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EFFECT OF MgO CONTENT IN SINTERED ORE ON VISCOSITY OF BLAST FURNACE SLAG BEARING HIGH Al_2O_3

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The effect of MgO content on the viscosity of blast furnace slag bearing high Al_2O_3 was studied under laboratory conditions. The viscosity of slag was determined by rotation method. The research results indicate that when the Al_2O_3 content in blast furnace slag is 17 % -18 %, the MgO content in blast furnace slag should be controlled at 10 %. When the Al_2O_3 content is 19 %, the MgO content should be controlled at 11 %, and the binary basicity of the slag should be controlled at around 1,10. This type of blast furnace slag has a lower melting point and better fluidity. The purpose of reducing the MgO content in the slag can be achieved by reducing the MgO content in sintered ore, that is, the MgO content in sintered ore should be controlled at 2,0 %-2,5 %.

Key words: blast furnace, the MgO content, sinter, slag bearing high Al_2O_3, viscosity

INTRODUCTION

China's iron and steel enterprises are increasingly dependent on imported iron ore, with imported iron ore powder mainly coming from Australia. However, the Al_2O_3 content in Australian ore is generally high, which leads to an increase in Al_2O_3 content in blast furnace slag, resulting in an increase in slag viscosity, poor desulfurization ability and fluidity, directly affecting the stability and smooth operation of blast furnaces [1-3]. MgO is a basic substance, and appropriate addition of MgO can improve fluidity and desulfurization ability of slag. When the content of Al_2O_3 in blast furnace slag is high, the role of MgO is particularly important, and the physical and chemical properties of the slag will be improved by appropriately increasing the content of MgO in the blast furnace slag.

MgO in the blast furnace is mainly brought in by sintered ore. MgO has the effect of improving reduction degradation index sintered ore, but the addition of MgO also leads to the decrease of sintering productivity and the increase of energy consumption. At the same time, the increase in MgO content in sintering raw materials has a certain inhibitory effect on the generation of calcium ferrite. Calcium ferrite decreases with the increase in MgO content in sintering ore, and the strength and high-temperature soft melting performance of sintered ore deteriorate [4-6]. The content of Al_2O_3 in blast furnace slag of a certain factory is mostly between 17 % and 18 %, and some are more than 19 %. In order to ensure the fluidity of blast furnace slag, the technical staff of the plant requires the content of MgO in the slag to be about 11 %. At the same time, the content of MgO in the sintered ore must be 4 %. At present, the strength of the sintering ore of the plant is relatively low, the drum strength is 75 %, and the coke ratio of the blast furnace is high, the coke ratio is 350 kg/t. In order to explore the possibility of appropriately reducing the content of MgO in sintered ore and ensuring good fluidity and desulfurization ability of blast furnace slag, this article studied the effect of MgO content on the viscosity of blast furnace slag bearing high Al_2O_3 under laboratory conditions, and the corresponding relationship between viscosity and the content of Al_2O_3 and MgO in the slag was studied, thus providing a theoretical basis for on-site production.

EXPERIMENTS

The relation between temperature and viscosity of blast furnace slag was determined by rotating cylinder method in a silicon molybdenum rod high-temperature furnace. The slag used for experimental research was prepared in the laboratory using chemical reagents based on the compositions range of blast furnace slag in actual production and the research needs. In order to compare and contrast, the viscosity of blast furnace slag retrieved from the site (No.7) was also determined. The slag composition is shown in Table 1.

RESULTS AND DISCUSSION

The viscosity of the above seven test slag samples was determined, and the results are shown in Figure 1.

