УДК 504:669.1(477)

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INFLUENCE OF ENVIRONMENTAL INDICATORS ON THE DEVELOPMENT OF UKRAINIAN METALLURGY

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This article considers the basic indicators of emissions by branches of metallurgical industries. Here, we substantiate the necessity to maintain the interrelation between the environment and the economic development of the Ukrainian mining and metallurgical complex and show that there is a necessity to develop and use promising energy-saving technologies for metallurgical production.

Keywords: emission indicators, metallurgical enterprises, economic development, energy saving technologies

Background. Nowadays, the state of the Ukrainian ferrous metallurgy bears a serious threat to the country's ecology and economy, in particular – economic instability, dependence on the conditions of the world market, inefficient use of natural resources, pollution of the environment. It is becoming obvious that the tasks of maintaining the environmental and economic development are interrelated: steady economic development is impossible to ensure when destroying and depleting the natural environment.

On the one hand, large metallurgical enterprises produce a powerful foundation for Ukraine's economic development, but on the other hand, they seriously damage the environment and the health of the population. Considering the fact that Ukraine is one of the most polluted countries in the world, the environmental problems should be discussed and resolved at all the levels of concern. The complexity of the ecological problem in Ukraine is in that all the constituents of the natural environment are exposed to pollution: exhausts of harmful substances into the atmosphere, mine waters merge into rivers, the natural landscapes are ousted with technogenic ones, with their quarries, tailings, industrial sites, growing areas of affected lands and more frequent landslides. [1]

The problem to solve. The beginning of the Ukraine's transition period striding to the market economy revealed serious disproportions in the structure of the national economy, which had been oriented to the market criteria and the own needs in the improper way. The need for structural reorganization of the economy appeared along with the need for modernization of the material base and facilities, the use of fundamentally new approaches to managing the economy of the country, identifying opportunities for saving primary raw materials, fuels and energy resources. Over the past 15 years, the leading industrial countries have convincingly confirmed the successful use of the resource- and energy-saving approaches. Thus, using only some part of the economically acceptable technological innovations Ukraine achieved the 40% growth in the gross national product (hereinafter referred as GNP) with only 4% increase in the energy consumption.

Moreover, the level of the ecological safety for the society is becoming the criterion of the civilized society. The world community has come to the conclusion that the growth rates of GNP can not be the only indicator of the nation's well-being, which is also characterized by the quality of life, largely dependent on the environmental situation in the country. Furthermore, 20-30% of diseases on the planet are due to deterioration of the environment, according to the data of the World Health Organization (WHO)

However, it should be noted that the severity of the Ukrainian economic crisis has pushed aside the solutions of the environmental problems in Ukraine to the second place by the government policy. Presumably, it seems that the turn to solve them will come after the economy is recovered. Eventually, the non-synchronic exit out from the both crises (economic and environmental) is not possible, as reviving the economy with environmentally hazardous technologies can plunge the country into another economic crisis due to exorbitant costs on eliminating the negative environmental consequences.

The aim and scientific novelty. The article aims at analyzing the influence of the energy parameters on the ecological, technical and economic parameters in relation to the field of the metallurgical production. The scientific novelty of the study is in identifying the relation between the energy and ecological parameters of metallurgical production, and in determining the ecological factors affecting the development in the Ukrainian ferrous metallurgy.

An account of the main materials of the study. The efficiency of metallurgical production and the competitiveness of steel products depend significantly on energy prices. The share of fuel and electricity costs in the cost of commodity products of metallurgy in Ukraine is 40-60%, while the USA, Germany, and Japan - 28-35%. No less important factor are the environmental indicators that determine the prospects for the development of metallurgy in Ukraine. In this regard, consider the influence of energy parameters on the environmental parameters of metallurgical production. It should be noted that in the Ukrainian ferrous metallurgy, carbon dioxide emissions amount to 97.3-98.8% of total emissions [2] (Fig. 1), therefore in future calculations we will focus on CO_2 emissions.

