UDC 311:42
JEL Classification: C 80; L 70; L 72; L 79

Sierhieiev S.S., Dudka A.S., Ivanova M.V.

ECONOMIC STATISTICS IN SOLVING ENVIRONMENTAL PROBLEMS OF THE ENTERPRISE

Ukrainian State University of Chemical Technology, Dnipro, Ukraine

The scientific and practical problem of the accumulation of slag waste from metallurgical enterprises of Ukraine has been investigated. Possible directions of slag utilization offered by modern science are analyzed. It is substantiated that in Ukraine these areas are implemented point wise and fragmentary. The purpose is to reveal the problem of the accumulation of slag waste from an objective market position by means of a statistical assessment of the potential demand for slag. The technique of statistical analysis of macroeconomic indicators of production of certain types of industrial products in Ukraine was used. Considering the volumes of metallurgical production, the formation of slags in an amount of up to 11.4 mln.t/year is calculated. Also, analyzed are statistical data on the possible market demand for slag as a material resource. It has been proven that the market demand and supply of slag resources are equal. That is, the volumes of slag waste in Ukraine can be fully demanded by the market of manufacturers of building materials and in road construction. The emphasis is made on such important aspects of slag processing in related industries as the need for its granulation, high transport costs and requirements for the quality of raw materials. The analysis showed a reliable trend of accumulation of slag waste, if not on the scale of an individual enterprise, then on the scale of the metallurgical industry and the economy of Ukraine as a whole. The economic mechanisms of waste management of enterprises, based on compensation for environmental damage, do not work effectively. At the legislative level, the problem of environmental risks of the accumulation of slag waste is only declared and is not really solved. The algorithm of statistical analysis, calculations and conclusions described in the work allows for a comprehensive presentation of the scale of the environmental problem from the accumulation of slag waste and reveals the market mechanisms for its solution. To do this, it is necessary at the state level to develop a system of measures and responsibilities that will oblige enterprises to solve the environmental problems they create.

Keywords: metallurgical slag, statistical data, environmental tax, building materials, road construction.

DOI: 10.32434/2415-3974-2020-12-2-80-86

Introduction and problem statement

The problem of the state of the environment is very acute for the Ukrainian economy. To a particular extent, this concerns the economic activities of industrial enterprises, and to the greatest extent – metallurgy enterprises. The main technological pollutants of these enterprises are air emissions and solid waste. Metallurgical slags are classified as solid technological waste. Slag is a mineral constituent of iron ore and fluxes, which is separated from the liquid metal during the production of iron and steel and accumulates on its surface. The main chemical components of metallurgical slags are silica (SiO_2), alumina (Al_2O_3), iron oxide (FeO) and lime (CaO).

The volumes of metallurgical slag accumulated in the slag dumps of Ukraine are enormous, amounting to about 200 million tons [1]. Slag waste is concentrated at the geographical location of metallurgical plants. Basically, these are large industrial centers of Ukraine: Mariupol, Krivoy Rog,

Zaporizhzhia, Kamenskoe, Dnipro. Huge slag mountains are a kind of anti-tourist attraction in cities. Further accumulation of slag waste, deterioration of the environmental situation — can develop into a social and social conflict.

The social and ecological situation in Mariupol looks especially depressing at the Azovstal metallurgical plant. In view of the technological features of blast-furnace production (increased sulfur content in slags), the geographic profile of the area (chemical activity of sea water and high air humidity), the issue of accumulation of slag wastes is most acute. A particular cause for concern is the fact that the waters of the Sea of Azov were poisoned by sulfur compounds.

In terms of the risks of environmental impact, potential social tension and public resonance in large cities of Ukraine, and especially in the seaside Mariupol, the problem of the accumulation of slag dumps is very acute.

Analysis and research of scientific publications

Problems of utilization of technogenic waste is one of the global scientific and practical problems, especially characteristic of resource economies [2]. These problems are traditionally in the field of view of technical and industrial sciences. A number of possibilities are known for the processing and reuse of metallurgical slags. Modern possibilities of using various types of technological slags as building materials include the production of ceramics, geopolymer materials and functional materials from solidified slags. Such as sintered glass ceramics, porous ceramic materials, ceramic bricks, functional zeolites for wastewater treatment and refractory materials.

