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Iron and Steel Institute named after Z.I. Nekrasov of the NAS of Ukraine

TRENDS IN THE DEVELOPMENT OF ENERGY-SAVING TECHNOLOGIES IN METALLURGY

Summary. The purpose of the analysis is to identify trends in the development of metallurgical production and the use of energy-saving metallurgical technologies. It is shown that the world continues a steady trend of increasing steel production. This indicates an increase in metal consumption in industry. Despite the downward trend in steel production in Ukraine, the attention of metallurgists to the use of energy-saving technologies has not diminished. Trends and examples of the use of energy-saving technologies in world practice in comparison with trends in domestic metallurgy are given. Perspective technologies of blast furnace, steelmaking and rolling production are shown. Their advantages and disadvantages are noted. It is shown that the production volumes of metallurgical products are closely related to the technical level of production and the structure of steel smelting. It is noted that the development trends of domestic metallurgical production on a general basis coincide with the development trends of world metallurgy. The advantages and disadvantages of domestic ferrous metallurgy are shown. The directions of scientific research of the Iron and Steel Institute named after Z.I. Nekrasov NAS of Ukraine (ISI), which correspond to global trends in the development of metallurgy and cover the whole range of problems in the production of metal products. The developments are comprehensive, which is a very important advantage in the modern world. The ISI has a serious scientific potential for the latest modern technological and technical solutions for domestic metallurgical production, which are already at the development stage adapted to existing technological and raw materials conditions and their changes. Most of the new developments in technological content and intellectual level of implementation are not inferior to world analogues.

Keywords: metallurgical production, trends, technologies, Institute of ferrous metallurgy, research, development

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The state of the problem. Since 2009, the world has continued a steady growth trend in steel production, which indicates an increase in the consumption of metal products in industry. Since 2011, Ukraine is gradually losing ground and reducing steel production (Figure 1).

At the same time, the attention of Ukrainian metallurgists to the use of energy-saving technologies is not weakening. The enterprises of the mining and metallurgical complex of Ukraine (MMC) in 2019 compared to 2018 reduced natural gas consumption by 2% (with a similar reduction in pig iron production), and also reduced electricity consumption by 5% (with a decrease in steel production by 1.2% and rental - by 0.9%). This indicates the close attention of metallurgists to the use of energy-saving technologies even in conditions of unstable production.

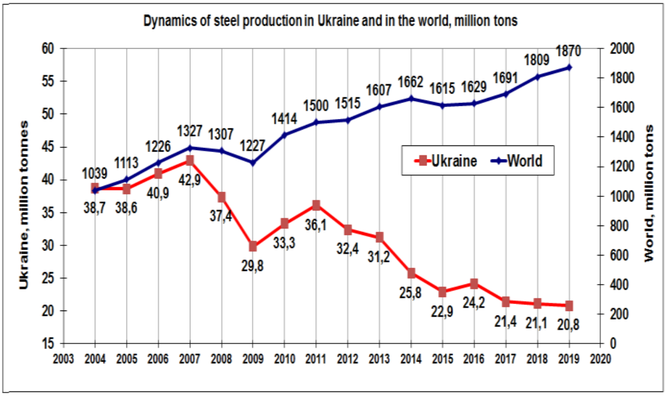

Figure 1 - Dynamics of steel production in Ukraine and in the world, million tons

The purpose of the analysis is to identify trends in the development of metallurgical production and the use of energy-saving metallurgical technologies.

Statement of the main research materials.

The indicators of production of metallurgical products are closely related to the technical level of production and the structure of steel smelting. If in Ukraine in 2004 the ratio between production volumes of converter, open-hearth and electric furnace steel was 51.3%, 45.3% and 3.4%, then in 2009 this ratio becomes 69.2%, 26.3% and 4.5%, respectively, and in 2010 - 68.7%; 25.4% and 5.9%, respectively (Figure 2).

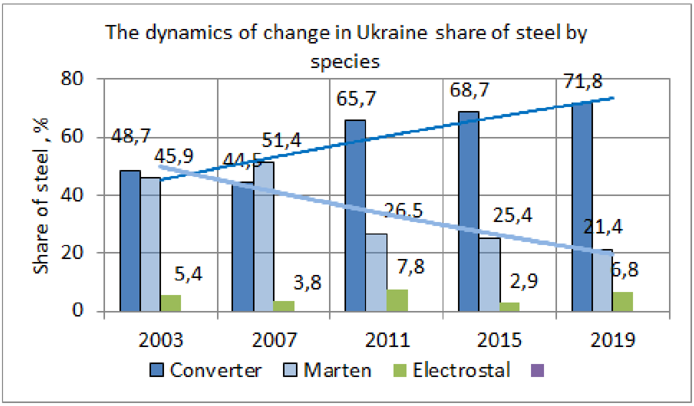

Figure - The dynamics of change in Ukraine share of steel by species

It should be noted that the upward trend in converter steel production in Ukraine is in line with global trends, while the share of open-hearth and electric steel is diametrically opposite (Figure 3). The increase in electric steel smelting in the world is associated with the development of steel production at mini-plants using metal scrap, while in Ukraine this method of steel smelting is used on a limited scale.