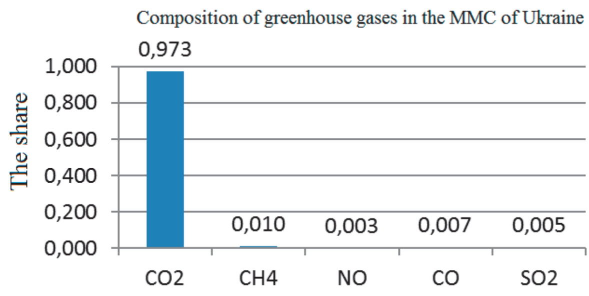

Figure 1 – The main constituents of greenhouse gas mix produced during the metal products manufacture.

Furthermore, the analysis how the energy parameters influence the environmental, technical and economic ones in the field of metallurgical production is topical in connection with the United Nations Framework Convention on Climate Change (Kyoto Protocol) signed by Ukraine. Ukraine assumed the obligation not to exceed the harmful emissions of its base year (1997). Thus, to evaluate how much greenhouse gas is exhausted at the main stages of domestic pig iron smelting, steel-making and rolled steel production is becoming an urgent problem under such conditions. Therefore, let us consider the methods to carry out this estimation.

The point is that there are several approaches to the calculation of greenhouse gas emissions. These methods differ by the choice of the initial data and way of their processing, but, in fact, they are based on the Guidelines of the international group of experts on climate change of the planet.

In the 1996 IPCC Guidelines [3], CO_2 emissions from the pig iron smelting (Vc, t CO_2) are calculated as follows:

$$V_c = k_c \cdot A_c + (m_r \cdot A_r/100 - m_c \cdot A_i/100) \cdot 44/12 \quad (1)$$

where k_c – CO_2 emission factor for combustion and/ or the reducing agents use (t CO_2 / t);

A_c – mass of reducing agents (t);

m_r. m_c – carbon content in ore and processing pig iron (%);

A_r. A_i – the amount of ore and produced cast iron (t).

The CO_2 emission factor due to combustion and reducing agents can be calculated as follows:

$$k_c = (d_c/100) \cdot 44/12\ , \quad (2)$$

where d_c – carbon content in reducing agents (%).

According to the IPCC, coke, coal, petroleum coke can serve as the reducing agents in the pig iron smelting.

Furthermore, the calculations of CO_2 emissions in the steelmaking industry (Vs, t $_{CO2}$) are offered to perform as follows:

$$V_s = ((m_c - m_s)/100) \cdot A_s \cdot 44/12 + k_{es} \cdot A_{es}, \quad (3)$$

where m_s – carbon content in steel (%);

k_{es} – CO_2 emission factor in electric arc furnace production (t $_{CO2}$ / t$_{steel}$);

A_s – the amount of steel produced in oxygen converters or open hearth furnaces, (t);

A_{es} – the amount of steel produced in electric arc furnaces, (t).

The above methodology is intended for conducting a national inventory of greenhouse gases, and not for determining specific greenhouse gas emissions in the production of the main types of products at metallurgical enterprises. It does not fully take into account the peculiarities of metallurgical enterprises in Ukraine and does not allow quantifying standards for the production of pig iron, steel and rolled products. At the same time, the dependences (1) - (3) qualitatively show a practically direct dependence of ecological parameters on the energy parameters of metallurgical production. Based on the use of actual data, we have constructed the dependence of the greenhouse gas (CO2) emissions on the specific energy costs for the production of various types of metal products in Ukraine (Fig. 2).

