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## INTERNATIONAL CONFERENCE «TITANIUM 2018. PRODUCTION AND APPLICATION IN UKRAINE»

International Conference «Titanium 2018. Production and application in Ukraine» was held on June 11–13, 2018 at E.O. Paton Electric Welding Institute of the NAS of Ukraine (Kyiv). It was organized by the National Academy of Sciences of Ukraine, E.O. Paton Electric Welding Institute of the NAS of Ukraine, JSC «Motor Sich», PJSC «Titanium Institute», Zaporozhye National Technical University, International Association «Welding». The Conference was dedicated to 100 anniversary of the National Academy of Sciences of Ukraine. More than 120 people from 40 organizations participated in it. Among them are the famous scientists of a series of academic institutes of Ukraine, namely academicians L.M. Lobanov, G.M. Grigorenko, O.M. Ivasishin, S.A. Firstov, Z.T. Nazarchuk, corresponding-members S.V. Akhonin and V.M. Nesterenkov, professors of educational institutions, heads and leading specialists of state and commercial enterprises.

Foreign specialists from Physical-Technical Institute of the NAS of Belarus, Polish Institute of Welding, Sichuan Henghui New Material, China, Sichuan Technical Exchange Center, China, Sichuan Vanadium & Titanium Industrial Technology Institute, China, Panzhuhua Innovation and Startup S&T Development, China, Panzhuhua Iron and Steel Group, China, Panzhuhua University, China, ASTEC Engineering GmbH, Austria, Astron Ltd., New Zealand participated in the Conference work.

The Conference was opened by Deputy Director of the E.O. Paton Electric Welding Institute Prof. L.M. Lobanov. He noted relevance of the Conference topics, high importance of the achievements of Ukrainian scientists and specialists in this field, thanked nonresident and foreign participants for their coming and wished all fruitful work.

16 presentations were made at the Conference during plenary session. Presentation of Prof. M.O. Ivasishin from G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine «The main tendencies in development of powder metallurgy and titanium 3D technologies» provoked large interest. The main problem of materials science of titanium alloys is de-

velopment of new technological approaches, which would provide decrease of production prime cost of titanium products at retention of unique complex of physicochemical characteristics of these materials. Application of powder technologies in production of titanium alloys and products is an effective method for reduction of their prime cost, increase of competitiveness with other structural materials and, as a result, expanding sphere of practical application of titanium. The presenter told about modern technologies of powder metallurgy of titanium, which provide products with required physicochemical properties being not inferior to properties of the materials received by traditional casting or hot deformation methods. The latest developments in the field of titanium additive manufacturing present the significant interest. They are directed on reduction of production wastes during manufacture of high-quality products for different areas of technique and medicine. Effect of used technological approaches on microstructure, content of impurities, and, as a result, complex of properties of obtained titanium alloys, composites and products of them was discussed in the paper.

Presentation of Prof. S.A. Firstov (I.M. Frantsevich Institute of Problems of Materials Science of the NAS of Ukraine) «Some tendencies in development of new titanium alloys» noted that specific activity in publications dedicated to new titanium-based alloys has two directions, namely high-temperature and heat resistant titanium alloys and titanium alloys of biomedical designation.

Titanium alloys, doped in addition to other «usual» elements (aluminum, tin, zirconium etc.) by boron and silicon as well as intermetallic titanium alloys and titanium alloys strengthened by intermetallics are of interest in the first group.

Based on the affinity of the constitutional diagrams of titanium-silicon and iron-carbon system alloys it is proposed to consider so-called titanium steels and titanium cast irons. Thermomechanical treatment of the first group of alloys containing up to 3 % of silicon allows rising the yield limit to 650 MPa at 700 °C temperature at reaching the strength above 1150 MPa



Presentations of academicians O.M. Ivasishin, S.A. Firstov, corresponding member V.M. Nesterenkov, academician Z.T. Nazarchuk

at room temperature. At that, heat resistance of such alloys significantly exceeds heat resistance of, for example, alloy T16242. In «titanium steels» it is possible in the wide ranges to change the morphology of martensite phases and regulate hardenability varying content of other doping elements.

For «titanium cast irons» it is possible to provide high heat resistance. Yield limit at 800 °C reaches 330 MPa and more. It is possible significantly increasing Young’s modulus to 160 GPa and above. Formation of ternary nanodispersed eutectic structures is of high interest.

In the case with alloys of titanium of biomedical application there is usually a problem of production of alloys with Young’s modulus approaching to Young’s modulus of bone material in order to increase biomechanical compatibility. However, at that reduction of the modulus inevitably involves decrease of strength characteristics.

Therefore, optimizing of strength and elastic characteristics is necessary for specific applications. In order to provide biocompatibility it was proposed to develop the alloys doped with «non-toxic» or even «useful» for human body elements. «Titanium steel» doped with optimum amount of silicon attracts attention in this case the same as with the heat-resistant materials. It is shown that addition of silicon allows dramatically increase biocompatibility of titanium implants in comparison with known alloy VT6 containing «toxic» aluminum and vanadium, and, even, pure titanium.

