduction method, led by Cand. of Tech. Sci. Degree, Corresponding Member A.M. Petrunko and Cand. of Tech. Sci. Degree A.Ye. Andreyev;
- Production of electrolytic magnesium, led by Dr. of Tech. Sci. Degree V.M. Devyatkin;
- Electrolysis of titanium and production of titanium powders, led by Cand. of Tech. Sci. Degree V.M. Anokhin.

PRESENT DAY

At present, despite the difficulties that our Institute is experiencing — similar to many research and design organisations — JSC "Institute of Titanium" remains a powerful organisation capable of resolving many complex and challenging tasks in the development of technological processes and the design of industrial enterprises.

For domestic enterprises, JSC "Institute of Titanium" has carried out and continues to carry out a comprehensive range of work in the fields of scientific research, design, pilot-industrial testing, raw material testing, metrology, analytical control, standardisation and certification of products, and the full spectrum of environmental activities. Our domestic partners include: LLC "Zaporizhzhia Titanium-Magnesium Plant", LLC "Mykolaiv Alumina Plant", OJSC "Zaporizhzhia Aluminium Plant", LLC "Pobuzhzhia Ferronickel Plant", PJSC "Zaporizhstal", the branches "Vilnohirsk Mining and Metallurgical Plant" and "Irshansk Ore Processing Plant", PJSC "Ukrhrafite", PJSC "Poltava Mining and Metallurgical Plant", OJSC "Ukrtsink", OJSC "Zaporizhkoks", LLC "Valky-Ilmenit", LLC "Mezhrichensky Ore Processing Plant", OJSC "Zaporizhabraziv", and many others.

JSC "Institute of Titanium" possesses significant developments and substantial capabilities for their realisation, based on existing international cooperation experience, as confirmed by completed and active contracts for the development and improvement of technologies and equipment, and the provision of engineering services to foreign countries. Our foreign partners are companies from countries including the USA, Canada, the People's Republic of China, Kazakhstan, India, the Republic of Korea, Vietnam, Israel, Egypt, Austria, Poland, Australia, Indonesia, Guatemala, the Republic of South Africa, Mozambique, and others.

Over the past 5 years:

- 2 projects on improving the technology for producing sponge zirconium were completed within the framework of the Targeted Research Programme of the National Academy of Sciences of Ukraine "Scientific and Technical Support for the Development of Nuclear Power and the Use of Radiation Technologies in Economic Sectors";
- Productions built using the technologies and designs of JSC "Institute of Titanium" were commissioned in China, India, and Vietnam;
- Major contracts with foreign clients were executed;
- Technology transfer for the organisation and operation of production lines for the industrial production of pigment titanium dioxide by the sulphate process (Song Binh Minerals Joint Stock Company, Vietnam);
- Execution of design works and provision of technical services for the reconstruction of a titanium slag production section (Saraf Agencies Pvt. Ltd., India);
- Establishment of steel production using the argon-oxygen decarburisation (AOD) method in a 20-tonne converter (Kashi Vishwanath Steels Pvt. Ltd, India);
- Supply of technology and equipment for the desulphurisation of liquid pig iron using granulated (granular) magnesium in 32-tonne blast furnace ladles (GoodRich MAGMA Industrial Technologies Limited, India);
- Laboratory testing of a titanium-silicon concentrate (SMS group Process Technologies GmbH, Austria);
- Design work and provision of technical services under a titanium slag production project (IRENA GROUP INVESTOR SP ZOO, Poland);
- A comprehensive set of works on the modernisation of titanium slag, sponge titanium, and reducing magnesium production at JSC "UKTMK", Kazakhstan;
- Development of technology and pilot equipment for the production of silicon tetrachloride by the chlorination of metallurgical silicon (PCC SE, Germany);
- Development of technology for the production of silicon nanopowder from silicon tetrachloride feedstock, adapted to the plasma-chemical synthesis process (PCC SE, Germany);
- Design works for the establishment of a gallium production section (JSC "Aluminium of Kazakhstan", Kazakhstan).

Using internal resources, exploratory research is being conducted with the aim of developing new, modern, and highly efficient technologies for obtaining commercially tradeable products that are in high demand on the global market; negotiations are being held and technical and commercial proposals are being submitted to leading metallurgical companies worldwide.

PROSPECTS FOR DEVELOPMENT AND INNOVATION

The most promising research directions of JSC "Institute of Titanium" are as follows:

- Production of titanium and titanium alloy products, titanium hydride, titanium powders, zirconium and intermetallic powder compositions, including those suitable for the manufacture of parts by additive manufacturing methods;

- Production of rare and rare-earth metals (gallium, germanium, zirconium, hafnium, vanadium, tantalum, and niobium).

JSC "Institute of Titanium" currently offers the following modern, high-efficiency innovative technologies for implementation:

- Technology for the production of low-cost titanium powders by the hydrogenation-dehydrogenation method from sponge titanium or other titanium-bearing materials of various grades and particle size distributions;
- Resource-saving comprehensive technology for the production of alloyed sponge titanium for the manufacture of titanium alloys and alloyed metal-powder compositions, including for 3D technologies, based on titanium powders;
- Technology for the production of sponge zirconium by the metallothermic reduction method;
- Technology for the production of sponge hafnium by the metallothermic reduction method;
- Technology for the production of gallium from aluminium-bearing solutions;
- Technology for the production of vanadium from chloride wastes;
- Technology for the extraction of germanium from various types of germanium-bearing raw materials, including scrap from various electronic devices and fibre-optic communication lines during their processing and disposal, grinding powders, fly ash from thermal power plants, waste from coke chemical productions, and others;
- Technology for the extraction of tantalum and niobium from chloride wastes.
- The scientific and technical activities of JSC "Institute of Titanium" are carried out in the interests of the national security and defence of Ukraine. The implementation of new innovative developments will enable the establishment of production of components for rocket and space technology, aircraft, helicopters, and other sophisticated equipment, thereby enhancing the defence capability and scientific-technical potential of our state.

The substantial scientific potential, innovative technologies, and pioneering projects being implemented by JSC "Institute of Titanium" enable it to keep pace with the times and maintain its leading position in its industrial sector.

Behind everything that JSC "Institute of Titanium" takes pride in today stands the persistent and creative work of hundreds of people. They are the driving force without which the 70th anniversary would have been impossible. Over these years, a great path has been travelled — and it has not always been easy. At the same time, our collective has always been distinguished by shared values, creative activity, the desire to move forward, teamwork and cohesion, high professionalism, careful respect for traditions, and a constant search for new directions of development.

We wish our team breakthrough discoveries, modern and relevant technological solutions, the realisation of bold scientific projects, and high results and achievements!

May the knowledge and experience accumulated over 70 years of activity be transformed into new technologies and projects, and may JSC "Institute of Titanium" remain a centre of innovation and professionalism!

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