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Background of creation, further development, and establishment of Kharkiv Locomotive Plant

***Abstract.** The late XIX century was marked by the rise of industry in the Russian Empire. This period was characterized by shifting the core of industrial development from the Ural region to the south of the country, associated with the development of abundant coal deposits in Ukraine, and accompanied by extensive railroad construction in the central and southern parts of the Russian Empire. This aspect spurred the expansion of machine-building industries under the protectionist economic policy of the Russian Empire's government toward Russian enterprises. It was aimed at shielding them from the influence of foreign competitors. In the early 1870s, Kharkiv started growing rapidly as a major industrial hub in the south of the Russian Empire.*



The railroad offered an opportunity for the delivery of the most advanced equipment and technology, something that foreign companies never failed to take advantage of. In the 1890s, transport machinery gained significant development. Since 1891, the monopoly on steam locomotive construction in the Russian Empire, which had been concentrated in the 1880s at the Kolomna Locomotive Plant alone, was disrupted. In the mid-1890s, steam locomotive construction was deployed at eight major machine-building enterprises of the Russian Empire. This article is intended to provide a thorough analysis of the background of the creation, further development, and establishment of the Kharkiv Locomotive Plant. It offers an overview of different stages throughout the history of the Kharkiv Locomotive Plant. This article discusses the conditions and prerequisites for choosing the location of the plant; considers the stage of the establishment (foundation) of the plant; examines the stage of plant construction and equipping it with technological facilities in detail; analyzes the development and establishment of the plant between 1897 and 1914. A brief analysis of locomotive designs produced by the Kharkiv Locomotive Plant from 1897 to 1914 has been made. The article shows the significance of Consultative Congresses of Traction Engineers for the development of railway machinery both at Kharkiv Locomotive Plant and for the entire railway industry.

Keywords: *steam locomotive; history of steam locomotive construction; Kharkiv; steam locomotive of the “normal type”; “O” class steam locomotives; “Shch” class steam locomotive*

Introduction.

December 2022 marks the 125th anniversary since the first steam locomotives were manufactured in Ukraine at the Kharkiv Locomotive Plant (hereinafter referred to as KhLP).

Many aspects concerning the background of the creation, further development, and establishment of the Kharkiv Locomotive Plant are considered by many authors (Baker, 2006; Diakova, 2018; Gatrell, 1994; Grant, 1999; Jacolin & Roth, 2016; Kryvokon, 2014; Le Fleming & Price, 1960; Radoguz, Zaitsev, Gutnyk, & Tverytnykova, 2019; Redka, Islamova, Borzilo, & Shelukhina, 2020; Sorochynska, 2009, 2013, 2015a, 2015b; Yeremenko & Kroytor, 2020; Zhaloba, 2016).

The articles by Sorochynska (2009, 2013, 2015a, 2015b) briefly discuss the contribution of Kharkiv Locomotive Plant to the development of the locomotive industry in Ukraine. The main types of locomotives that were built at Kharkiv Locomotive Plant are presented. The importance of the origin of the steam locomotive industry in Ukraine is determined. However, Sorochynska's papers focus on the study of the scientists and workers of the plant (O. S. Rayevsky, M. L. Shchukin, Yu. V. Lomonosov, and others), and the consideration of their contribution to the steam locomotive industry as a whole, rather than the background of the creation and development of the Kharkiv Locomotive Plant.

The scientific work carried out by Annenkova (2014) investigates the arrangement of machine tool production at the Kharkiv Locomotive Plant from its foundation to nationalization by the Soviet authorities in 1919. It was found that there was a deficit of such equipment in the country at the time of the introduction of machine tools at the KhLP, which contributed to the improvement of this direction.

An article by Diakova (2018) highlights the welfare of workers at the Kharkiv Locomotive Plant. It is noted that social infrastructure for the employees of the enterprise was initially created during the construction of the plant.

Kryvokon (2014, 2021) covered the stages of creation and the functioning of the Kharkiv Locomotive Plant in more detail. However, his articles are focused on the study of the background and peculiarities of the arrangement of the tractor industry in Ukraine. In this context, these articles describe the establishment of Kharkiv Locomotive Plant from its foundation to its transition to tractor production.

Thus, a thorough analysis of the background of the creation, further development, and establishment of the Kharkiv Locomotive Plant is still an urgent task for researchers of science and technology development in Ukraine. This article is aimed at solving this problem.

Research methods

During the preparation of the article, chronological, comparative methods of historical knowledge, classification, and systematization of historical sources and bibliographic material were used (Pylypchuk, O. Ya., Strelko, & Pylypchuk, O. O., 2021; Strelko, 2021; Strelko, Berdnychenko, Pylypchuk, Pylypchuk, Sorochynska, & Horban, 2021; Strelko, & Pylypchuk, 2021a). The use of these methods and approaches to scientific research allowed to retrace the of the creation, further development, and establishment of the Kharkiv Locomotive Plant systematically and critically evaluate the sources used, highlight the main points in the current state of studying the subject and the results of predecessors, specify the most promising directions of research, give a description of the previous works on this issue and clearly distinguish issues that have not yet been resolved.

