

ABSTRACT

for dissertation work on the topic:

«RESEARCH AND DEVELOPMENT OF TECHNOLOGY FOR TWO-STAGE STEEL-MAKING PROCESSING FOR SMELTING, PRODUCTION, FINE-TUNING IN A LADLE FURNACE OF A CARBONACEOUS SEMI-FINISHED PRODUCT INTO STEEL»,

presented for the degree of doctor of philosophy PhD

specialty 6D070900-Metallurgy

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The purpose of the dissertation research is to study and technological improvement of a two-stage steel-making process for smelting and producing a carbon semi-product into steel, which helps to reduce waste during deoxidation and alloying of materials at the stage of redistribution of a carbon semi-product and a decrease in the proportion of non-metallic oxide inclusions in steel.

The object of the research is the technology and steel-making equipment of the metallurgical enterprise JSC «ArcelorMittal Temirtau» («AMT» JSC).

The subject of the research is the technology of obtaining a carbon semi-product in a converter and finishing the metal to a given chemical composition and temperature in a ladle-furnace unit.

Research objectives.

The main tasks of research include:

- carrying out a literature and patent search for the smelting of a carbonaceous intermediate in an oxygen converter;
- study of the features of the metal processing process on the ladle furnace in the converter shop of «AMT» JSC;
- improvement of the technology for the separation of metallurgical melts in order to improve the quality of the metal product;
- development of options for the separation of metal from slag in the starting and final period of cutting off the slag when tapping from the converter for the conditions of «AMT» JSC.

Research methods.

The research methods are based on improving the technology of steelmaking processes, equipment and patterns of formation of iron-based melts. To achieve this goal and solve problems within the framework of the dissertation work, the following methods were used: critical analysis of patent information sources, planning and conducting a semi-industrial experiment, statistical methods of analysis, modeling and direct smelting of metal at «ArcelorMittal Temirtau» JSC in the oxygen converter shop.

The main provisions for the defense.

The following provisions are submitted for the defense of the dissertation work:

- the results of substantiating the technology of a two-stage redistribution in the starting, intermediate and final period of metal production;
- methods for cutting off slag when draining metal from the converter;
- results of substantiation of waste reduction during deoxidation and alloying of materials at the stage of redistribution of carbon semi-finished products;
- the results of substantiating the reduction in the proportion of oxide nonmetallic inclusions in steel.

The main results of the study:

- Technological methods for smelting a carbon semi-product in a converter have been developed.
- The relationship between the oxidation of the slag and the concentration of carbon in the metal has been established.
- Regularities of precipitating metal deoxidation and connections with the presence of technological high-iron slag in the steel-pouring ladle during metal tapping from the converter have been established.
- For the first time, methods have been developed to increase the assimilation of aluminum, manganese and silicon, which are part of the chemical composition of ferroalloys. When using the devices, manganese waste decreased by 4.2%, silicon by 3.7%, aluminum by 4.4% at the JSC «ArcelorMittal Temirtau».
- For the first time, methods were proposed for separating slag from metal by special methods in the initial, intermediate and final periods of metal tapping from the converter.
- The results obtained prove the possibility of increasing the degree of assimilation of the elements of deoxidizers, a significant decrease in the proportion of non-metallic inclusions in steel. The proposed methods make it possible to reduce the proportion of non-metallic inclusions by 1.2% and to exclude an accident rate by definition of «breakthrough».

Justification of the novelty and importance of the results obtained.

The novelty of the work lies in the technological improvement of the two-stage steelmaking process for the smelting and production of carbon semi-finished products into steel, which makes it possible to reduce waste of useful elements by introducing additional devices for cutting off slag, supplying deoxidizers and alloying materials, and reducing the proportion of non-metallic inclusions in steel.

The basis for the development of the topic of the dissertation is the technology of two-stage steel-making processing, and the development of additional devices in the starting and final periods of metal production, which will reduce the waste of useful elements and reduce the proportion of non-metallic inclusions in steel.

