Spanish Journal of Innovation and INTEGRITY
ISSN: 2792-8268
Volume: 40, Mar-2025
http://sjii.indexedresearch.org

Development of Technology that Provides Resource Saving in the Process of Steel Melting in an Induction Furnace

B.D. Mukhammadaliev, M. N. Gaybullaev
Namangan Engineering-Construction Institute

T. S. Khalimjonov, Sh. T. Toshmatova, N. T. Nazarova
Tashkent State Technical University

Abstract: *In this article, in the process of melting a steel alloy in an induction furnace, cast products were obtained based on technology that ensures resource saving, which was mainly achieved by reducing the melting time and developing the procedure for loading the slag into the furnace. Also, resource-saving technology is aimed at obtaining high-quality molten bulk products.*

Keywords: *induction furnace, steel, alloy, solid materials, oxygen, alloyed metal, crucible, inductor*

INTRODUCTION

Steel is obtained from the raw materials of cast iron and small solids in steel production furnaces. There are three main methods of melting liquid steel: marten, oxygen converter and electric furnace steelmaking. Melting in Marten furnaces is outdated, economically and environmentally unprofitable. Alternative methods are steel melting in oxygen converters and modern electric arc furnaces. Today, they have about the same thawing time of the same power, averaging about 50 minutes [1-4]. Converters and modern electric arc furnaces produce not finished steel, but a semi-finished product that matches steel in terms of carbon and phosphorus content. This semi-finished product is then processed into quality steel. In addition, steel is poured into continuous casting machines and steel ingots are obtained [5].

Steel is produced by performing a number of technological operations aimed at achieving the finish of melting [6], various complex physico-chemical and physical processes carried out in a certain sequence or in a certain combination.

The ultimate goal of melting in any steel melting furnace is to obtain liquid steel of a certain chemical composition (brand) and temperature data with labor, material, raw materials and fuel - energy resources.

The most difficult task is to obtain a certain chemical composition of the finished steel, because it is necessary to carry out a large number of complex physico-chemical and physical processes. Most of them are difficult to manage [7], and some are not clearly regulated.

Due to the nature of modern melting in foundries, it is divided into two main parts, which are carried out continuously and often at different working volumes:

- metal refining (the main task is to reduce excess carbon and phosphorus in the steelmaking furnace);
- return - alloyed metal (reducing excess oxygen, sulfur and dissolved gases (hydrogen and nitrogen) from the steel, alloying and modification, it is important to bring the chemical composition of the steel to the values specified by the brand. This stage is often carried out in steel production by processing outside the furnace and in vacuum [8-12].

This division is due to the incompatibility of the purification and recovery processes [13]. Processing is mainly carried out by oxidation of alloys (oxygen is introduced into the metal). Reduction is the reduction of excess dissolved oxygen from the metal.

Heating the metal to a certain temperature is the second most difficult task in steelmaking. It is very important to ensure simultaneous heating of the metal and cleaning from oxidizers [14-16], because only carbon is removed from the metal at the last stage of cleaning. During this melting period, the main task is to decarbonize the metal and synchronize the heating processes.

MATERIALS AND METHODS

If the induction furnace is designed as a crucibleless furnace (Figure 1), the inductor is located outside the crucible in the form of a cylindrical copper tube. The charged material in this crucible is exposed to the electromagnetic field created by the current passing through the copper coil [17]. This field induces irregular magnetic field currents in the metal. These magnetic field currents move the metal atoms relative to each other and eventually heat up and melt the metal.

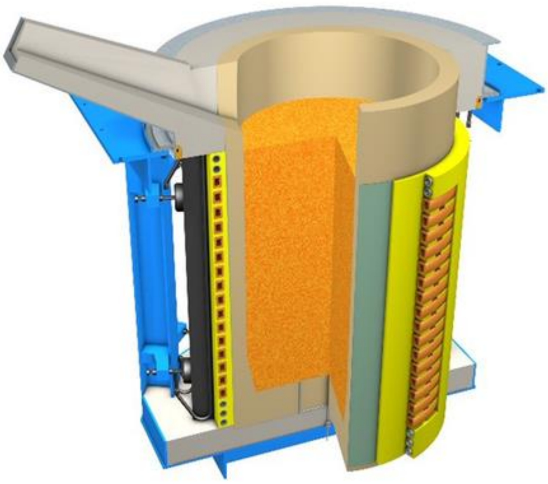
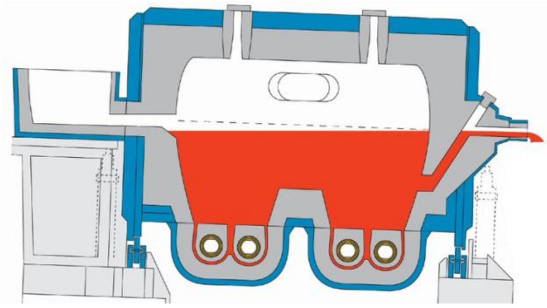


