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RESEARCH AND IMPROVEMENT OF STEEL REFINING MODES IN INDUCTION FURNACES IN ORDER TO IMPROVE THE PRODUCTS QUALITY

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Abstract

Theoretical and experimental studies on the behavior of sulfur and phosphorus in a steelmaking bath have been carried out, which made it possible to conduct comprehensive studies on refining steel in an induction crucible furnace (ICF) using slags in experimental industrial conditions in this paper. At the same time, by selecting special slags and reducing the height of the meniscus of the bath mirror, they provided an increased refining ability of the slag, which allowed it to be kept above the metal melt and reduce “sliding" to the crucible wall. The thermodynamic, kinetic and technological parameters of the metal refining process using slag in ICF are determined. Quantitative dependences of the main technological parameters of metal refining are obtained, which form the basis of a new technological instruction for steel production, reflecting the effect of temperature on the dephosphorization process and the duration of metal exposure under slag in ICF on the final sulfur content in the metal.

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1. Introduction

Continuously growing and stricter requirements for the quality of critical cast parts of freight cars force manufacturers to provide higher mechanical and operational properties of these castings, finding new promising methods of influencing liquid metal. The development of technologies for the production of high-quality castings has made it possible to significantly affect the quality of the products obtained.

The most important task formulated by machine builders before the metallurgical industry is a significant improvement in the quality of steel produced. First of all, this applies to structural metal, which at the moment does not always meet the requirements of consumers in terms of performance characteristics. Traditional methods of out-of-furnace metal processing during the smelting of the initial semi-product, both in arc and induction furnaces, have a number of restrictions on the degree of refining from impurities such as phosphorus, sulfur, oxygen, non-metallic inclusions and others, which largely determine the quality of the finished metal products.

The increase in freight traffic in the world places increased demands on steel used for the manufacture of railway parts, poses new challenges in the field of metallurgy, while reliability and durability are the most important of them. The fulfillment of these requirements determines the competitiveness of products in the relevant segment of the railway transport market. Currently, in the CIS-countries, a model 18-100 trolley and its modifications are used as a freight car trolley. One of the main components of this design is the "side frame", because it combines into a single system a spring beam, spring suspension, wheel pairs with axle boxes and mounted braking equipment. The side frame is cast from 20GL steel according to GOST 32400-2013.

One of the problems of the side frames is a fracture. According to statistics, with the growth of freight traffic, the problems of cast parts of model 18-100 bogies have sharply increased in railway transport, and over the past 15 years, the fractures of the side frames have increased by 3...5 times. The fracture leads to its decommissioning, respectively, to economic losses, and most importantly, if a defect is detected belatedly, it can lead to human casualties. Recently, the fracture of the side frame has increased, and manufacturers are trying to stop it or at least reduce the risk. Despite the changes in the design and manufacturing technology of the side frame in order to

reduce the risk of accidents on the railways, the number of problems associated with this defect does not decrease, and in some cases increases.

2. Methods

The analysis of the fracture statistics, the study of its nature and the production technology of the side frames showed that the parts meet the requirements in terms of mechanical properties and chemical composition of the main elements, and the causes of the fracture may be related to the harmful effects of oxygen, phosphorus, sulfur and non-metallic inclusions, as evidenced by the results of a number of studies. In 2016, changes were made to GOST 32400 – 2013 on the chemical composition of steel grade 20GL for harmful impurities (mass fractions of sulfur and phosphorus should not exceed 0.020%) and mechanical properties. A number of enterprises face the problem of low values of toughness and strength, characterizing mechanical properties due to the increased content of phosphorus and sulfur.

As is known, when steel is smelted in induction crucible furnaces (ICF), the protective (coating) properties of slag play an important role. The main purpose of these slags is to reduce the contact of metal with the gas phase.

However, the role of slag in the melting of steel in ICF is not interpreted unambiguously. Most authors believe that the removal of phosphorus and sulfur is difficult if melting is carried out in ICF. At the same time, a number of researchers note the neutrality of slag to refining processes, which is due to the low reactivity of “cold” slags, which are heated only as a result of heat transfer in the contact zone with the metal surface, the small size of the metal–slag contact surface, the cooling of the slag by the crucible lining and their lower liquid mobility than in other aggregates, where refining processes are possible. At the same time, it is often concluded that the refining capacity of slags is insufficient for ICF and, accordingly, increased requirements are imposed on the metal charge in terms of the content of elements such as phosphorus and sulfur. Refining of metal in ICF according to traditional technological schemes is practically absent.

Other researchers believe that slag can participate in the metal refining process, but under certain conditions, for example, by reducing the height of the meniscus of the metal mirror, or connecting additional installations in the furnace vault (using a DC arc, a plasma torch, etc.), allowing to increase the activity of slag. But the second method is very expensive.

