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IRON AND STEEL INSTITUTE OF THE NAS OF UKRAINE. SCIENTIFIC AND TECHNICAL SUPPORT OF BLACK METALLURGY

Iron and Steel Institute of National Academy of Science of Ukraine

The state of black metallurgy as a basic branch of the Ukrainian economy is shown. The main scientific developments of the Institute on scientific and technical support and modernization of blast furnace, steelmaking and rolling production are presented.

Key words: metallurgy, modernization, Iron and Steel Institute, scientific developments

In the economy of most regions and countries of the world, steel products continue to be the main structural material. In 2014, 1.662 billion tons of steel was produced, which is a new record level. In 2015, world production fell somewhat to 1.599 billion tons, mainly due to a reduction in steel production in China. In 2016, world steel production (1.629 billion tons) again began to grow, which continued in 2017.

Tendencies in the development of Ukraine's metallurgical production, in general, coincide with the trends in the development of world metallurgy. However, after 2007, the trends in the production of steel in Ukraine and in the world vary significantly (Fig. 1). If before 2007 the nature of domestic production corresponded to world trends, after the financial crisis of 2008-2009 the country was not able to restore it, at least to the level of 2004. In recent years, the decline in steel production continued, which is one of the consequences of the Ukrainian economic crisis and military operations in the Donbass.

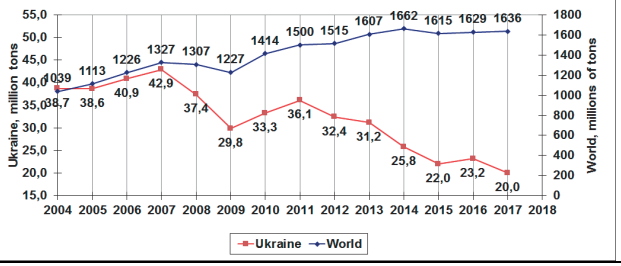

Fig. 1. Steel production in the world and in Ukraine in 2004-2017.

Analysis shows that world steel production volumes (Q_{st}) and gross domestic product (GDP) are closely correlated and with a 95% confidence can be described by a linear equation (Fig. 2):

GDP (Billions of US dollars) = 61,41 Q_{st} (Millions of tons) – 21217 R^2 = 0,949

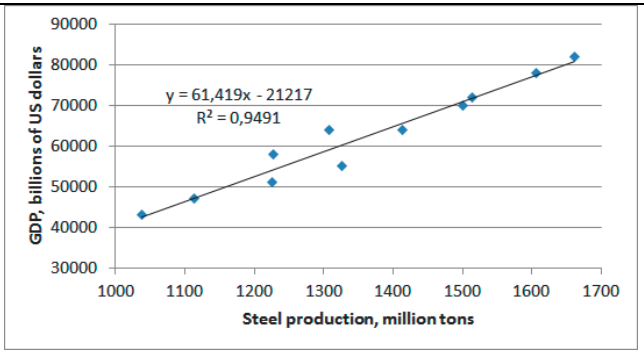

Fig.2. The relationship between global steel production and world GDP (according to data for the period 2004-2015).

In Ukraine, the relationship between the production of steel and GDP is less pronounced, but it is possible to trace the clear dependence of the increase in the deficit of the state budget of Ukraine on the decrease in the volume of steel production (Fig. 3).

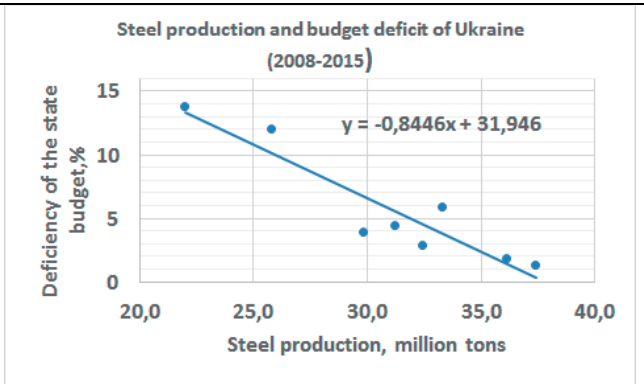

Fig. 3. Dependence of the increase in the state budget deficit on the reduction of steel smelting in Ukraine.

Thus, the problems of the mining and metallurgical complex are directly reflected in the state of the Ukrainian economy, which was especially evident in 2008-2015. Over the years of independence, the metallurgical complex has always played a decisive role in the country's economy and was the main supplier of currency to the country (34-44%). Today, this share can not be counted, because as a result of military operations some of the plants are standing, while the connections between enterprises and the supply of raw materials and energy resources are broken.