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Table 1 **BF slag compositions /%: and basicity**

No.	Al_2O_3	MgO	CaO	SiO_2	MnO	FeO	R
1	19	10	37,66	34,15	0,5	0,5	1,10
2	19	11	34,83	31,66	0,5	0,5	1,10
3	18	10	38,09	34,63	0,5	0,5	1,10
4	18	11	35,34	32,13	0,5	0,5	1,10
5	17	10	39,71	36,10	0,5	0,5	1,10
6	17	11	36,88	33,52	0,5	0,5	1,10
7	18,4	13.2	34,12	31,02	0,53	0,62	1,10

From Figure 1, it can be seen that the binary basicity of blast furnace slag is around 1,1, when the Al_2O_3 content in the slag is relatively high, increasing the MgO content in the slag appropriately reduces the viscosity of the slag. When the content of Al_2O_3 in the slag is 17 %-18 %, the content of MgO is 10 %, and the viscosity of the slag is less than 0,4 Pa.s at 1500 °C, which has good fluidity. When the Al_2O_3 content in the slag is 19 %, the MgO content should be increased to 11 %, at 1500 °C, the viscosity of the slag is less than 0,4 Pa.s, with good fluidity. For example, the viscosity values of samples No. 2, 3, and 5. The MgO content in the on-site blast furnace slag is relatively high, reaching 13,20 %, resulting in high viscosity and poor fluidity of the slag, which leads to an increase in coke ratio.

Properly increasing the MgO content in the slag can avoid the occurrence of high melting point $2CaO \cdot SiO_2$ in the slag, reduce the melting temperature of blast furnace slag, and also bring in more O^{2-} ions, reduce the polymerization degree of Si-O and Al-O anion groups, destroy their network structure, and form simple single and double tetrahedral structures.

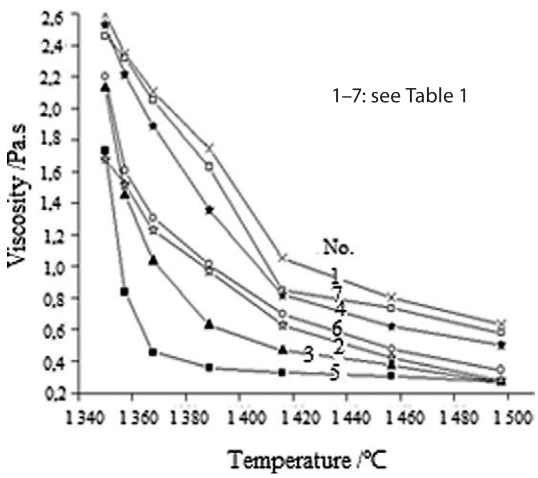

Figure 1 Slag viscosity of sample at different temperature

Figure 2 is the quaternary phase diagram of CaO-SiO_2-Al_2O_3-MgO.

From the Figure, it can be seen that under the conditions of blast furnace smelting temperature, the optimal composition of slag is best within the initial crystallization zone of melilitite. In this zone, the basicity of blast furnace slag is about 1,1, the isotherm distribution is sparsely distributed, and melting temperature of slag with this composition is low, that is, the slag forming performance is good, the slag viscosity is low, the fluidity is good, and the desulfurization ability is strong. If the binary basicity of slag is changed, the phase point moves up and down, and the slag composition easily leaves the initial crystallization zone of melilitite and enters the surrounding area with high melting temperature, resulting in a large increase in the viscosity of slag. On the other hand, when the binary basicity of the blast furnace slag remains constant at around 1,1, with an appropriate increase in MgO content, the phase point moves left and right, and the slag composition is still in th initial crystallization zone of melilitite, which will not cause a deterioration in fluidity. Especially in the composition range of high Al_2O_3 content in the blast furnace slag, the appropriate increase of MgO content in the slag often makes the slag composition move to the center of the low melting point of the melilitite initial crystallization zone, so that the slag viscosity is reduced, the fluidity is improved, and the metallurgical performance is improved. If the MgO content is further increased, forsterite and periclase appear in the slag, the melting temperature and viscosity of the slag increase, which worsens fluidity and metallurgical performance.