3. Results and Discussion

To create and provide thermodynamic and kinetic conditions, several modified slags have been tested, which differ from previously known ones and have been implemented in industrial conditions.

In this paper, theoretical and experimental studies on the behavior of sulfur and phosphorus in a steelmaking bath have been carried out, which made it possible to conduct comprehensive studies on refining steel in ICF using slags in experimental industrial conditions. At the same time, by selecting special slags and reducing the height of the meniscus of the bath mirror, they provided an increased refining ability of the slag, which allowed it to be kept above the metal melt and reduce “sliding" to the crucible wall. The thermodynamic, kinetic and technological parameters of the metal refining process using slag in ETC. are determined. Quantitative dependences of the main technological parameters of metal refining are obtained, which form the basis of a new technological instruction for steel production, reflecting the effect of temperature on the dephosphorization process and the duration of metal exposure under slag in ICF on the final sulfur content in the metal.

A new concept of melting technology in ICF is proposed, which allows for effective refining of metal from phosphorus, sulfur and other harmful impurities by using slag, increasing its amount, additional mixing of slag and metal, increasing the time of their mutual contact. It is shown that it is possible to provide an increased refining ability of slag during steel melting in the ICF by selecting special slag mixtures with a reduced melting point, a certain holding time of the metal melt under the slag at a specific bath temperature, obtaining a flat metal meniscus (for example: by increasing the metal level beyond the inductor, or by disconnecting the upper coils of the inductor to reduce the height of the meniscus) in order to maintain the necessary contact time of liquid-mobile slag with the refined bath by reducing the “sliding” of the slag to the crucible wall. This made it possible to provide a degree of dephosphorization up to 65% and a degree of desulfurization up to 60%. At the same time, the role of a solid-slag mixture in combination with aluminum and silicocalcium is shown.

4. Conclusion

The application of the proposed technology allowed to increase the degree of dephosphorization from 10 to 60% with the achievement of a phosphorus content of less than 0.020...0.017%, to increase the degree of desulfurization from 50 to 90% with the achievement of a sulfur content of less than 0.008...0.004%, to improve the quality of finished products and their mechanical properties, to improve the macro- and microstructure of metal, to replace expensive clean scrap (0.015% P, 0.016% S)

for cheaper (compared to the current technology) and increase the yield of suitable parts of railway trolleys by 40%.

On the basis of complex semi-industrial research, a rational technology for the production of 20GL steel in ITP and bucket processing with the use of rare earth metals have been developed and mastered, which provided a unique combination of service properties of railway trolley parts. The results of the study are the basis for the modified technology of 20GL steel production in ICF, which significantly improved the performance properties of the side frames.

The conducted research is the basis for the modified technology of steel production in the ICF, which allowed these furnaces to be transferred from a passive remelting plant to an active refining steelmaking unit.

References

1. Tursunov, N. K., Semin, A. E., & Kotelnikov, G. I. (2017). Kinetic features of desulphurization process during steel melting in induction crucible furnace. Chernye metally, 5, 23-29.
2. Турсунов, Н. К., & Тоиров, О. Т. (2021). Снижение дефектности рам по трещинам за счёт применения конструкции литниковой системы.
3. Toirov, O., & Tursunov, N. (2021). Development of production technology of rolling stock cast parts. In E3S Web of Conferences (Vol. 264, p. 05013). EDP Sciences.
4. Турсунов, Н. К., Семин, А. Е., & Санокулов, Э. А. (2017). Исследование процессов дефосфорации и десульфурации при выплавке стали 20ГЛ в индукционной тигельной печи с дальнейшей обработкой в ковше с использованием редкоземельных металлов. Черные металлы, (1), 33-40.
5. Кучкоров, Л. А. У., Турсунов, Н. К., & Тоиров, О. Т. У. (2021). ИССЛЕДОВАНИЕ СТЕРЖНЕВЫХ СМЕСЕЙ ДЛЯ ПОВЫШЕНИЯ ГАЗОПРОНИЦАЕМОСТИ. Oriental renaissance: Innovative, educational, natural and social sciences, 1(8), 831-836.
6. Турсунов, Н. К., Санокулов, Э. А., & Семин, А. Е. (2016). Исследование процесса десульфурации конструкционной стали с использованием твердых шлаковых смесей и РЗМ. Черные металлы, (4), 32-37.
7. Тоиров, О. Т., Турсунов, Н. К., Кучкоров, Л. А., & Рахимов, У. Т. (2021). ИССЛЕДОВАНИЕ ПРИЧИН ОБРАЗОВАНИЯ ТРЕЩИНЫ В ОДНОЙ ИЗ ПОЛОВИН СТЕКЛОФОРМЫ ПОСЛЕ ЕЁ ОКОНЧАТЕЛЬНОГО ИЗГОТОВЛЕНИЯ. Scientific progress, 2(2), 1485-1487.

