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On the 100th Anniversary of the Department of Electrometallurgy

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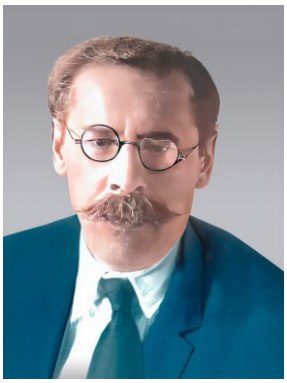
До 100-річчя кафедри електрометалургії

Abstract. *The article reflects the origin and development of the electrometallurgical industry in Ukraine. The emphasis is placed on the role of the Department of Electrometallurgy at the Dnipro Metallurgical Institute in this process. The Department of Electrometallurgy was established in 1925. This was facilitated by the leading role of scientists, professors, doctors of technical sciences Telnyi S. I., Khytryk S. Y., Hasyk M. I., who made a significant contribution to the development of the electrometallurgical industry in Ukraine and the training of highly qualified specialists. In the article, the key stages of formation and development of electrometallurgy have been outlined, and the crucial role of scientists and teachers of the Department has been stated.*
Key words: *electrometallurgy of steel and ferroalloys, abrasive and carbon-containing materials, non-ferrous metallurgy.*

Анотація. *В статті висвітлено походження та розвиток електрометалургійної галузі в Україні. Акцент зроблено на ролі кафедри електрометалургії Дніпровського металургійного інституту в цьому процесі. Кафедра електрометалургії була заснована у 1925 році. Цьому сприяла провідна роль вчених, професорів, докторів технічних наук Тельного С.І., Хитрика С.І., Гасика М.І., які зробили значний внесок у розвиток електрометалургійної промисловості України та підготовку висококваліфікованих фахівців. В статті окреслено ключові етапи становлення та розвитку електрометалургії, а також визначено вирішальну роль вчених і викладачів кафедри.*
Ключові слова: *електрометалургія сталі та феросплавів, абразивні та вуглецевмісні матеріали, кольорова металургія.*



Telnyi S.I.

Khytryk S.Y.

Hasyk M.I.

The Department of Electrometallurgy was organized as part of the Katerynoslav Mining School.

At the opening of the school in 1899, its faculty numbered 13 members. It should be noted that in the early years of the Katerynoslav Higher Mining School there were no departments as such, in the school there were two divisions – Mining and Factory - where the so-called cabinet system of education was implemented [1]. Mykhailo Oleksandrovych Pavlov, a graduate of the St. Petersburg Mining Institute and a metallurgical engineer, was invited to serve as Head of the Factory Department of the school and the full professor of metallurgy. By that time, he had established himself as a highly qualified and creative specialist.

Before that, he had been sent to a number of European enterprises to study industrial experience. In 1893, he visited Berlin, Paris, London, Milan, Venice and Vienna and familiarized himself with the work of Swedish metallurgical plants. This trip significantly enriched M.A. Pavlov as an engineer and metallurgical specialist.

Thus, M. A. Pavlov laid the foundation for metallurgical education in Katerynoslav and in Ukraine as a whole [2]. From the very first years of training specialists, the school paid great attention to chemical

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education, realizing that metallurgy was high-temperature chemistry.

In 1900, the board of the school elected the renowned scientist P. H. Rubin as the head of the metallurgy cabinet.

At the beginning of 1905, he was appointed as Acting Extraordinary Professor. He gave lectures on pig iron metallurgy, fuels, non-ferrous metallurgy, and metallography, as well as supervised graduates' theses.

As part of the steel metallurgy course in 1917, a section on electrometallurgy was introduced, focusing on metal smelting in electric arc furnaces. Stepan Ivanovych Telnyi was the founder of this course and the first lecturer. He graduated from the Factory division in 1914 and was retained as a scholarship holder to continue his research work. Under his active involvement and guidance, an electrometallurgical laboratory was established, where he, together with Professor H. Ye. Yevreinov developed the first electric steelmaking furnace with a rotating voltaic arc. In 1920, he was appointed Assistant Professor of this department, and from January 1, 1925 he became a Professor and head of the first in the country Department of Electrometallurgy. It should be said that at that time there was no research on the application of electricity in metallurgy for metal smelting in the country at all, so S. I. Telnyi is rightfully considered the founder of the national scientific school of electrometallurgy.

The first records of electric steelmaking in Ukraine date back to 1913. The Novokonstantynivka and Makiivka steel plants each had one electric furnace with a capacity of 0.5 tons.