The main obstacle to the recycling and reuse of slag is the presence of toxic metal elements, as well as the accumulation of harmful elements in the slag. In response to this, such a scientific and practical direction as «slag engineering» was formed [2]. It represents a special approach to controlling the solidification and crystallization properties of slags in order to improve their environmental compatibility.

The well-known scientific principles and technologies of metallurgical slag processing in Ukraine have been implemented and continue to be improved. However, due to the limitations of modern technologies and market demand, a large amount of solid metallurgical waste is not in demand. One of the economic mechanisms for regulating and utilizing waste from enterprises is a system based on tax payments for the generation and subsequent disposal of waste, together with a system of penalties for improper waste handling. However, at this stage, in the conditions of the Ukrainian economy, this system does not work, it is easier for an enterprise to pay tax and place waste on slag dumps and not deal with the problems of processing and disposal. The consequence of this policy was the difficult ecological situation that has developed in Mariupol, and at this stage, it seems an insoluble problem. Considering the above, a problem emerges: on the one hand, it is scientifically and practically grounded that metallurgical slag is a valuable economic resource, on the other, the accumulation of slag dumps in Mariupol is constantly increasing, and the sea in the coastal zone has all the obvious signs of chemical pollution.

To clarify this complex issue, we consider it necessary to highlight this environmental problem from the point of view of market mechanisms for regulating supply and demand for slag, as well as the administrative and economic motivation of enterprises to environmental protection measures.

The purpose of the work

The purpose of the work is to reveal the problem of accumulation of slag waste by metallurgical enterprises of Ukraine from objective market positions and a statistical assessment of the potential demand for slag.

Presentation of the main material

Absolutely correct analysis and obtaining reliable information about the quality of environmental protection activities of enterprises would be possible on the basis of forms of statistical, tax, financial and non-financial reporting. An obstacle for this is the lack of necessary data on environmental activities in the mandatory reporting of enterprises, as well as clearly defined legal requirements for indicators and completeness of information disclosure, which is justified in [3]. Therefore, the study used the following methodology for statistical analysis of macroeconomic indicators of production of certain types of industrial products in Ukraine.

1. Assessment of supply of slag waste as potential resources

It is generally known that the amount of slag formed depends on the volume of iron and steel production. An important point of this statistical analysis is the rate of formation of metallurgical slags per unit of iron and steel. The output of blast-furnace slag, its composition and properties depend on the chemical and mineralogical composition of waste rock of iron ores, coke ash, sulfur content in the charge, the nature of the recovery process and the thermal state of the furnace, as well as on the grade of cast iron. On average, for blast furnaces, the specific slag yield is 440 kg/t of pig iron. The specific output of converter slag is about 150 kg/t of steel [4, pp. 40–42]. Knowing the specific volume of the formed slag per ton of metal products and the average annual volume of iron and steel production, we can calculate the volume of the formed slag and its

Table 1

Statistical data on the production of metallurgical products in Ukraine

Product name	Unit	Volume of output of industrial products (gross output) in				
		2015	2016	2017	2018	2019
1. Pig iron and spiegeleisen in pigs, blocks or other primary forms	mln.t	21.9	23.6	19.8	20.5	20.1
2. Ingots, other primary forms and long semi-finished products for seamless tubes of steel	mln.t	11.5	11.5	11.2	10.4	10.0
3. Other ingots, primary forms and long semi-finished products including blanks of steel	mln.t	8.4	8.4	5.6	6.2	5.8
4. Other types of steel products	mln.t	1.4	1.6	1.8	1.8	1.7
5. Total steel products:	mln.t	21.3	21.5	18.6	18.6	17.5

Table 2

Results of calculating the volume of slag waste

Product name	Unit	Volume of output of industrial products (gross output) in				
		2015	2016	2017	2018	2019
1. Blast-furnace slag	mln.t	9.6	10.4	8.7	9	8.8
2. Converter slag	mln.t	3.2	3.2	2.8	2.8	2.6
3. Total	mln.t	12.8	13.6	11.5	11.8	11.4

dynamics.