One of the most important problems is transfer to 3D prototyping that requires solution of the problems



Corresponding Member S.V. Akhonin (in the center) with staff and colleagues

of production of granules with necessary dispersion from new group of alloys.

Presentation of corresponding member of the NAS of Ukraine S.V. Akhonin (E.O. Paton Electric Welding Institute of the NAS of Ukraine) «Development of metallurgy of titanium and alloys on its basis in



Participants from JSC «Motor Sich» during poster session



During the visit to SE SPC «TITAN» of E.O. Paton Electric Welding Institute



At the stand of Zaporozhye Titanium & Magnesium Combine Ukraine» considers the peculiarities of metallurgical production of titanium and titanium semi-finished products in Ukraine.

Titanium is a unique structural material. The alloys based on titanium due to high specific strength have found wide application in aircraft and rocket construction, production of military equipment. Good corrosion resistance of titanium causes its significant application in chemical and power machine building, in manufacture of heat-exchange equipment and marine engineering. Excellent compatibility of titanium with biological tissues determines its application in development of implants.

Ukraine is one of the five countries of the world, which has a complete cycle of titanium production from extraction of titanium-containing ores, their dressing and production of spongy titanium to melting of titanium alloy ingots and production of virtual-



At the stand of PWI publishing house

ly complete spectrum of titanium semi-products , i.e. castings, forged pieces, bars, pipes and wires.

The basic of titanium conversion in Ukraine is technology of electron beam melting with intermediate crucible, which differs by a series of advantages in comparison with traditional method of ingot production by vacuum-arc remelting:

- complete elimination of consumable electrode pressing from a technological cycle, which requires special pressing equipment of large capacity;
- possibility of production of ingots of not only round section, but ingot-slabs of rectangular section used as billets for sheet products manufacture;
- guaranteed removal of refractory nonmetallic inclusions in the intermediate crucible and increase due to this of ingot metal quality;
- production of structurally and chemically homogeneous ingots with equiaxial structure;



Participants of the Conference at the entry to PWI main building

- increase of metal yield due to reduction of amount of remelts (one instead of two-three).

Developed at the E.O. Paton Electric Welding Institute of the NAS of Ukraine technological processes of electron beam melting provides the possibility to receive high-quality ingots of titanium and its alloys with homogeneous defect-free structure. Developed technologies allow reducing prime cost of titanium semi-finished products due to application of cheaper raw material and increase of through metal yield, and, respectively, rising competitiveness and expanding the fields of titanium application in different branches of industry.

Presentation on «EBW of thin-wall corrugated bearing airframes of titanium alloy and evaluation of their fatigue resistance» was made by K.S. Khripko (E.O. Paton Electric Welding Institute of the NAS of Ukraine, Kyiv). It shows economic advantages of EBW application and its technological peculiarities in production of beam structures.

S.P. Panov in his presentation «Titanium smelting in the laboratory disk bottom casting furnace» (Astron Ltd., New Zealand) provided the experimental investigations on development of new technology of production of titanium products or mastering of new compositions of titanium alloys in the furnace with bottom removal of the product of up to 100 kg mass. The tablets of titanium sponge are melted in the furnace using induction heating.

A.V. Ovchinnikov (Zaporozh'ye National Technical University of Ukraine) in presentation «Application of titanium in additive technologies» told about the main methods of product formation by additive technologies method. In his opinion it is possible to organize in Zaporozh'ye region a scientific-production cluster of additive technologies due to presence of production base for raw materials (ZTMC, ZMOZ) as well as research organizations.

Presentation on «Titanium and additive manufacture» was presented by D.V. Kovalchuk (PJSC «SPA Chervona Hvil'ya», Kyiv). It provided analysis of existing technologies of additive manufacture of titanium alloys, corresponding technical, technological and economical problems, was of their solution.

The presentations on the following topics were also made:

- «Conceptual solutions of production cycle in manufacture of parts from titanium alloys using additive technologies» (Yanko T.B., Dotsenko R.B., PJSC «Titanium Institute», PE «ELECTROMASH», Zaporozh'ye);

- «High Speed Friction Welding of Titanium Alloys — Structure and Properties of Joints» (Damian Miara<sup>1</sup>, Jolanta Matusiak<sup>1</sup>, Adam Pietras<sup>1</sup>, Maciej Krystian<sup>2</sup> (<sup>1</sup>Institut Spawalnictwa, Gliwice, Poland, <sup>2</sup>Austrian Institute of Technology, Vienna, Austria);

- «Effect of structure-phase state of titanium alloys on their mechanical properties depending on method and testing speed» (Markovsky P.E., G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine, Kyiv);