Results.

Conditions and prerequisites for selecting the location of the plant.

The late XIX century was marked by the rise of industry in the Russian Empire. This period was characterized by shifting the core of industrial development from the Ural region to the south of the country, associated with the development of abundant coal deposits in Ukraine, and accompanied by extensive railroad construction in the central and southern parts of the Russian Empire. This aspect spurred the expansion of machine-building industries under the protectionist economic policy of the Russian Empire's government toward Russian enterprises. It was aimed at shielding them from the influence of foreign competitors.

In the second half of the nineteenth century the Russian railways began to buy their locomotives and other equipment from domestic producers (Westwood, 1982).. However, this break from foreign suppliers was accompanied by a continuing interchange of experience between Russian railway engineers and their western counterparts. In 1892 the young International Railway Congress Association held its second conference in Moscow, presided over by the Belgian locomotive designer Belpaire. Belpaire, and French engineers, helped with the design of certain Russian steam locomotives. A little earlier, the Russian railway engineer Borodin had presented a paper to the Institute of Mechanical Engineers in London. In tsarist Russia there was hardly a national school of locomotive design as there was in Britain, America, or France. Both in external appearance and in the chosen technical solutions, Russian locomotives were akin to those of Central Europe. But in certain fields Russian locomotive engineers and researchers had not been content to follow others. Especially in the methodical testing of locomotives, and the adaptation of locomotives to burn unusual fuels, enough work had been done to attract the interest of foreign railways.

Kharkiv was chosen as a location for constructing a machine-building plant because of several favorable conditions: 1. Being a hub for the Kursk-Kharkiv-Sevastopol, Kharkiv-Mykolaiv, and Southeastern Railways, which provide transport links between the raw material base, the production site, and the country's industrial centers; 2. Proximity of the production site to the Donetsk coal and Kryvyi Rih iron-ore basins; 3. Opportunity to engage skilled workers from medium and small city enterprises in production; 4. Availability of the University and the Technological Institute for training engineers in the city; 5. Possibility of allocating a large area on the eastern outskirts of the city for construction, located close to the Balashovska freight station (today, the Kharkiv-Balashivsky railway station) of the Kharkiv-Balashivsky line of Southeastern Railways Company, commissioned in 1895.

The stage of the establishment (foundation) of the Kharkiv Locomotive Plant.

In the early 1870s, Kharkiv started growing rapidly as a major industrial hub in the south of the Russian Empire. The railroad offered an opportunity for the delivery of the most advanced equipment and technology, something that foreign companies never failed to take advantage of. Melgoze, Trepke, Helferich, von Ditmar, and Bergenheim built their plants in Kharkiv (Annenkova, 2014; Sorochnytska, 2015b). The late XIX century witnessed the emergence of Kharkiv as the capital of agricultural machinery and equipment production. The leading position was assigned to the largest plant of Helferich-Sade.

In the 1890s, transport machinery gained significant development. Since 1891, the monopoly on steam locomotive construction in the Russian Empire, which had been concentrated in the 1880s at the Kolomna Locomotive Works alone, was disrupted. In the mid-1890s, steam locomotive construction was deployed at eight

major machine-building enterprises of the Russian Empire, of which two plants (Kharkiv and Luhansk) emerged as specialized steam locomotive enterprises.

Kharkiv Locomotive Plant was founded by the Russian Locomotive and Mechanical Joint Stock Company (RLM JSC). Two board seats of the RLM JSC were given to Stéphane and Philippe Bouet, the owners of the machine-building plants in Paris. Philippe Bouet, as one of the co-founders of the RLM JSC, secured an agreement with the Administration of Russian State Railways, providing for 480 steam locomotives as the first order, as well as the right to establish a plant in the Russian Empire to manufacture steam locomotives, steam machinery, machine tools, and all kinds of mechanical devices and military equipment. As a result, the RLM JSC was given a government order and a loan to build steam locomotives a few months before plant construction began (Voskresenskij, 1958, p. 7).

On July 31, 1895, an agreement was concluded between the RLM JSC and the Administration of State Railways for the annual production of 150 steam locomotives (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 25).

On August 6, 1895, the Board of the RLM JSC agreed to be joined in the construction of the plant by French society, assuring a 10-percent profit on the entire revenue of the plant, but not less than 500,000 francs a year (Voskresenskij, 1958, p. 8). The Board of the RLM JSC approved the technical service of the plant presented by the Bouet Plant Company. The Bouet Plant Company undertook the following obligations:

“During the twelve years since the establishment of the RLM JSC... render its cooperation at no charge, so that the RLM JSC might benefit from its experience in building and have the assurance that:

- 1. the workshops to be built shall be arranged according to the technical excellence required by this kind of factory business;*
- 2. once established, these workshops shall be allowed to enjoy all the advances that have been made in terms of equipment”.*

Furthermore, once the machine tool workshops were launched, the Bouet Plant Society was required by contract to refuse to supply the Russian Empire with any machine tools that could compete with the Russian Company. In return, the RLM JSC refused to supply machine tools outside the Russian Empire without prior agreement with the Bouet Plant Company. Of the shares issued for the execution of the share capital of the RLM JSC, the Bouet Plant Company was bound to purchase three thousand shares from the RLM JSC at 125 rubles in gold each bearing a payment of 375,000 metallic rubles.