According to statistical data on the production of certain types of industrial products in Ukraine [5] table 1 was formed, which shows data on the production of iron and steel in dynamics.

Table 2 shows the results of calculating the volume of slag that is annually formed at metallurgical enterprises in Ukraine.

For items 1–5 table. 1, you can objectively assess the dynamics of the volume of slag waste in Ukraine. It follows from the table that in 2019 the volume of steel production (item 5) was 17.5 million tons and pig iron (item 1) was 20.1 million tons. Over the past 5 years, the decline in steel production was 17.5%; cast iron – 9.0%. The volume of slag that is generated annually directly depends on the production of pig iron and steel, therefore, in Table 2, we also observe a downward trend in the resulting slag, in 2019 by 11% or 1.4 million tons less than in 2015.

2. Let's analyze the main directions of slag utilization and give an estimate of the potential demand for slag in each direction of utilization.

The exact data on the needs of the economy for slag resources are also unknown. But they can be approximately estimated by analyzing the dynamics of production of products that already contain (or may contain) metallurgical slag in their composition. In the well-known areas of processing slag waste:

2.1 Cement production

The cement industry uses slag as an active mineral additive in the production of slag-Portland cement – a binder that hardens in water and air. The current volume of cement production in Ukraine is 9.1 million tons, on average 24% of slag is added to cement. Given the widespread use of slag-Portland cement in the production of concrete, the current volume of slag consumption by this industry is 2.2 million/tons per year.

According to Doctor of Science Barkhatov V.I. and his colleagues [6], no less than 21% and no more than 60% of slag can be added to slag-Portland cement, depending on the grade of cement. When calculating that the slag content in cement will increase to 35%, an additional demand for slag will be formed in the amount of 1 million/tons per year.

The capacities of domestic cement plants are loaded by 65%. Given the positive outlook for the industry, capacity utilization can potentially be increased to 85–90% (primarily due to government support for construction and infrastructure projects). This will make it possible to additionally utilize up to 0.9 million tons of slag per year.

Thus, at the moment, the cement industry uses 2.2 million tons of slag per year, but there is the potential to use 2.2 + 1 + 0.9 = 4.1 million tons of slag per year.

2.2 Production of granular slag

Granulation of slag is a process of production of vitreous granules from liquid slag by means of its sharp cooling by water, steam, air or other gas. The size of the obtained granule is 1–5 mm [7]. The price of blast-furnace (dump) slag is 50–80 UAH / ton, depending on the fraction. And granulated blast-furnace slag costs 130–150 UAH / ton, which is 2.0–2.5 times more than the price of dump slag. At the same time, in the manufacture of cement, slags are used in exclusively GRANULAR FORM.

Thus, granulation will make it possible to make a semi-finished product from the slag, which can be exported, which will additionally use 0.9 million tons of slag per year.

2.3 The use of slag in road construction

The annual production of crushed stone, which is used as concrete filler, for road surfaces and similar purposes, is 60.4 million tons / year [5]. Of this amount is spent:

– for the production of building materials – 5 million tons;

– for road construction – 55.4 million tons.

Crushed blast-furnace slag is a complete substitute for natural crushed stone, which is extracted from open pits. Therefore, it is economically feasible to replace expensive crushed stone (120–190 UAH / ton, depending on the fraction) with slag, which is 2.0–2.5 times less, of which a huge amount has accumulated, it is stored in dumps and is not used.

Currently, 1.2 million tons of slag is used annually in road construction. Taking into account the government's chosen course to increase the volume of construction, reconstruction and repair of roads and infrastructure facilities, the CMU published order № 1420-r dated December 4, 2019 «On the use of industrial waste in road construction», on the obligation of builders to purchase metallurgical waste from metallurgists when laying roads production in the amount of at least 10% of the required volume of building materials.

This initiative will create an additional potential demand for slag in the amount of 5.5 million tons.

