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Dmytro Zhurylo

ORCID [0000-0002-0015-9412](https://orcid.org/0000-0002-0015-9412)
 National Technical University
 Kharkov Polytechnic Institute (Kharkov, Ukraine)
zhurilo.dm@gmail.com



Volodymyr Levchenko

ORCID [0000-0002-2411-4198](https://orcid.org/0000-0002-2411-4198)
 O.Ya. Usikov Institute for Radiophysics and Electronics,
 National Academy of Sciences of Ukraine (Kharkov, Ukraine)
goldangel271@gmail.com

Mykola Zaveriushchenko

ORCID [0000-0003-2364-7299](https://orcid.org/0000-0003-2364-7299)
 National Technical University
 Kharkov Polytechnic Institute (Kharkov, Ukraine)
nzav@ukr.net

Oleh Zhurylo

ORCID: [0000-0001-7505-2022](https://orcid.org/0000-0001-7505-2022)
 Kharkiv National University of Radio Electronics
 (Kharkiv, Ukraine)
oleh.zhurylo@nure.ua

The Contribution of Petro Mukhachov (1861–1935) to the Development of Mechanical Engineering and Metallurgy

PUBLICATION INFO		e-ISSN 2543-702X ISSN 2451-3202		 DIAMOND OPEN ACCESS
Zhurylo, Dmytro; Levchenko, Volodymyr; Zaveriushchenko, Mykola; Zhurylo, Oleh 2026: The Contribution of Petro Mukhachov (1861–1935) to the Development of Mechanical Engineering and Metallurgy. <i>Studia Historiae Scientiarum</i> (FirstView Article). DOI: 10.4467/2543702XSHS.26.019.22708 .				
RECEIVED: 21.12.2025 ACCEPTED: 16.09.2026 PUBLISHED ONLINE: 14.10.2026		ARCHIVE POLICY OPEN POLICY FINDER	LICENSE 	
WWW		https://ojs.ejournals.eu/SHS/ ; https://pau.krakow.pl/Studia-Historiae-Scientiarum/archiwum		

Abstract

In the second half of the 19th century, the Second Industrial Revolution began worldwide. One of its achievements was the discovery of new technologies for steel smelting: in Bessemer and open-hearth furnaces, as well as steel working by pressure. This significantly reduced the cost of steel production, which began to be used en masse for the manufacturing railway rails. For many years, railways became the main consumer of ferrous metallurgy products. The development of railways, in turn, accelerated the development of mechanical engineering, primarily the production of steam locomotives and railcars.

Ukraine, as part of the Russian Empire since the abolition of serfdom in 1861, experienced a railway boom which was common in almost all countries of Europe and the United States in the second half of the 19th century.

During the 80–90s of the 19th century, a powerful industry for that time developed on the territory of modern Ukraine, which before the World War I provided the production of 72.2% of all iron ore mined in the Russian Empire, 86.9% of all mined coal, 73% of coke, 77.6% of all produced soda, 75% of all rail production, 40% of all steam locomotive production, etc.

Ukraine's railways accounted for less than 19% of the Russian Empire's total railway network at the beginning of the 20th century, yet they handled more than 40% of the cargo turnover. That is, Ukrainian railways were used approximately twice as intensively as the national average.

Ukrainian railways played a key role in the development of the Donbas and the entire Ukrainian industry. In the last third of the 19th century, neither Ukrainian metallurgy, coal and chemical industries, nor domestic mechanical engineering could do without railway building.

Therefore, studying the formation and development of domestic transport engineering, as well as metallurgy, represents an important stage in the research of the global history of science and technology. One of the most prominent figures in steam locomotive construction and hot metalworking was the extraordinary personality Petro Matviiovych Mukhachov – Honored Professor of the Kharkiv Technological Institute (KhTI), its fifth director from 1905 to 1917, and the first director of the Ukrainian Scientific and Research Institute of Metals (UkrNIIMet) from 1928 to 1929.

Thanks to his visits to several advanced factories located in Germany, France, Belgium, England, and Russia, and to World Industrial Exhibitions, Petro Mukhachov authored numerous works on steam locomotive theory, metallurgy, and mechanical engineering. His works were among the first ones in Eastern Europe and were subsequently widely used in engineering practice.

Thanks to Petro Mukhachov's persistent and diligent work, railway science was significantly extended in promising areas, primarily the production and improvement of steam locomotive designs. He made a significant contribution to the training of scientists and engineers in locomotive construction and hot metalworking, published a large volume of specialized literature on these topics. His students, trained at the KhTI, subsequently worked at many railways, machine-building and metallurgical plants throughout the Russian Empire.

Keywords: *Ukraine, higher education, pedagogical activity, transport engineering, Kharkiv Technological Institute, Ukrainian Scientific and Research Institute of Metals, steel, cast iron, charity, Kharkiv, metalworking by pressure*

Wkład Petra Muchachowa (1861–1935) w rozwój inżynierii mechanicznej i metalurgii

Abstrakt

W drugiej połowie XIX wieku na całym świecie rozpoczęła się druga rewolucja przemysłowa. Jednym z jej osiągnięć było odkrycie nowych technologii wytopu stali: w piecach Bessemera i martenowskich, a także obróbki stali pod ciśnieniem. Znacznie obniżyło to koszty produkcji stali, która zaczęła być masowo wykorzystywana do produkcji szyn kolejowych. Koleje stały się na wiele lat głównym odbiorcą produktów hutnictwa żelaza. Rozwój kolei przyspieszył natomiast rozwój przemysłu maszynowego, przede wszystkim produkcji lokomotyw parowych i wagonów.

Ukraina, będąca częścią Imperium Rosyjskiego od zniesienia poddaństwa w 1861 roku, przeżyła boom kolejowy, który w drugiej połowie XIX wieku był powszechny w niemal wszystkich krajach Europy i Stanach Zjednoczonych.

W latach 80. i 90. XIX wieku na terenie współczesnej Ukrainy rozwinął się potężny jak na tamte czasy przemysł, który przed I wojną światową zapewniał m.in. wydobycie 72,2% rudy żelaza w całym Imperium Rosyjskim, 86,9% wydobycia węgla, 73% koksu, 77,6% produkcji sody, 75% produkcji kolejowej i 40% produkcji parowozów.

Pod względem długości koleje ukraińskie na początku XX wieku stanowiły mniej niż 19% kolei Imperium Rosyjskiego, ale zapewniała ponad 40% obrotu towarowego. Oznacza to, że koleje ukraińskie były eksploatowane około dwukrotnie intensywniej niż średnia krajowa.

Ukraińskie koleje odegrały kluczową rolę w rozwoju Donbasu i całego ukraińskiego przemysłu. W ostatniej tercji XIX wieku ani ukraińskie hutnictwo, ani przemysł węglowy i chemiczny, ani rodzima budowa maszyn nie mogły obejść się bez budowy kolei.

Dlatego dokumentowanie powstawania i rozwoju krajowej inżynierii transportowej, a także metalurgii, stanowi ważny etap w badaniach światowej historii nauki i techniki. Jedną z najwybitniejszych postaci w dziedzinie budowy parowozów i obróbki metali na gorąco był Petro Matwijowicz Muchachow – zasłużony profesor Charkowskiego Instytutu Technologicznego (ChTI), jego piąty dyrektor w latach 1905–1917 oraz pierwszy dyrektor Ukraińskiego Naukowo-Badawczego Instytutu Metali (UkrNIIMet) w latach 1928–1929.

Dzięki wytrwałej pracy Petra Muchachowa nauka o kolejnictwie znacznie się rozszerzyła, przede wszystkim w stronę dobrze zapowiadającej się produkcji parowozów i doskonalenia ich konstrukcji. Publikując obszerne tomy literatury specjalistycznej, wpłynął on znacząco na kształcenie naukowców i inżynierów w dziedzinie budowy parowozów i obróbki metali na gorąco. Jego uczniowie, kształceni w ChTI, pracowali następnie na kolei, w zakładach budowy maszyn i hutnictwie w całym Imperium Rosyjskim.

Słowa kluczowe: *Ukraina, szkolnictwo wyższe, działalność pedagogiczna, inżynieria transportowa, Charkowski Instytut Technologiczny, Ukraiński Naukowo-Badawczy Instytut Metali, stal, żeliwo, działalność charytatywna, Charków, ciśnieniowa obróbka metali*

1. Introduction

Studying the history of Ukrainian transport engineering and metallurgy requires a comprehensive approach, that is, identifying key events, in-depth examination of scientific schools, and biographies of renowned engineers and educators. In this research, the authors utilized the following methods: content analysis, historiographical analysis, chronology, historical and comparative analyses, biographical methods, and critical analysis based on historicism and objectivity, and, in part, the prosopographical method. The scientific and educational work of Petro Matviiovych Mukhachov formed an exceptionally important chapter in the history of Ukrainian transport engineering and requires detailed study. Furthermore, the personality and professional activities of Petro Matviiovych Mukhachov have not yet been studied. Although brief information about the scientist and educator has been presented in numerous studies on the history of the National Technical University “Kharkiv Polytechnic Institute”, these works contained certain inaccuracies and did not reflect his contribution to the history of Ukrainian transport engineering and metallurgy.

The sources of this study were the materials of the Central State Archive of the Supreme Authorities (Kyiv), the Central State Historical Archive (Kyiv), the Central Scientific and Technical Archive of Ukraine (Kharkiv), and the State Archive of the Kharkiv Region (Kharkiv).

This article presents a brief biography, interesting forgotten and little-known facts about the Kharkiv period of Professor Petro Matviiovych Mukhachov's life, his significant scientific and pedagogical achievements, which are an integral and important part of the history of mechanical engineering and metallurgy in the 20th century.

2. Biographical information

Petro Matviiiovych Mukhachov was born on February 27, 1861 in St. Petersburg into a civil servant's family.¹ According to the collection,² his father, Matvii Petrovych Mukhachov, held the rank of collegiate councilor in 1863, equivalent to the rank of army colonel, and was an accountant in the chancery of the Main Redemption Institution of the Russian Empire (the government agency that dealt with issues of subsidizing peasants to buy back from landowners the land plots granted to them after the abolition of serfdom in 1861 – the so-called redemption operations). In 1875, Matvii Mukhachov worked as a records clerk in the chancery of the Main Redemption Institution of the Russian Empire.³ In 1880, he held the rank of actual state councilor (equivalent to the rank of army major general) and was deputy head of the chancery of the Main Redemption Institution of the Russian Empire.⁴

In 1898, retired state councilor Matvii Mukhachov owned a house in St. Petersburg on Ropshinskaya Street at the corner of Maliy Avenue, 19/40. He was listed as the treasurer of the Pokrovsky Charity Society and a member of the Vvedenskaya Gymnasium Student Charity Society. Olimpiada Matviiiovna Mukhachova, an arithmetic teacher at the S.P. von Derviz Women's Vocational School,⁵ also lived in the same house. This means the family had a daughter in addition to a son.

However, already in 1899, the name Matvii Mukhachov disappears from the list of homeowners. Olimpiada Mukhachova lived in 1899 on Vvedenskaya Street at number 15.⁶ And in 1900, Mariia Ivanivna Mukhachova, the widow of a retired state councilor, lived with her at the same address.⁷ Therefore, Petro Mukhachov's parents were Mariia and Matvii Mukhachov.