The stage of construction and technological equipment of the plant.

On July 20, 1895, the Board of the RLM JSC invited Pavel Rizzoni, a technical engineer, to the construction of the Kharkiv plant with a salary of 12,000 gold rubles a year, and entrusted him with the purchase of a land plot in Kharkiv for the construction

of a locomotive plant and assigned him to manage the construction activities (Voskresenskij, 1958, p. 7).

Following the purchase of the land plot to build the plant, on September 18, 1895, the Board of the RLM JSC issued the following power of attorney to Rizzoni (Voskresenskij, 1958, p. 8):

“The Board of the Russian Locomotive and Mechanical Joint Stock Company, entrusting Pavel Pavlovich Rizzoni, a technical engineer, to manage the construction of the Company's locomotive and mechanical plant in Kharkiv, authorizes him to communicate and negotiate with governmental and public institutions and private individuals on all matters relating to the above construction; to conclude agreements and contracts on the construction of the plant; to procure materials necessary for the work; to make orders to contractors and suppliers; to make cash payments for the work performed; to hire employees for the plant and the technical office; to approve drawings and methods of technical constructions; to file motions in the Company's affairs at all judicial and administrative institutions; to file claims and, upon submission, to defend them; to file all kinds of petitions, reviews, letters of appeal and complaints; to receive documents, writs of execution and money; to give power of attorney to other persons. Whatever Rizzoni, or persons authorized by him, do under this power of attorney, the Board accepts and shall neither quarrel nor interfere with”.

The director of the Kharkiv Locomotive Plant, Pavel Rizzoni visited the machine building factories of Usines Bouhey and The Société Alsacienne de Constructions Mécaniques in France in 1895 prior to launching the Kharkov plant (Kulikov, 2015).

In October 1895, the Board of the RLM JSC invited A. I. von Goghen, an academician, to join its staff and entrusted him with drafting estimates and construction projects for all the factory buildings, as well as supervising their construction (Voskresenskij, 1958, p. 8).

In late October – early November 1895, the following construction operations began on the plant's main facilities: production buildings and workshops (steam locomotive assembly, foundry, modeling, copper foundry, forge, and boiler shop); power plant; main office; pass office; plant director's house with all services; a house for 24 apartments for families of craftsmen, heads of departments and workshops; two and three-story houses for guest engineers, technicians, and senior office employees; a 100-bed house for single workers. Over 1,700 employees were employed in construction (Voskresenskij, 1958, p. 11).

Construction of the main facilities of the expected plant was deployed on the eastern outskirts of Kharkiv (Balashovka area), on the vacant land between the freight station commissioned in 1895 by South-Eastern (Kharkiv-Balashivsky) Railway and Cyril and Methodius cemetery (today, Park of Machine Builders). The new plant was built specifically for the production of steam locomotives for the Russian state railroads.

The construction of the plant facilities was initiated by laying the foundation of the iron foundry with an area of 2,320 m², with a total length of 70 meters, and a total

width of two 33-meter spans (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 26).

On November 10, 1895, a general meeting of the RLM JSC shareholders was arranged. The following positions were approved during this meeting: plant management formed by the director, assistant director, chief accountant, and director's secretary; plant administration formed by the plant manager, assistant manager, head of the pass office, and the plant's office. The Board of the RLM JSC decided to complete the steam locomotive and machine-building departments of the plant by 1896, and by 1897, to postpone the construction and equip only that part of the plant buildings, which would not significantly affect the fulfillment of orders for steam locomotives already received by the government. The Board ordered 89 complex machines for equipping the plant for the amount of 420,635 gold rubles from the Bouet Company in Paris and approved a cost estimate for the construction of the plant. Out of the total sum of 4,603,370 rubles, 1,316,000 rubles were allocated for constructing the buildings of the steam locomotive department, and 1,839,195 rubles for equipping it with machinery and machine tools (Voskresenskij, 1958, p. 11).

In November 1895, long before the plant was supposed to be commissioned, the issue of housing for workers became urgent. The director suggested a plan to build a workers' camp for the Board of the RLM JSC. He asked to allocate 450,000 rubles for this purpose. However, the Board deemed such costs unaffordable and burdensome and having therefore rejected Rizzoni's proposal, only financed the construction of barracks and houses, which would have been profitable to operate. The decision of the Board stipulated the following (Voskresenskij, 1958, p. 12): *“The barracks shall be built by the household method, in the least expensive way possible, to house as many of the workers as may be required”*. The director adopted this decision without any objection and undertook the construction of the barracks. Somewhat later, the director of the plant initiated a plan to build special commercial houses that would be both self-refunding due to high rents and profit-making. These houses were intended mainly for highly paid employees and the “working aristocracy”. The Board adopted the plan and the estimate. However, since prices for plant apartments for workers were 1.5 times higher than average city prices, hundreds of working families, unable to pay the high rent, sheltered in cramped and uncomfortable barracks, while apartments in the new buildings remained unoccupied.