2.4 Metallurgical slags can also be used in the production of heat-insulating materials and heaters

Slag wool production. Without taking into account humidity and production losses, 0.82 tons of slag and 0.18 tons of ceramic clay to obtain 1 ton of slag wool. Taking into account production losses, the practical consumption of slag per 1 ton of cotton wool will be 1.13 tons. In comparison with its production from rocks, a significant reduction in labor intensity and cost of producing mineral wool is ensured with a simultaneous increase in labor productivity.

Metallurgical slags are a good raw material for obtaining highly efficient building materials – slag-glass products. Slagositall is a highly wear-resistant building material. Slag consumption per 1 ton of material is 0.5–0.6 tons / ton.

Modern and relevant products for construction, like porous glass-crystalline materials. According to modern scientific developments, taking into account Ukrainian raw materials, it is possible to use up to 20% of metallurgical slags in the production of multilayer insulating glass materials [8].

The market demand for slag resources for enterprises for the production of slag vitrified metals and slag wool will amount to 0.189 million tons or 189 thousand tons per year, respectively, with an upward trend.

3. Comparison of market demand and supply of slag as an economic resource

Thus, the annual market demand for blast furnace slag can be: 4.1+0.9+5.5+0.189=11.3 million tons. Considering the volume of metallurgical production throughout Ukraine (tab. 1; 2) and the corresponding formation of slags in the amount of up to 11.4 million tons / year, we can conclude that the market demand and supply of slag resources are equal. That is, the volumes of slag waste in Ukraine may be in demand by the market of manufacturers of building materials and in road construction. A similar conclusion was formulated in analytical materials on the study of international experience in the use of slag waste [7]. However, one should take into account such important aspects of slag processing in related industries as the need for its granulation, high transport costs and requirements for the quality of raw materials:

– slag granulation is carried out either at the smelting unit, or at stand-alone installations with the transportation of the slag melt to them in ladles, or in specially organized granulate basins. Such technological improvement in each case (production) requires a separate investment justification;

– high costs for the transportation of slag waste from the south-eastern part of Ukraine to the central and western regions reduce the economic feasibility of such logistics;

– the chemical composition of slag resources is of particular importance in the production of building materials: the presence of impurities complicates the course of technological processes, and the sulfur content increases the amount of harmful emissions during the roasting of raw materials.

The above aspects of slag processing in related industries actually reduce the market demand for slag resources. The practice of Ukrainian metallurgical enterprises shows that the potential of slag resources remains undeveloped: and slag continues to accumulate in slag dumps and pollute the atmospheric air, soil, groundwater, and surface waters of Ukraine.

On 01.01.2020, the Law of Ukraine «On the foundations (strategy) of the state environmental policy of Ukraine for the period up to 2030» [9] came into effect. A special emphasis in the preamble of this law is made on the fact that Ukraine has a very high share of industrial waste – more than 75% of all generated waste. The actual volumes of accumulated waste exceed those reflected in the statistical reporting. The state statistical observations do not include the volumes of the waste that was

accumulated earlier by bankrupt enterprises and not already operating enterprises. Waste disposal sites located on the territory of such enterprises negatively affect the state of the environment. There is an extremely low level of replacement of primary natural resources due to the use of production waste or by-products (including slags). The main reason for this situation is an imperfect legislative framework, the absence of an effective accounting and reporting system, a monitoring system in the field of waste management. After a detailed listing of the environmental damage from industrial enterprises and the declaration of the state's strategic goals and plans for regulating the environmental activities of enterprises, indicators are given to assess the implementation of the state environmental policy. A careful study of this law shows that in the above 30 estimates there is not a word about solving the problems of accumulation of slag waste. The closest to the problem under consideration are the positions "Discharge of contaminated wastewater into water bodies" and "Share of waste for disposal", however, none of the problems presented directly corresponds to the problem of disposal of slags. Pollution and poisoning of water bodies from slag dumps occurs under the influence of gravity, and this waste is not subject to burial. Thus, even at the legislative level, the problem of environmental risks of the accumulation of slag waste is only declared and practically not solved.