At the age of ten, Petro Mukhachov entered the St. Peter's Realschule (Petrischule), one of the most renowned educational institutions of the time, offering in-depth study of foreign languages, including German, Greek, and Latin. In May 1883, he graduated from the mechanical department of the St. Petersburg Practical Technological Institute (SPbPTI) with the title of engineer-technologist, that is, with honors,⁸ having obtained a thorough technical education. At that time, SPbPTI had two departments – chemistry and mechanics. First-year studies were united for both departments. The mechanical department, however, was divided into two divisions: factory and railway ones.

On October 17, 1884, Petro Mukhachov began his professional career at Pavel Demidov's Nizhny Tagil plant and was admitted to teaching mechanics at the Nizhny Tagil real school,⁹ since it was quite difficult problem at that time to find a certified engineer with the makings of a teacher in the Urals.

The Nizhny Tagil plant had a full production cycle, including blast and open-hearth furnaces, sheet metal rolling, and it was powered by steam engines and turbines. The enterprise produced refractory bricks and ferroalloys with the charge delivered by rail. The plant's products were repeatedly recognized with awards at international and domestic exhibitions. It was an advanced enterprise of industrial production.¹⁰

Petro Mukhachov was working at the plant for four years. While fulfilling his duties, he thoroughly studied the machines produced at the plant at the time, their design, and their

¹ Yablonsky 1900, p. 349.

² Anon₁ 1863, p. 459.

³ Anon₂ 1875, p. 523.

⁴ Anon₃ 1880, p. 562.

⁵ Anon₇ 1898, p. 330.

⁶ Anon₈ 1899, p. 646.

⁷ Yablonsky 1900, p. 148.

⁸ State Archives of the Kharkiv Region (hereafter SAKhR), f. R-1682, desc.2, case 210, p. 411.

⁹ *Ibid.*, p. 400.

¹⁰ Brockhaus, Efron 1897, pp. 45–46.

practical operations. However, after the death of Pavel Petrovich Demidov, the plant began to decline. Pavel Demidov's heirs were largely indifferent to the plant's affairs, and, for example, in 1896, the Nizhny Tagil plant did not participate in the All-Russian Exhibition in Nizhny Novgorod.¹¹

3. The beginning of Petro Mukhachov's work in Ukraine

With the opening of the Practical Technological Institute (KhPTI) in Kharkiv in 1885, Director Viktor Lvovych Kyrpychov was faced with a challenging task: providing faculty for the specialized courses that emerged with the appearance of senior students. While professors and teachers from the Imperial Kharkiv University were recruited to teach general engineering subjects such as mathematics, physics, and chemistry, teaching heat engineering, sugar production, metallurgy, and other technical disciplines required teachers or engineers with the appropriate education and practical experience. Furthermore, there was virtually no specialized methodological literature to properly provide the teaching of these disciplines. Faculty members had to develop it themselves, ensure its publication, and demonstrate its fundamental concepts to students. The lack of specialized higher education institutions further complicated the task: finding a professor of metallurgy or mechanical engineering in the city was nearly impossible. Therefore, V.L. Kyrpychov, basing on his own organizational experience, decided to train scientific personnel directly at the Institute. While working at the St. Petersburg Polytechnic Institute, he served for a time as the acting secretary of the Academic Council. Even after his moving to Kharkiv, there were many colleagues with whom he corresponded and met at various meetings and congresses. They recommended talented young people to the director of the KhPTI for vacant positions as lecturers, adjunct professors, and ordinary professors.

V.L. Kyrpychov, who personally knew Petro Mukhachov as a talented engineer having the abilities of teaching and research work, invited him to teach drawing at the KhPTI, beginning in September 1887.¹² Petro Mukhachov arrived in Kharkiv with his wife, Yuliia Petrivna (her maiden name was Kuznetska), she was the daughter of a doctor.¹³ They married on July 22, 1887. Petro Mukhachov's wife was born on April 30, 1870¹⁴.

Due to his transfer to the Kharkiv educational district, Petro Mukhachov was dismissed from the Nizhny Tagil Real School on August 1, 1887. His personal file contains a certificate from November 25, 1887, from the director of the KhPTI, V.L. Kyrpychov, which allowed Petro Mukhachov as teacher at the Institute to reside freely in Kharkiv with his family in private apartments.¹⁵ The Mukhachov's family got a government-owned apartment on the Institute's campus only in 1901.¹⁶

In 1888, he was tasked to teach courses on factory machines and design of hydrostatic structures, and also supervised the implementation of hydraulic receiver projects by students in the fourth year.¹⁷

On January 1, 1890, Petro Mukhachov was approved for the rank of court councilor (class VII according to the Table of Ranks),¹⁸ and on June 1, 1890, for the rank of adjunct professor.¹⁹

¹¹ Anon₅ 1896.

¹² SAKhR, f. R-1682, desc. 2, case 210, p. 1.

¹³ *Ibid.*, p. 349.

¹⁴ *Ibid.*, p. 342.

¹⁵ *Ibid.*, p. 4.

¹⁶ Anon₉ 1901, p. 553.

¹⁷ SAKhR, f. R-1682, desc.2, case 210, p. 8.

¹⁸ *Ibid.*, p. 16.

¹⁹ *Ibid.*, p. 18.

This year he was on a scientific trip, during which he became acquainted with the advanced experience of foreign and domestic steam locomotive construction, repair, metallurgical and machine building enterprises, in particular in Munich, Berlin, Vienna, Paris, Hanover, Odesa, St. Petersburg, Voronezh, etc. Before the trip, V.L. Kyrpychov characterized him as follows:

Among the educational staff of the Institute, attention should be paid to the engineer-technologist Mukhachov, who has been teaching factory machines and hydraulic structures at the Institute for two years now, and also supervises student projects of the 4th and 5th years. The excellent theoretical training of P.M. Mukhachov, the practical achievements he obtained during his service at the Tagil plants, talent of a lecturer introduced by him are guarantees of success in teaching the course on steam locomotives. (SAKhR, f. R-1682, desc. 2, case 210, p. 12)

After returning from his five-month assignment (from June 1 to November 1, 1890),²⁰ Petro Mukhachov began teaching subjects related to the design and operation of steam locomotives and railway rolling stock – courses such as “Steam Locomotive Theory” and “Steam Locomotive Design”. He also subsequently supervised on the design of steam locomotives for students of the fifth year. This was significant, as the number of KhPTI students, wanting to work on steam locomotive design during execution of their final (graduation) projects, was constantly growing. Future graduates aspired to pursue careers in rail transport, which was rapidly developing at the time. As an experienced specialist, Petro Mukhachov taught all courses and practical classes assigned to him at a high level. The projects developed by students under his supervision were part of a serious technical work in the education system for training of future engineers.

The business trip provided a lot of useful information about metalworking and mechanical engineering, particularly steam locomotives construction. By the end of the 19th century, the steam locomotive was undoubtedly one of the most complex and perfect machines. Its production required to learn numerous general engineering and specialized courses, the main ones were drawings and design basics, strength of materials, metallurgy, metal working by pressure, and machining, technical mechanics, heat engineering, heat transfer, heat engines, chemical analysis of fuel and water for steam locomotives, and so on. Teaching steam locomotive design required a thorough knowledge of these fundamental courses and, in addition, the ability to summarize and systematize the material for students.

4. Pedagogical and professional work of Petro Mukhachov

In 1900, Petro Mukhachov, along with a group of professors and laboratory assistants, visited the World Exhibition in Paris. Professors were given 300 rubles each to cover expenses, and laboratory assistants 175 rubles each.²¹ The exhibition was highly popular and attracted interest: over 50 million people visited it in six months. A review of the diverse exhibits and the latest experience of international colleagues allowed Petro Mukhachov to identify the main directions for the development of domestic steam locomotive construction and make adjustments to the lecture courses and practical classes.

At the beginning of the 20th century, rail transport in the Russian Empire developed rapidly. As of December 1, 1911, there were 23 state-owned and 13 private railways, not counting local railways, with a total length of almost 69,000 versts (more than 73,000 km).²²

In June 1889, the Economic Committee of the Kharkiv Technological Institute (KhTI) (KhPTI was renamed KhTI in 1898) considered allocating premises for the steam locomotive and mechanical departments.²³ Premises were allocated in the building for the mechanical workshops for two new departments. Separate entrances were created, and the building for the

²⁰ *Ibid.*, p. 14.

²¹ SAKhR, f. 770, desc. 1, case 359, p. 1.

²² Spassky 1913, p. 40.

²³ SAKhR, f. 770, desc. 1, case 106, pp. 1–3.

mechanical workshops, which had a rectangular plan, was partially completed. Before the reconstruction, these workshops were separate, unconnected premises. The new departments were not opened, but the allocation of these premises became the basis for the development of future specialties – steam locomotive construction and machining.

Only February 1, 1895, the professorial department of steam locomotive construction was opened in the KhTI. At the time, the department was a professorial position only. It could be held, but not headed. Thus, the “Steam Locomotives” department was staffed by one person – Professor Petro Mukhachov (Fig. 1). The department didn’t even have a laboratory assistant position, let alone a second teacher or adjunct professor. There was no laboratory for steam locomotive construction.²⁴

Consequently, beginning with the first graduating class of KhPTI in 1890, students obtained railway specialization. The significant number of graduates at the Institute confirmed the desire of KhPTI’s first director, V.L. Kyrpychov, to open a steam locomotive construction specialization. His petition was implemented in a special methodological publication, “Rules for testing students of the KhTI who have completed the full course of study for the title of engineer-technologist and technologist”, approved by the Minister of Public Education on April 15, 1890.²⁵

This publication focused on the key stages of completing a graduation project on steam locomotive design. Additionally, a comparative analysis of steam locomotive types and their components was presented. For example, the following types of steam locomotives were considered: freight (six- and eight-wheel), passenger, and express ones. Steam locomotives of each of these types differed in the method of steam action in the cylinders (simple, complex, and compound cylinders); the position of the cylinders relative to the frame (inner and outer cylinders); the type of valve mechanism (Stephenson, Hooke, Allanvalve gears and others); the position of the frame relative to the wheels (inner and outer frames), etc.

To develop steam locomotive designs, students of the mechanical department were required to conduct research (or design) that included a description of steam locomotive design, classifying them into types based on speed, and information on the dimensions of the main components of different types of steam locomotives. Students had to explain the choice of steam locomotive boiler type, provide data on determining the boiler geometric dimensions, strength, and steam output of various components, and determine the efficiency of the firebox and heating surface. They were also required to describe the dimensions of smokestacks, explain the greater efficiency of conical stacks, the structure and dimensions of cones, its beneficial and harmful effects, and the design and dimensions of the ash pan.