The introduction of electric steelmaking gave impetus to the development of electric furnace construction in various regions of the Russia of that time. Ukrainian scientists were at the forefront of this process, including the first head of the Department of Electrometallurgy at the Dnipro Metallurgical Institute, Doctor of Technical Sciences, Professor, Honored Worker of Science and Technology Stepan Ivanovych Telnyi (1890-1962).

His 1914 diploma project on electrometallurgy was awarded a prize by the Council of the Mining Institute, which decided to retain S. I. Telnyi at the Department of Metallurgy to prepare him for teaching and research as a professor's scholarship holder. Already in those years, the young scientist demonstrated his wide range of knowledge. In 1914, together with Professor of Chemistry L. V. Pisarzhevskyi, he published an article on electrochemistry entitled "Electrolytic Method of Obtaining Solid Iodine from Solution." Later, S. I. Telnyi devoted himself to the development of electrometallurgical furnaces, which was greatly facilitated by a research trip to the Kyiv Polytechnic Institute (KPI), where he worked under the supervision of Professor V. P. Izhevskyi.

Such rapid career growth was facilitated by outstanding scientific achievements. In 1919, the first arc steelmaking furnaces designed by H. S. Yevreinov and S. I. Telnyi were installed in the Katerynoslav railway workshops and at the metallurgical plant in Katerynoslav. The results of the furnaces' operation were successful.

As noted in the book "The Development of Electrothermal Engineering," S. I. Telnyi's idea attracted attention of many scientists, along with L. I. Morozenskyi's invention of a device for arc control and simultaneous metal stirring. On this basis, in the 1940s, devices for electromagnetic stirring of liquid metal in electric furnaces were developed in Sweden, which were used for several decades to equip most large arc furnaces.

The staff of the Department was gaining recognition within the scientific community, and new young engineers joined the Department. In 1924, the Central District Electrotechnical Trust established a group at the Kharkiv Electromechanical Plant to organize the production of domestic electric furnaces, headed by electrometallurgist L. I. Aronov and designer A. P. Ionov. In the history of electrothermal technology development, 1925 was marked as the year of creation of the first industrial electric steelmaking furnace designed by L. I. Aronov and A. P. Ionov with a transformer capacity of 2000 kW and a capacity of 250 kg, which was characterized by more advanced technical solutions compared to foreign models. In 1926, the German company AEG purchased licenses from the State Electrotechnical Trust for the right to construct such furnaces in Europe.

Starting from 1925, the need arose for rapid development of steel electrometallurgy and its quality basis, the electro-ferroalloy industry. In the early 20s, there were only a few ferroalloy furnaces with a capacity of 280-1000 kV-A for the production of ferrosilicon and ferrochromium, so there was a need to further develop the domestic ferroalloy industry.

At this time, in 1926, Spyrydon Yosypovych Khytryk (1895-1980), the future patriarch of the Ukrainian scientific school of ferroalloy production, Honored Worker of Science and Technology of the Ukrainian SSR, Professor, Doctor of Technical Sciences, graduated from the Mining Institute with a degree in Electrometallurgy of Steel and Ferroalloys.

For his excellent academic performance and successful defense of his diploma project in electrometallurgy, after graduating from the institute in 1926, S. Y. Khytryk was invited to take the position of assistant at the Department of Electrometallurgy at the Dnipropetrovsk Mining Institute. In connection with the separation of the metallurgical faculty of the Dnipropetrovsk Mining Institute into an independent multidisciplinary Dnipropetrovsk Metallurgical Institute (DMetI) in 1930, S. Y. Khytryk transferred to DMetI initially as an assistant and then as an associate professor at the Department of Electrometallurgy. At the same time, he was engaged in extensive social and scientific work. From 1932, he worked for eight years in the editorial office of the journals "Robochyi Metalurh", "Domez" and "Theory and Practice of Metallurgy" as a scientific secretary, deputy editor, and editor-in-chief. Notably, the journal "Theory and Practice of Metallurgy" is the

oldest scientific publication of the Ukrainian metallurgical industry, having been published since 1928.

In 1930, Mykola Makarovych Chuyko, a graduate of the Minsk Polytechnic Institute, joined the Department and later became a leading scientist in the field of steel electrometallurgy. At that time, S. I. Telnyi was appointed Dean of the Metallurgical Faculty and a design consultant at Dnipro Industrial Complex, and the Department of Electrometallurgy became a truly national center for training electrometallurgical specialists.

