ISSN 1028-2335 (Print)
Теорія і практика металургії, 2025, № 1
Theory and Practice of Metallurgy, 2025, No. 1

https://doi.org/10.15802/tpm.1.2025.04

UDC 669.183

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Ukrainian steel and ferroalloys in 2022-2024: how russian aggression has impacted on the work of the country's metallurgical industry

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Українська сталь та феросплави у 2022-2024 роках: як російська агресія вплинула на роботу металургійної промисловості країни

Abstract. *This article analyzes the state of the Ukrainian metallurgical industry, particularly steel and ferroalloy production, between 2022 and 2024, emphasizing the significant impact of the full-scale russian aggression. It highlights the industry's successes in 2021, when growth in steel and ferroalloy production was driven by favorable market conditions. The consequences of the russian invasion are detailed, including territorial occupation, infrastructure destruction, challenges with logistics and raw materials, and a shortage of qualified personnel, which led to a threefold reduction in steel production in 2022 and a substantial decline in ferroalloy output. Statistical data for 2022-2024 is presented, showing a gradual recovery in steel production volumes and a continued decrease in ferroalloy production, even leading to plant shutdowns in the fourth quarter of 2023. Special attention is given to the measures undertaken by Ukrainian enterprises to adapt to the new circumstances, including reorienting towards alternative raw material sources and optimizing electrotechnological regimes. The systemic problems facing the industry are highlighted: proximity to conflict zones, high electricity tariffs, personnel shortages, and logistical difficulties. In the context of Ukraine's European integration and its commitment to "green metallurgy," the prospects for the recovery and development of the domestic metallurgical sector are discussed, including projects for direct reduced iron and "green" steel production. Ukraine's potential to become a key supplier of "green" metallurgical raw materials for Europe is underscored.*
Key words: *Ukrainian metallurgy, russian aggression, steel production, ferroalloys, decarbonization, green metallurgy, recycled materials.*

Анотація. *У статті проаналізовано стан української металургійної промисловості, зокрема виробництва сталі та феросплавів, у період з 2022 по 2024 роки, наголошуючи на значному впливі повномасштабної російської агресії. Висвітлено успіхи галузі у 2021 році, коли зростання виробництва сталі та феросплавів було обумовлено сприятливими ринковими умовами. Детально описано наслідки російського вторгнення: окупацію територій, руйнування інфраструктури, проблеми з логістикою та сировиною, а також дефіцит кваліфікованого персоналу, що призвело до трикратного скорочення виробництва сталі у 2022 році та значного падіння виробництва феросплавів. Наведено статистичні дані за 2022-2024 роки, демонструючи поступове відновлення обсягів виробництва сталі та скорочення виробництва феросплавів, аж до зупинки заводів у четвертому кварталі 2023 року. Окрему увагу приділено заходам, вжитим українськими підприємствами для адаптації до нових умов, включаючи переорієнтацію на альтернативні джерела сировини та оптимізацію електротехнологічних режимів. Висвітлено системні проблеми галузі: близькість до зони бойових дій, високі тарифи на електроенергію, нестача кадрів та логістичні труднощі. У контексті європейської інтеграції України та курсу на "зелену металургію" обговорюються перспективи відновлення та розвитку вітчизняної металургії, включаючи проекти з виробництва відновленого заліза та "зеленої" сталі. Підкреслюється потенціал України стати ключовим постачальником "зеленої" металургійної сировини для Європи.*
Ключові слова: *українська металургія, російська агресія, виробництво сталі, феросплави, декарбонізація, зелена металургія, вторинна сировина.*

In April 2025, the centennial of the establishment of the Department of Electrometallurgy of the Ukrainian State University of Science and Technology (at the time of its establishment - the Dnipropetrovsk Metallurgical Institute) will be celebrated. It will not be an exaggeration to say that it was the Department of Electrometallurgy, for many of us - the "alma mater", that became the founder of the world-famous school of Ukrainian electrometallurgy, the educator of a galaxy of many thousands of ferroalloy and electric steelmakers who held and hold leading positions at industry enterprises, the developer of many highly efficient technological processes of world class. Congratulating our native department on its anniversary, we sincerely wish to continue to firmly hold the banner of domestic electrometallurgical science in our hands, which is especially important now, in the difficult conditions in which the metallurgical industry of Ukraine found itself

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with the beginning of large-scale Russian aggression in February 2022.