The technical level of domestic metallurgical production is significantly lower than the world level, while high-tech types of metallurgical products are practically not produced. Ukraine exports semi-finished products and raw materials for metallurgical products. On the one hand, it provides a constant

market for the sale of products, and on the other hand, does not stimulate an increase in the technical level of production [1,2]. As a result, for the last three decades the technological base of metallurgy practically did not change, which in turn reduced the industry's need for innovations and new scientific and technological developments, did not create a basis for economic and social development of the country, increased threats to its national security. At the same time, Ukraine belongs to one of the five countries of the world (Ukraine, China, Australia, USA and Russia), which has all the necessary resources for the development of metallurgy (iron ore, coal, ferroalloys, fluxes, manganese and all necessary components for production).

Metallurgy refers to inertial industries, while the creation and implementation of new metallurgical technologies worldwide is much faster than in Ukraine. Trends in the development of ferrous metallurgy abroad are well known to metallurgists in Ukraine, but the implementation of scientific achievements is hampered by insufficient attention from the state to the problems of the industry and the lack of the necessary volume of investments. At the same time, Ukraine has a sufficiently developed scientific potential for the development of metallurgy.

An example is the Iron and Steel Institute of the National Academy of Sciences of Ukraine, which is the leading scientific organization of Ukraine in the field of metallurgy. The Institute was established in 1939 and was initially aimed at fulfilling one of the most important tasks of the Academy - conducting fundamental scientific research and creating metallurgical technologies with subsequent implementation in production.

Researchers of the Institute have developed a large number of new technologies in the main redistribution of metallurgical production, many of which were created for the first time in world practice and today constitute the face of world metallurgy. The contribution of Ukrainian scientists to the development of world metallurgy is significant and indisputable. The use of scientific developments of scientists of the National Academy of Sciences of Ukraine and the Iron and Steel Institute of the National Academy of Sciences of Ukraine allowed:

to prove the prospects and advantages of the construction of large blast furnaces. For the first time in world practice, the world's largest blast furnace with a capacity of 5000 cubic meters was built at the Krivorozhstal Combine;

to develop alternative energy sources for blast-furnace smelting, in particular pulverized coal, coke oven gas and solid fuels. This technology allows to save coke to 20%;

to create the first in the world small-section rolling mill of endless rolling;

for the first time to develop and widely implement in the world practice technologies and installations for the desulphurization of cast iron with granular magnesium;

for the first time in the world practice, under the guidance of Academician K.Starodubov, to develop and implement energy-saving technologies of thermal hardening of rolled products of wide assortment using the heat of rolling heating;

under the leadership of Academician A.Chekmarev, to solve the problem of producing a high-quality sheet for the automotive industry.

All these developments are a major milestone in the history of Ukraine, its National Academy of Sciences and are widely used today throughout the world.

As an example, we consider it expedient to cite some of the Institute's recent scientific developments.

The Institute's scientists directly participated in the development of such program documents as the "Concept for the Development of the Mining and Metallurgical Complex" and the draft "National Program for the Development of the Mining and Metallurgical Complex," which allowed the adoption at the state level of a number of legislative decisions aimed at stabilizing the industry and outlining promising areas development of metallurgy [4,5].

The scientifically grounded technology of loading multicomponent mixed portions of charge materials into a blast furnace equipped with cone-free charging devices is developed. The technology makes it possible to effectively use coke substitutes and garnet-forming materials, to reduce the negative effect of coke of different qualities, and to improve the melting parameters when loading multicomponent portions consisting of agglomerate, pellets and coke.

Further work was done to improve the technology of blast furnace smelting with injection of pulverized coal, study the regularities of the energy balance of blast furnace smelting, improve the methodology for calculating the effect of the chemical composition of alternative fuels on the performance of the blast furnace.

Technological measures to protect the lining of blast furnaces with the loading of coke of different quality into the furnace have been developed, scientifically substantiated and implemented in the conditions of the metallurgical combine. Recommendations are developed to increase the consumption of secondary resources through their preliminary training.

The main provisions of a rational technology for preparing pig iron for smelting low-sulfur oxygen-converter steel are determined. In this case, the desulphurization of cast iron is carried out by injecting granular magnesium using a two-nozzle tuyere without an evaporation chamber. Correction of the chemical composition of the ladle slag is carried out by the addition of fractionated lime, which ensures: minimum costs for the reagent, high ability of the slag to absorb sulfur and minimal losses of metal during subsequent loading.