Metallurgy refers to inertial industries and the trends in its development change rather slowly [1]. However, in the advanced industrially developed foreign countries, the change in the technical level of metallurgy and the creation of new metallurgical technologies is much faster than in the CIS countries.

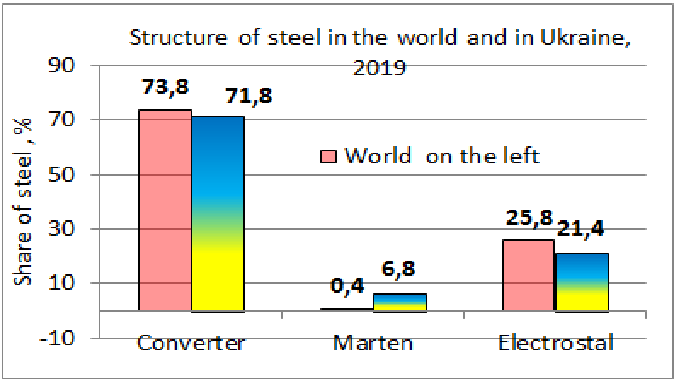

Figure - Steel structure in Ukraine and in the World (2019)

The trends in the development of metallurgical production in Ukraine in general coincide with the trends in the development of world metallurgy. The difference is the availability of our own iron ore raw material base, unique deposits of manganese ore, the presence of developed metallurgical production at integrated enterprises, the presence of highly qualified personnel and our own scientific and technical potential.

One of the main trends in the development of world metallurgy is the environmental focus when creating new and reconstructing existing facilities. Reducing the load on the environment is based on an integrated approach to solving this problem, with the main focus being on measures to reduce energy intensity. In particular, new blast furnaces abroad have a new standard of environmental protection measures regardless of the region. These measures are especially strict in Japan and some countries of Western Europe, including Germany. However, the reconstruction of the existing production with equipping it with environmental protection means is much more expensive than a similar new production.

The most energy-intensive metallurgical process is blast furnace production. General trends in the development of blast furnace production can be considered the construction of large-scale blast furnaces, the decommissioning of small-volume furnaces, the modernization of blast furnaces during overhaul, the search for the possibility of using alternative energy sources (Figure 4), the improvement of smelting technology (Figure 5) and the creation of automated control systems using models and software. Thus, in comparison with the use of pulverized coal, the technology most widely used today, the use of hot reducing gases simultaneously with hot blasting will increase the efficiency of blast furnace smelting by another 12-15% and reduce greenhouse gas emissions by 8-9%.

Currently, the operating parameters of highly efficient blast furnaces are close to the thermodynamic and economic optimum. An analysis of the trends in the development of blast furnace production technology suggests that the scheme of the traditional method of smelting cast iron in blast furnaces using coke and alternative energy carriers is the best option for the production of cast iron and stainless steel, although other technological schemes of metallurgical production are discussed and used, in particular without using blast furnaces [2]. At present, new technologies of coke-free metallurgy have been developed, in particular technologies of direct and liquid-phase reduction of a new generation, which make it possible to use coal as energy carriers.

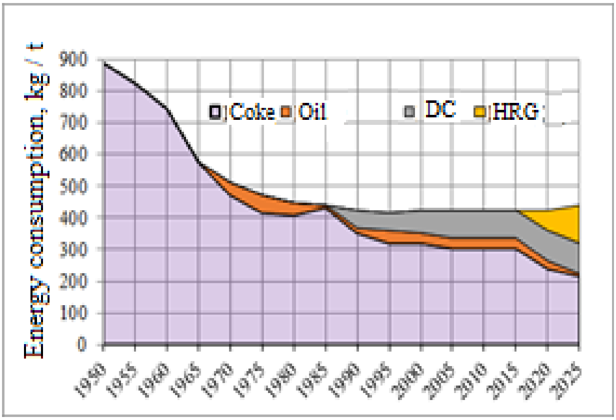

Figure 4 - Dynamics of changes in the composition and consumption of energy for BF by year (world average and forecast calculations).