We will begin our analysis of the work with 2021 - the last pre-war year for our country. As is known, in 2021, global steel production in the world increased by 3.7% compared to 2020 - to 1.95 billion tons. 2021 was also successful for Ukrainian metallurgists - favorable conditions in external markets and high demand for rolled steel in the domestic market (due to the active phase of the "Great Construction") contributed to the growth of production indicators. Compared to the previous year, steel production in Ukraine in 2021 increased by 3.6% - to 21.4 million tons. Ukraine was in the top twenty world steel producers.

The production of ferroalloys of all types (ferrosilicomanganese, high-carbon ferromanganese, metallic manganese, ferrosilicon) in the pre-war 2021 also increased and amounted to 858.7 thousand. tons, which corresponds to 115% compared to the previous year 2020.

The full-scale Russian aggression has caused, along with other losses for Ukraine, a crisis situation in the metallurgy industry. The occupation of part of the territory in eastern Ukraine, where the main metallurgical facilities are located, constant shelling and destruction, disruptions in the supply of raw materials and energy resources, disruption of logistics routes for the export of finished products due to the blockade of sea ports, and the loss of qualified personnel during mobilization have led to a three-fold reduction in steel production and a reduction in steel production. In 2022, Ukrainian metallurgists produced only 6.4 million tons of steel (29.9% compared to the previous year, including Mariupol plants in January-February 2022), of which more than half (3.4 million tons) fell on the pre-war first two months of the year. In 2023, global steel production amounted to 1.851 billion tons (-0.1% compared to 2022). In Ukraine, this indicator amounted to 6.228 million tons (+26.9% compared to the previous year), respectively, the volume of finished rolled products increased to 5.372 million tons (+31.2%). Depending on the enterprise, or rather, the region of its location, the utilization of pig iron, steel and rolled products in 2023 ranged from 20% to 70%. It should be noted that a significant part of the production capacities (over 60%) of the MMC of Ukraine is located in the temporarily occupied territory.

Ferroalloy production in 2022 also decreased significantly - to 537.9 thousand tons, which corresponds to 62.6% of the previous year's level. This trend took place and intensified in 2023: ferroalloy production was only 43.9% compared to the previous year. In the fourth quarter of 2023, Ukrainian ferroalloy plants were forced to completely stop production activities.

With what indicators did the metallurgical industry of Ukraine end 2024? Let us recall that according to the World Steel Association, global steel production in 2024 decreased by 0.9% compared to 2023 - to 1.839 billion tons. This is evidenced by the global ranking of steel-producing countries [1], Fig. 1.

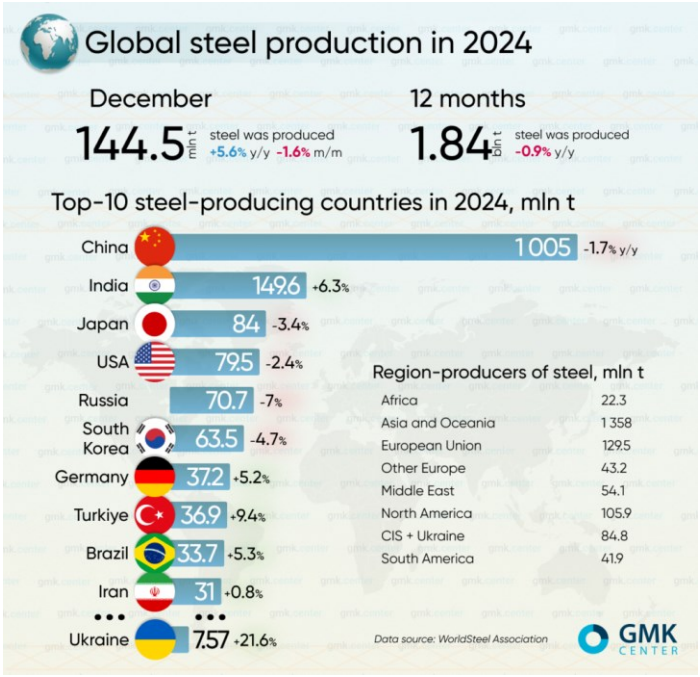

Fig. 1. Global steel production in 2024.

