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**ACADEMICIAN MYKOLA PAVLOVYCH PETROV (1836-1920): LIFE AND  
ACTIVITIES**

*The article describes the life and activities of the formidable scientist, engineer, statesman, Academician Mykola Pavlovych Petrov (1836-1920). He was widely known as a reformer of the railway transport and at the same time, as one of the core founders of the technical education in Russian Empire.*

*Solid knowledge and experience gained abroad in mechanics were successfully used by M. P. Petrov in his further practical scientific activities. He played a considerable role in solving the vast variety of railway issues. Among those should be mentioned the following ones: achieving the concessions for railway building, taking part in the formation process of the democratic joint stock railway partnerships, countless researches dedicated to the lowering of spendings for the railway in general and rolling stock in particular. Due to M. P. Petrov all the foreign experience which that he was able to gather used for the railway in a practical way that made the work of the railway engineers easier and more efficient.*

*The track record of Academician M. P. Petrov is just amazing. Various activities on railways show us that M. P. Petrov had indisputable authority among the scientists, engineers and statesmen of his time, in particular in the Railway Ministry.*

*All the tasks that performed M. P. Petrov were closely connected to the hardest and most important issues of the railways and building mechanic.*

*The article also describes the most important researches which were carried out by M. P. Petrov. First of all, his hydrodynamic lubrication theory should be mentioned. He was the first scientist in the world that implemented the totally new concept of friction between the solid materials with usage of the lubricating fluids. He evaluated the characteristics of the lubricating fluids depending on the pressure and temperature and their influence on the friction process. One more important research conducted by M. P. Petrov was his work on the question about the braking systems for the locomotives. It helped the engineers all over the world to have the understanding how the ideal braking system should look like and work.*

*In addition to the statesman work and performing the engineering tasks on the railway, M. P. Petrov was also a Professor of the Engineer Academy and Technological Institute and could be considered as one of the founders of the technical education, combining not only the theoretical knowledge, but also the practical experience. M. P. Petrov started a lot of new courses, wrote huge amount of books and manuals.*

*In addition, the article provides information about the awards of N. P. Petrov, as well as detailed description about his career.*

**Key words:** *M. P. Petrov, railway transport, hydrodynamic lubricating theory, engineer education.*

## **АКАДЕМІК МИКОЛА ПАВЛОВИЧ ПЕТРОВ (1836-1920): НАРИС**

### **ЖИТТЯ ТА ДІЯЛЬНОСТІ**

*У статті висвітлюється діяльність видатного вченого, інженера та державного діяча М. П. Петрова – відомого своїми реформаторськими діями у сфері залізничного транспорту, одночасно будівничого технічної освіти в Російській імперії.*

*Знання та досвід, набуті за кордоном у сфері прикладної механіки пізніше успішно використовувалися ним у практичній діяльності в царській Росії. М. П. Петров брав участь в реконструкції низки важливих питань залізничної справи: отримання концесій на будівництво залізниць, процесу формування демократичних акціонерних залізничних товариств. Завдяки діям М. П. Петрова зарубіжний досвід був спрямований вітчизняними інженерами-залізничниками у практичне русло їхньої діяльності.*

*Послужний список М. П. Петрова вражає. Різноманітна діяльність М. П. Петрова-реформатора залізничної справи свідчить про визнання його авторитету в наукових і адміністративних колах Міністерства шляхів сполучення. Де б він не застосовував свої знання і кваліфікацію інженера, це були найбільш важливі ділянки державної політики в галузі залізничного транспорту, а також будівельної механіки.*

*В статті також висвітлюються найважливіші дослідження М. П. Петрова. Перш за все – це гідродинамічна теорія змащування. М. П. Петров був першим вченим, що впровадив цілком нову концепцію у термі*

*твердих матеріалів при явному змащуванні. М. П. Петров експериментально визначив характеристики змащувальних матеріалів в залежності від температури тертя та тиску. Крім того, М. П. Петров провів колосальну роботу щодо визначення та розрахунку характеристик гальмівних систем для рухомого складу залізниці.*