Knowledge of the design and operating principle of injectors and the reasons for using dual steam engines in steam locomotives was also required. The data used to determine cylinder dimensions was needed. This included a graphic determination of traction force for the long piston position, adhesion force, window sizes, and data determining slide valve size. Analysis of various valve gears and an explanation of the diagram determining their dimensions were also required. A description of the frame construction and dimensions and its connection to the boiler and cylinder, the design and dimensions of the axle boxes had to be included here. It was also needed to know all the forces applied to the drive axle. It was necessary to characterize the pressure exerted on the rails by the wheels of various types of steam locomotives, the reasons for the use of leaf springs on steam locomotives, explain the causes of incorrect movement of steam locomotives, leading to the destruction of the railway tracks, and so on.

It should be noted that excursions to industrial plants and students’ practical work in production were considered an important components of the educational process at KhTI. In

²⁴ *Ibid.*, p. 3.

²⁵ SAKhR, f. 770, desc. 1, case 146, p. 13.

1896, students, led by Petro Mukhachov, visited the Yekaterinoslav province, where they toured the Oleksandrivsky and Kamensky metallurgical plants.²⁶

In 1896, the 16th All-Russian Industrial and Art Exhibition was held in Nizhny Novgorod, in which scientists from the KhTI also participated. It was practically the equivalent of a World Exhibition. For the participants of this event, the main condition for displaying exhibits was the manufacture of goods from domestic raw materials. A considerable amount of money from the state treasury was spent on the exhibition; numerous pavilions and buildings were built, the area of which exceeded 110 thousand square meters; thousands of exhibits and product samples from a wide variety of enterprises and institutions were presented; numerous congresses of industrialists, electricians, beekeepers, sheep farmers, etc. were held. This exhibition also showcased products from the KhTI workshops, a variety of devices invented and manufactured by the Institute professors, and the works of students. KhTI was awarded the highest award.²⁷

Five professors (including Petro Mukhachov) and one laboratory assistant were sent to the exhibition. Many students, taking advantage of the free railway travel granted to them in 1896, visited the 16th All-Russian Industrial and Art Exhibition.²⁸

It should be noted that on June 1, 1894, Petro Mukhachov got the rank of State Councilor (5th class). He was awarded the Order of St. Stanislav of 2nd Class (1900), and St. Anna of 3rd Class. Being the son of an official, he obtained a salary of 2,400 rubles, as well as 300 rubles of table money, and 1,400 rubles for conducting classes and consultations, that is a total of 4,100 rubles per year.²⁹

The organization of systematic training by Petro Mukhachov, the introduction of new courses, and the increasing number of pre-graduation practice bases contributed to the fact that the first graduates of KhPTI in 1890 obtained a higher education diploma of railway specialization. In particular, the first graduates of the Institute worked in this field – engineers-technologists (who graduated with honors) from the mechanical department: Balashov Serhii Semenovych, Borzenko Kostiantyn Ivanovych, Yezeranskyi Ivan-Kostiantyn Feliksovych, Kurylo Vasyl Pavlovych, Maksymov Porfyrrii Mykytovych;³⁰ from the chemistry department: Bulanov Mykola Mykolaiovych, Kotsiubynskyi Hryhorii Andriiovych, Lebedynskyi Oleksandr Oleksandrovych, Tsehelskyi Henrikh-Andrii Ivanovych, Tsymmerman Liudovyk Leonovych (Liudviih Lvovych).³¹

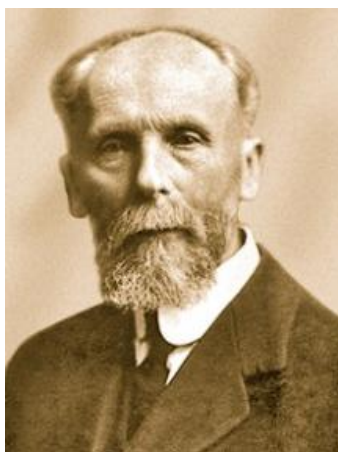


Fig. 1. Petro Matviiiovych Mukhachov (after D. Zhurylo 2016, p. 54)

²⁶ Anon⁶ 1896, p.14.

²⁷ *Ibid.*, p. 20.

²⁸ *Ibid.*, p. 31.

²⁹ SAKhR, f. R-1682, desc. 2, case 210, p. 551.

³⁰ SAKhR, f. R-1682, desc. 4, case 4802, p. 1.

³¹ *Ibid.*, p. 2.

In addition, technologists (who graduated without honors) from the mechanical department also worked in this area: Martsynkevych Petro Pavlovych, Tochyskyi Henrikh Feliksovych; from the chemical department: Vlasov Mykola Dmytrovych, Kozhevnykov Mykola Abramovych.³²

Although the first graduates get their specialization completing their graduation projects, their fundamental basic education enabled them to work successfully not only in machine building enterprises but also on railways, depots, traction services, rolling stock repair workshops, and elsewhere. Such a significant number of KhTI graduates, involved in railway transport, confirmed the desire of KhTI first director, V.L. Kyrpychov, to open a specialization of steam locomotive construction.

Under the supervision of Adjunct Professor Petro Mukhachov, the graduation project was completed by Mykola Ivanovych Kartashov, Doctor of Technical Sciences, Director of the Tomsk Technological Institute, author of numerous published works, books, manuals, and textbooks. In 1891, the following persons graduated from the steam locomotive construction specialty at the KhTI: Andreiev Oleksandr Yelyseiovych (chief of the Derbent depot and carriage workshops), Aheiev Mykhailo Vasylovych (master of the main steam locomotive workshops of the Yekaterinoslav railway), Bazhanov Leonid Mykolaiovych (later – head of the South-Western Railways and senior inspector of the People's Commissariat of Railways), Balashov Heorhii Andriiovych (engineer of the Kyiv District Railway Administration), Bondarevskyi Mykola Semenovych (head of the technical department of the track and building repair service of the Kursk-Kharkiv-Sevastopol railway administration), Bulhakov Volodymyr Arkadiiovych (from 1900 to 1903 – head of the steam locomotive construction department of the Kharkiv plant, depot, and, later – a teacher at the KhTI), Bohomolov Vasyl Illich (head of a section of the Moscow-Kyiv-Voronezh railway), Kostiukov Oleksii Stepanovych (traction service engineer of the Yekaterininskaya Railway Administration), Nazarov Vasyl Serhiiovych (head of the traction section of the Moscow-Kyiv-Voronezh Railway Administration), Starchenko Pavlo Spyrydonovych (head of the Kyiv Technical Railway School), Strekozov Vasyl Mykolaiovych (assistant of the head of the 1st section of the Libavo-Romny Railway Administration).³³

The second graduating class of engineers also included other outstanding specialists who had realized themselves in their professional activities and brought glory to their Institute, for example, Mykhailo Karlovych Ziegler, later a professor, a classic of metallurgy, one of the researchers of the behavior of sulfur in iron-carbon alloys³⁴ and Mykhailo Kostiantynovych Chekurul-Kush – a builder, politician, firefighter.³⁵

At the end of the 19th century, the number of students at the KhTI, completing their graduation projects devoted to steam locomotive designs, was steadily increasing, as reported by Petro Mukhachov to the Academic Committee. Data on student design works on steam locomotives and enterprises in the 1891/1892, 1892/1893, and 1893/1894 academic years are presented in Table 1. Therefore, Petro Mukhachov requested increasing the number of hours for supervising diploma projects from 9 to 15.³⁶

³² *Ibid.*, pp. 174–175.

³³ Anon⁴ 1891.

³⁴ D. Zhurylo, Levchenko 2023, p. 430.

³⁵ D. Zhurylo 2016, p. 57.

³⁶ SAKhR, f. R-1682, desc. 2, case 210, p. 40.

Table 1. Rates of steam locomotives and enterprises designs of the KhTI students completed graduation projects in the 1891–1894 academic years

Academic year	Graduates who designed steam locomotives, people	Graduates who designed enterprises, people
1891/1892	12	1
1892/1893	13	8
1893/1894	17	6
Total	42	15

All this provided the basis for establishing the steam locomotive construction department at the KhTI in 1893–1894 with the aim of training specialists in this field. This department was one of the first ten specialized in the Institute.³⁷

Petro Mukhachov, moving up the career ladder, became a leading professor at the KhTI at the beginning of the 20th century. If we analyze the reports on activities of the Institute, for example, for 1903, we can find that, besides him, two more professors of mechanics worked at the Institute: Oleksii Ivanovych Predtechenskyi and Vasyl Ivanovych Albytskyi.³⁸ But the subjects taught by the professors of mechanics were different. In the 1902/1903 academic year, V.I. Albytskyi taught courses of applied mechanics and hydraulics,³⁹ O.I. Predtechenskyi taught courses of steam boilers, structural mechanics, and graphic statics,⁴⁰ and Petro Mukhachov taught courses of steam locomotives and factory machines.⁴¹

During this period, Petro Mukhachov was a correspondent (as the position of consultant was then called) for K. Osovskyi's Berlin technical office.⁴² He was also a member of the examination commission for fifth-year students (analogous to the modern state examination commission), along with Professors Hryhorii Oleksiiovych Latyshev and Oleksii Ivanovych Predtechenskyi.

The majority of KhTI students specialized in the subjects taught by Professor Petro Mukhachov. The total number of student interns in the mechanical engineering specialty was 220, of them 150 students were studying steam locomotive construction.⁴³

The following year, 1904, Petro Mukhachov served as head of the commission for testing fifth-year students in the mechanical engineering department and acted as secretary of the Institute's educational committee.⁴⁴ He taught the courses "Steam locomotives", "Blowing engines", and "Metallurgical machines". That same year, he and his students visited the Moscow water supply system and the Bromley, Hopper, and List factories.⁴⁵

There was an expansion of the number of enterprises providing pre-graduation practice for fifth-year students of the mechanical department. These were, first of all, the railways, where the majority of students completed their practice. For example, the Kharkiv-Mykolaiv Railway (17 people), the Transbaikal Railway (14 people), and the Kursk-Kharkiv-Sevastopol Railway (10 people).⁴⁶ Practice was also completed at industrial enterprises, including the following plants: Kolomna Machine-Building Plant (4 people), Putilov Plant (1 person), Russian-Baltic Carriage Plant (2 people), and Sevastopol Tram (2 people).⁴⁷ The total number of student-

³⁷ Kutsenko 1967, p. 8.

³⁸ Anon₁₃ 1903, pp. 10–11.

³⁹ *Ibid.*, p. 24.

⁴⁰ *Ibid.*, p. 27.

⁴¹ *Ibid.*, p. 26.

⁴² *Ibid.*, p. 39.

⁴³ *Ibid.*, p. 4.

⁴⁴ Anon₁₁ 1904, p. 12.

⁴⁵ *Ibid.*, p. 44.

⁴⁶ *Ibid.*, p. 45.

⁴⁷ *Ibid.*, p. 46.

trainees in the mechanical specialty was 155 persons, of them 124 were steam locomotive builders.⁴⁸ Data on the practice of fifth-year students in 1904 are presented in Table 2.

When Petro Mukhachov began teaching professional subjects, he discovered a complete lack of specialized literature. At that time, relevant publications, particularly scientific and technical journals, textbooks, manuals, and other reference literature, were practically nonexistent, even in foreign languages. Kharkiv did not yet have a scientific and technical library, and the Institute's library was too small to meet the needs of students and faculty for scientific and technical literature. Technical books were expensive and rare at the time, and in most cases, only a single copy was available.