Fig. 1. 3D diagram of an induction furnace without a crucible

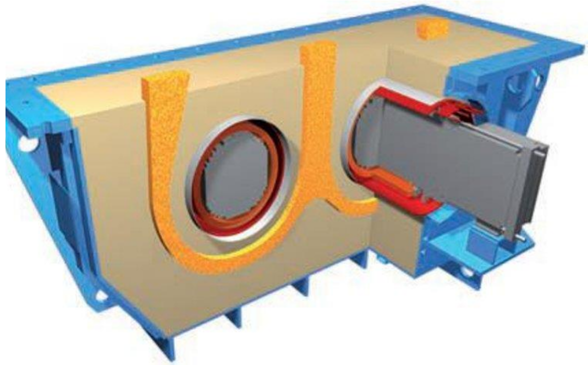
Such without a crucible induction furnaces achieve efficiencies of over 80% for ferrous materials and over 70% for highly conductive materials such as copper or aluminum, provided the inductor is made of highly conductive copper and must be made of non-conductive textalite to prevent current from passing through the transformer plate layers to provide a return path for the magnetic field [18-23].

Alternatively, an induction furnace can be built based on the principle of a channel-type furnace (Fig. 2). In this case, the induction furnace works on the basis of a two-inductor type inductor (Fig. 3). The liquid solution is heated according to the principle of a short-circuit transformer. The copper inductor forms the primary winding and the liquid metal channel forms the short-circuited secondary winding. The short-circuit current of the transformer then flows through this channel, and its erratic movement of the magnetic fields in turn heats the metal. The efficiency achieved using this electric principle is 10-15% higher than the crucibleless furnace principle [24-25]. However, it has the disadvantage that the liquid metal cannot be completely discharged from the furnace, which limits its versatility with respect to alloys and performance.

Spanish Journal of Innovation and INTEGRITY
ISSN: 2792-8268
Volume: 40, Mar-2025
http://sjii.indexedresearch.org



2. A drum-type induction furnace for ing steel on the principle of a channel-type ace



3. Two-inductor channel induction furnace

RESULTS

The main advantage of a crucibleless furnace is that significantly higher results can be achieved. As a result, stainless steel furnaces are successfully used for iron and steel with a capacity of more than 20 MW and a melting rate of more than 40 tons per hour.

Even though induction furnaces can operate carbon-free when powered by renewable electricity sources, foundries that use them still strive to minimize electricity consumption. This is done taking into account sustainable resource savings, as well as increasing the profitability of foundries and semi-finished products, especially in the context of rising energy prices. About 500-560 kW/t for smelting iron and its alloys, that is, energy costs are often a decisive factor in the production of ingots and semi-finished products.

Ensuring resource conservation in the induction furnace steelmaking process includes optimizing energy consumption, minimizing material waste, and increasing overall process efficiency. Induction furnaces are highly efficient at melting steel due to their ability to generate heat directly in the metal through a magnetic field, resulting in better control and efficiency compared to conventional furnaces. Key strategies to ensure resource savings in induction furnace operations:

Improving energy efficiency

Precise temperature control: Induction furnaces allow precise temperature regulation, which helps prevent the metal from overheating or overheating. Overheating wastes energy, and under heating the alloy can result in poor quality steel. Choosing the right temperature can minimize energy consumption.

Advanced power management: Using advanced power systems with dynamic control algorithms can reduce unnecessary power consumption. For example, adjusting frequency and power based on steel content and desired melting temperature can optimize energy consumption.

Heat Recovery Systems: Heat recovery technologies can capture and reuse heat from furnace waste. This energy can be used to preheat the solids or the furnace, reducing the need for additional energy input.

CONCLUSION

In conclusion, achieving resource savings in the induction furnace steelmaking process requires advanced technological solutions, efficient operational practices and regular process optimization. By integrating intelligent control systems, using high-quality inductors, using energy-saving technologies and minimizing material losses, steelmakers can significantly reduce resource consumption, lower costs and improve the stability of the overall smelting process.