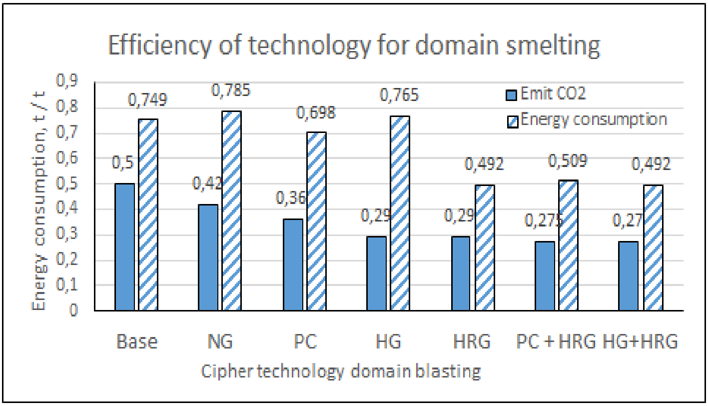

Figure 5 - Efficiency of blast furnace technologies using alternative energy sources

In Fig. 5, the following notation is used: Base - traditional blast furnace smelting; NG - blast furnace using natural gas; PC - blast furnace using pulverized coal fuel; HG - blast furnace using hot blast; HRG - blast furnace smelting using heated recirculation gases; PC + HRG blast furnace using heated reducing gases and pulverized coal; HG + HRG - blast furnace smelting using hot blast of heated reducing gases.

One of the most effective and most widely used technologies in world practice is the scheme of end-to-end steel production technologies at integrated metallurgical enterprises. At the same time, the development of electric steelmaking for the redistribution of scrap metal (in particular in the USA) contributed to a significant decrease in the production of cast iron for steel smelting (Figure 6) [3].

Steelmaking in the world is characterized by the rapid development of oxygen-converter and electric steelmaking and a significant decrease in steel production in open-hearth furnaces (Figure).) The oxygen-converter method of steel production in the world is considered the most modern.

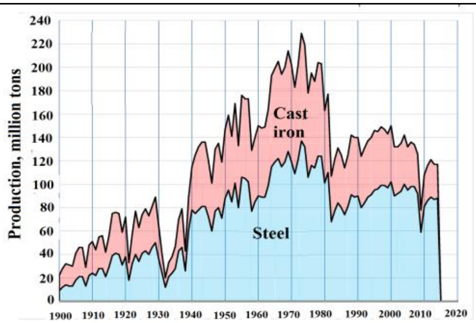

Figure 6 - Динамика производства чугуна и стали на примере США [3].

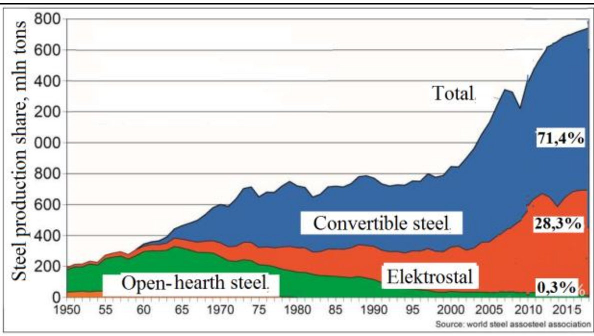

Figure 7 - World steel production by type.

The development of out-of-furnace steel processing processes has shown that it is possible to transfer part of the operations from the converter to the «ladle-furnace" unit, including the removal of gases from steel. At the same time, improving the processes of oxygen-conversion steel allows to achieve a significant reduction in the level of gases in the melt. For comparative analysis, we used the results of research on oxygen-converter smelting technology with upper purge (O_2), the technology of combined oxygen purge from above and nitrogen below (O_2 + N_2), the technology of combined oxygen purge from above and below (O_2 + O_2), and the technology of combined oxygen purge from above and purified converter gas from below (O_2 + KG). The results of comparing the efficiency coefficients of these technologies are shown in Figure 8.

The results show that the combined purge of the converter with nitrogen from below allows you to get the oxygen content in the melt is 30-34% less (compared with the upper blowing lance), but the nitrogen content is significantly higher than the upper blowing lance. The greatest effect was obtained when the melt was purged from below with purified converter gas, which simultaneously reduced the oxygen and nitrogen content in steel by 40–50%.