On July 30, 1896, the Board of the RLM JSC passed a proposal by the director of the Rizzoni plant to manufacture 120 steam locomotives annually, starting from 1898 (Voskresenskij, 1958, p. 12).

Early in August 1896, the main production facilities of the plant were completed. It was the main office of the plant, as well as steam locomotive assembly, forge, and iron foundry were built and partially put into operation.

The first iron castings were produced by the iron foundry less than a year after construction began, and its output was used for shop equipment with machine tool

stands, roof trusses, and rafters (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 27).

In September 1897, the following workshops were completed: machine-building, copper foundry, modeling, boiler shop, and paint shop (Voskresenskij, 1958, p. 134).

In October 1897, members of the RLM JSC Board from St. Petersburg came to the construction site of the plant. It was attended by A. I. Muranyi and A. I. Grube who inspected the construction and concluded that the main shops and departments of the plant could be commissioned.

In November 1897, the RLM JSC meeting formally decided to start up the plant. The decision stated (Voskresenskij, 1958, p. 13):

“Whereas the constructions and equipment at the Kharkiv Locomotive Plant, designed under an agreement with the Administration of the State Railroads of July 31, 1895, for the annual production of 150 steam locomotives and the estimates, approved by a general meeting of shareholders on November 11, 1895, are now completed, the construction and equipment of the Kharkiv Locomotive Plant... shall be deemed to be completed by November 1, 1897”.

Thus, November 1, 1897, was officially marked by the completion of the stage of construction and technological equipment of the KhLP.

The stage of development and establishment of the plant (1897–1914).

In 1896–1897, steam locomotive building and machine-building departments (divisions) were formed at the plant, including model, tool, and material warehouses; model, tool, iron foundry, copper foundry, forge, machine-building, steam locomotive assembly, and boiler workshops (shops). Since 1902, KhLP started producing steam boilers not only for its production (steam locomotive boilers) but also for the outside (boilers of different types and purposes) (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 31).

Moreover, the boiler department was established as part of the machine-building department. In 1903, such workshops as copper and ammunition were put into operation. In 1906, following the reconstruction of the plant, repair, and construction shops were put into operation. In 1909, by the decision of the board of the RLM JSC, the loans were allocated for the reconstruction of the plant aimed at producing internal combustion engines (gas and oil), agricultural machines, and high-power steam locomotives. In this regard, Ya. P. Korobko (1907–1917), the director of the KhLP, submitted a plan for the reconstruction of the plant, suggesting an implementation period of 6–8 years and a cost of up to 2 million rubles (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 35).

During 1911–1912, such departments as heat engines and agricultural machinery were formed at the plant, and accordingly, the “heat” (for the production of internal combustion engines) and “agricultural tools” shops were commissioned; the iron foundry and forge shop were upgraded; installation of a powerful press to produce crankshafts for steam and internal combustion engines was begun and the copper

foundry was expanded (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 28).

In 1914, the steel foundry was completed, and the agricultural tool shop was converted into a wagon shop. In 1916, the steel foundry and bolting shop were commissioned (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 26).

For the first six years after the startup, the plant had a guaranteed state order for steam locomotives and was developing as a specialized steam locomotive plant, launching its “minor” metallurgical production. The first O^D class steam locomotive (O^A in Russian) was produced on December 5, 1897 (Gutnyk, Tverytnykova, Radohuz, Krylenko, & Tkachenko, 2021).. However, in 1897, KhLP ended up reliant on outside iron and steel factories, which led to an increase in turnover, stocks of raw materials, and supplies in warehouses (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 27).

In 1899, the plant hit the normal production cycle with a gross output volume of 5,546,000 rubles. In 1902, owing to a considerable increase in steam locomotive production, the gross output amounted to 6,940,000 rubles. Since 1903, up to the outbreak of the First World War, the annual gross output of the plant stabilized, not exceeding 6,000,000 rubles (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 35).

In 1903, the plant got its first orders from the Navy Department, which initiated the process of mastering the production of different types of machinery apart from steam locomotives. In particular, by order of the Navy Department, the plant manufactured such large-size machine tools as armored shaping, radial drill, lathe, chiseling, as well as a hydraulic press, and cranes. (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 31).

Since 1904, KhLP mastered the production of certain types of engineering equipment, such as overhead cranes, presses, pumps, and drilling machines. According to the documents of the Navy Department, for the first time, the plant was officially named Kharkiv Locomotive and Mechanical Plant (Tsvetkov, 1990, p. 96).

During the Russo-Japanese War of 1904–1905, KhLP fulfilled an order from the Navy Department for 100,000 shrapnel shells (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 31).