Graduates of the Department of Electrometallurgy of DMetI stood at the origins of the formation and development of domestic electrometallurgy, including the Ukraine's first electrometallurgical enterprises – Dniprostal (now Dneprospetsstal) and a ferroalloy plant in Zaporizhzhia.

In 1925, a group of metallurgists working on the problem of Dniprobud as part of a commission headed by I. H. Oleksandrov put forward a project to organize and construct a ferroalloy plant in Zaporizhzhia (formerly Oleksandrivsk) utilizing the low-cost electricity from the Dnipro hydroelectric power station.

Since 1928, and more specifically with the construction of the Dnipro hydroelectric power station, the steel and ferroalloys industry began to emerge as an independent sub-industry. During the first five-year plan (1928-1932), two electric arc steelmaking furnaces were put into operation at the Dneprostal plant (since 1939, Dneprospetsstal, Zaporizhzhia), along with two ore-reduction ferroalloy electric furnaces at Zaporizhzhia Ferroalloy Plant.

The first foundation of Dniprostal (now Dniprospetsstal, Zaporizhzhia) was laid on April 22, 1931, and on October 10, 1932, on the day of the ceremonial opening of the Dnipro hydroelectric power station, the first smelting was produced using Dnipro power.

From the first years of the plant's operation, the scientific research conducted by the Department and its graduates has been related to the development of various steel grades, improvement of existing technological processes, development of theoretical foundations and deepening of the theory of deoxidation, refining, and alloying of a wide range of electrometallurgical steels. An outstanding metallurgical scientist, Doctor of Technical Sciences, Professor M. M. Chuyko was always at the head of most of these developments. His contribution to the formation and development of Ukrainian electric steelmaking science and technology is invaluable. The beginning of his scientific career coincided with the first years of operation of the first Ukrainian specialized steel production plant – Dneprospetsstal. M. M. Chuyko dedicated nearly his entire life to the establishment and development of scientific research and the improvement of technological processes at this enterprise.

Other electrothermal production facilities were established on the basis of the Dnipro hydroelectric power station. In 1932, the construction of the Dnipro Aluminum Plant, consisting of three plants – an alumina plant, an electrolytic plant, and an electrode plant with alumina from its own production – continued at a rapid pace. At that time, the electrode plant produced its first products – anodes, coal blocks and anode paste – in October 1933. In June of the same year, Dnipro Aluminum Plant was launched without the participation of foreign specialists.

The invaluable contribution of the Department of Electrometallurgy to the development of scientific foundations, the design, implementation and improvement of electrothermal equipment and technological processes for the production of a wide range of special electric steels and various types of ferroalloys, as well as the training of electrometallurgical engineers for almost the entire country, was widely recognized by the scientific community. Notably, the Department of Electrometallurgy played a leading role in the establishment of the Ukrainian scientific school of electrometallurgy, which led to the scientific and professional growth of its leading members.

In 1932, S. I. Telnyi was appointed Deputy Director for Research at DMetI, and in 1934 he became Deputy Director for Academic Work, the positions he held until 1939, while also managing the Department of Electrometallurgy. In 1936, by the decision of the Higher Attestation Commission, S. I. Telnyi was awarded the academic title of Professor, and in 1937, without defending his dissertation, he was awarded the degree of Candidate of Technical Sciences. S. Y. Khytryk defended his Candidate's dissertation in 1936 and in the same year he was awarded the academic title of Associate Professor of the Department of Electrometallurgy. In 1939, M. M. Chuyko defended his Candidate's dissertation and was also elected to the position of Associate Professor.

The pre-war period was marked by the rapid development of the electrometallurgy of steel and ferroalloys worldwide. The country was ranked first in the world in the production of electric steel and ferroalloys (1940), and this is due in no small part to the scientists and faculty of the Department of Electrometallurgy of the DMetI. Between 1924 and 1941, about 200 electrometallurgical engineers were trained, who successfully worked in the most responsible positions in ministries, factories, research, design, and educational institutes.

The Great Patriotic War (1941-1945) was a severe trial for the entire Ukrainian people. Nearly all major plants were evacuated to the east, along with some of the highly skilled engineers and skilled workers in the leading smelting specialties.

Between July and October 1941, all the equipment of the ferroalloy plant and Dneprospetsstal was evacuated from Ukraine. This equipment was used to put into operation electric steelmaking and rolling mills in the east, and in 1942, the ferroalloy production facility was put into operation.