*Крім того в статті описується не лише адміністративна та інженерна діяльність М. П. Петрова, а й його наукова робота як професора Інженерної академії та Технологічного інституту. Поєднавши безцінний практичний досвід, закордонні напрацювання та теоретичні знання, М. П. Петров запровадив цілий ряд нових курсів в інститутах, приймав участь у відкритті нових навчальних закладів, видав велику кількість підручників та наукових посібників.*

*Крім того в статті подається інформація про нагороди М. П. Петрова, а також детальна інформація щодо його кар'єри.*

**Ключові слова:** *М. П. Петров, залізничний транспорт, гідродинамічна теорія змащування, техніка, інженерна освіта.*

**Introduction.** Mykola Pavlovych Petrov (1836 – 1920) – the scientist in railway transport area, the Honorable Member of Petersburg Academy of Science (1894), Engineer general-lieutenant. Based on the research of the railway carriage bearings friction he created the hydrodynamic theory of lubrication (honoured for it with Lomonosov award in 1884). M. P. Petrov was the head of the Engineer Council of the Railway Ministry of Russian Empire, "companion" (Vice-Minister) of the Minister since 1893, took part in the building of the Trans-Siberian Railway. M. P. Petrov initiated the creation of the Moscow Engineer Specialized School (1896). During 1896–1905 M. P. Petrov was the head of the Russian Technical Fellowship. Main scientific works by M. P. Petrov were dedicated to the calculations of the railway paths, hydrodynamic theory of lubrication, braking systems in locomotives, traction calculations.

The name of the formidable engineer Mykola Pavlovych Petrov relates to the creating of one of the most important theories in the technical science, friction theory. M. P. Petrov is author of 21 publications dedicated to this research. The most noticeable one among those was "Friction in machines and influence of the lubricating fluids on it" (1883). This work gained a vast popularity in the scientific world and made M. P. Petrov known as a founder of the hydrodynamic lubricating

theory [1]. However, there are not a lot of sources about M. P. Petrov available [2; 3; 4; 5].

The purpose of this article is to gather the information related to the life and activities of Academician Mykola Pavlovych Petrov, systematize it and order it in a chronological way. Moreover, this research is going to be a basement for the future more deep and solid research.

**Research methods.** The methodologic of the following research is based on the general principals of the historical research: historicism, multifactorial, comprehensive knowledge, complexity, and in addition on the special historical methods (problem-chronological, subject-logical, historical-genetic and comparatively-historical). Due to the historical method of research it was possible to analyze the sources containing the information about the life and activities of M. P. Petrov and, moreover, to form in the chronological way all the gathered information [6].

**Results and discussion.** Formidable scientist, engineer and statesman M. P. Petrov was born on the May, 13, 1836, in the city Trubchevsk in nobleman family. Elementary education M. P. Petrov gained while he was living in parents' house in Novgorod region. When M. P. Petrov was thirteen, he was going to start military career following the family traditions. First of all, M. P. Petrov was trying to enter the Institute of the Railways. Those days the Institute was a military educational institution. M. P. Petrov was attending the training courses before entering the institute during the one year. However, after finishing the courses he was not able to enter the institute. So, in 1849 instead of the Institute of the Railways M. P. Petrov entered the cadet corps in Petersburg [7]. In addition, M. P. Petrov was also attending special military classes, and in 1855 he finished the cadet corps and gained ensign rank. In the same year he entered the Engineer Academy in Petersburg.



**Figure 1.** Academician Mykola Pavlovych Petrov (1893).

M. P. Petrov was noticed and supported in the academy by the well-known scientist, lecturer of the mathematics M. V. Ostrogradskyi (1801–1861). M. V. Ostrogradskyi was the first who had seen in M. P. Petrov the future great scientist and enrolled him in his department in 1858 when he graduated from the academy. M. P. Petrov continued his education even after the graduating the academy increasing his knowledge and gaining more and more scientific experience. Furthermore, M. P. Petrov also attended additional lectures in Petersburg Technological Institute, learning mechanics and higher mathematics. During the lectures M. P. Petrov met and got to know one more formidable scientist, I. O. Vushnegradskyi.