Table 2
Pre-graduation practice for fifth-year students of the mechanical department of the KhTI in 1904⁴⁹

Place of practice	Number of student interns
Railways:	
Kharkiv-Mykolaiv	17
Transbaikal	14
Kursk-Kharkiv-Sevastopol	10
Other railways	74
Total	115
Industrial enterprises:	
Kolomna Machine-Building Plant	4
Putilov Factory	1
Russian-Baltic Carriage Plant	2
Sevastopol tram	2
Total	9

Petro Mukhachov found himself in a difficult situation: it was impossible to teach difficult technical subjects using lecture notes alone. Even his natural talent for drawing didn't save the situation – many of his contemporaries recall the large number of complex drawings he masterfully produced during his lectures.

Petro Mukhachov's methodology for providing students with a solid understanding steam locomotive design was interesting. Beginning in their first year, he assigned students to complete training drawings not of abstract figures, but of actual steam locomotive parts. Future models for the drawings were purchased in advance from the Southern Railway (out of respect for the KhTI and Petro Mukhachov personally, they were sold at scrap prices). For example, in 1914 alone, the following steam locomotive parts were acquired: a coupler head, a siren whistle, a Friedman injector, a Lindner faucet, a Recourt valve, a Westinghouse control head and brake regulator, and a crosshead along one parallel.⁵⁰ Using this original method, under the guidance of laboratory assistant Valentyn Dmytrovych Dolhov, students mastered the technique of drawing complex steam locomotive parts. Subsequently, in student's senior years, drawing even more complex designs no longer presented problems for them. Considering that the number of students being trained in steam locomotive specialization was growing, this was the right decision.⁵¹

Thus, based on his fundamental theoretical training and experience gained during practical work at the factory, Mukhachov began preparing educational and methodological literature. Recognizing the need to develop professional literature, Petro Mukhachov worked intensively. After a business trip to foreign and domestic factories in 1890, he systematized the

⁴⁸ *Ibid.*, p. 47.

⁴⁹ Anon¹¹ 1904, p. 14.

⁵⁰ SAKhR, f. 770, desc. 1, case 792, p. 53.

⁵¹ SAKhR, f. R-1682, desc. 2, case 210, p. 40.

collected material and prepared his first printed work for publication. This was a lithographed lecture course on factory machines.

From the next year, the publication of a number of books by Petro Mukhachov on specialized factory equipment in particular, blowing engines and rolling machines, mechanisms for hot metal working, etc. began. In accordance with the tradition of that time, atlases with graphic material, various schemes and images on the relevant courses were added to the textbooks.⁵²

On April 12, 1899, Petro Mukhachov was appointed secretary of the Educational Committee of the KhTI by order of the Minister of Public Education.⁵³

On October 30, 1902, P.M. Mukhachov was released from his duties as secretary of the Educational Committee, according to his application.⁵⁴ This was due to the serious illness of his wife, Yuliia Petrivna, who, on the advice of doctors, was forced to live in Crimea at least from February to June 1901.⁵⁵ Mukhachov himself helped with the move of his wife and daughters to Sevastopol, for which he took temporary leave.⁵⁶ The Mukhachov's family had three daughters: Kateryna, born on May 21, 1888, Olha, born on May 31, 1890, and Vera, born on August 15, 1896.

In 1904, Mukhachov was again appointed secretary of the Educational Committee,⁵⁷ and a member of the Economic Committee for a period of three years.⁵⁸

That same year, in relation to the dismissal of Professor Hryhorii Oleksiiovych Latyshev, Petro Mukhachov was assigned to supervise design projects in mechanics.⁵⁹ Mukhachov got to work actively: his wife's treatment required considerable funds.

The director of the Institute, Mykola Mykolaiovych Shyller, representing P.M. Mukhachov for the position of secretary of the Educational Committee, reported in telegram to the Department of Public Education: "Mukhachov P.M. is working impeccably".⁶⁰

Mukhachov's authority was quite high. His knowledge and experience were used, for example, in court cases. He repeatedly acted as an expert in court cases, for example, on January 18, 1905.⁶¹

On February 14, 1905, Petro Mukhachov was appointed acting assistant director of the KhTI.⁶² On March 16, 1905, this decision was approved by the Minister of Public Education.⁶³

As a result of the elections for the director of the KhTI, Petro Mukhachov was elected to the position of director in 1905. Mukhachov P.M. was appointed director of the KhTI by telegram of the Minister of Public Education dated September 2, 1905.⁶⁴

On September 11, 1905, Mukhachov P.M. was approved as the director of the Institute from September 7, 1905, in accordance with the elections.⁶⁵ Thus, he became the first elected director of the Emperor Alexander III Kharkiv Technological Institute.

Students have never been considered wealthy. Aware of this, the Mukhachovs actively participated in charity events for KhTI students. For example, Petro Matviiiovych's wife, Yuliia Petrivna Mukhachova, directed and participated in a charity performance in 1910 for insolvent

⁵² Mukhachov 1895.

⁵³ SAKhR, f. R-1682, desc. 2, case 210, p. 69.

⁵⁴ *Ibid.*, p. 76.

⁵⁵ *Ibid.*, p. 73.

⁵⁶ *Ibid.*, p. 75.

⁵⁷ *Ibid.*, p. 84.

⁵⁸ *Ibid.*, p. 82.

⁵⁹ *Ibid.*, p. 83.

⁶⁰ *Ibid.*, p. 85a.

⁶¹ *Ibid.*, p. 92.

⁶² *Ibid.*, p. 93.

⁶³ *Ibid.*, p. 94.

⁶⁴ *Ibid.*, p. 114.

⁶⁵ *Ibid.*, p. 115.

students of the Vyatka-Perm Siberian Community. This amateur performance has allowed depositing 267 rubles and 10 kopecks into the KhTI account.⁶⁶

That same year, the musical evening, held to benefit insolvent students of the music circle, has allowed depositing 82 rubles and 99 kopecks into the KhTI account.⁶⁷ At first glance, this was not a large sum of money. But that same year, an evening held on November 28, 1910, in the Drawing Building of the KhTI for students who were unable to pay their tuition fees, allowed depositing 2,403 rubles and 02 kopecks into the KhTI account.⁶⁸ Undoubtedly, the base of this evening was the music circle, which Petro Mukhachov had led for many years. Considering that the total amount of donations for 1910 was 7,092 rubles and 14 kopecks, the contribution of the Mukhachovs was substantial (2,753 rubles and 11 kopecks, or 38.8% of entire revenues to the Institute).

Similar donations were made in other years as well. For example, in 1913, an evening held for the benefit of insolvent students of the music circle resulted in the deposit of 135 rubles and 73 kopecks into the KhTI account.⁶⁹ In 1914, 48 rubles and 49 kopecks were gotten.⁷⁰

In 1908, Yuliia Petrivna Mukhachova was the initiator of organizing a holiday for the children of KhTI employees. Living on the KhTI campus, being by then the mother of three daughters (in July 1912, a fourth daughter, Nina, was born in the Mukhachov family),⁷¹ communicating daily with the wives of the Institute employees, and knowing full well the inadequacy of a monetary reward obtained by their husbands, she applied to the KhTI Economic Committee for permission to organize a holiday for the children of KhTI employees. At that time, the chairman of the KhTI Economic Committee was Yuliia Petrivna's husband, Petro Matviiovych Mukhachov, and the members were professors Volodymyr Matviiovych Serebrovskyi, Mykola Oleksandrovych Chernai, Richard Edmundovych Hartman, and Volodymyr Serhiiovych Knabbe.

With the exception of Mykola Oleksandrovych Chernai, the all members of the KhTI Economic Committee lived in government-owned apartments on the Institute's campus. Most of them were married, had children of their own, and understood well that allocating space for a children's party was a useful and noble action. Especially since the party was held in the evening during the Easter holidays. The party has a success. The Kharkiv newspaper "Southern Region" reported on April 18:

The Economic Committee of the Technological Institute, at the request of the director's wife, Yu.P. Mukhachova, permitted a cinematographic performance to be held on the third day of Easter for the children of the Institute's lower-level employees. The performance attracted many spectators: the auditorium was overflowing with children and their parents. Before the start of the first act, the folk anthem was performed and repeated by everyone present, accompanied by Yu.P. Mukhachova. Between acts, the children were given gingerbread, caramel, and chocolate eggs. (Anon₁₂ 1908)

It was thanks to Yuliia Petrivna Mukhachova that the first cinematic session in the history of the Institute was shown at the KhTI in 1908.

The director of the KhTI, P.M. Mukhachov, repeatedly went on business trips abroad to get acquainted with factories in Germany, France, England, Belgium, and Switzerland, led student excursions to the factories of the South-Russian Dniprovskiy Metallurgical and Oleksandrivskiy South-Russian Societies, visited the Russian Kolomensky, Obukhov, and

⁶⁶ Anon₁₃ 1910, p. 54.

⁶⁷ *Ibid.*, p. 55.

⁶⁸ *Ibid.*, p. 55.

⁶⁹ Anon₁₄ 1913, p. 75.

⁷⁰ Anon₁₅ 1914, p. 71.

⁷¹ SAKhR, f. 40, desc. 121, case 317, p. 74.

Putilov steam locomotive construction plants, in 1907 he took part in the work of the 15th Congress of Rolling Stock and Traction Engineers, and in 1910 he visited the World Exhibition in Brussels.⁷²

Nevertheless, Petro Mukhachov did not abandon his leadership of the KhTI orchestra or the Institute's museum. He managed the museum without pay for 11 years – from 1905⁷³ to 1916.⁷⁴ Petro Matviiiovych diligently oversaw the replenishment of contemporary exhibits to his collection. Some were purchased, others obtained as gifts from various institutions and individuals, including many KhTI graduates and former students, while the rest were produced by the Institute's mechanical workshops (Fig. 2, 3). The museum was located on the second floor of the Main Building (today, the Main Auditorium Building).

The museum and its exhibits were actively used in the KhTI educational process: they conducted tours and studied the operation and design of various mechanisms and devices, used drawings to design new machines and parts, workshops and factories, and explained the evolution of scientific developments and the paths of scientific and technological progress.

By the early 20th century, Petro Mukhachov had gained recognition as a teacher and specialist, had significant authority and was considered one of the leading scholars in the field of steam locomotive construction. This is confirmed by the fact that Petro Mukhachov was repeatedly invited to the Kyiv Polytechnic Institute (KPI) as an opponent in thesis defenses.⁷⁵ It should be noted that one of the dissertation candidates was Volodymyr Volodymyrovych Farmakovskiy, a professor at KPI since 1914.⁷⁶

We can also mention another candidate for a dissertation, who was a graduate of the KhTI in 1897, an engineer at the Kharkiv steam locomotive plant, and later a teacher at the KPI, Yakiv Mykolaiovych Markovych, who in 1913 defended his thesis on the topic of "Calculation and theoretical study of a steam hammer with automatic steam distribution." Mukhachov wrote a letter regarding the thesis of Yakiv Markovych to the dean of the Mechanical Faculty of the KPI, Petro Feofanovych Yerchenko (incidentally, also a graduate of the KhTI in 1893) on March 2, 1913.⁷⁷

Petro Mukhachov was often sent various articles for review. For example, in May 1911, he received an article by Volodymyr Yakovych Sokolov, author of "Notes on Steam Locomotive Driving, with a Brief Outlining Steam and Steam Locomotive Technology", to which Mukhachov responded that he was delighted with the author's diligence.⁷⁸

The assistant of the head of the traction section at the Konotop station, engineer Serhii Hukov, asked Petro Mukhachov to send a copy of his book to Hukov's address by cash on delivery.⁷⁹

⁷² Zaveryushchenko 2023, p. 72.