In July 1906, KhLP joined the “Steam Locomotive Union” which included Kolomna Locomotive Plant, Putilov Plant, Bryansk Machine-Building Plant, Sormovo Plant, and Luhansk Plant. This union assisted in getting additional orders for steam locomotives and provided conditions for the development of new steam locomotives based on cooperation and competitive process. In 1909, the KhLP started producing agricultural tools and machinery, such as plows, harrows, haymakers, and threshing machines. These products have repeatedly been awarded imperial diplomas at all-Russian exhibitions, and in 1911–1913, these products have received 38 medals (9 of them gold): 12 (3 of them gold) for the plows; 7 (1 of them gold) for harrows; 9 (2 of them gold) for seeders; 8 (2 of them gold) for reapers; 2 (1 of them gold) for horse

threshers. By 1912, the refitting of some workshops for the production of internal combustion engines (ICE) was completed and a new “heat” workshop was established. Production of ICE, as compared to the steam locomotive and boiler construction, required a higher level of production technology (in terms of accuracy class, quality and strength of materials used, technical level of personnel training and their qualifications), as well as production equipment given the lack of experience in ICE production and operation at the plant (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 32).

In 1914, the plant commissioned its first in-house iron and steelmaking production. Internal “backyard furnaces” fully met the needs of production in castings and forgings, as well as external orders. Such production arrangement ensured a reasonable combination of related machinery branches. Apart from steam locomotives, the range of mastered engineering products during the first 15 years after commissioning included boilers, pumps, compressors, internal combustion engines, machine tools, agricultural machinery, and tools (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, pp. 12–13).

Down to 1917, the KhLP, fulfilling state orders, developed independently within the RLM JSC system in terms of securing additional orders and was able to manage its profits alone. In particular, the KhLP accepted orders for spare parts and all kinds of repairs for every steam locomotive type (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 29).

Before the revolution, the KhLP offered the highest wages compared to all the enterprises in Kharkiv. However, during the First World War (1914–1917), the plant was forced to switch completely to the execution of state military orders (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 14).

The Kharkiv Locomotive Plant in 1916 – one of the argest plants in the region – was very complex, with departments, subdepartments and a hierarchy of professional managers (Kulikov, 2015). Each unit within the plant had its own administrative office, some of them were even housed separately from the main buildings of the plant. Theoretically each could operate as an independent business enterprise. Considering the structure of the Kharkiv Locomotive Plant and some other major companies we can say that by the beginning of World War I there existed modern enterprises in South Russia, which were characterized by a standard functional division of production: research and development, production, marketing, finance and accounting. The joint-stock form of entrepreneurial activity arrived to Russia as an already fully formed institution after several centuries of development by European lawyers and merchants. The adoption of this type of business organization by itself can be considered as a transfer of Western innovation.

A brief analysis of the designs of locomotives produced by the Kharkiv Locomotive Plant from 1897 to 1914.

***O* class steam locomotives.**

O class (main; “ОСНОВНОЙ” in Russian) was the first steam locomotive that became the basic one in the locomotive fleet of Russian railroads (Rakov, 1995). Between 1890 and 1915, twelve steam locomotive plants of the Russian Empire produced over 9 thousand locomotives of this series, which made the *O* class locomotive the most mass-produced of the pre-revolutionary locomotives. This locomotive was employed on all state and most private railroads of the Russian Empire, as well as on all railroads of the Soviet Union. The best known (and mass) varieties are the O^V (O^B in Russian) and O^D (O^A in Russian), nicknamed “ovechka” and “joika”, respectively.

The Kharkiv-Mykolaiv railroad was one of the first to receive new *O* class steam locomotives from the Kolomna Locomotive Plant. During the first year of their operation (1895), it was found out that in comparison with steam locomotives of 0-4-0 *Ch* (*Ч* in Russian) class which had a simple machine and steam pressure in the boiler 2 kgf/cm² lower, the new locomotives were not cost-effective since coal overspending reached 9%, even though the weight of trains had not been changed. A similar problem with O^D class steam locomotives was experienced by other railroads as well. Therefore, in 1896, at the XVII Consultative Congress of Traction Engineers, the Ministry of Railways raised the issue of constructive shortcomings of these steam locomotives for discussion (Rakov, 1995). As a result, it was resolved to make 99 changes in the steam locomotive design, of which the increase of wheel diameter from 1,150 to 1,200 mm and the increase of steam pressure in the boiler from 11 to 11.5 kgf/cm² (the latter was required to maintain traction force) were particularly worth mentioning. Production of new drawings was entrusted to Kolomna Locomotive Plant.

O. I. Hleb-Koshansky, director of Kolomna Locomotive Plant, based on the point, made by A. P. Borodin about the necessity to make different cutoffs of low- and high-pressure cylinders for the compound machines, suggested setting a cutoff of 0.5 of the large cylinders with a cutoff of 0.4 of the small cylinders (Westwood, 1982). This is how the “normal type steam locomotive of 1897” arose, which in 1912 was assigned with O^D class, meaning the “basic type” with Joy valve gear and increased wheel diameter (Rakov, 1995).

It is worth noting here how important for the development of railway machine-building were the Consultative Congresses of Traction Engineers. The first Congress, initiated by the famous scientist N. L. Shchukin, was held in Moscow in 1879. This and subsequent Congresses covered issues related to the choice of technical policy in the construction and operation of steam locomotives, the focus of scientific developments, as well as identified ways to modernize the rolling stock. Further Consultative Congresses were held alternately in different cities of the Russian Empire. Due to the positive impact of these Congresses on the development of the industry, their experience was adopted by other railway services (track and traffic). Similar scientific and technical forums became practiced internationally as well.