The method of using electric influences in the process of oxygen-converter smelting has been scientifically substantiated, developed and implemented at domestic and foreign plants. The imposition of electric potentials of low power allows reducing metal losses during melting, reducing the content of gases in the melt and improving the environmental parameters of melting. Studies are

continuing on the use of this method in other metallurgical processes, including blast furnace smelting and out-of-furnace cast iron processing.

In the field of rolling production, methods have been developed for determining rational schemes for the production of rolled products of various grades from continuous cast billets that enable us to determine rational solutions for the design of casting and rolling complexes for the production of graded and staffed rolled products. The solutions are based on the results of mathematical modeling of the temperature and energy parameters of rolling, the forecasting of mechanical properties and the accuracy of the geometric dimensions of finished rolled products.

A mathematical model of the roll-casting-rolling process has been developed, which makes it possible to calculate the fields of temperature, velocity, and the stress-strain state of solidified metal in the center of crystallization-deformation. The use of this model in the design of industrial plants makes it possible to determine the main parameters of the process and to prevent the occurrence of instability in the casting-rolling process.

In the field of metal science and heat treatment, the principles of the process of thermal and thermomechanical processing of rolled products using the heat of rolling heating, which was first developed by the Institute.

The principal possibility of formation of bainitic structures with an increased degree of misorientation during thermal processing of low-carbon microalloyed steels is shown. The most important condition for the formation of these structures in the heat treatment of rolled products is the presence of potential nucleation centers, which can be used as particles of titanium carbonitrides and aluminum nitrides. A mechanism for controlling the concentration and ratios of particles of different nature over a wide temperature range of their formation has been developed.

The modes of thermo-mechanical processing of wire rod made of carbon steel, microalloyed with boron and vanadium, provide the necessary complex of mechanical properties of high-strength ropes without the use of intermediate heat treatment (patenting).

Further ideas were developed on the regularities of the formation of defects on the surface of rolling of railway wheels and the influence of the chemical composition of wheel steel on this process. The regularities of the influence of carbon on the resistance to the formation of defects on the rolling surface of the wheels are established. The ways of increasing the reliability and durability of railway wheels made of continuously cast billets are determined.

At present, the Institute's scientists concentrate on the development of the following issues:

- development of scientifically grounded methods for improving the technology of blast furnace smelting, steel production, rolling and thermomechanical steel processing with the creation of software complexes;

- development of new technological and technical solutions to improve the smelting of steel of specified quality and to study the mechanisms that take place in the process of its production;
- studying the influence of new technological schemes of production, alloying and microalloying of steel, thermal and thermomechanical processing on the formation of the structure and properties of rolled metal for mass and special purposes;
- analysis of problems and trends in the development of metallurgical production and preparation of recommendations for the development of the mining and metallurgical complex of Ukraine.

Remaining at present the largest center of metallurgical science in the country, the Institute has new developments in its activity aimed at increasing the efficiency of all metallurgical operations. The implementation of these developments will significantly improve the efficiency of metallurgical enterprises in modern conditions, improve the quality of manufactured metal products and its competitiveness in the world market [6].

Cooperation with industrial enterprises is very important for the development of the scientific potential of the Institute. On the one hand, this is an excellent opportunity to implement their research in practice, the introduction of new developments and technologies aimed at saving material resources and energy. On the other hand, it is a significant contribution to the improvement of industrial metallurgical technologies.

Ukrainian metallurgical science still has developments that allow to significantly increase the technical level of metallurgical production at Ukrainian enterprises and bring it to the level of the best world achievements [7]. And yet, the main problem of effective public administration is the lack of a clearly defined target setting. Today, the country's iron and steel industry, including as a result of military operations in the Donbass, is in an extremely difficult situation, which negatively affects the Ukrainian economy. And today the Strategy of our actions for the preservation of ferrous metallurgy and the country as a whole is extremely needed.

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Институт черной металлургии НАН Украины. Научно-техническое сопровождение черной металлургии

Показано состояние черной металлургии как базовой отрасли экономики Украины. Приведены основные научные разработки Института по научно-техническому сопровождению и модернизации доменного, сталеплавильного и прокатного производства.

Ключевые слова: металлургия, модернизация, Институт черной металлургии, научные разработки

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Інститут чорної металургії НАН України. Науково-технічний супровід чорної металургії

Показано стан чорної металургії як базової галузі економіки України. Наведено основні наукові розробки Інституту з науково-технічного супроводу та модернізації доменного, сталеплавильного і прокатного виробництв.

Ключові слова: металургія, модернізація, Інститут чорної металургії, наукові розробки