The top ten steel producing countries in 2024 according to World Steel include: China – 1.005 billion tons (-1.7% y/y); India – 149.6 million tons (+6.3%); Japan – 84 million tons (-3.4%); USA – 79.5 million tons (-2.4%); Russia – 70.7 million tons (-7%); South Korea – 63.5 million tons (-4.7%); Germany – 37.2 million tons (+5.2%); Turkey – 36.9 million tons (+9.4%); Brazil – 33.7 million tons (+5.3%); Iran – 31 million tons (+0.8%).

Steel production in Ukraine in 2024 amounted to 7.57 million tons (+21.6% compared to the previous year 2023), thus the country took 24th place in the

global ranking of steel producers. In order not to return to statistics, we note that in the first 2 months of 2025, steel production in Ukraine amounted to 1.183 million tons (+9.9% compared to the corresponding period in 2024); in the world ranking, Ukraine has been in 20th place since the beginning of this year.

The current situation in the ferroalloy industry looks as follows (Fig. 2).

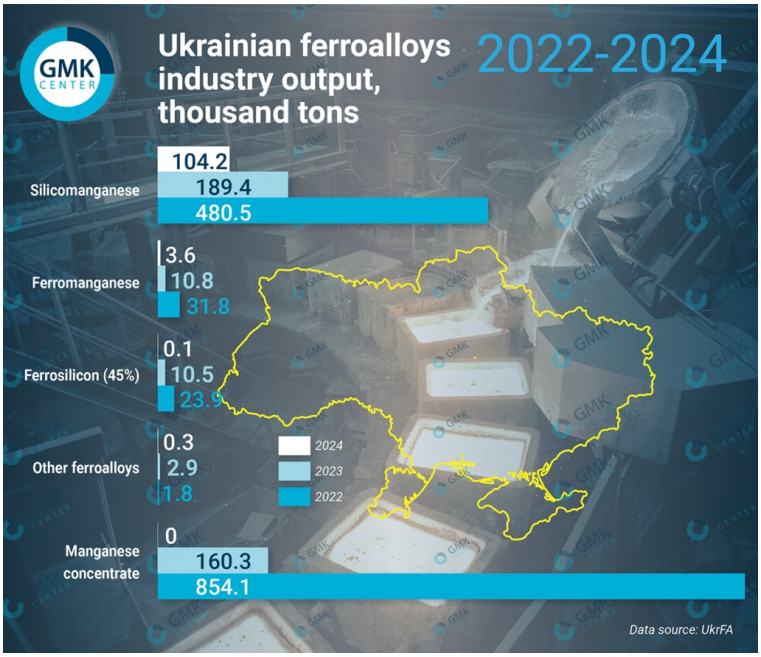

Fig. 2. Production output at enterprises of the ferroalloy industry of Ukraine in 2022-2024, thousand tons.

The industry resumed its work in April-May last year after the above-mentioned forced shutdown in the fall of 2023. According to the results of 2024, Ukrainian ferroalloy enterprises reduced production by 49.4% compared to 2023 - only to 108.2 thousand tons. By type of ferroalloys, production decreased as follows last year: silicomanganese - by 45%, to 104.2 thousand tons; ferromanganese - by 66.5%, to 3.6 thousand tons. The output of ferrosilicon (calculated at 45%) and other ferroalloys amounted to only 0.12 thousand tons and 0.28 thousand tons, respectively. The production of metallic manganese and manganese concentrate was not carried out last year.

Significantly, more than 4.5 times in 2024, the export of Ukrainian ferroalloys was reduced - to 77.3 thousand tons from 344.2 thousand tons in 2023 [2].

The temporary occupation of the territory of the Luhansk and Donetsk regions by the aggressor required metallurgical and ferroalloy enterprises to radically reorient the raw material base to replace the lost permanent suppliers. First of all, it was necessary to resolve the issue of using alternative reducing agents, which were previously produced from coking coal of the Donetsk basin. In cooperation with coke and chemical industry enterprises, the main parameters and specifics of using coke of various brands from new suppliers for smelting the entire range of ferroalloys were worked out, including such requirements for the quality of reducing agents as CRI, CRS and electrical resistance.

Similar work was carried out on limestones used in blast furnace and ferroalloy charges and for lime production. Alternative sources of limestone have been found, including dolomitized, high- and low-phosphorus for various types of cast iron and ferroalloys. The technology of calcining limestones of a new composition and macrostructure in shaft furnaces has been developed, improving the quality of the produced lime while simultaneously increasing the service life of the lining of the calcining furnaces from 1-2 years to 3 years.