Besides the Kolomna Locomotive Plant, all enterprises of the Russian Empire that had the opportunity to build steam locomotives began producing “normal type steam

locomotive of 1897”. Thus, the “normal type steam locomotive of 1897” originated the stream locomotive construction at the Kharkiv, Sormovo, and Luhansk Plant. Steam locomotives of this type were produced from 1897 to 1903 and were widely used at the state and many private railroads of the Russian Empire.

***O^D* class steam locomotives.**

From 1897 to 1903, the Kharkiv Locomotive Plant produced 733 *O^D* class steam locomotives (Figure 1).. These were four-axle locomotives of the so-called basic type (hence the letter “*O*” by the Russian word “основной”) with a steam engine capacity (depending on the modification) of 550-720 hp (Kharuk, 2019, pp. 8–9) and a Joy valve gear. Their axle formula was defined as 0-4-0, where the middle digit indicates the number of leading axles (with large-diameter wheels; the more powerful the locomotive, the more leading axles it has). The first digit indicates the number of guide axles (in front of the leading axles; their purpose is to reduce the probability of the locomotive derailing when passing curves), and the third digit indicates the supporting axles (located behind the leading axles and designed to reduce the loads on them).



Figure 1. Blessing the first “normal type” *O* class steam locomotive at the Kharkiv Locomotive Plant (Malyshev Plant, n. d.).

***O^V* and *O^K* class steam locomotives**

In 1901, the XXIII Consultative Congress of Traction Engineers addressed the operation of the “normal type steam locomotive of 1897” (*O^D*) once again, resulting in several recommendations for design changes. Among these changes the most serious were the following:

1. Using lever-spring valves instead of the safety valves of the English engineer John Ramsbottom (1814-1897);

2. Adopting four-axle tenders along with three-axle tenders;
3. Installing the Walschaerts valve gear instead of the Joy valve gear.

The modernization, carried out according to the suggestions of the XXIII Consultative Congress, resulted in a steam locomotive that was designated the “1901 normal type”. Like the “1897 normal type” steam locomotives, the new locomotives were manufactured by Russian plants in rather large quantities. Moreover, these steam locomotives were produced both with the original Walschaerts valve gear and a modified one by the Kolomna Locomotive Plant. Over the course of production, the design of steam locomotives underwent some changes, and steam pressure in the boiler was raised to 12 kgf/cm². Steam locomotives with the modified design were named “1904 normal type”. In 1912, steam locomotives with the original Walschaerts valve gear were designated as an O^V class (by the Russian phrase “основной Вальсхарта” meaning the Walschaerts main type), and steam locomotives with a modified valve gear were designated as an O^K class (by the Russian phrase “основной коломенский” meaning the Kolomna main type).

From 1901 to 1905, the Kharkiv Locomotive Plant produced 271 “1901 normal type” steam locomotives and 269 “1904 normal type” steam locomotives.

Following 1907, when the steam locomotive plants began mass production of the more powerful and high-speed steam locomotive of the “Shch” “1905 normal type” class, production of O^V steam locomotives dropped sharply. From 1908 to 1915, the Kharkiv Locomotive Plant produced only 130 steam locomotives of this class.

***Shch* (Ш in Russian) class steam locomotives.**

From 1906 to 1916, the Kharkiv Locomotive Plant was manufacturing *Shch* class steam locomotives (Figure 2).

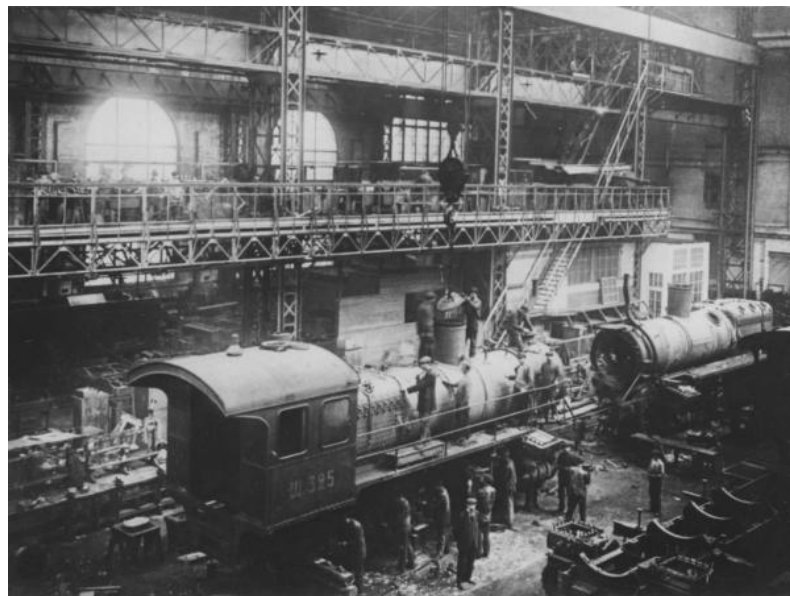


Figure 2. Construction of the *Shch* class freight locomotive designed by Kharkiv Locomotive Plant, in the 1900s. (Malyshev Plant, n. d.).