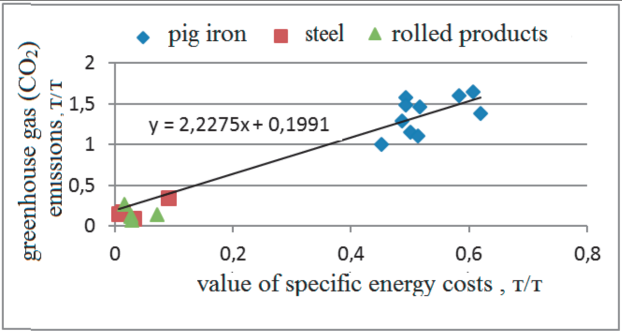

Figure 2 – Dependence of CO_2 emissions on the specific energy costs for various types of metal products in Ukraine

Using the above methodology, we calculated the greenhouse gas (CO_2) emissions in the metallurgical complex of Ukraine over the past 25 years (Fig. 3).

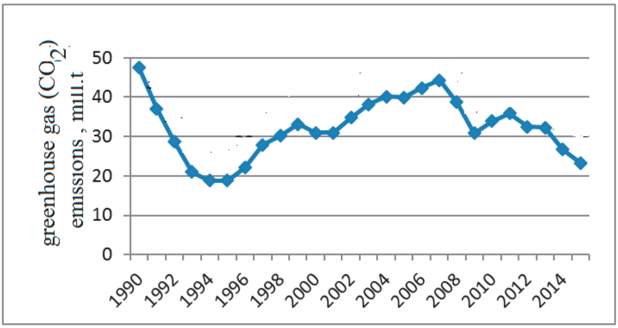

Figure 3 – CO_2 emissions in the blast-furnace production, steelmaking and rolling industries of Ukraine for the time period of 1990-2015..

The global crisis had its reflections in the Ukrainian ferrous metallurgy over the past 25 years and has led to the drop in production and, as a result, to the reduction in the total consumption of energy resources, which, in turn, led, as can be seen from the data in Fig. 3, to the better environmental performance of the steel industry. Thus, there was only 33%-decrease of greenhouse gases emissions within the iron and steel industry during the period from 1990 to 2015, however the overall amount of greenhouse gases emissions from all the Ukrainian industries was decreased by almost 60% for the indicated period. This means the increase in the iron and steel industry share of greenhouse gas emissions within the overall emission data in Ukrainian as much as from 8.8% to 12.9%.

Additionally, of undoubted interest is the analysis on the factors that affect the value of CO_2 emissions by production technologies.

It should be noted that there is a dependence of the specific consumption of coke on the annual capacity of the blast furnace (Fig. 4). This dependence is constructed from the actual pig and cast irons production data.

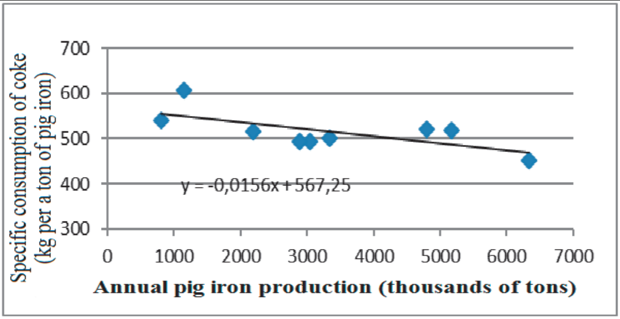

Figure 4 – Dependence of the specific consumption of coke on the annual production of pig iron on blast furnaces in Ukraine according to 2004 data.

An important factor is also the level of capacity utilization. Based on the performance of the industry for the period of 1990-2013, we have calculated the dependence of the specific energy consumption for end-to-end rolling production technology on the level of capacity utilization and show it in Fig. 5. It is interesting to note, that incomplete utilization of production capacities in the metal products manufacture causes the increase in specific energy inputs as much as 1.2-1.8 times higher, which significantly affects the increase in production costs and, correspondingly, the decrease in the price competitiveness of the products.

An important role for the level of greenhouse gas emissions is the structure of energy carriers used in the production of metal products. Coke and blast furnace gas, which is a product of incomplete combustion of coke in blast furnaces, account for almost 65% of fuel consumption in the ferrous metallurgy (Fig. 6).