The types of iron-containing raw materials used in ferrosilicon smelting have been expanded; in particular, steel shavings have been replaced with other materials containing reduced iron and minimal impurities.

Increased attention has been paid to the processing of previously accumulated slags from ferrosilicon smelting using products for remelting. Technologies for casting this alloy into thin ingots in a mold with a reduced depth on a carousel-type casting machine have been mastered, which has reduced losses in the form of metal beads. Losses of commodity alloys in the process of product fractionation have been reduced. Due to these and other measures, the consumption of the ore part of the raw material containing manganese, in the form of agglomerate and ore, has been reduced by 15-20%, carbon reducing agents by 10-15%, and electricity by 13-15%.

In conditions of periodic power outages, optimal electrotechnological modes of ferroalloy smelting have been worked out with regulation of the use of electric furnace capacities - reduction or complete cessation of energy consumption in the time intervals of the

greatest daily deficit of electricity and its maximum cost.

The above-described measures have allowed to stabilize the situation in the MMC to a certain extent, but unfortunately, the so-called systemic current issues remain unresolved. The current problems of metallurgical and ferroalloy enterprises are as follows [2]:

- a larger share of enterprises that remained in the territory controlled by Ukraine are located mainly in the zone of direct active hostilities or in adjacent regions, with all the inherent risks for equipment and personnel;
- metallurgical and, above all, ferroalloy enterprises are suffering greatly from high electricity tariffs. Electricity prices for industrial consumers in Ukraine are now often several times higher than in developed European countries. In addition, industry pays 100% of the prepayment for electricity for the next month. For enterprises, this means significant frozen working capital, and if there is no electricity for two days after another shelling, no one will compensate for these losses;
- there is a constant shortage of production personnel due to constant mobilization and departure of employees to safer areas;
- logistical problems that MMC enterprises constantly face. There is an increase in the cost of port cargo handling operations in the ports of "Great Odessa". A transition to annual transportation along the Danube is possible, but the tariffs there are even more expensive due to the increase in the burden of railway freight transportation and the low volume of vessel loading.

We very much hope that the development of the domestic metallurgical and ferroalloy industries is included in the pool of state interests. To support the sector, the authorities must, first of all, resolve the situation with the rise in energy prices and in general for the services of the so-called "natural monopolists". Otherwise, our industry will simply disappear, and Ukraine will not have its own production of metallurgical products and ferroalloys.

In the difficult realities of martial law, the main efforts of the industry are aimed at preserving and maximizing the use of production capacities. But it is already obvious that a radical revision of all previously developed programs and plans for technical re-equipment and development of the industry will be required, based on new conditions and guided by new principles. It is necessary to focus not only on the restoration of facilities destroyed by the war, but also to take into account all the latest achievements of world metallurgy, world and European standards in the field of energy efficiency and environmental friendliness, minimizing the use of raw materials and waste-free production, and producing high-quality products based on the requirements of metal-consuming industries, primarily the construction and defense industries. This approach is embedded in the Concept of the program for the revival of domestic metallurgy in the post-war period, which is currently being developed by the associations of Ukrainian MMCs together with industry and academic scientific institutions and universities.

When developing this document, Ukrainian scientists and manufacturers take into account global and European trends in the development of the so-called "green metallurgy." Let us recall that green metallurgy is a set of measures aimed at reducing carbon dioxide emissions in steel production. According to the European Green Deal, this level should be reduced by 80% by 2050 - to 250 kg of emissions per ton of steel [3].

Even before the Russian invasion, the export-oriented Ukrainian industry was actively planning for the “green” modernization of production. This was facilitated by several factors: Ukraine’s obligations under the Association Agreement with the EU, the high requirements of the European market for the environmental friendliness of products, and the pressure of the Ukrainian public, which does not want to put up with the depressing state of the natural environment in industrial cities.

In the pre-war years, the share of spending on environmental protection measures in the total volume of capital investments of mining and metallurgical companies increased from 39.8% in 2017 to 53.8% in 2020. And the share of “environmental” investments in the entire industry in the total volume of investments and expenditures on environmental protection in industry increased, according to the State Statistics Service, from 41.1% to 54.8%, that is, the lion’s share of all pre-war investments is environmental investments.