Serving as Deputy Head of the Technical Department, S. Y. Khytryk headed all research work on improving the technology for producing ferrochrome, silicochrome, and ferrosilicon. For the first time, the technology was developed for producing low-carbon

ferrochrome by blowing ferrochrome with air in a converter, for producing ferrotungsten from domestic ores, as well as for creating alloys so necessary for the front and victory.

During this period, M. M. Chuyko headed the electrometallurgical laboratory at the plant and lectured at the Siberian Metallurgical Institute, while also leading research on the development and improvement of armor steel production technology for tanks. S. Y. Khytryk and M. M. Chuyko were awarded high governmental awards for their wartime efforts.

After the liberation of Dnipropetrovsk from the German occupation in October 1943, the DMetI began to revive, with the Department of Electrometallurgy as one of its main divisions.

In October 1943, after the liberation of Zaporizhzhia, work began on the restoration of the Zaporizhzhia Ferroalloy Plant. As early as August 1944, the plant organized calcium carbide smelting for construction and reconstruction work at enterprises in Zaporizhzhia, Donbas, and Kryvyi Rih. By 1950, the production of electric steel and ferroalloys reached the pre-war level. The era of rapid development of Ukraine's industrial potential began, and new processes and materials were created, in the development of which the Department of Electrometallurgy played a significant role [3].

In January 1944, S. Y. Khytryk was appointed Acting Head of the Department of Electrometallurgy. Based on the results of ongoing research, S. Y. Khytryk developed the theory of energy and material balance in ferroalloy electric smelting, the theory of vacuum refining of chromium alloys, and introduced and implemented the technology of vacuum treatment of liquid ferrochrome in a ladle at leading industrial plants. These achievements allowed him to successfully defend his Doctoral Dissertation in 1953. In 1954, he was awarded the degree of Doctor of Technical Sciences and the title of Professor at the Department of Electrometallurgy. From 1953 to 1962, working as Vice-Rector for Research at the DMetI, S. Y. Khytryk dedicated significant efforts to the establishment and advancement of science at the institute, while remaining Head of the Department of Electrometallurgy [4].

The development of the nuclear industry required the creation of new structural materials, which in many cases are based on chromium steels and alloys with exceptionally low carbon content and minimum permissible content of harmful impurities (S and P) and gases (N2 та H2). The Department was prepared to meet that challenge. Research was conducted in two areas – vacuum treatment of chromium alloys in liquid and solid states. The second direction particularly captivated the young scientist Mykhailo Ivanovych Hasyk, the future academician of the National Academy of Sciences of Ukraine, Professor, Doctor of Technical Sciences, future Head of the Department of Electrometallurgy. At the beginning of the 60s (1962-1964), the Department's research staff included about 60 researchers and engineers.

The rapid growth of scientific potential could not but affect the Department's research outcomes, expanding its scientific interests and the scope of application of the accumulated scientific experience. A special group was created at the Department to deal with classified topics on the production of ultra-low-carbon chromium steels for pipe assortment [5].

M. I. Hasyk played a leading role in the scientific substantiation and search for alternative materials to replace bauxite in the domestic abrasive industry and alumina production. At the same time, he continued to work on the theoretical aspects of solid-phase refining of ferrochrome; established regularities between the maximum carbon content, metal oxidation levels and the degree of removal of harmful impurities and gases; developed technological regulations for a three-stage process; provided initial data for the creation of a unique vacuum processing unit and supervised its creation, development and industrial implementation. He achieved significant success in obtaining high-quality super-refined chromium-based alloys used in the nuclear industry.

Summarizing the obtained results, M. I. Hasyk defended his doctoral dissertation in 1968, and a year later, in 1969, he was awarded the academic title of Professor at the Department of Electrometallurgy.

Electric steelmaking production was becoming increasingly predominant in specialized metallurgical plants and heavy and medium engineering plants, such as Kharkiv Malyshev Plant, Novo-Kramatorsk Machine-Building Plant, Nikopol Pivdennotrubnyi Plant, Dnipropetrovsk Pipe Rolling Plant, Sumy Oil and Gas Pipe Plant, Kremenchuk Steel Plant, Kryvyi Rih Central Ore Repair Plant, Dnipropetrovsk Switch Plant, Kramatorsk Energomashspetsstal Plant, and others.