After Academician Ostrogradskyi's death in 1862 M. P. Petrov became a temporarily lecturer in the Engineer Academy and taught the higher mathematics. Later, in a few years, M. P. Petrov went to the business trip abroad. The main goal of that trip was increasing the knowledge in mechanics. M. P. Petrov came back to Russia in 1867. He gained new knowledge and foreign experience and became a mechanics lecturer in the Technological Institute and Engineer Academy. Moreover, in 1867 the young scientist was promoted to mechanics Professor in the Engineer Academy.

M. P. Petrov performed his first engineer work while he was studying in the Technological Institute under the mentorship of I. O. Vushegradskyi. It was the designing of the special mechanism for the gun powder plant. Also, M. P. Petrov designed the oil pumps for that plant. In 1869 M. P. Petrov received the new order from the Artillery department and worked as a designer of the new plant.

M. P. Petrov started his scientific work in 1870, when his first research work was published in the Engineer magazine [8]. That research was called: "Outline of the toothed cylindrical wheels by the arcs of the circle" [9]. The main goal of the research was the accurate mathematic calculation of the toothed gear mechanism teeth for providing the smooth running. The scientists all over the world also were trying to solve this issue, however, only M. P. Petrov succeeded in it. He was able to find the easy implementable rules to calculate needed values. As the matter of fact, the inaccuracy of teeth connection was lowered to the lowest possible value. M. P. Petrov continued his researches in this field during the following years increasing the quality and accuracy of the calculations. In 1873 and in 90's M. P. Petrov published two more scientific works related to the toothed wheels calculations.

In 1871 M. P. Petrov started to work with the new issue. That year he began to teach the new course about the railway rolling stock. Foreign scientists were using only the empirical methods in this field and only M. P. Petrov was the one who started to implement true scientific methods. He justified in the theoretical way the formula of the train`s resistance while it was moving on the rails. Also, in 1871 M. P. Petrov was elected as a professor in the Petersburg Practical Technological Institute.

As for the practical work of M. P. Petrov on the railway, it began in 1873, when he held the position of the auditor of the rolling stock issues of the Main Russian railway partnership. While working as the auditor, M. P. Petrov faced a lot of exploitation issues on the railway that were demanding the scientific solution. It appeared that the railway became the main scientific interest of M. P. Petrov. Solving of the practical issues on the railway demanded a lot of researches and preparations from M. P. Petrov. However, as a result of his work, the railway business achieved a

significant amount of scientific publications related to the most common issues. Having the great advantage in comparison to other railway workers and scientists, M. P. Petrov combined solid mathematics knowledge and practical experience while solving the issues on high scientific level.

In 1876, M. P. Petrov went to the abroad business trip one more time. He visited the world wide exhibition in Philadelphia (USA). In 1878 the important scientific work for the railway was published by M. P. Petrov. It was the research about the continuous braking systems. In the end of 19th century the scientists understood that it was not possible to increase the speed of the trains without the upgrading of the braking systems. That is why a lot of researches were made related to this issue. However, there was no clear cut definition of how the ideal braking system should look like. In addition, the criteria of braking system evaluation were not found. This issue was solved by M. P. Petrov using the accurate mathematic calculations. He proved that the best braking system for stopping the train is the one that could hold the spinning of the wheels during the whole braking period.

During the Turkish war M. P. Petrov was promoted to the new rank Engineer general major. The reason for this high promotion was his perfect engineer work. First of all, he designed special pulling together mechanisms for deploying steamboats on railway carriages. Those steamboats were used to transfer soldiers on the river Danube. This task was performed by M. P. Petrov in the shortest possible time.

M. P. Petrov was the founder of the hydrodynamic theory of friction in machines which is considered as his biggest contribution in modern science. As the matter of the development of machine building and increasing of the railway networks all across the world the new complicated issue appeared. The engineers and designers were trying to lower the friction in mechanisms. They were researching the lowering of friction due to the using of the various lubricating materials. Unfortunately the results of those researches did not provide the clear cut answer on the existing questions. Furthermore, sometimes those results were quite opposite. In addition, the theories designed by the scientists did not have any practical proofs.