The war changed everything, and not only in Ukraine. The Ukrainian events became an additional factor that influenced the decline in industrial production in the world. Restrictions on gas supplies by Russia caused an energy crisis, rising food prices and global inflation. The World Bank predicts an annual increase in consumer prices of up to 8.8%; inflation in the eurozone, according to the European Commission, will be 7.6%, and in the EU - 8.3%. High energy prices negatively affect European industry, and the need to change energy import routes causes an imbalance in supply chains.

The taxonomy has changed: Europe had to include nuclear energy and natural gas in the taxonomy as fuels that contribute to the transition to a carbon-free economy. It has become obvious that abandoning fossil fuels is not so easy. Investments in their development are growing, which means emissions in the extraction process will decrease more slowly.

However, the EU's overall policy of moving away from fossil fuels has remained unchanged. Moreover, Russia's gas blackmail has convinced Europe of the correctness of the chosen path. We quote the decision of the European Commission: "Modernisation and decarbonisation of energy-intensive industries must be a top priority. The European Green Deal aims to create new markets for climate-neutral and year-round products such as steel, cement and basic chemicals. To lead this change, Europe needs new industrial processes and cleaner technologies to reduce costs and increase market readiness. The Commission will support breakthrough clean steel technologies leading to

a zero-carbon steel production process. The EU ETS Innovation Fund will help to deploy other large-scale innovation projects to support clean products in all energy-intensive sectors."

All these decisions also concern the Ukrainian metallurgy, taking into account the acceleration of Ukraine's European integration with the EU: on June 23, 2022, Ukraine acquired the status of a candidate for membership in the European Union and now we will have to accelerate reforms in order, including in the environmental sphere, to truly enter the European family.

A number of environmental programs have been developed in Ukraine, which are included in the draft National Recovery Plan of Ukraine, including projects in the metallurgical industry. The developers of the Recovery Plan intend to join the chain of added value of "green" steel: increase the production of DR-class pellets, ensure the production of direct reduction iron and hot-briquetted iron, including using H2, and produce "green" steel in electric arc furnaces. The total approximate cost of metallurgical projects is $5.8 billion. This includes private and public investments. It is expected that most of the investment will come from private players after the introduction of competitive interest rates, war zone insurance and measures to improve the business environment.

To address these issues, we need to develop relations between European and Ukrainian companies in the metallurgical sector in the post-war period and would like to present some ideas on the possibility of developing these relations. We have always held the opinion that Ukraine needs to integrate its metallurgical industry with Europe for the following reasons:

- Ukraine is an important part of Europe – territorially, historically, even being a part of the European geological structure and is working on a strategic plan for full economic integration with the European Union; the metallurgical industry should be part of this integration;

- Ukraine has large resources of metallurgical raw materials, which allows it to produce semi-finished products necessary for the metallurgical industry of Europe;

- Ukraine, like Europe, does not have sufficient natural gas resources along with coal. At the same time, the metallurgical sector, as is known, is a large consumer of natural gas and coal using traditional technologies. Europe has begun to phase out that part of the metallurgical industry that is heavily dependent on gas and coke used in blast furnaces and has begun to switch to electric arc furnaces that do not require the latter. Ukraine should also adhere to this policy, producing semi-finished products for European steel production: direct reduction iron pellets (DRI Pellets), hot briquetted iron (HBI);

- Europe is working on the development of "green energy" resources in various sectors, including the metallurgical sector, and has recently launched a new program for the production of iron pellets using such a renewable energy source as hydrogen. Ukraine has great potential for the production of "green energy", including hydrogen, and has reserves of iron ore of a certain quality; thus, Ukraine will be able to effectively participate in this program and integrate with Europe.

Specialists of MMC-Center [4] have made calculations that indicate the best positions of Ukrainian metallurgy to become major suppliers of "green" metallurgical raw materials, to ensure a "green" transition to Europe. According to these calculations, Ukrainian producers have the opportunity to increase steel production by 2035 to 15 million tons at a capacity utilization level of 80%, including 6.0 million tons of steel - using low-carbon technology.

Maintaining and developing ties with the world metallurgical and ferroalloy community, Ukrainian metallurgists will continue to look for ways to stabilize the situation, first of all - to stop Russian aggression, and in this regard we count on the active assistance and support of our foreign colleagues.

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Отримано редколегією / Received by the editorial board: 17.01.2025
Прийнято до друку / Accepted for publication: 20.02.2025