⁷³ SAKhR, f. 770, desc. 1, case 792, p. 14.

⁷⁴ SAKhR, f. R-1682, desc.1, case 1, p. 20.

⁷⁵ Central State Archive of the Supreme Authorities of Ukraine (hereafter CSASA), f. 166, desc. 12, case 5183, p. 1.

⁷⁶ Savic 2004, p. 4.

⁷⁷ SAKhR, f. R-1682, desc. 2, case 210, p. 310.

⁷⁸ *Ibid.*, p. 251.

⁷⁹ *Ibid.*, p. 239.



Fig. 2. Model of a steam locomotive with a 1-5-0 wheel arrangement, made at Kharkiv Mechanical Engineering Institute under the supervision of P.M. Mukhachov. Photo by M. Zaveriushchenko

On January 1, 1910, Mukhachov corrected Yakiv Modestovych Gakkel's calculations on fuel standardization for steam locomotives, making minor corrections to the calculations.⁸⁰

On July 29, 1911, Mukhachov received a letter from Borys Ivanovych Bukhovets, director of the Bryansk Rail Rolling Plant, expressing gratitude for the KhTI graduate, Yevhen Mykolaiovych Dubeha, to whom Mukhachov had provided a letter of recommendation, and "for other recommended students and pupils". The director invited Mukhachov to visit the plant to "see on the spot the conditions under which KhTI graduates work and the tasks assigned to them."⁸¹



Fig. 3. FD-20 steam locomotive with a 1-5-0 wheel arrangement and a six-axle tender. Photo in the public domain

On June 29, 1912, the Head of the Main Workshops of the Polissya Railways expressed interest in the timing of the publication of the second edition of Professor Mukhachov's "Steam Locomotive Course" and the price for this book.⁸² For which the response was sent regarding the publication of the book "Theory of Steam Locomotives" in 620 pages, the price of which had not yet been set, and a lithographed edition of "Theory of Steam Locomotives" was published at a price of 3 rubles and 50 kopecks.⁸³

In April 1913, Viktor Andriiovych Tovstonohov, a graduate of the KhTI and, at the time of this correspondence, assistant to the Chief Engineer of the Podolsk Railway, upon the advice

⁸⁰ *Ibid.*, p. 221.

⁸¹ SAKhR, f. R-1682, desc. 2, case 210, p. 262.

⁸² *Ibid.*, p. 295.

⁸³ *Ibid.*, p. 296.

by Mukhachov visited the bureau of “Councils of Steam Locomotive Plants”, located at Hohol Street, 9 in Kyiv. The bureau’s management happily agreed to collaborate. Viktor Andriiovych wrote:

After inspecting the Institute, I happily walked around almost all the premises and was amazed at their significant expansion, increasing and order. Thus, the huge changes and striking expansions have occurred, after the seven years of my absence. Now I ask you to do me a favor. I would like to have a jubilee album for the 25th anniversary of the Institute, containing 75 photographs. I will be very pleased to have such a memento of the Institute. (SAKhR, f. R-1682, desc. 2, case 210, p. 301)

In Mukhachov’s practice there was also other correspondence, for example, with the Baku police chief, who reported on a certain Vadirov, who was called an engineer-technologist, but was prosecuted under the law for forgery of documents.⁸⁴

On December 1, 1914, Yurii Yuriovych Lomonosov, Chief Director of Experiments on Steam Locomotive Types, contacted Mukhachov with a request to provide a copy of the latest edition of the steam locomotive course.⁸⁵ Somewhat later, on April 16, 1915, the office of the Chief Director of Experiments on Steam Locomotive Types sent Mukhachov the technical passports of the steam locomotives of S and Shch types.⁸⁶

As director, Mukhachov taught classes on steam locomotive construction, metallurgical machinery, and steam boilers also. Evidence that he himself taught the classes is the announcement of the postponement of the exam on course of steam boilers from December 15 to December 21, 1907⁸⁷ and the announcement of February 1, 1908, that “due to departure for business purposes to St. Petersburg, lectures on steam locomotives and factory machinery will not take place next week and will be deferred to a later dates.” (SAKhR, f. R-1682, desc. 2, case 210, p. 182)

Working as director had a negative impact on Mukhachov’s health. He wrote to the Trustee of the Academic District:

The difficult circumstances, under which the past academic year wore on, have had a very adverse effect on my health. The Institute’s doctor Oleksandr Yuliovych Philips, and doctor Volodymyr Antonovych Rubinskyi strongly advise me to take advantage of the two-month leave I requested for a complete rest and to treat the nervousness and fatigue that have developed over the past year. In turn, my wife, who has been suffering from pulmonary tuberculosis for many years, must, at the request of the doctors, spend the summer in the Crimea. Being forced to bear very large expenses under such circumstances, I have the honor to more respectfully ask Your Excellency to provide me with assistance for the treatment of my illness in the amount of 300 rubles from the Institute’s special funds, on the basis of the Supreme Order of September 28, 1911 (SAKhR, f. R-1682, desc. 2, case 210, p. 325).

In December 1913, Mukhachov was treated in Kislovodsk.⁸⁸ In February 1915, Mukhachov petitioned for 300 rubles for his wife’s funeral.⁸⁹ Despite his more than respectable salary, which reached 7,500 rubles per year (3,000 of salary, 1,200 rubles of dining, 1,800 rubles for lectures, and an additional 1,500 rubles), there was not enough money for the treatment of his wife or Mukhachov himself.⁹⁰

⁸⁴ SAKhR, f. R-1682, desc. 2, case 210, p. 344.

⁸⁵ *Ibid.*, p. 416.

⁸⁶ *Ibid.*, p. 425.

⁸⁷ *Ibid.*, p. 181.

⁸⁸ *Ibid.*, p. 405.

⁸⁹ *Ibid.*, p. 420.

⁹⁰ *Ibid.*, p. 424.

In 1913, Petro Matviiiovych organized and opened courses in rural fireproof construction at the KhTI and directed them until 1919. It should be noted that on September 24, 1913, the Ministry of Public Education granted permission to organize fireproof construction courses at the KhTI, basing on the grounds established by the Educational Committee and the reports submitted on August 31 of that year. This permission was considered by the Educational Committee on October 8, 1913.

A design for an academic building was completed, and under the supervision of architect Yulii Semenovich Tsaune, the building was constructed in 1916 at a cost of 66,165 rubles.⁹¹ More than 532,000 bricks were used in the building for Fireproof Construction Courses.⁹² This was not hampered by World War I, limited funding, or the expensiveness at that time. The building, constructed in the ancient so called Moorish style, is today a local historical monument, adorning the northern part of the National Technical University «Kharkiv Polytechnic Institute» (NTU «KhPI») campus.

A reasonable question arises: why did Petro Matviiiovych Mukhachov, the director of the KhTI, agreed to supervise these Courses? The answer can be found in Mukhachov's personal file⁹³ and in the parish registers of the Institute's Church of the Nativity of the Blessed Virgin. The serious illness and death of his beloved wife, Yuliia Petrivna, from rapid tuberculosis in February 1915⁹⁴ required considerable financial resources. Almost every summer, Yuliia Petrivna traveled to the Crimea, where she attempted to improve her health. And in July 1912, a fourth daughter, Nina, was born into the family.⁹⁵ All this required considerable financial resources.

To maintain his family's level of living, Petro Matviiiovych made extensive use of his organizational abilities. Thus, in January 1914, Fireproof Construction Courses under the direction of Professor P.M. Mukhachov were opened on the KhTI campus.

During that historical period, opening of the Courses was an exceptionally important educational and organizational event. Fires were a real scourge for the Russian Empire: wood had long been the most common structural and building material. Its availability and excellent thermal properties led to its widespread use in Ukraine. The vast majority of residential buildings and structures were constructed of wood, not to mention barns, poultry houses, sheep farms, fences, and so on.

Unfortunately, the archival documents of the Courses were destroyed during the World War II and it is impossible to find information about the teaching staff of the Courses, the number of students in the Courses, not even about to whom, when, in whose name and what diplomas or certificates of the Courses graduation were issued.

It is known that fireproof construction courses continued its work until the early 1920s. These Fireproof Construction Courses contributed to saving many lives and peasants' property. This helped the Russian Empire survive World War I: unlike many warring countries, the Russian Empire practically did not use rationing system of distribution for basic foodstuffs, and food although increasingly expensive was freely available.

As envisaged by the Academic Committee, the new academic building became the Institute's sole property after the courses were closed. The building, constructed at the height of World War I and surviving numerous regime changes, the october coup, the Civil War, and World War II virtually undamaged, for a long time were being used for training students in the evening program of education. This kind of study was a form of higher education without interruption from work and was common practice in the former Soviet Union. The building was

⁹¹ SAKhR, f. 770, desc. 1, case 801, p. 1.

⁹² SAKhR, f. 770, desc. 1, case 799, p. 2.

⁹³ SAKhR, f. R-1682, desc. 2, case 210.

⁹⁴ SAKhR, f. 40, desc.121, case 399, p. 57.

⁹⁵ SAKhR, f. 40, desc.121, case 317, p. 71.

named the “Evening Building” and, despite the abolition of evening education, retains its name today. It now houses the university’s IT departments. The building itself (warm and cozy) has faithfully served the higher education for more than one hundred years, being as a monument to its founders and the members of the Academic Committee of KhTI, who cared for the future of their beloved Institute.

Petro Matviiovych headed the Institute until February 1915, when Ivan Pavlovych Osypov became director of the KhTI. Of course, P.M. Mukhachov could have continued to apply for position of the Institute director, but due to health problems and the fact that he had a three-year-old daughter left without maternal care, he was forced to leave the leadership of the Institute.

After leaving his position as director, Mukhachov received an additional lecture workload: in addition to lecturing and managing the museum and model shop, he taught a special course on steam locomotives, supervised the design of blast furnaces, steelmaking, rolling, and forging plants, as well as the design of steam locomotives, for which he was receiving an additional 2,200 rubles⁹⁶. Interestingly, the professor’s workload was a minimum of 5 hours per week.

Upon retirement and leaving the official apartment, Mukhachov proposed to transfer to the Institute, or to the next tenant of the state apartment, the works he had made at his own expense: a fenced garden with fruit trees, an arbor, a fountain, a water supply system, tables, benches, electric lighting, a partition of carpentry work, linoleum in three rooms, a large wardrobe, electric chandeliers, sconces, street light, etc.⁹⁷

5. Activities of Petro Mukhachov after the october coup

On October 25 (according to the new calendar on November 7), 1917, the october coup took place, which 10 years later has been named the Great October Revolution.