As for M. P. Petrov, he offered quite a new theory based on his new physical scheme of friction for the lubricated solid materials. The mechanism of friction was explained by M. P. Petrov in the following manner: lubricating layer totally separates the solid materials, so the friction between two solid bodies did not exist. As for the friction value, it could be determined by inner friction of lubricating fluid. So, it is a hydrodynamic issue. M. P. Petrov designed the formula that determined the friction value depending on the conditions of mechanisms' work. In a few years this formula gained wide popularity among the scientists in general and physicians in particular. The formula was called "Petrov's principle". M. P. Petrov published his hydrodynamic friction theory in 1883 in "Engineer magazine" with the topic "Friction in machines and influence of lubricating materials on it" [10]. Petersburg Academy of Science awarded M. P. Petrov with the Lomonosov prize for his theory.

However, to support the designed theory M. P. Petrov was forced to start more researches about the viscosity of lubricating materials. The researches M. P. Petrov began in 1883 in Petersburg Practical Technological Institute. Studying were divided into two groups and lasted for three years.

The first group, technical researches, was held to determine the ways of evaluation of fluids' characteristics depending on the various friction conditions that could be experienced during the machine work. The special experimental machine was designed to evaluate those characteristics.

As for the second group, physical researches, it was held for determining the dependence between the values of the inner friction of various lubricating materials and temperatures of that friction. Moreover, there was a necessity to determine whether lubricating fluid stick to the solid material or not. For solving those issues M. P. Petrov created an experimental setup. It consisted of long capillary tubes with different diameters. Those tubes were used under the various conditions with different temperatures and pressures. That experimental setup was shown on the exhibition in Petersburg in 1888. The manual for that setup was written in the scientific work called: "The description of the instrument for determining the inner friction value and keeping the instrument in right conditions" [11]. In 1889



M. P. Petrov published detailed instructions for his experimental setup. It should be mentioned that M. P. Petrov was awarded with the highest prize of Russian Technical Partnership for his experimental setup, – gold medal.

The whole results of physical and technical researches were published by M. P. Petrov in his work "Friction in machines and influence of lubricating fluids on it. The description and research results" in 1886 in the magazine of Technological Institute. Petersburg Academy awarded M. P. Petrov for his work with the metropolitan Macariy high prize.

In 1887 M. P. Petrov published the shortened edition of his hydrodynamic friction theory and its results. The main focus this time M. P. Petrov made on practical value and possibility to use the results of the experiments.

For the spreading of the hydrodynamic friction theory M. P. Petrov translated his scientific works from 1883 – 1990 period on French. As the matter of fact Petrov's works gained vast popularity among the world scientists. The reviews of Petrov's works started to appear in foreign magazines and scholar publications in Germany in 1887 and in Italy in 1888.

The creation of the hydrodynamic theory of friction made M. P. Petrov famous and well-known among the world wide scientific community. Various Academic Councils invited him to join them. In 1894 he was chosen as an honorary member of Petersburg Academy of Science.

Usage of the results of M. P. Petrov's researches dedicated to the friction theory had a significant role for the development of railways and the rolling stock. The usage of the lubricating fluids and fuel was lowered considerably and as the matter of fact the economy on the railway was more cost-efficient.

Combining the work of professor of Engineer academy and the member of the Council of Main partnership of Russian railways, M. P. Petrov was forced to solve the dilemma in 1885. Starting from 1885 it was forbidden to combine military service and work for the private partnerships. Finally, M. P. Petrov decided to continue his scientific work and stayed on the position of professor in Engineer academy.

In 1888 M. P. Petrov was appointed to the position of the head of State railway control of Russian empire and from the 1<sup>st</sup> of January 1892 – head of the railways. The scientist was able to continue the professor's activities in Engineer academy at the same time with the work on the high state positions. While the work on railways and administrative work demanded a lot of time from M. P. Petrov, until 1892 he was able to publish a couple of works related to the mechanic and railway science.

The administrative work of M. P. Petrov was quite considerable. He promoted the creation of the Engineer council in 1892 that was under the mentorship of Ministry of communication paths. The main goal of the council was the solving of the technical tasks for the railways. In the same 1892 M. P. Petrov was promoted to the first head of the Engineer council. After his quite the work for the Ministry, he was left as the honorary member of the council.