8. Tursunov, N. K., Semin, A. E., & Sanokulov, E. A. (2017). Study of dephosphoration and desulphurization processes in the smelting of 20GL steel in the induction crucible furnace with consequent ladle treatment using rare earth metals. Chernye Metally, 1, 33-40.
9. Tursunov, N. K., Semin, A. E., & Sanokulov, E. A. (2016). Study of desulfurization process of structural steel using solid slag mixtures and rare earth metals. Chernye metally, 4, 32-7.
10. Турсунов, Н. К., Тоиров, О. Т., Железняков, А. А., & Комиссаров, В. В. (2021). Снижение дефектности крупных литых деталей подвижного состава железнодорожного транспорта за счет выполнения мощных упрочняющих рёбер.
11. Турсунов, Н. К., Семин, А. Е., & Котельников, Г. И. (2017). Кинетические особенности процесса десульфурации при выплавке стали в индукционной тигельной печи. Черные металлы, (5), 23-29.
12. Tursunov, N. K., Semin, A. E., & Sanokulov, E. A. (2017). Research of dephosphorization and desulfurization processes in smelting of 20GL steel in an induction crucible furnace with further processing in a ladle using rare earth metals. Chern. Met., 1, 33-40.
13. Toirov, O. T., Tursunov, N. Q., & Nigmatova, D. I. (2022, January). REDUCTION OF DEFECTS IN LARGE STEEL CASTINGS ON THE EXAMPLE OF" SIDE FRAME". In International Conference on Multidimensional Research and Innovative Technological Analyses (pp. 19-23).
14. Toirov, O. T., Tursunov, N. Q., Nigmatova, D. I., & Qo'chqorov, L. A. (2022). USING OF EXOTHERMIC INSERTS IN THE LARGE STEEL CASTINGS PRODUCTION OF A PARTICULARLY. Web of Scientist: International Scientific Research Journal, 3(1), 250-256.
15. Нурметов, Х. И., Турсунов, Н. К., Кенжаев, С. Н., & Рахимов, У. Т. (2021). ПЕРСПЕКТИВНЫЕ МАТЕРИАЛЫ ДЛЯ МЕХАНИЗМОВ АВТОМОБИЛЬНЫХ АГРЕГАТОВ. Scientific progress, 2(2), 1473-1479.
16. Семин, А. Е., Турсунов, Н. К., & Косырев, К. Л. (2017). Инновационное производство высоколегированной стали и сплавов. Теория и технология выплавки стали в индукционных печах.
17. Рахимов, У. Т., Турсунов, Н. К., Кучкоров, Л. А., & Кенжаев, С. Н. (2021). ИЗУЧЕНИЕ ВЛИЯНИЯ ЦИНКА Zn НА РАЗМЕР ЗЕРНА И КОРРОЗИОННУЮ СТОЙКОСТЬ СПЛАВОВ СИСТЕМЫ Mg-Nd-Y-Zr. Scientific progress, 2(2), 1488-1490.

18. Турсунов, Н. К. (2022). Исследование режимов рафинирования стали, используемые для изготовления литых деталей подвижного состава железнодорожного транспорта. Лучший инноватор в области науки, 1(1), 667-673.
19. Рисқулов, А. А., Юлдашева, Г. Б., Турсунов, Н. Қ., & Нурметов, Х. И. (2022). ТАЪЛИМДА ЗАМОНАВИЙ ИННОВАЦИОН ТЕХНОЛОГИЯЛАРНИ ҚЎЛЛАШ–ЮКСАК МАЛАКА ЭГАСИ БЎЛИШ ДЕМАКДИР. Academic research in educational sciences, 3(TSTU Conference 1), 146-150.
20. Nurmetov, K., Riskulov, A., & Avliyokulov, J. (2021). Composite Tribotechnical Materials for Autotractor Units (No. 5039). EasyChair.
21. Tursunov, N. K., Toirov, O. T., Nurmetov, K. I., & Azimov, S. J. (2022). Improvement of technology for producing cast parts of rolling stock by reducing the fracture of large steel castings. Oriental renaissance: Innovative, educational, natural and social sciences, 2(Special Issue 4-2), 948-953.
22. Tursunov, N. K., Toirov, O. T., Nurmetov, K. I., Azimov, S. J., & Qo'chqorov, L. A. (2022). Development of innovative technology of the high-quality steel production for the railway rolling stock cast parts. Oriental renaissance: Innovative, educational, natural and social sciences, 2(Special Issue 4-2), 992-997.