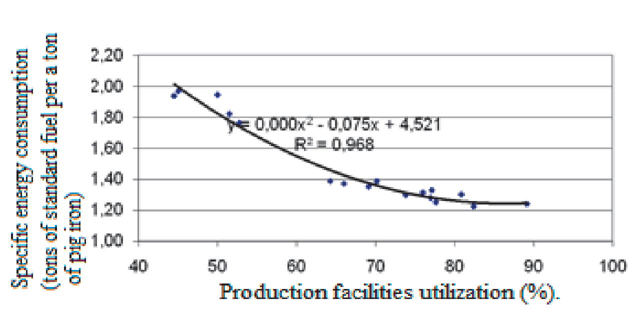

Figure 5 – The changes in the energy consumption accompanying the change in the production capacities (for the production of finished rolled stock in Ukraine for the period of 1990-2013).

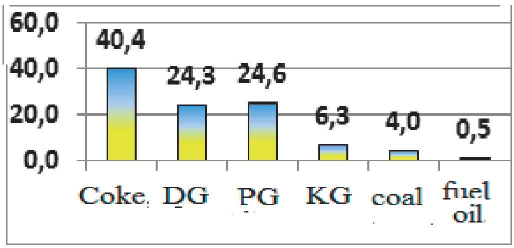

Figure 6 – Consumption of fuels at metallurgical enterprises of Ukraine,%. DG - blast furnace gas; PG - natural gas; KG - coke oven gas.

At the same time, the type of energy carrier is largely determined by the type of metallurgical technology and equipment used. In particular, the range of specific greenhouse gas emissions produced by Ukrainian pig iron smelters is between 1.10-1.66 t $_{CO2}$ / t $_{\text{pig iron}}$. Moreover, this difference in the amount of greenhouse gas emissions is related to the following issues: the efficiency of fuel consumption by the blast furnace, adopted and applied technologies, equipment in the shops and losses of blast furnace gas. The blast furnace process itself consumes a significant part of the own off gases for pig and cast irons production because this gas is used as of the blast for the process, as thermal energy of the process, and for the blast preheating in the stove system of the blast furnace. Simultaneously with the blast furnace gas, a small amount of natural and coke gases mixture is burnt. Additionally, the blast furnace gas can be partially consumed on generating electricity, which usually reduces greenhouse gas emissions in the production of pig iron. Some other part of the blast furnace gas is burned away directly in the blast furnace by a candle effect or make a share of unorganized losses (0.002-0.071 t $_C$ / t $_{\text{iron}}$).

Furthermore, the reduction in coke consumption is possible due to the injection of various types of fuel additions (natural gas, pulverized coal, etc.), but for each specific case it is necessary to conduct studies to determine the comparative efficiency for the most rational use of each. It should be noted that the injection of fuel as a partial substitution of coke results in a certain increase in the specific heat consumption for a smelting, but this is economically reasonable, since it saves scarce and expensive coke.

The next important ferrous metallurgy industry to consider is steel-making. Thus, the oxygen-converters produce steel exhausting from 0.3-0.36 t_{CO2} / t_{steel}. The data of this range differ with different enterprises, which operate applying the oxygen-converter technology. The determining factor in greenhouse gas emissions for this type of production is carbon burning in pig iron (85-95%). The other important steel-making process is electric arc steel production, where the specific emission of greenhouse gasses is 0.18-0.25 t_{CO2} / t_{steel} with fuel burning as the determining factor in these emissions (60-85%). The process applies the electrodes as energy transporters to the process. Burning the carbon from the electrodes has the share of 10-25% in the indicated emissions.

The concluding stage of the metallurgical cycle, rolling also adds to greenhouse gas emissions as much as 0.048-0.241 $t_{CO2} / t_{rolled\ products}$ of the specific emissions. The certain contribution to greenhouse gas emissions (all rolling mills on average) is made by as follows: blast furnace gas burning totals 60% of total rolling process emissions, burning of natural gas- 27%, burning of coke oven gas - 13%.