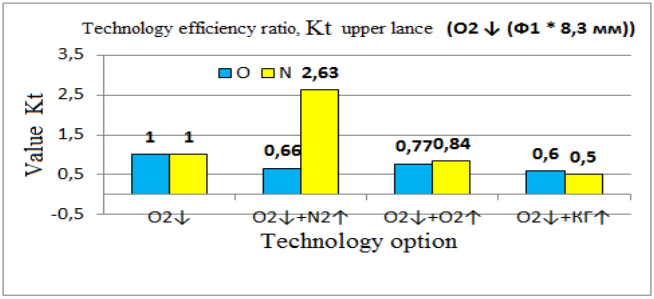

Figure 8 – Results of comparison of efficiency coefficients of technologies of oxygen-converter melting.

Rolling technology has changed little in recent years. But characterized by the improvement of equipment for the production of rolled products. [4]. Using combined processes allows us to achieve not only high energy efficiency, but also to ensure minimal greenhouse gas emissions (Figure 9).

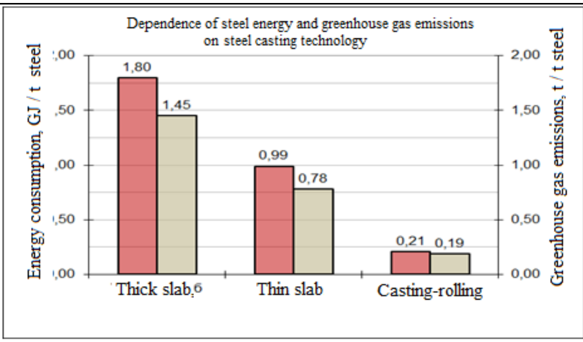

Figure 9 – Dependence of steel energy and greenhouse gas emissions on steel casting technology

The analysis showed that in MMC there are no insoluble problems of a systemic nature that can impede the successful and economically viable development of the industry, primarily due to the use of scientific research results. Here are some of the results of scientific research of the Iron and Steel Institute of the National Academy of Sciences of Ukraine (ISI), implemented at metallurgical enterprises. In particular, «ArcelorMittal Kryvyi Rih MK», which was the base enterprise of the ISI prior to its sale, notes a rather high technological level of metallurgical production at the plant, which was achieved with the participation of the Institute. As acknowledged by its owners, the existing technological level of the plant is one of the highest in the company and, therefore, does not need to be improved at the moment [5].

You can also give a few more examples of ISI developments that are consistent with global trends in the development of metallurgy [6].

To reduce the energy intensity of sintering production, a study was made of the properties of various types of iron ore raw materials and metallurgical indicators of promising and current rational compositions of sintering and blast furnace charge were determined. Implemented technological methods and recommendations allowed to reduce the equivalent fuel consumption by 2-7 kg / t of pig iron.

It is shown that an increase in the low-temperature strength of the sinter, an increase in its recovery, a decrease in the volume of refractory masses in a blast furnace can potentially reduce the consumption of coke by 1.6-2.0 %.

Promising measures to improve converter smelting may be to use the construction of a three-tier lance, as well as improving the technology of blast and slag modes. Adjustable flow rates are used for primary (380-400 m^3 / min) and additional (20-40 m^3 / min) oxygen

A set of measures has been developed and implemented to ensure uniform consumption of pulverized coal around the circumference of blast furnaces. This allows you to stabilize the theoretical combustion temperature and to ensure a constant temperature on the tuyeres of blast furnaces. Specific consumption of coke is reduced by 2 %.Установлено, что с введением в шихту марганца увеличивается производство чугуна на 4 %, уменьшается расход кокса на 1,5 %, рациональным диапазоном содержания марганца в чугуне является 0,30-0,35 %.

A new direction of research for the industry has begun – the development of technology for the injection of pulverized coal into rotary lime kilns, which has reduced fuel consumption by 7 %.

It is shown that optimization of the chemical composition of steels and the use of rational heat treatment modes of railway wheels (using modernized vertical quenching machines) increase the reliability and durability of railway metal products. A significant economic effect is achieved.

For the production of high-quality metal products, metallographic studies of the critical temperatures of the beginning and end of phase transformations at various cooling rates of various steel grades are important. The developed recommendations for accelerated cooling modes allow us to identify areas of modernization of equipment for heat treatment of railway wheels of various chemical composition.

However, it should be noted that not all metallurgical enterprises in the industry pay enough attention to interaction with scientific organizations, including due to the lack of a programmatic approach to future development in the industry and sufficient funds for scientific research [7]. Such a policy leads to the loss of creative ties with traditional partners, and prevents both the authority of scientific organizations and their financial support. Under these conditions, the Institute is forced to seek a way out of this situation, including by attracting foreign partners. The scope of promising research on metallurgical topics can be significantly expanded with the availability of financing by metallurgical enterprises.