The International railway congress was held in Petersburg in 1892 and M. P. Petrov was chosen as the head of that congress. From that time he became the lifelong member of the International congress bureau. The same year M. P. Petrov was promoted to the position of the "fellow" of the Railways Minister. However, M. P. Petrov was forced to leave his professor position in Technological institute. For his considerable scientific achievements M. P. Petrov was chosen as the honorable member and honorable engineer-technologist of Technological Institute.

It was not the first time for M. P. Petrov to achieve such honor from various technical fellowships or scholar institutions. While M. P. Petrov was the true member of Russian Technical Fellowship in 1875 and the member of its Mechanical department, he was among the designers of the first French-Russian-German technical dictionary. For the performing such complicated task M. P. Petrov was added to the list of the lifelong members of the Russian Technical Fellowship.

In 1896 M. P. Petrov was chosen for the first time as a head of the Russian Technical Fellowship, and after it was chosen for two more times to that high position in 1900 and in 1903. However, in 1905 M. P. Petrov was forced to leave the head's position due to the age.

M. P. Petrov's lecturer activities in various highest scholar institutions lasted for around forty years. The scientist founded a lot of new courses, wrote the huge amount of books and manual counting more than 2000 lithographic pages. Also M. P. Petrov played a considerable role in creation of the new polytechnic institutes. His scientific views found places in his various articles and conferences.

In 1900 M. P. Petrov was promoted to the position of the member of State council and till 1906 he was the member of the Department of industry, science and trade. After 1906 he held the position of the railway department head. While M. P. Petrov left his professor's position he did not left his scientific work and continued his research for additional 15 years. M. P. Petrov designed the new theory dedicated to the calculation of the rails' strength. The results of his investigations were published in 1910 and 1915 [12, 13].

In the beginning of the 20th century the question about the cost-efficiency of the railways appeared for the first time. The vast critic among the society was the reason for the creation of the special high commission to investigate the railway question. M. P. Petrov was chosen as the head of that commission. The main task was to evaluate the true conditions of the railway and to find the ways of solving the possible problems.

The special commission was working for 4 years and published around 100 works containing the results of the investigations, it should be mentioned that 16 from those 100 reports were made by M. P. Petrov. In 1912 M. P. Petrov wrote the summary report and based on the real financial calculations and results showed the true cost-efficiency of the railways. He pointed that only due to the fast development of the railways the country may increase its economy and overall tempo of development. However, M. P. Petrov noticed that all the decisions on the railways should be based on real scientific investigations.

In 1911 M. P. Petrov was congratulated with his 40<sup>th</sup> scientific work anniversary in Engineer Academy. A lot of scientists and representatives from various scholar institutions came to take part in this assembly to honor the formidable scientist.

The last high promotion M. P. Petrov achieved in 1915, when he became a head of the highest commission of investigations the reasons for lack of weaponry in Russia. Unfortunately, M. P. Petrov was not able to finish his work. In 1917, he got ill with pneumonia and moved to the coast of the Black sea. In 1919 M. P. Petrov moved to city Tyapse where he died on 2<sup>nd</sup> of January 2020.

**Conclusions.** The article covers the main events of the Academician Mykola Pavlovych Petrov's life. The information about the scientist's activities was gathered, observed, systematized and ordered in a chronological way.

The scientific activities of the Academician were described in the article, and their analysis showed that M. P. Petrov took a considerable part in scientific life of Russian Empire. The hydrodynamic theory of lubrication and friction theory in machines were among the most noticeable scientific works by M. P. Petrov which made him well-known all around the scientific world.

In addition, the information about the administrative work of M. P. Petrov on the railway was covered. The importance of his decisions and his reformative vision were shown. Moreover, we mentioned M. P. Petrov's scientific approach in solving all the railway issues which was innovative for that period of time.

Furthermore, it was proved that still the knowledge about the formidable scientist M. P. Petrov lacks a lot of facts and information. So, we could make a conclusion that it would be crucial to continue the research, looking for new facts about the life and scientific activities of the Academician.

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