And this is the difference between Ukraine and the economies of European law: in Europe, solid waste from metallurgical enterprises is considered potentially aggressive and such that it is subject to mandatory processing. The potential chemical aggressiveness of slags stored in slag dumps has been experimentally proven by scientific research [10]: metallurgical solid waste contains several heavy metals (As, Cr, Mo, Cd, Pb, Ni, Zn, Hg), which can have a hazardous potential for all environmental factors (soil, air, and water) and human health. And although this study was carried out for the conditions of production in some regions of Europe, the author convincingly shows the possibility of extrapolating the results obtained to all metallurgical processes of metal smelting. Considering that those studies [10] were supported by the European Social Fund through Sectoral Operational Programs Human Resources Development, it can be concluded about the real measures of the influence of investment organizations on solving the environmental problems of the accumulation of slags in Europe.

Conclusions

The carried out statistical analysis showed a reliable tendency for the accumulation of slag waste in the scale of the metallurgical industry and the economy of Ukraine as a whole. Potential market demand and supply of slag resources are on par and amount to about 10.4 mln.t/year. That is, the volumes of slag waste in Ukraine can be fully demanded by the market of manufacturers of building materials and in road construction. But in fact, this economic mechanism is not implemented. Slag waste is not completely utilized and pollutes the environment. It is shown that for the economies of European law, solid metallurgical waste is subject to mandatory processing. Because they represent a potential risk due to the content of heavy metals.

The economic mechanisms for regulating waste from enterprises in Ukraine are based on compensation for environmental damage. In our opinion, these mechanisms are ineffective, which is confirmed by the positive dynamics of waste accumulation. In principle, there are options for activating and initiating environmental protection measures by the business entities themselves. But this is not enough to solve environmental problems, and without effective government incentives the problem cannot be solved. First of all, it is necessary to revise the rate of the environmental tax, which is currently 5 UAH/t for the placement of industrial waste of the 4th risk class outside the city. Practice shows that even an increasing coefficient of 3 to the rate of this tax for waste disposal in the neighborhood of the city does not stimulate metallurgical enterprises to solve the problem of industrial waste accumulation. Enterprises prefer to pay this minimum tax and not solve the problems of processing and disposal of slag waste. Thus, in order to solve the problem of the accumulation of slag wastes, it is necessary at the state level to develop a system of measures and responsibilities that will oblige enterprises to solve the environmental problems they create.

REFERENCES

1. Demidik, V.N. (2014). Ustojchivoe razvitie i recikling othodov v chernoj metallurgii [Sustainable development and recycling of waste in the iron and steel industry]. *Metall i lit'e Ukrainy*. 8 (255), 36-40 [in Ukrainian].

2. Matinde, E., Simate, G. S., & Ndlovu, S. (2018). Mining and metallurgical wastes: a review of recycling and re-use practices. *Journal of the South African Institute of Mining and Metallurgy*. Retrieved from URL http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S2225-62532018000800007&lng=en&nrm=iso&tlng=en [in English].

3. Kupalova, G., & Matvienko, T. (2012). Ekologichna zvitnist' pidpriємstv yak skladova nacional'noï informacijnoï sistemi z ohoroni dovkillya [Environmental reporting of enterprises as a component of the national information system on environmental protection] *Visnik Kiïvs'kogo nacional'nogo universitetu im. T. Shevchenka*, *Ser. Ekonomika*, *142,* 12-16 [in Ukrainian].

4. Valuev, D.V., & Gizatulin, R.A. (2012). Tekhnologii pererabotki metallurgicheskih othodov: uchebnoe posobie [Metallurgical waste processing technologies: a tutorial]. Tomsk: Izd-vo Tomskogo politekhnicheskogo universiteta [in Russian]

5. Oficijnij veb-sajt Derzhavnoї sluzhbi statistiki Ukraïni. Virobnictvo osnovnih vidiv promislovoї produkciї [Official website of the State Statistics Service of Ukraine. Production of basic industrial products]. *www.ukrstat.gov.ua*. Retrieved from URL http://www.ukrstat.gov.ua/operativ/operativ2006/pr/prm_ric/prm_ric_u/vov2005_u.html [in Ukrainian].

6. Barhatov, V. I. (2017). Othody proizvodstv i potrebleniya — rezerv stroitel'nyh materialov : monografiya [Waste from production and consumption - a reserve of building materials: monograph]. CHelyabinsk : Izd-vo CHelyab. gos. un-ta. [in Russian].