Due to the mass replacement of light and worn-out rails by heavier ones on state-owned railways and the need to discharge a significant number of 0-3-0 steam locomotives built in the 1850s and 1860s, it was reasonable to introduce more powerful steam locomotives. Therefore, in 1905, Minister of Railways K. S. Nemeshaev instructed Professor N. L. Shchukin to prepare a design of a new type of freight locomotive for state-owned railways (Strelko & Pylypchuk, 2021b). At this time, steam locomotives of the 0-5-0 type were already operating on some railways in Europe, but Professor N. L. Shchukin decided to stick only with the 1-4-0 type (Figure 3), taking the *Shch* class steam locomotive of the Chinese-Eastern and Vladikavkaz Railways as the basis for the project. To gain experience of operating these locomotives on state-owned railways, 10 *Shch* class locomotives of the were sent to Ekaterininsk Railways, and one to the South – Western Railways. However, this was done with a delay.

After the work of various commissions, the technical bureau of the Kharkov Steam Locomotive Plant under the guidance of engineer O. S. Rayevsky in 1906 designed a freight steam locomotive with a two-cylinder machine compound type 1-4-0 (Bogatchuk, Mazylo, Pikovska, Makarov, Bielkin, Mangora, & Mangora, 2022). In the technical documentation, the new locomotive was known as the “Chinese-Eastern Railway modified type 1-4-0” or “normal type 1905” (Figure 4). In the same 1906 Kharkiv plant built the first steam locomotive of the “normal type of 1905”, which received the designation Yuh3501 and was sent to the Ekaterinisk Railway. In 1912, such locomotives were designated as the *Shch* class after the name of Professor N. L. Shchukin.



Figure 3. *Shch* class freight locomotive designed by Kharkiv Locomotive Plant (today, the Malyshev Factory). In total, about 2000 Sch class locomotives were manufactured by different plants in the 1900s – 1920s (Malyshev Plant, n. d.).

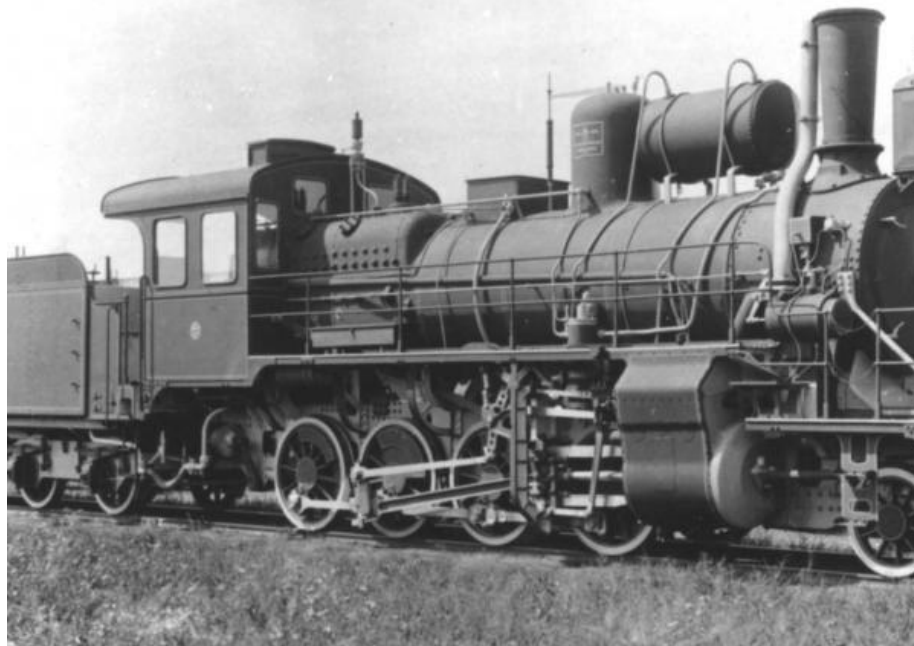


Figure 4. The freight locomotive, designed by the Kharkiv Locomotive Plant (today, the Malyshev Plant) was originally called “East China Railway Type”, by the name of the first railway customer. In 1912, locomotives of this type received the designation *Shch* class (Malyshev Plant, n. d.).

The results of the locomotive building at the Kharkiv Locomotive Plant in the late XIX – early XX century.

Since the commissioning of the Kharkiv Locomotive Plant, up to the outbreak of the First World War, steam locomotive construction was the main type of production activity of the enterprise.

A specific percentage of steam locomotive construction by year (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 28): 1897–1902 – 100%; 1902–1903 – 91.6%; 1903–1904 – 92.2%; 1905–1906 – 95.2%; 1907–1908 – 93.2%; 1908–1909 – 92.2%; 1909–1910 – 91.1%; 1911–1912 – 67.7%; 1913–1914 – 79.0%; 1914–1915 – 80.0 %; 1915–1916 – 80.0%.