Beginning September 1, 1917, Petro Mukhachov was dismissed from his post at his own request by Order No. 190 of the Provisional Government dated October 5, 1917. According to the state regulations current at the time, a professor with 30 years of teaching experience was to receive a pension of 4,500 rubles per year,⁹⁸ for which Petro Mukhachov submitted a corresponding petition to the Minister of Education. Unfortunately, however, the chronological period of 1917–1919 in Ukraine was not characterized by stability.

Petro Mukhachov’s pension was awarded at 4,500 rubles, taking into account cost-of-living increases but with a 2% deduction. Thus 4,410 rubles per year remained for payment. The pension was set from the date of his dismissal, that is, from September 1, 1917.⁹⁹ However, it was now paid by the Department of Higher Education of the Ukrainian People’s Republic, and not by the Ministry of Public Education, where he had served previously.¹⁰⁰ Hetman Pavlo Skoropadskyi assumed power in Ukraine in April 1918. Before his pension was set, Petro Mukhachov lived on his rapidly depleting savings. Furthermore, with his dismissal, he lost his official housing. Moving to a new apartment also required money.

While in the time of the Tsarism a pension of 3,000–4,000 rubles allowed not only a decent living (so officials at the time typically served “impeccably”) but also hiring servants, vacations at resorts, and so on, during the october coup it was a very small amount of money, because they quickly had depreciated. Wages were growing slowly, and pensions, of course, weren’t increasing adjusted for inflation. And the youngest daughter, who was at the time dependent on Petro Mukhachov, required financial support.

⁹⁶ SAKhR, f. R-1682, desc. 2, case 210, p. 438.

⁹⁷ *Ibid.*, pp. 440–441.

⁹⁸ CSASA, f. 2201, desc. 5, case 16, p. 33.

⁹⁹ *Ibid.*, p. 56.

¹⁰⁰ *Ibid.*, p. 67.

Under these circumstances, Petro Mukhachov was forced to seek employment. His activities during this period are significantly less documented than in the time before the October coup. However, it is known that in 1917, he served for six months as acting head of the technical bureau of the Sevastopol-Kursk Railway, which was located in Kharkiv. Following the cancellation of regular trains on this railway as a result of the Civil War, from 1918 to 1920, he served in the Metals Department of the Industrial Bureau, where he held the position of head of the general mechanical engineering section. Petro Mukhachov then transferred to the Ukrainian Railways District, where he held the position of engineer for assignments. Only in October 1920 he had returned to KhTI for teaching.¹⁰¹

Of course, Petro Mukhachov could have submitted a petition for reinstatement as a professor at KhTI earlier. His petition would likely have been granted. However, he first had to wait for assignment of his pension, which was supposed to be designated from the date of his dismissal, and it was inconvenient to ask for ourselves his former subordinate, Ivan Adamovych Krasuskyi.

Returning to the Institute, Petro Mukhachov first managed the mechanical workshops. His position was called “director of the demonstration and manufacturing department”. Petro Mukhachov’s employment per week was 29.5 hours.¹⁰² It must be said that his return was approved by the scientific and technical society of Glavprofobr (the Main Directorate of Vocational Education), which decided who could teach at the higher education institution and who could not.

On December 11, 1920, by order No. 29 of the KhTI, a regulation was adopted on the demonstration and manufacturing department, according to which one of the Institute’s teachers was appointed as its head (managing director) by order of the rector. He was in charge of the higher education institution’s power and electrical stations, the machine-building plant, the factory of galvanic cells, the distillery, the glass-blowing workshop, the chemical plant, the production of photocopying paper, and a repair team of plumbers, stove makers, and carpenters. Valentyn Dmytrovych Dolhov, a former employee of Petro Mukhachov at the museum and model workshop, was appointed assistant to the head of the machine-building plant.¹⁰³

From October 7, 1921, Petro Mukhachov was assigned to teach the discipline “Machine Elements” in the fourth trimester – 4 hours of lectures and 2 hours of practical classes per week (order No. 218 of October 11, 1921).¹⁰⁴

An important factor in favor of Petro Mukhachov’s return to KhTI was a significant reduction in the graduation of engineer-technologists and technologists who were completing a final (graduation) projects related to steam locomotive construction. Thus, in 1917 (from January to September), 12 students defended their appropriate projects (Vasyl Zakliuchynov, Frantyshek Susskyi, Hryhorii Okulych-Kazarin, Vladislav Oshurko, Andrii Yachnyi, Adolf Yakutovych, Vasyl Sheludko, Serhii Bulhakov, Heorhii Yaremenko, Serhii Hnuzdiev). And over the next three years (from September 1917 to September 1920) there were only 6 such students, one of the projects was defended as an external one (Vasyl Nezhandtsev, Mykhailo Matvieiev, Oleksandr Kondratov, Pavlo Albov, Leonid Livanskyi, Borys Voronkov).¹⁰⁵

With the reinstatement of Professor Petro Mukhachov only in 1922, many projects were defended, for example, on the topics “Steam locomotive of type 0-5-0”, “Steam locomotive of type 2-3-0”, “Steam locomotive of type 2-3-1”. The number of students who completed such projects was 26 persons (Kostiantyn Savin, Kostiantyn Myklashevskyi, Mykhailo Bas-Basov, Zelman Arshavskyi, Volodymyr Masov, Volodymyr Holiakovskyi, Viktor Vehner, Ivan

¹⁰¹ CSASA, f. 166, desc. 12, case 5183, p. 1.

¹⁰² SAKhR, f. R-1682, desc.1, case 80, p. 97.

¹⁰³ *Ibid.*, p. 26.

¹⁰⁴ SAKhR, f. R-1682, desc. 1, case 94, p. 11.

¹⁰⁵ SAKhR, f. R-1682, desc. 1, case 113, pp. 42–51.

Alieksieienko, Andrii Pravdyuk, Pylyp Dosychev, Mechyslav Skopynytskyi, Mykhailo Lipko, Leonid Kohuienko, Ruvym Shpihler, Borys Miroshnyk, Petro Kulahin, Illia Aronovych, Semen Aronovych, Dmytro Miroshnyk, Dmytro Horbachev, Borys Bohuslavskyi, Oleksii Hromov, Volodymyr Svyschenko, Mykhailo Petrov).¹⁰⁶

To this list we must add Hanna Hershman, who on October 24, 1922, defended her main project on the topic of “Hospital Steam Power Plant” under the supervision of Professor Petro Mukhachov and get a diploma with honors, as one of the first female graduates of the Institute.¹⁰⁷

At the same time, Petro Mukhachov worked in the city’s technical schools, for example, at the Kharkiv Evening Electromechanical Technical School named after Profintern (Profintern is an abbreviation for “Red International of Trade Unions”), where, together with his student Vasyl Vasylovych Monich, he taught technical subjects – mechanics and internal combustion engines.¹⁰⁸ Based on the results of his studies, he developed curricula for technical schools specializing in mechanical engineering.¹⁰⁹

From Petro Mukhachov’s questionnaire, filled out on November 27, 1923, one can be find out that he supported his daughter Nina, 12 years old, his daughter Olha (widow), 30 years old, his granddaughter Zoya, 10 years old, and partially his daughter Vera, 26 years old (widow).¹¹⁰ Petro Mukhachov’s petition was granted. On December 15, 1923, he was transferred to the 4th category.¹¹¹ He continued to obtained academic rations, like most professors and associate professors, until his death.

In the 1935 list of residents of the Kharkiv region, No. 102, opposite to the name of the honored professor Petro Mukhachov, there is a note: “died”.¹¹² The case contains information about the attitude of the authorities at the time toward scientists. For example, people were excluded from the ration lists for leaving the territory of Ukraine, for expulsion from the party, for lack of sufficient scientific data, and for ceasing scientific activity.¹¹³

After returning to the KhTI, having demonstrated a high level of professional qualifications, Petro Mukhachov continued writing scientific, technical, and methodological literature. Thus, in the early 1920s, he prepared and published “A Lithographed Course in Mechanics for Drivers” and, on request of the Main Directorate of the Sugar Industry (Glavsakhar), “Pumps for Sugar Factory Workers”.¹¹⁴ Unfortunately, the number of book copies published was small, and today even the Vernadsky National Library lacks them.

The Mukhachov’s printed works on mechanical engineering, heat engineering, and pneumatics appeared also. In 1922, Petro Mukhachov’s manual devoted to thermal engines, “A General Course of Heat Engines”, was published in two-parts. In the 45-page first part steam boilers were discussed, which were used at that time in almost all branches of industry.¹¹⁵ In the 312-page second part the author had considered in detail steam engines, which were then most commonly used in transport – steam locomotives and steamships.¹¹⁶

In 1922, under his editorship, a 239-page course entitled “Machine Elements” was published, which was taught at the KhTI.¹¹⁷ At the beginning of 1923, published the book for

¹⁰⁶ *Ibid.*, pp. 147–157.

¹⁰⁷ *Ibid.*, p. 156.

¹⁰⁸ CSASA, f. 331, desc. 2, case 117, p. 23.

¹⁰⁹ Mukhachov 1922a.

¹¹⁰ CSASA, f. 331, desc. 2, case 93, p. 259.

¹¹¹ *Ibid.*, p. 248.

¹¹² *Ibid.*, p. 30.

¹¹³ CSASA, f. 331, desc. 2, case 93, p. 8.

¹¹⁴ *Ibid.*, p. 259.

¹¹⁵ Mukhachov 1921.

¹¹⁶ Mukhachov 1922b.

¹¹⁷ Mukhachov 1922c.

the researchers “Simple Machines” in the Library of Industrial and Technical Knowledge series of books.¹¹⁸

Petro Mukhachov prepared two editions of the textbook “Steam Locomotives”¹¹⁹ (each edition contained over 400 pages), and an album of accompanying illustrations,¹²⁰ which were published by the Kyiv State Publishing House. A comparison of the two editions reveals that they are not identical. The second edition contains a more comprehensive history of the development of steam locomotive construction worldwide. Clearly, the scholar had been collecting and systematizing this information for many years.

In 1929, Petro Mukhachov edited the book “Types of Steam Locomotives and Tenders for Normal Railway Tracks”,¹²¹ which, although written by Mykhailo Kitaiev, was, in fact, a direct continuation of Mukhachov’s fundamental work “Theory and Design of Steam Locomotives for Broad-gauge Tracks”.¹²² It is not surprising that the author invited Petro Mukhachov to edit the publication: most of the material was based on his data, collected back in the late 19th century.

In 1931, Petro Mukhachov published a manual on regulating stroke of heat engines.¹²³ This relatively small book (less than 100 pages) was written specifically for practical use in factories, and it was used in most enterprises associated with heat engines.

In addition, the English-Russian Technical Dictionary was published in 1926 under the editorship of Petro Matviiovych Mukhachov and Mefodii Ivanovych Kuznietsov.¹²⁴ Three years later, in 1929, a two-volume manual on compressors and air blowers, translated from German, was published under the editorship of Petro Matviiovych Mukhachov and Veniamin Mykhailovych Maizel.¹²⁵ Two more years later, the book was reprinted.¹²⁶ According to the recollections of Petro Mukhachov’s colleagues, his daughters, who spoke German fluently, helped the scientist to translate scientific and technical literature published in Germany.