Conclusions

The analysis shows that scientific research in the iron and steel industry of the most industrialized countries is mainly aimed at improving existing and developing new technologies in all metallurgical processes, which reduce the consumption of material and energy resources, reduce costs and improve the quality of metal products.

It is shown that fundamental and applied research at the Iron and Steel Institute of the National Academy of Sciences of Ukraine fully corresponds to the development trends of scientific research and the main trends in the development of world metallurgy. In a number of promising areas, the Institute's fundamental developments were carried out for the first time in world practice

The rapid pace of world scientific and technological progress shows the metallurgical enterprises the need for closer cooperation with scientific organizations. Scientific and technical potential of domestic science, including the Iron and Steel Institute of named after Z.I. Nekrasov NAS of Ukraine, and today is on the crest of world metallurgical science, which will allow production not only to meet global trends, but also to ensure the promising development of metallurgy,

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Тенденції розвитку енергозберігаючих технологій в металургії

Анотація. Метою аналізу є виявлення тенденцій розвитку металургійного виробництва та використання енергозберігаючих металургійних технологій. Показано, що в світі триває стійка тенденція зростання виробництва сталі. Це свідчить про зростання споживання металопродукції в промисловості. Незважаючи на тенденцію скорочення обсягів виробництва сталі в Україні, увагу металургів до використання енергозберігаючих технологій не слабшає. Наведено тенденції і приклади використання в світовій практиці енергозберігаючих технологій у зіставленні з тенденціями вітчизняної металургії. Показано перспективні технології доменного, сталеплавильного і прокатного виробництв. Відзначено їх достоїнства і недоліки. Показано, що обсяги виробництва металургійної продукції тісно пов'язані з технічним рівнем виробництва і структурою виплавки стали. Відзначено, що тенденції розвитку вітчизняного металургійного виробництва в загальній основі збігаються з тенденціями розвитку світової металургії. Показано переваги та недоліки вітчизняного чорної металургії. Показаны направления научных исследований Института черной металлургии им. З.И. Некрасова НАН Украины (ІЧМ), которые соответствуют мировым тенденциям развития металлургии и охватывают весь круг проблем производства металлопродукции. Розробки мають комплексний характер, що є дуже важливою перевагою в сучасному світі. ІЧМ має серйозний науковий потенціал новітніх сучасних технологічних і технічних рішень для вітчизняного металургійного виробництва, що вже на стадії розробки адаптуються до існуючих технологічних і сировинних умов та їхніх змін. Більшість нових розробок за технологічним змістом і інтелектуальному рівню реалізації не поступаються світовим аналогам.

Ключові слова: металургійне виробництво, тенденції, технології, Інститут чорної металургії, дослідження, розробки

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Аннотация

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Тенденции развития энергосберегающих технологий в металлургии

Целью анализа является выявление тенденций развития металлургического производства и использования энергосберегающих металлургических технологий. Показано, что в мире продолжается устойчивая тенденция роста производства стали. Это свидетельствует о возрастании потребления металлопродукции в промышленности. Несмотря на тенденцию сокращения объемов производства стали в Украине, внимание металлургов к использованию энергосберегающих технологий не ослабевает. Приведены тенденции и примеры использования в мировой практике энергосберегающих технологий в сопоставлении с тенденциями в отечественной металлургии. Показаны перспективные технологии доменного, сталеплавильного и прокатного производств. Отмечены их достоинства и недостатки. Показано, что объемы производства металлургической продукции тесно связаны с техническим уровнем производства и структурой выплавки стали. Отмечено, что тенденции развития отечественного металлургического производства в общей основе совпадают с тенденциями развития мировой металлургии. Показаны преимущества и недостатки отечественно черной металлургии. Показаны направления научных исследований Института черной металлургии им. З.И. Некрасова НАН Украины, которые соответствуют мировым тенденциям развития металлургии и охватывают весь круг проблем производства металлопродукции. Разработки имеют комплексный характер, что является очень важным преимуществом в современном мире. ИЧМ имеет серьезный научный потенциал новейших современных технологических и технических решений для отечественного металлургического производства, которые уже на стадии разработки адаптируются к существующим технологических и сырьевых условий и их изменениям. Большинство новых разработок по технологическому содержанию и интеллектуальному уровню реализации не уступают мировым аналогам.

Ключевые слова: металлургическое производство, тенденции, технологии, Институт черной металлургии, исследования, разработи

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