7. Glushchenko, A. (2019) Mezhdunarodnyj opyt ispol'zovaniya metallurgicheskih shlakov [International experience in the use of metallurgical slags]. *Analiticheskie materialy GMK Center. gmk.center*. Retrieved from URL https://gmk.center/wp-content/uploads/2019/08/Mezhdunarodnyj_opyt_ispolzovaniya_shlakov_compressed.pdf [in Russian].

8. Bilij YA. I., Kol'cova YA.I., & Nikitin S.V. (2013). Sirovinna sumish dlya vigotovlennya poristih sklokristalichnih materialiv [Raw material mixture for the manufacture of porous fiberglass materials]. *Ukraina Patent № 106006. Ukrainskij institut intellektal'noj sobstvennosti (Ukrpatent). base.uipv.org*. Retrieved from URL: https://base.uipv.org/searchINV/search.php?action=viewdetails&IdClaim=202223 [in Ukrainian].

9. Zakon Ukrainy «Pro Osnovni zasadi (strategiyu) derzhavnoї ekologichnoї politiki Ukraïni na period do 2030 roku» [Law of Ukraine «On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the period up to 2030»]. *zakon.rada.gov.ua*. Retrieved from URL: https://zakon.rada.gov.ua/laws/show/2697-19#Text [in Ukrainian].

10. Dana - Adriana Iluюiu-Varvara (2016). Researching the Hazardous Potential of Metallurgical Solid Wastes. *Polish Journal of Environ. Stud.* Vol. 25, No. 1, 147-152. Retrieved from URL: https://pdfs.semanticscholar.org/a7e7/dcedd978aec4dd9bf5fbe23e58a8e462862c.pdf [in English].

Received 15.10.2020
Reviewer: PhD in Economics, Prof. Kolesnikov V.P.

ЕКОНОМІЧНА СТАТИСТИКА У РІШЕННІ ЕКОЛОГІЧНИХ ПРОБЛЕМ ПІДПРИЄМСТВА

Сергєєв С.С., Дудка А.С., Іванова М.В.

Досліджено науково-практична проблема накопичення шлакових відходів металургійних підприємств України. Проаналізовано можливі напрями утилізації шлаків, які пропонує сучасна наука. Обґрунтовано, що в Україні ці напрями реалізуються фрагментарно. Поставлено мету розкрити проблему накопичення шлакових відходів з об'єктивних ринкових позицій шляхом статистичної оцінки потенційного попиту на шлак. Була використана методика статистичного аналізу макроекономічних показників виробництва окремих видів промислової продукції в Україні. З урахуванням обсягів металургійного виробництва розраховано обсяги утворення шлаків в кількості до 11,4 млн.т / рік. Також проаналізовані статистичні дані щодо можливого ринковому попиту на шлак як матеріальний ресурс. Доведено, що ринковий попит і пропозиція шлакових ресурсів є паритетними. Тобто обсяги шлакових відходів в Україні можуть бути повною мірою затребувані ринком виробників будівельних матеріалів та в дорожньому будівництві. Зроблено акцент на таких важливих аспектах переробки шлаку в суміжних галузях як необхідність його грануляції, високі транспортні витрати і вимоги до якості сировини. Виконаний аналіз показав достовірну тенденцію накопичення шлакових відходів, якщо не в масштабі окремого підприємства, то в масштабі металургійної промисловості та економіки України в цілому. Економічні механізми регулювання відходів підприємств, засновані на відшкодування збитку за екологічну шкоду через сплату екологічного податку, ефективно не працюють. На законодавчому рівні проблема екологічних ризиків накопичення шлакових відходів тільки декларується і реально не вирішується. Описаний в роботі алгоритм статистичного аналізу, розрахунків і висновків дозволяє комплексно уявити масштаб екологічної проблеми від накопичення шлакових відходів і розкриває ринкові механізми її вирішення. Для цього необхідно на державному рівні розробити систему заходів і відповідальності, яка буде зобов'язувати підприємства вирішувати створювані ними екологічні проблеми.