6. Participation of Petro Mukhachov in the establishment and development of the Kharkiv Scientific and Research Institute of Metals

Throughout his active teaching career, Petro Mukhachov was well-informed about the problems of the metallurgical industry of that time. For example, he personally knew Adam Oleksandrovykh Svitsyn, director of the Yuzovskyi Metallurgical Plant, having repeatedly visited metallurgical plants with students. These two men were extraordinary individuals. One was a specialist in steam locomotive construction and hot metalworking, and the other was an outstanding organizer of the metallurgical industry. The number famous specialists, such as Mykhailo Kurako and Ivan Bardin, began their work in the field of metallurgy at the plant headed by A.A. Svitsyn. Alexander Kuprin wrote about the plant also. Even during World War I, there was not a single strike at the plant, because the supply of raw materials and food to the staff was impeccable.

One of the main reasons for the opening of the Ukrainian Scientific and Research Institute of Metals (UkrNIIMet) in Kharkiv was the scientific and technological revolution, which led to significant achievements in chemistry (organic and inorganic) and related metallurgy and

¹¹⁸ Mukhachov 1923.

¹¹⁹ Mukhachov 1927a.

¹²⁰ Mukhachov 1927b.

¹²¹ Kitaiev 1929.

¹²² Mukhachov 1895.

¹²³ Mukhachov 1931.

¹²⁴ Melenevsky 1926.

¹²⁵ Ostertag 1929a; 1929b.

¹²⁶ Ostertag 1931.

electricity in the late 19th century. By the early 20th century, nearly all industries began to make increased demands on the quality of metals, their smelting, and working technologies.

In the 1920s, it was necessary to supply Ukraine's rapidly developing heavy industry with raw materials, primarily steel and cast iron. It was necessary to learn how to cost-effectively recover ores not only with a metal content of over 70% (for example, ores from Kryvyi Rih), but also from low-grade ores, in which the metal content was 30% or less, with increased phosphorus and sulfur content (for example, Kerch ores). The country did not produce ferroalloys and alloying components, without which it was impossible to obtain any high-quality stainless or spring steel. Accordingly, there was no equipment for the production of rolled products of various profiles. The technologies used in Ukrainian metallurgy at that time were decades behind. As a result, consumers did not obtain metal of the required quality. For example, the supply of rolled products to enterprises in 1926–1927 did not exceed 73% in the USSR, and 59% in Ukraine.¹²⁷ To increase metal smelting, a large number of railcars were needed to transport ore, reducing agents, fluxes, refractories, etc. to the metallurgical plants, and to carry smelted metal and rolled steel products. However, there was a shortage of metal to manufacture the railcars.

The general doctrine of the Communist Party ruling at that time, aimed at transforming the country from an agrarian to an industrial one, required the metallurgical industry to reach a modern technological level. Considering that in 1920, only one blast furnace was operating in Ukraine, and ore mining was nonexistent, the smelting of 126 million poods of pig iron (a pood is a Russian unit of weight equal to 16.38 kilograms) in 1926–1927 was a significant achievement.¹²⁸

Ukraine's large reserves of metallurgical raw materials, as well as its giant metallurgical plants, required significant capital investment to resume production. The metallurgical industry and metallurgical research institutes were required to implement a number of measures:

- more thorough preparation of metallurgical raw materials for smelting furnaces, as well as the use of new sources of raw materials;
- increasing the productivity of metallurgical units and devices;
- organizing the production of quality and high-quality steels for transport, the automotive industry, and other mechanical engineering sectors;
- efficient use of metallurgical waste and reducing losses;
- replacing scarce and imported materials and equipment with less deficient domestically produced ones;
- increasing efforts to mechanize and electrify labor-intensive processes in metallurgy;
- developing new forms of labor – socialist competition and shock work.

These measures are forming the foundation for the technical development of ferrous metallurgy. Therefore, it was necessary primarily to change the technology for smelting iron and steel to achieve more complete metal recovery and reduce the proportion of unrecovered metal in slag. It was necessary to improve a technology for manufacturing semi-finished product No. 3 (rolled products) on existing rolling mills, and to develop new calibrations for them with positive, rather than negative, allowances. Without scientific developments, these challenges could not be resolved.

During World War I, factory laboratories were established at domestic industrial enterprises, where numerous researches were conducted on the various properties of ores, fluxes, slag, molding materials, cast irons, steels, non-ferrous alloys, and products made from them, etc. Initially, most positions in these laboratories remained vacant: at that time, no higher education institution was graduating specialists in this field. Laboratory research methods were lacking: graduates of chemistry departments, most of who worked in these laboratories, were

¹²⁷ CSASA, f. 337, desc. 1, case 4063, p. 15.

¹²⁸ Anon₁₆ 1927, p. 94.

skilled in chemical analysis, but their knowledge of metallography, the dependence of metal properties on their structure, and the fundamentals of heat treatment were insufficient.

An additional argument for opening a research institute in Kharkiv was its geographic location: the main centers of the Ukrainian metallurgy and coal industries (including coke deposits) were nearby, and the presence in the city of the KhTI and the corresponding scientific and teaching staff. Moreover, Kharkiv was the capital of Ukraine at the time. However, it must be said that finding specialists to work at the newly established Institute of Metals and providing them with housing was difficult problem.

Considering the urgency of the problem, a government decree on October 30, 1928, established the Ukrainian Scientific and Research Institute of Metals under the Supreme Council of National Economy of the Ukrainian SSR. A charter of Institute was also adopted, stating that UkrNIIMet was a research institution under the jurisdiction of the Supreme Council of National Economy of the Ukrainian SSR, with location of the Institute's management in Kharkiv.

The charter defined the institution's primary objectives, which included conducting scientific researches in the metal industry and all its technological processes, as well as studying issues of scientific labor management. In addition, these tasks included providing technologies and organizing production for the metallurgical and metalworking industries, as well as addressing issues related to the economics of the metal industry.

The UkrNIIMet was to fulfill the assigned tasks by conducting experimental laboratory research in the field of metallurgy of metals and alloys; organizing experimental productions with the aim of improvement of existing and searching for new production methods and technical solutions; comprehensive research and solving theoretical and practical problems raised by the metal industry; testing of finished and semi-finished products of the metal industry; maintaining constant communication between the Institute and other research institutions both within the country and abroad; printing periodical and non-periodical publications of the metal industry topic; convening periodic conferences, congresses and meetings in compliance with the established procedure, etc.¹²⁹

At the time of its opening and start of activity (1928–1930), the Institute was tasked with simultaneously working in two important sectors of the national economy – metallurgy and mechanical engineering, and only in 1931 UkrNIIMet was finally formed as a research institution exclusively for the ferrous metallurgy of Ukraine.

Honored professor Petro Mukhachov was appointed director of the Institute, as he had many years of experience in teaching specialized disciplines at KhTI related to metallurgy, relevant scientific and educational developments, as well as an experience of practical work. He had also repeatedly visited numerous metallurgical and machine-building plants in Ukraine, including with students, and understood existing and potential manufacturing problems like no other. He was personally acquainted with many of the managers, engineering and technical personnel at the enterprises where many KhTI graduates worked. It should be noted that the country's new authorities did not entirely trust the “bourgeois” specialists, calling them “former” ones, but, having no replacements, were forced to hire them. It is appropriate to note that after an arrival of specialists educated during the Soviet regime and of the “correct” origins (from working or peasant class), the old bourgeois specialists began to be harassed or dismissed.

At the initial stage, problems arose in organizing UkrNIIMet's work. The city lacked a building suitable for the institution's specific work; it lacked the necessary equipment, as it was not produced domestically, and Petro Mukhachov lacked the foreign currency to purchase foreign equipment. The staffing problem was extremely acute: finding highly qualified specialists with the appropriate specialization and providing them with housing, rations, and

¹²⁹ Anon₁₇ 1928, p. 936.

salaries was difficult in Ukraine in the late 1920s. According to the requirements active at the time, a scientist was also necessary to be provided an office, preferably with a telephone, where he could place his own library, as technical literature was highly valuable at the time: scientific and technical publications were in short supply and scarce.

At the end of 1928, it was decided to locate the UkrNIIMet in the former buildings of the Congress of Mining Industrialists of the South of Russia at Sumska Street, 18 and 20. In the late 1920s, the street was renamed Karl Liebknecht Street, and its former name was restored only after World War II. Initially, the Institute occupied two small rooms next to various offices and departments of the Supreme Council of the National Economy (VSNKh), for example, the Industrial Academy, the All-Union Coal Research Institute, the Ukrainian Scientific and Research Institute of Industrial Energy, the Ukrainian Scientific and Research Institute of Structures, and some other institutions.¹³⁰ And since 1935, UkrNIIMet was located in a specially built separate building at Darwin Street, 10/2, which became house number 20 after the street had been built up.¹³¹ Residential apartments were also located in the same building.

At that time, taking into account the shortage of qualified specialists, various trusts, factories, institutions, and so on often poached engineers from each other, often the specialists worked part-time at several organizations, including higher education institutions. Therefore, Petro Mukhachov invited many colleagues from KhTI to work at the newly established research institute. For example, Mykola Fedorovych Leve held the position of deputy director (later director). As a communist, he had some administrative experience: after his graduation from KhTI, he served as a political commissar of Institute and simultaneously held the position of vice-rector for economic affairs. Mykola Leve has subsequently become a leading specialist in the field of steel smelting.

Petro Mukhachov was not a member of any party, and according to the requirements of that time, a non-party manager had to have a party deputy. This requirement applied to all spheres – a military, industry, education, and so on. For example, in order for a certain document related to educational activities to be valid, it had to be signed by the rector of the higher education institution and the political commissar.¹³² At that time, Ukraine lacked a sufficient number of specialists in various fields who, in addition to their professional achievements, were also communists.

In addition to N.F. Leve, professors of the KhTI Yevhen Yevhenovych Farafonov (foundry)¹³³, Volodymyr Andriiovych Mozharov (metallurgy), and Naum Yosypovych Reznikov (cold metal working) were invited to the positions of department heads, and experienced engineers Iona Davydovych Derechynskyi, Anatolii Kuzmych Khodulin, Dmytro Ivanovych Apatov, and others were invited to the positions of researchers.

At the same time, many specialists were invited to work at the new institute, who either had experience in scientific work or an inclination for it, for example, professors Pavlo Hermanovych Rubin (blast furnace production), Andrii Pavlovych Vynohradov (steel production), highly qualified engineers Yulii Yuliovych Hapanovych (refractories), Ivan Pavlovych Platonov (rolled metal production) and other specialists.

With the opening of UkrNIIMet, departments of iron and steel production, metallurgical processes, metal analysis, foundry, cold metal working, tool making, and economics were created in this institute. Over time, these departments were expanded with new subdivisions and laboratories.

Thus, under Petro Mukhachov's leadership, the first laboratories were established: mechanical, metallographic, radiographic, chemical, and others. They not only were focused

¹³⁰ Anon₁₈ 1930, p. 235.