As the initial data for the development of the research topic, the following were selected: low-carbon steel grades used in the converter shop of «AMT» JSC to obtain slab billets.

Compliance with the direction of development of science or government programs.

A feature of the development of the world metallurgical industry is characterized by the transition from open-hearth steel production with casting in molds to oxygen-converter and electric steel-making production with continuous casting. The so-called ladle metallurgy has become widespread, taking over the functions of ensuring the required chemical composition and temperature of the poured metal.

The transition to new economic conditions of management demanded a radical modernization of the domestic metallurgical industry, the most important feature of which was the replacement of outdated technologies with new processes and the modernization of existing equipment.

According to the State Program of Industrial and Innovative Development of the Republic of Kazakhstan for 2020-2025, the metallurgical industry belongs to medium-tech industries, which requires strengthening the scientific and innovative potential at all stages of production of finished products.

The main provisions of the above program provide for a direction that assumes that: «the policy in the development of ferrous metallurgy will be aimed at implementing priority areas for the production of high-quality raw materials for steel production, the production of new types of steel and the expansion of the range of high-alloy steel. In international markets, steel consumption is expected to grow 1.3 times by 2030 due to such global trends as growth in consumption in developing countries (India, Iran, the Middle East and Africa), urbanization, increasing consumption in new sectors of the economy (renewable sources energy, new transport), the complexity of substitution with alternative products».

Currently, the largest metallurgical enterprise in the Republic of Kazakhstan is the transnational company «ArcelorMittal Temirtau» JSC.

The converter shop has three oxygen converters with a capacity of 300 tons and two mixers of 2500 tons each, three ladle furnaces, 2 double-strand continuous casting machines, each with a capacity of 2.6 million tons of slabs per year and a six-strand machine with an annual production of 0.7 tons of bloom blanks. In the production of converter steel, raw materials are used from a combined cast iron based on traditional and phosphorous.

Modern steel production is based on the redistribution of metal by a tandem process, where in the first unit a molten carbon intermediate product (CIP) is produced, and in the second unit, the chemical composition is adjusted (desulfurization, deoxidation, alloying, modification, etc.) and the metal is brought to a predetermined temperature.

Nowday, the cages of the oxygen converter have increased and reach 400 tons, and that of electric furnaces - 420 tons, respectively, and ladle furnace units (LFU).

The presented technology and equipment operates at almost all metallurgical plants, in particular, in March 2019, the third ladle-furnace unit was launched at «AMT» JSC, with a capacity of 300 tons with a transformer capacity of 45 MVA, as well as on small-capacity furnaces - 20 and 60 ton units of the Pavlodar metallurgical plant «Casting», where these units for finishing metal are available.

The problem is the contamination of the sheet metal with oxide non-metallic inclusions. In connection with the above, the assessment of the current state of the scientific problem being solved is modern and relevant.

The importance of the obtained results of the work lies in innovative devices for separating molten metal and slag, reducing the waste of useful elements and the proportion of non-metallic inclusions in steel, which is confirmed by the receipt of six patents of the Republic of Kazakhstan for an invention, two applications for an invention in the Eurasian Patent Office.

Contribution of the doctoral student to the preparation of each publication.

The author has repeatedly reported on the results of his work at scientific forums. Based on the results of work for 2017-2020. 12 publications have been published, including:

- 1 article in a publication with a non-zero impact factor, included in the scientometric Scopus database (percentile 38),

- 3 articles - in scientific publications included in the List of publications recommended by the Committee for Quality Assurance in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan (QAIES MES RK),

- 8 articles in collections of scientific papers of international conferences.

The novelty of technical solutions is confirmed by 6 patents for the invention of the Republic of Kazakhstan and 2 applications for an invention are under examination at the Eurasian Patent Office at the stage (there is a positive decision on the result of the formal examination).