Considering the problem of the emissions from the other side of the standpoint, it is worth noting that for the economy of Ukraine, it is important to find the use of the available unused reserve of greenhouse gas emissions. With a significant reduction in greenhouse gas emissions due to a decrease in production within key industries, Ukraine sold 30 million tonnes of CO_2 quote to Japan in March 2009, followed by another 3 million tones of CO_2 quote to Spain. New Zealand and Switzerland also expressed the intention to purchase more of an unused greenhouse gas reserve as much as 150 million tonnes of CO_2 quote.

At the same time, Ukraine has not yet developed an effective mechanism for influencing the enterprises to reduce greenhouse gas emissions, which is a potential threat to the long-term development of the Ukrainian industry. The European Commission has presented a roadmap to perform the transition to a low-carbon economy to have been completed until 2050. It has been planned to have 20% reduction in greenhouse gas emissions by 2020 and 80% reduction by 2050. Moreover, the EU Commission has planned a complete the transition to carbon-free electricity generation by 2050. Following the calculations of the international group of the experts on climate change (IPCC), it has been proposed to shift the basic obligations of the countries to reduce greenhouse gas emissions into the sphere of their businesses. For this purpose, standards for greenhouse gas emissions will have been altered by the countries and sectors of the economy. In particular, for the ferrous metallurgy, IPCC proposes to establish standards at the following levels [4]:

- Production of pig iron 1.35 t $_{CO2}$ / t $_{of\ pig\ iron}$,
- Steel production: oxygen converters - 1.46 t $_{CO2}$ / t; open hearth furnaces (open-hearth furnaces) 1.72 t $_{CO2}$ / t; electric furnaces 0.08 t $_{CO2}$ / t.

The approach proposed by the European Commission fundamentally changes how the commitments to reduce greenhouse gas emissions can be fulfilled. Ukraine from the donor country, which sold quotas for greenhouse gases, can become their buyer under the new conditions. Moreover, quotas will be bought individually by Ukrainian enterprises, which under contemporary conditions have not reached the level of technologies of the developed producers of iron and steel. Furthermore, according to the calculations of the association of European producers of iron and steel (Eurofer), there may be many producers of ferrous product in Europe experiencing this situation, which could lead to the transfer of steel production beyond the eurozone.

Eventually, the analysis of the actual energy, technical and economic indicators of metal production allows us to conclude that there is a direct effect of energy parameters on the environmental, technical and economic ones in the field of metallurgical production. At the same time, the type of products and the technical level of metallurgical technology have a significant impact on the amount of greenhouse gas emissions. The approach to solving the existing problems in the field is the optimal combination of energy and environmental requirements for contemporary metallurgical production, they should be comprehensive and aim at implementing environmental and energy-saving measures.

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Статья поступила в редакцию сборника 21.06.2017
и прошла внутреннее и внешнее рецензирование

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Вплив екологічних показників на розвиток металургійного виробництва України

Розглянуто основні показники викидів металургійними підприємстввами. Підтверджено взаємозв'язок між станом навколишнього середовища і економічним розвитком українського гірничометалургійного комплексу. Показано необхідність в розробці та використанні перспективних енергозбережних технологій для металургійного виробництва,

Ключові слова: показники викидів, галузі металургійних підприємств, економічний розвиток, енергозбережні технології

Л.Г.Тубольцев, В.А.Горохова

Влияние экологических показателей на развитие металлургического производства Украины

Рассмотрены основные показатели выбросов металлургическими предприятиями. Подтверждена взаимосвязь между состоянием окружающей среді и экономическим развитием украинского горно-металлургического комплекса. Показана необходимость в разработке и использовании перспективных энергосберегающих технологий для металлургического производства.

Ключевые слова: показатели выбросов, металлургические предприятия, экономическое развитие, энергосберегающие технологии.