By late 1903, the KhLP had built 1000 steam locomotives; from 1897 to 1912 – 1846 steam locomotives (Bystrichenko, Dobrovolskiy, Drobotenko, & Kalugin, 1995, p. 30). By 1915, the KhLP accounted for over 20% of all steam locomotive production in Russia (Zaborsky, 2001).

Discussion.

The current situation in the railway sector of Ukraine is largely similar to the one that took place in Ukraine before the revolution of 1917. It implies not only high rates of construction but also the widespread use of private investment, as well as a unity of interests of the state and individual enterprises. Therefore, a retrospective analysis of the formation and development of the railway industry in Ukraine, the establishment

of financial management, and control of this industry are now gaining both scientific and important practical importance. Historical experience proves that it is the clear organization of state management of the railway industry that can ensure its stable and dynamic development, as well as the alignment of national and private interests in the economic sphere (Bogatchuk, Mazylo, Pikovska, Makarov, Bielkin, Mangora, & Mangora, 2022; Kulikov, 2015; Medvedeva, Kucher, Lipsa, & Hełdak, 2021; Shtepenko & Vergeles, 1997; Yeremenko, & Kroytor, 2020). In this regard, the authors believe that it proved to be extremely important to turn to the history of the development of railway transport in the Russian Empire in general, and the beginning of the production of the first steam locomotives in Ukraine at the Kharkiv Locomotive Plant, in particular.

Many researchers admit that the Russian Empire in the early XX century was a leader in the theoretical development of new types of traction and their practical application in transport; internal combustion engines; power supply systems (Gutnyk, Tverytnykova, Radohuz, Krylenko, & Tkachenko, 2021); the development of devices for rolling stock (Sorochynska, 2015a); and the development of track facilities (Bogatchuk, Mazylo, Pikovska, Makarov, Bielkin, Mangora, & Mangora, 2022). The need for new railways and the lack of funds for their construction were compensated by improving the management structure (Kulikov, 2015).

The economic growth rate of the Russian Empire in the late XIX – early XX centuries was quite high, but the country still lagged far behind the industrialized West. There was an obvious need for transition to a qualitatively different level of development, related to the use of advanced experience in the evolution of science and technology. Engineers of different steam locomotive designs became the creators of the theories of motion, construction, and applied mechanics, as well as the pioneers in the use of new materials in the manufacture of steam locomotives. It can be said that their efforts resulted in the creation of the national school of locomotive engineers, one of the best at that time. Among their leading representatives were the locomotive engineers of the Kharkiv Locomotive Plant.

Conclusions.

This article discusses the conditions and prerequisites for choosing the location of the plant; considers the stage of the establishment (foundation) of the plant; examines the stage of plant construction and equipping it with technological facilities in detail; analyzes the development and establishment of the plant between 1897 and 1914. A brief analysis of locomotive designs produced by the Kharkiv Locomotive Plant from 1897 to 1914 has been made. The article shows the significance of Consultative Congresses of Traction Engineers for the development of railway machinery both at Kharkiv Locomotive Plant and for the entire railway industry.

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Conflicts of interest.

The authors declare no conflict of interest.

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Передумови створення, подальшого розвитку та становлення Харківського паровозобудівного заводу

Анотація. Кінець 19 століття – період підйому промисловості в Російській імперії, що характеризується переміщенням центру промислового розвитку з Уралу на південь країни, у зв'язку з початком розробки багатих вугільно-рудних родовищ на території України, що супроводжується інтенсивним будівництвом залізниць у центральній та південній частині Російської імперії. Це стимулювало розвиток машинобудівних галузей, в умовах протекціоністської економічної політики уряду Російської імперії по відношенню до російських підприємств, з метою убезпечення їх від впливу зарубіжних конкурентів. На початку 1870-х Харків починає швидко розвиватись як великий промисловий центр півдня Російської імперії. Залізниця створила умови для доставки найпередовішого обладнання та технологій, чим не

преминули скористатися представники іноземних компаній. У 1890-ті роки значний розвиток набуло транспортного машинобудування. Починаючи з 1891 року було порушено монополію на паровозобудування у Російській імперії, яке було зосереджено у 1880-х роках одному лише Коломенському заводу. У 1890-х роках паровозобудування розгортається на восьми найбільших машинобудівних підприємствах Російської імперії. Метою статті є ґрунтовний аналіз передумов створення, подальшого розвитку та становлення Харківського паровозобудівного заводу. Запропоновано періодизацію різних етапів історії Харківського паровозобудівного заводу. У статті проаналізовано умови та передумови вибору місця будівництва заводу; розглянуто етап заснування (підстави) заводу; детально розглянуто етап будівництва заводу та оснащення його технологічним обладнанням; проаналізовано етап розвитку та становлення заводу в період 1897–1914 років. Виконано короткий аналіз конструкцій локомотивів, які виготовляв Харківський паровозобудівний завод з 1897 по 1914 роки. У статті показано наскільки важливе значення для розвитку залізничного машинобудування, як на Харківському паровозобудівному заводі, так і для всієї залізничної галузі загалом, мали дорадчі з'їзди інженерів служби тяги.

Ключові слова: паровоз; історія паровозобудування; Харків; паровози “нормального типу”; паровози класу “О”; паровози класу “Щ”

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