- «Complexly-doped alloys based on titanium aluminides  $\gamma$ TiAl/ $\alpha_2$ Ti<sub>3</sub>Al» (Firstov S.A.<sup>1</sup>, Gornaya I.D.<sup>1</sup>, Podrezov Yu.N.<sup>1</sup>, Bondar A.A.<sup>1</sup>, Romanenko P.M.<sup>1</sup>, Goltvyanitsa V.S.<sup>2</sup>, Sheremetiev A.V.<sup>3</sup>, <sup>1</sup>I.M. Frantsevich Institute of Problems of Material Science of the NAS of Ukraine, Kyiv, <sup>2</sup>«Rial» LLC, <sup>3</sup>SE Ivchenko-Progress, Zaporozh'ye);

- «Theoretical description of equilibrium diagrams and phase transformations in titanium alloys of titanium-aluminum system» (Kostin V.A., Grigorenko G.M., Grigorenko S.G., E.O. Paton Electric Welding Institute of the NAS of Ukraine, Kyiv);

- «Peculiarities of production of strip cast billets of VT-1 grade or GRADE 2 of ungraded spongy titanium» (Kalinyuk A.N., Derecha A.Ya., Telin V.V., Kostenko V.I., Ivanov N.M. («Strategiya BM» LLC, Kyiv);

- «Microstructure and properties of multilayer materials based on Ti-6Al-4V alloy produced by powder technology» (Ivasishin O.M.<sup>1</sup>, Markovsky P.E.<sup>1</sup>, Savvakina D.G.<sup>1</sup>, Stachyuk A.A.<sup>1</sup>, Prikhodko S.V.<sup>2</sup>, <sup>1</sup>G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine, Kyiv, <sup>2</sup>Material Science and Engineering department, University of California, Los-Angeles, USA).

45 poster papers were also presented at the Conference. They could be examined before and after the end of plenary papers of the Conference and during the breaks.

Exhibition «Production and welding of titanium» was held during the Conference in scope of PWI exposition. Zaporozh'ye Titanium and Magnesium Combine, PJSC «SPA Chervona Hvil'ya», SE STC «Paton-Armeniya» of E.O. Paton Electric Welding Institute of the NASU, «Vitova» LLC, «Melitek-Ukraine» LLC, «Spektro-Ukraine» LLC participated in it. A unique exposition of art objects from titanium presented by welder-artist Dmitrii Kushniruk was very interesting to Conference participants.

Participants of the Conference have a possibility to familiarize with PWI publishing activity, including

«Avtomaticeskaya Svarka» Journal, «Technical Diagnostics and Non-Destructive Testing», «The Paton Welding Journal» as well as books and collections of papers on welding and titanium production. The fourth issue of «Titanium. Technologies. Equipment» collection of papers (Kyiv: International Association «Welding», 2017, 254 p.) attracted particular interest. The collection includes more than 40 papers published mainly in «Sovremennaya Elektrometallurgiya» (Electrometallurgy Today) Journal and «Paton Welding Journal» for the period of 2014–2016 on electrometallurgy and welding of titanium and its alloys (previous three collections of papers «Titanium. Technologies. Equipment. Production», including the papers from «Sovremennaya Elektrometallurgiya» (Electrometallurgy Today) Journal and «Paton Welding Journal» for 2001–2004, 2005–2010, 2011–2013 are in open access on [www.patonpublishinghouse.com/rus/compilations](http://www.patonpublishinghouse.com/rus/compilations)).

At the end of the plenary paper session the participants of the Conference were invited to a boat trip over the Dnieper River. Discussions and arguments about a new topic of the Conference: Titanium — Metal of Present and Future, took place during the trip. In such informal environment it was possible to put questions to the academicians, directors of the institutes and enterprises, and, that is more important, get answers on them.

On June 13, the participants of the Conference had a tour to SE SPC «Titan» of E.O. Paton Electric Welding Institute. The enterprise is specialized on production of ingots of titanium and its alloys as well as heat-resistant alloys using electron beam remelting. Technology of surface flashing of produced EBM ingots, which replaces further machining of the ingots, was of high interest.

Proceedings of the Conference «Titanium 2018. Production and Application in Ukraine» will be published to the end of September 2018. They can be ordered in editorial board of «The Paton Welding Journal» or get in open access on <http://patonpublishinghouse.com/eng/proceedings> site.

Friendly, hospitable, creative atmosphere of the Conference promoted development of useful discussions, establishing business contacts. The participants of the Conference expressed unanimous approval of the proposal to carry out the Conference on titanium production and application on a constant basis.

The Organizing Committee expresses thanks and gratitude to PJSC «Titanium Institute», PJSC «SPA Chervona Hvilya», SE SPC «Titan» of E.O. Paton Electric Welding Institute and Center of Electron Beam Welding of E.O. Paton Electric Welding Institute for charity support of the Conference «Titanium 2018. Production and Application in Ukraine».

Prof. V.N. Lipodaev