¹³¹ Anon₁₉ 1935, p. 325.

¹³² SAKhR, f. R-1682, desc. 1, case 94, p. 1.

¹³³ A. Zhurylo 2013, p. 47.

on theoretical issues but also carried out research related to basic production topics at metallurgical plants. An experimental casting system was also designed, and workshops were established to support laboratory researches. This enabled fundamental research to be conducted at the world scientific level of the time.

UkrNIIMet staff immediately began working actively, continuing their researches, begun before joining the Institute. In particular, one of the first scientific works devoted to the study of refractories for converters, fuel oil furnaces, and the use of talc stone as a refractory was completed by the talented engineer Yu. Yu. Hapanovych.¹³⁴ The research led to the following results: not only the operating conditions of refractories in powerful open-hearth furnaces, used not by expensive coke, but by inexpensive fuel oil, were analyzed, but also the parameters for stable melting and subsequent treatment of the molten steel with slag (the so-called Tochynskyi method) were determined.

The work allowed developing the method for most efficient furnace heating, which significantly reduced rapid refractory wear with increased productivity and furnace fuel overloads. It also contributed to the development of measures preventing rapid melting of checkers and its clogging with smelting dust. The conclusions made had a significant economic impact: with efficient heating and thermal regime, the smelting company of high-power open-hearth furnaces used fuel oil could be increased by 25–30%. Thus, on average, one cold repair per furnace per year was reduced, saving up to 25% on refractory bricks made of silica (silicon dioxide). At the same time, the workshop annual productivity increased by 8–10 thousand tons of metal.

Engineer I.D. Derechynskyi, under the supervision of Professor Ye.Ye. Farafonov, fulfilled the first in Ukraine studies of molding materials – sands and clays in accordance with the requirements and standards of the American Foundry Association.¹³⁵ Comparing them with similar data for domestic materials, I.D. Derechynskyi determined their properties – gas permeability, grain size, destruction from thermal shocks, the use of various binder materials, etc. This work not only determined the possibility of using spent molding mixtures, but also led to a reduction in the volume of molding materials used by enterprises, as well as a decrease in their range, which significantly reduced the cost of their delivery and storage.

I.D. Derechynskyi spoke several European languages and translated some technical manuals and textbooks. It is known that the originals were, on average, a third shorter: the translator incorporated his own industrial experience into the translated text. In early 1930, Iona Derechynskyi went to work at the Kharkiv Tractor Plant, and in 1938 he was executed on a false conviction. The talented engineer was rehabilitated only in 1957.¹³⁶

Another interesting research work of the UkrNIIMet was the determination of the proportions of various ingots and molds, carried out under the supervision of Professor Ye.Ye. Farafonov. At the F.E. Dzerzhinsky Metallurgical Plant in Kamianske, the calculations was performed, based on which the proportions of all 36 types of molds were changed.¹³⁷ The operating conditions of the molds – a temperature of about 1500°C and a mass of poured metal of 250–400 kg, sometimes led to the appearance of various defects, namely, cavities, porosity, segregations. According to the results of the research, the occurrence of shrinkage cavities alone at one plant was reduced by 2.5%, which made it possible to obtain additional tons of steel. After testing the new technology, it began to be implemented at many metallurgical plants in Ukraine, in particular in the manufacture of square molds from gray and alloyed cast irons, in

¹³⁴ Central Scientific and Technical Archive of Ukraine (hereafter CSTAU), f. 13, coll. 3–5, desc. 1, case 31 and case 21.

¹³⁵ *Ibid.*, pp. 2–17.

¹³⁶ D. Zhurylo 2021, p. 135.

¹³⁷ CSTAU, f. 13, coll. 3–5, desc. 1, case 1, p. 2.

their unification, identification of the causes of defects, extension of service life, etc. All these improvements were based on the research work carried out in 1929 at the plant in Kamianske.

UkrNIIMet worked on addressing the problems of certification of metallurgical enterprises, mechanization, implementation of negative tolerance deviations during steel working by pressure, improvement of wage scales at various plants, labor protection, and even attempted to use wooden bearings in rolling mills.¹³⁸

In the late 1920s and early 1930s, the development of a system of measures to prevent rail wear on railways, particularly abrasion and crumpling, was the relevant issue. That is, an urgent need to improve rail production has arisen. Research of rail sorbitization was organized at the Institute, as Petro Mukhachov, as a specialist in steam locomotive construction, understood the importance of developing rail transport. Also, to improve the quality of transport metal, work was organized to reduce defects in production of axles.¹³⁹

However, Professor Petro Mukhachov's tenure as director of the Institute was not too long. As early as January 17, 1930, he requested his immediate dismissal, stating explicitly that he "does not wish to be the target of unfounded attacks and accusations and does not wish to be guilty without having any guilt". (CSASA, f. 34, desc. 14, case 1006, p. 42)

He had not been able to work when the primary criterion for leadership was not knowledge or education, but party affiliation. It should be noted that at that time, many leaders in various sectors of industry – from the Supreme Council of the National Economy to enterprises – had no higher education. The new authorities, first and foremost, needed people loyal to the regime.

It should be noted that on November 2, 1929, the head of the steam locomotive construction department, Vasyl Vasylovych Monich, passed away.¹⁴⁰ This also influenced the decision of Petro Mukhachov, who also had serious health problems. He focused on his work at the KhTI, as it was difficult to simultaneously manage the Institute of Metals and head the steam locomotive construction department, which he headed after V.V. Monich's death.

After Petro Mukhachov's dismissal from his post as director, UkrNIIMet did not lose contact with KhTI, as many of the Institute's part-time employees worked there. Professor Mykola Fedorovych Leve, who had headed the institution for a long time and simultaneously served as head of the department, became the Institute's director in 1930, and Professor Volodymyr Andriiovych Mozharov was his deputy for research work during many years. Volodymyr Andriiovych Mozharov made a significant contribution to world metallurgy.¹⁴¹ In the early 1930s, Yevhen Yevhenovych Farafonov, Mykhailo Viktorovych Vratskyi, Naum Yosypovych Reznikov, and Yevhen Havrylovych Shumovskyi served as heads of departments at the Institute. At that time Iona Davydovych Derechynskyi, Lev Samiilovych Dluhach, Dmytro Ivanovych Apatov, and others were among the research fellows. UkrNIIMet became the base for practices and the first place of work for many young engineers who graduated not only from KhTI, but also from other higher education institutions.

The Institute quickly became a flagship of domestic metallurgy, with its employees making significant contributions to metal science, on par with the best international standards and sometimes surpassing the world analogues. UkrNIIMet held a leading positions in the smelting of ARMCO iron (iron without impurities, commercially pure iron), the development of two of the three known continuous casting methods, the production of cost-effective roll-formed sections, fundamental work using non-aging steels, and more.

¹³⁸ *Ibid.*, pp. 1–7.

¹³⁹ CSASA, f. 34, desc. 14, case 1006, p. 40.

¹⁴⁰ SAKhR, f. R-6532, desc. 21, case 765, p. 106.

¹⁴¹ D. Zhurylo, Levchenko 2025, p. 595.

7. Conclusions

This publication analyzes the scientific, organizational and educational activities of the outstanding mechanical engineer and metallurgist Petro Mukhachov.

Petro Mukhachov's active work in Kharkiv began in September 1887 and continued, with interruptions (1917–1920), until 1935. Having begun his career as a teacher of drawing and courses on factory machines, he ended it as an Honored professor at the Kharkiv Technical Institute and the founder of the domestic steam locomotive construction industry.

Petro Mukhachov was the author of numerous lecture notes, textbooks, monographs, manuals, and atlases on steam locomotive construction, as well as specialized plant equipment, including blowing engines, rolling machines, and mechanisms for hot metalworking. Thanks to Petro Mukhachov's painstaking work as well as educational and methodological developments, KhPI established new specialties – steam locomotive construction, metalworking by pressure, and equipment for metallurgical and machine-building plants. NTU “KhPI” continues to train engineers in some of these specialties today. His collaboration with domestic machine-building and metallurgical companies has led to an expansion of internship opportunities for future engineers.

Petro Mukhachov's textbooks and manuals, compiled with taking into account the best practices of foreign and domestic companies and the newest technologies, were in high demand not only among students but also among engineers at steam locomotive construction and metallurgical plants, as they were, in essence, the first technical publications in Ukraine.

Petro Mukhachov was one of the first educators providing personnel to the steam locomotive construction industry in Ukraine and the Russian Empire. He has managed to get extensive experience by studying the best practices of factories located in Russia and Europe (Germany, France, Belgium, and England), and by attending several World Industrial Exhibitions, including the Paris Exhibition of 1900 and the Brussels Exhibition of 1910. His scientific works on steam locomotive theory and metallurgical engineering were pioneering in Eastern Europe and were widely used in engineering practice.

In the early 20th century, Petro Mukhachov was considered a leading expert in the field of domestic steam locomotive construction.

In 1905, he became the first elected director of the KhTI and headed the Institute until February 1915.

Petro Mukhachov, using his organizational abilities, had succeeded in opening a fireproof construction courses on the KhTI campus in January 1914, and became director of the courses. Opening these courses was an exceptionally important educational and organizational event at that time, as wood was widely used as a building material in Ukraine.

Petro Mukhachov's activities as director contributed to the establishment of KhTI as a leading technical institution of higher education in Ukraine.

Petro Mukhachov and his wife promoted cultural and educational work among students at KhTI in order to popularize the arts and sports, and were actively involved in charitable work for insolvent students. In 1910 alone, the Mukhachov family's donations accounted for 38.8% of the entire Institute's income.

Despite the difficult period in Ukraine's history after the 1917 October coup, Petro Mukhachov's scientific, pedagogical, and organizational activities were equally productive. He returned to his position as a professor at KhTI, continued teaching specialized subjects, supervised graduation projects, managed the Institute's mechanical workshops and the Department of Steam Locomotive Construction, and published a number of scientific, technical, and methodological works. At the same time, he taught at other educational institutions, participated in the development of curricula for technical specialties, headed the general mechanical machine-building section in the Metals Department of the Industrial

Bureau, held an engineer position at the Ministry of Railways of Ukraine, and actively participated in the establishment and development of the Ukrainian Institute of Metals.

Petro Mukhachov, as director of UkrNIIMet, having extensive management and practical experience, and as a leading scientist, played an important role in the Institution's development. With his assistance, newest researches in metallurgy was quickly organized and subsequently implemented into production. This enabled domestic metallurgical plants to become one of world industry leaders.

Unfortunately, not all of Petro Matviiiovych Mukhachov's archival materials and research achievements are yet available to researchers or published in the public domain. This suggests that these materials will be accessible to historians, and researchers will be able to uncover previously unknown information about the scientist's and educator's life and the results of his scientific research.

8. Acknowledgments

The authors take the opportunity to express their deep gratitude to: Associate Professor, Candidate of Technical Sciences **Alla Grygorivna Zhurylo** – the first researcher of the Ukrainian Scientific and Research Institute of Metals, Halyna Viktorivna Pavlova – head of the department of rare books of scientific and technical library of NTU “KhPI”, for help in writing the article.

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