Due to shifts in the structure of smelted steel and in the methods of its production, as well as an increase in the share of low-alloy and alloy steels, it became necessary to expand the production of ferroalloys. For this reason, it was decided to construct two ferroalloy plants in Ukraine – the Stakhanov Ferroalloy Plant, for the production of ferrosilicon of various grades, and the Nikopol Ferroalloy Plant, for the production of manganese alloys.

The Department of Electrometallurgy at DMetI gained a reputation as one of the country's largest centers for research and personnel training in the field of electrothermal production. It established close scientific ties and conducted joint research with the Georgian Polytechnic Institute and the Institute of Metallurgy of the Academy of Sciences of the Georgian SSR. Highly appreciating the scientific achievements, they sent their students to the department for scientific internships and theoretical experiments. The department became an all-Union training highly hub for highly qualified electrometallurgical specialists.

Young scientists from Kazakhstan came to the Department to test their research, receive evaluations on its value and significance, and obtain recommendations for their dissertation defenses.

At that time, the construction of one of the world's largest ferroalloy plants, the Nikopol Ferroalloy Plant, began.

For Ukraine, which has globally significant manganese ore reserves, the decision to construct a manganese ferroalloy plant in the Nikopol manganese ore deposit area was a strategic one.

Head of the Department, Professor, Doctor of Technical Sciences Khytryk S. Y. was present at the historic groundbreaking ceremony. Acknowledging scientific merits of the Department, the State Committee for Science and Technology and the Ministry of Higher and Secondary Specialized Education issued a decree in 1966 to establish a Problem Ferroalloy Laboratory at the Department of Electrometallurgy of the DMetI to solve the scientific problems of the plant. At that time, it was the only laboratory in the country equipped with the latest research equipment and electric furnace capacities, such as an X-ray microanalyzer "Cameca", X-ray structural analysis unit, electron microscopes, Balzers gas analysis unit for steel, automated volumetric and gravimetric analysis systems, viscosity and electrical conductivity measurement setups for oxide melts, laboratories for chemical analysis, petrographic and metallographic studies; three electric arc furnaces with a capacity of 0.5 to 1.5 tons, a plasma furnace, a high-frequency induction furnace, vacuum furnaces and other equipment that ensures the implementation of the full metallurgical cycle.

In 1973, Professor, Doctor of Technical Sciences M. I. Hasyk was elected Head of the Department of Electrometallurgy of the DMetI.

The diversity of scientific issues and interests that M. I. Hasyk had to delve into broadened his horizons, allowed him to critically assess the state of a particular scientific issue at the time and eventually transfer this experience to the Department. In 1973, the Department of Electrometallurgy, together with the Problem Ferroalloy Laboratory, had 214 members, including 5 doctors and 32 candidates of technical sciences. At that time, the structuring of scientific research began to emerge with the formation of separate creative groups headed by doctors and candidates of science, professors and associate professors.

In order to assess the contribution of the Department's scientists to the formation and development of the Nikopol Ferroalloy Plant, it is necessary to note the uniqueness of electric furnace melting units, which had no analogues in the world at that time, the scale and breadth of the range of manganese ferroalloys produced by the plant [6].

For the first time in the world, the plant installed a domestic rectangular closed electric ore-reducing furnace with a capacity of 63,000 kV-A, a bath size of 22×10m, and 6 self-heating electrodes measuring 2.8×0.9 m. This unique unit, which resembles a 25-meter swimming pool in size, smelted up to 310 tons of ferrosilicon manganese and ferromanganese per day, while other electric furnaces at that time melted no more than 90-100 tons per day. However, the development of the technology for the production of manganese alloy production in these furnaces and the improvement of their reliability were a serious challenge for the Ukrainian electric ferroalloy industry and, above all, for the staff of the plant and the Department of Electrometallurgy of the DMetI, from which they came out with honor, further enhancing their scientific credibility in the country and in the world [7].

The achievements of the Department in developing new and improving existing technological processes are due to the high theoretical and professional training of its graduates, the effective work of the postgraduate and doctoral programs at the Department of Electrometallurgy. This is evidence that over the years, the Department's educational and research work has been constantly improving in line with contemporary requirements. Currently, training is conducted under such educational and professional programs as Electrometallurgy of Steel and Ferroalloys, Special Metallurgy and Non-Ferrous Metallurgy, with 152 undergraduate and 200 postgraduate students enrolled in the department. Over the 100 years of its existence, the department has trained more than 2,500 broad-profile specialists in cross-industry areas and specialties, 140 candidates and 25 doctors of technical sciences, many of whom received state and international awards and grants.

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