Ключові слова: металургійний шлак, статистичні дані, екологічний податок, будівельні матеріали, дорожнє будівництво

ЭКОНОМИЧЕСКАЯ СТАТИСТИКА В РЕШЕНИИ ЭКОЛОГИЧЕСКИХ ПРОБЛЕМ ПРЕДПРИЯТИЯ

Сергеев С.С., Дудка А.С., Иванова М.В.

Исследована научно-практическая проблема накопления шлаковых отходов металлургических предприятий Украины. Проанализированы возможные направления утилизации шлаков, которые предлагает современная наука. Обосновано, что в Украине эти направления реализуются точечно и фрагментарно. Поставлена цель раскрыть проблему накопления шлаковых отходов с объективных рыночных позиций путем статистической оценки потенциального спроса на шлак. Была использована методика статистического анализа макроэкономических показателей производства отдельных видов промышленной продукции в Украине. С учетом объемов металлургического производства рассчитано образование шлаков в количестве до 11,4 млн.т/год. Также проанализированы статистические данные по возможному рыночному спросу на шлак как материальный ресурс. Доказано, что рыночный спрос и предложение шлаковых ресурсов паритетные. То есть объемы шлаковых отходов в Украине могут быть в полной мере востребованы рынком производителей строительных материалов и в дорожном строительстве. Сделан акцент на таких важных аспектах переработки шлака в смежных отраслях как необходимость его грануляции, высокие транспортные расходы и требования к качеству сырья. Проведенный анализ показал достоверную тенденцию накопления шлаковых отходов, если

не в масштабе отдельного предприятия, то в масштабе металлургической промышленности и экономике Украины в целом. Экономические механизмы регулирования отходов предприятий, основанные на возмещении ущерба за экологический вред посредством уплаты экологического налога, эффективно не работают. На законодательном уровне проблема экологических рисков накопления шлаковых отходов только декларируется и реально не решается. Описанный в работе алгоритм статистического анализа, расчётов и выводов позволяет комплексно представить масштаб экологической проблемы от накопления шлаковых отходов и раскрывает рыночные механизмы ее решения. Для этого необходимо на государственном уровне разработать систему мер и ответственности, которая будет обязывать предприятия решать создаваемые ими экологические проблемы.

Ключевые слова: металлургический шлак, статистические данные, экологический налог, строительные материалы, дорожное строительство

ECONOMIC STATISTICS IN SOLVING ENVIRONMENTAL PROBLEMS OF THE ENTERPRISE

Sierhieiev S.S., Dudka A.S., Ivanova M.V.*

Ukrainian State University of Chemical Technology, Dnipro, Ukraine

***email: 470629.marina@gmail.com**

Ivanova M.V. ORCID: https://orcid.org/0000-0003-2620-7168

The scientific and practical problem of the accumulation of slag waste from metallurgical enterprises of Ukraine has been investigated. Possible directions of slag utilization offered by modern science are analyzed. It is substantiated that in Ukraine these areas are implemented point wise and fragmentary. The purpose is to reveal the problem of the accumulation of slag waste from an objective market position by means of a statistical assessment of the potential demand for slag. The technique of statistical analysis of macroeconomic indicators of production of certain types of industrial products in Ukraine was used. Considering the volumes of metallurgical production, the formation of slags in an amount of up to 11.4 mln.t/year is calculated. Also, analyzed are statistical data on the possible market demand for slag as a material resource. It has been proven that the market demand and supply of slag resources are equal. That is, the volumes of slag waste in Ukraine can be fully demanded by the market of manufacturers of building materials and in road construction. The emphasis is made on such important aspects of slag processing in related industries as the need for its granulation, high transport costs and requirements for the quality of raw materials. The analysis showed a reliable trend of accumulation of slag waste, if not on the scale of an individual enterprise, then on the scale of the metallurgical industry and the economy of Ukraine as a whole. The economic mechanisms of waste management of enterprises, based on compensation for environmental damage, do not work effectively. At the legislative level, the problem of environmental risks of the accumulation of slag waste is only declared and is not really solved. The algorithm of statistical analysis, calculations and conclusions described in the work allows for a comprehensive presentation of the scale of the environmental problem from the accumulation of slag waste and reveals the market mechanisms for its solution. To do this, it is necessary at the state level to develop a system of measures and responsibilities that will oblige enterprises to solve the environmental problems they create.