REFERENCE

1. Saidmakhamadov N. M., Abdullah T. Development of a micro-structured photonic crystal fiber as a biological or chemical sensor based plasmonic application.: Development of a micro-structured photonic crystal fiber as a biological or chemical sensor based plasmonic application. – 2023.
2. Valida B. et al. Improvement of the Technology of Production of Quality Semi–Finished Product Products from Steel Alloy. – 2023.
3. Turakhodjaev, N., Saidmakhamadov, N., Turakhujaeva, S., Akramov, M., Turakhujaeva, A., & Turakhodjaeva, F. (2020). Effect of metal crystallation period on product quality. Theoretical & Applied Science, (11), 23 – 31.
4. Turakhodjaev, N. D., Saidmakhamadov, N. M., Zokirov, R. S., Odilov, F. U., & Tashkhodjaeva, K. U. (2020). Analysis of defects in white cast iron. Theoretical & Applied Science, (6), 675 – 682.
5. Djahongirovich, T. N., & Muysinaliyevich, S. N. (2020). Important features of casting systems when casting alloy cast irons in sand – clay molds. ACADEMICIA: An International Multidisciplinary Research Journal, 10(5), 1573 – 1580.
6. Nodir, T., Nosir, S., Shirinkhon, T., Erkin, K., Azizakhon, T., & Mukhammadali, A. (2021). Development Of Technology To Increase Resistance Of High Chromium Cast Iron. The American Journal of Engineering and Technology, 3(03), 85 – 92.
7. Nodir T. et al. Development of 280X29Nl Alloy Liquefaction Technology to Increase the Hardness and Corrosion Resistance of Cast Products //International Journal of Mechatronics and Applied Mechanics. – 2021. – T. 154. – C. 2021.
8. Turakhodjaev N. et al. Quality improvement of the steel melting technology in an electric arc furnace //ACADEMICIA: An International Multidisciplinary Research Journal. – 2021. – T. 11. – №. 7. – C. 48 – 54.
9. Saidmakhamadov N., Abdullaev K., Khasanov J. Теория и практика современной науки //теория и практика современной науки Учредители: ООО" Институт управления и социально – экономического развития". – №. 2.–С. 3 – 8.
10. Nosir S. et al. Development of High Chromium White Cast Iron Liquefaction Technology //Eurasian Journal of Engineering and Technology. – 2022. – T. 4. – C. 123 – 127.
11. Nosir S. et al. Development of technology for obtaining quality castings from steel alloys //Eurasian Journal of Engineering and Technology. – 2022. – T. 5. – C. 135 – 138.
12. Nosir S. et al. Technology for Obtaining High Quality Castings from Resistance White Cast Iron //Eurasian Journal of Engineering and Technology. – 2022. – T. 5. – C. 139 – 148.
13. Nosir S. et al. Technology to Increase the Hardness and Resistance of High – Chromium White Cast Iron //European Multidisciplinary Journal of Modern Science. – 2022. – T. 6. – C. 665 – 670.
14. Nosir S. et al. Development of Technology for Production of Wear–Resistant Cast Products //Middle European Scientific Bulletin.–2022.–T. 25.516–522.
15. Nosir S. et al. Improvement of the Technology of Obtaining High – Chromium Wear – Resistant White Cast Iron //Spanish Journal of Innovation and Integrity. – 2022. T. 07. 498 – 504.

16. Nosir S. et al. Study of the Effect of Copper Addition on Secondary Carbides with High Chromium Wear – Resistant White Cast Iron //International Journal of Innovative Analyses and Emerging Technology. – 2022. T. 2. 37 – 43.
17. Valida B. et al. Explore of the Technology of Liquefaction of High – Quality Ingots from Steel Alloys //Czech Journal of Multidisciplinary Innovations. – 2022. – T. 8. – C. 1 – 7.
18. Nosir S. et al. Improvement of Technology of Liquefaction of Gray Cast Iron Alloy //Global Scientific Review. – 2022. – T. 6. – C. 19 – 28.
19. Saidmakhamadov N., Abdullaev K., Khasanov J. DEVELOPMENT OF 280X29NL BRAND RESISTANCE WHITE CAST IRON LIQUEFACTION TECHNOLOGY //Теория и практика современной науки. – 2022. – №. 2 (80). – С. 3 – 8.
20. Kholmirzaev N. et al. Development of Technology of Making Shafts from Steel Alloy 35XGCL //International Conference on Reliable Systems Engineering. – Cham : Springer Nature Switzerland, 2023. – C. 216 – 223.
21. Saidmakhamadov N. M. et al. Energy Balance In Steel Liquefaction In Induction Furnaces And Electric Arc Furnaces //Academicia Globe: Inderscience Research. – 2023. – T. 1. – №. 2. – C. 9 – 9.
22. Kholmirzaev N. et al. Effects of titanium (Ti) contents on the wear resistance of low – alloy steel alloys //E3S Web of Conferences. – EDP Sciences, 2024. – T. 525. – C. 03003.
23. Kholmirzaev N. et al. Mathematical Modeling of the Effect of TiC Nanopowder Particles on the Wear Resistance Properties of Low-Alloy Steel //Materials Science Forum. – Trans Tech Publications Ltd, 2024. – T. 1139. – C. 11-19.
24. Kholmirzaev N. et al. Improvement of the Technology of Melting of Low Alloy Steel Alloy in an Electric Arc Furnace //Materials Science Forum. – Trans Tech Publications Ltd, 2024. – T. 1139. – C. 3-9.
25. Saidmakhamadov N. M. et al. REDUCTION OF GAS PORES AND NONMETALLIC IMPLEMENTS IN CASTINGS FROM 35ХГСЛ AND 110Г13Л STEEL //Web of Technology: Multidimensional Research Journal. – 2024. – T. 2. – №. 10. – C. 64-70.
26. Valida B. et al. Improvement of the Technology of Production of Quality Semi–Finished Product Products from Steel Alloy. – 2023.