Keywords: metallurgical slag, statistical data, environmental tax, building materials, road construction.

REFERENCES

1. Demidik, V.N. (2014). Ustojchivoe razvitie i recikling othodov v chernoj metallurgii [Sustainable development and recycling of waste in the iron and steel industry]. *Metall i lit'e Ukrainy*. № 8 (255), 36-40 [in Ukrainian].

2. Matinde, E., Simate, G. S., & Ndlovu, S. (2018). Mining and metallurgical wastes: a review of recycling and re-use practices. *Journal of the South African Institute of Mining and Metallurgy*. Retrieved from URL http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S2225-62532018000800007&lng=en&nrm=iso&tlng=en [in English].

3. Kupalova, G., & Matvienko, T. (2012). Ekologichna zvitnist' pidpriємstv yak skladova nacional'noї informacijnoї sistemi z ohoroni dovkillya [Environmental reporting of enterprises as a component of the national information system on environmental protection] *Visnik Kiïvs'kogo nacional'nogo universitetu im. T. SHevchenka*, *Ser. Ekonomika*, *142,* 12-16 [in Ukrainian].

4. Valuev, D.V., & Gizatulin, R.A. (2012). Tekhnologii pererabotki metallurgicheskih othodov: uchebnoe posobie [Metallurgical waste processing technologies: a tutorial]. Tomsk: Izd-vo Tomskogo politekhnicheskogo universiteta [in Russian]

5. Oficijnij veb-sajt Derzhavnoї sluzhbi statistiki Ukraïni. Virobnictvo osnovnih vidiv promislovoї produkciї [Official website of the State Statistics Service of Ukraine. Production of basic industrial products]. *www.ukrstat.gov.ua*. Retrieved from URL http://www.ukrstat.gov.ua/operativ/operativ2006/pr/prm_ric/prm_ric_u/vov2005_u.html [in Ukrainian].

6. Barhatov, V. I. (2017). Othody proizvodstv i potrebleniya — rezerv stroitel'nyh materialov : monografiya [Waste from production and consumption - a reserve of building materials: monograph]. CHelyabinsk : Izd-vo CHelyab. gos. un-ta. [in Russian].

7. Glushchenko, A. (2019) Mezhdunarodnyj opyt ispol'zovaniya metallurgicheskih shlakov [International experience in the use of metallurgical slags]. *Analiticheskie materialy GMK Center. gmk.center*. Retrieved from URL https://gmk.center/wp-content/uploads/2019/08/Mezhdunarodnyj_opyt_ispolzovaniya_shlakov_compressed.pdf [in Russian].

8. Bilij YA. I., Kol'cova YA.I., & Nikitin S.V. (2013). Sirovinna sumish dlya vigotovlennya poristih sklokristalichnih materialiv [Raw material mixture for the manufacture of porous fiberglass materials]. *Ukraina Patent № 106006. Ukrainskij institut intellektal'noj sobstvennosti (Ukrpatent). base.uipv.org.* Retrieved from URL: https://base.uipv.org/searchINV/search.php?action=viewdetails&IdClaim=202223 [in Ukrainian].

9. Zakon Ukrainy «Pro Osnovni zasadi (strategiyu) derzhavnoї ekologichnoї politiki Ukraïni na period do 2030 roku» [Law of Ukraine «On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the period up to 2030»]. *zakon.rada.gov.ua*. Retrieved from URL: https://zakon.rada.gov.ua/laws/show/2697-19#Text [in Ukrainian].

10. Dana - Adriana Iluюiu-Varvara (2016). Researching the Hazardous Potential of Metallurgical Solid Wastes. *Polish Journal of Environ. Stud.* Vol. 25, No. 1, 147-152. Retrieved from URL: https://pdfs.semanticscholar.org/a7e7/dcedd978aec4dd9bf5fbe23e58a8e462862c.pdf [in English].