Taking into account the thermal stability, desulfurization ability, and viscosity of the slag as a function of temperature, it is proposed that the optimal conditions for the slag under the existing raw material conditions and when the binary basicity of the slag is around 1,1, the matching of Al_2O_3 and MgO content is as follows: when the Al_2O_3 content reaches 19 %, the MgO content should be 11 %; When the Al_2O_3 content is 17 % -18 %, the MgO content should be around 10 %; In summary, under the condition that the Al_2O_3 content in the slag does not exceed 19 %, the MgO content should preferably not exceed 11 %.

A good slagging system should meet the requirements of good slag fluidity, strong desulfurization ability and thermal stability. To reduce the content of MgO

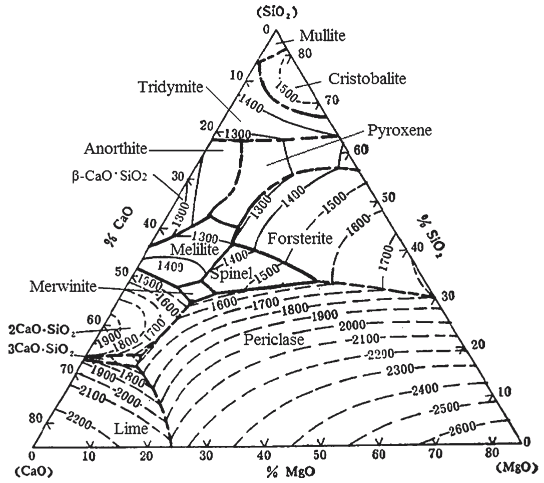

Figure 2 Quaternary phase diagram for CaO-SiO_2-Al_2O_3-MgO (ωAl_2O_3 = 15 %)

in slag, for this plant, it is possible to reduce the content of MgO in sintered ore. At present, the content of MgO in the sintered ore of the plant is 4 %, if the content of MgO can be reduced by 1,5 % to 2,0 %, that is, the content of MgO in the sintered ore is about 2,0 % to 2,5 %, which can not only reduce the content of MgO in the slag, but also improve the grade of the sintered ore. The increase of sintered ore grade also creates conditions for the reduction of slag quantity and the increase of production. At the same time, the viscosity of slag is reduced and the fluidity is better, which is very beneficial for the stable and smooth operation of the blast furnace.

CONCLUSIONS

– The content of Al_2O_3 and MgO in the slag has a suitable proportion, under the current raw material conditions, the content of MgO in the blast furnace slag of the plant (Al_2O_3 content in the range of 17 %-19 %) should be controlled at 10 %-11 %, and the basicity of the binary slag is controlled at 1,10, so the blast furnace slag has good fluidity.

– For blast furnace slag bearing high Al_2O_3, as the MgO content in the slag increases appropriately, the slag composition enters the low viscosity initial crystallization zone of melilitite ($2CaO·MgO·2SiO_2$). In this area, the melting temperature is lower and the viscosity of the slag is also lower, so the fluidity of the slag is good.

– To appropriately reduce the MgO content in blast furnace slag, the MgO content in sintered ore can be reduced. For the plant, reducing the MgO content in the sintered ore from 4,0 % to 2,0 % -2,5 % is beneficial for improving the blast furnace output and ensuring the stable operation of the blast furnace.

REFERENCES

[1] F. M. Shen, X. Jiang, Q. J. Gao. Theoretical Basis of Suitable MgO/ Al_2O_3 Ratio in BF Slag. Ironmaking 38(2019)2, 17-21.

[2] H. B. Zhao, L. K. Ma, Zh. J. He. Law of Effect of MgO/ Al_2O_3 Ratio on Flow Properties and Thermal Stability of Low Aluminum Slag System for BF. Angang Technology (2021)5, 12-18.

[3] F. M. Shen, X. iang, H. Y. Zheng. Control theory and Application of MgO/Al_2O_3 Ratio in BF Slag. In Proceedings of the 10th China Iron and Steel Annual Conference. 2022, 62-63.

[4] F. M. Shen, X. Jiang, Q. J. Gao. Study on MgO Addition Method and Effect Based on Suitable MgO/ Al_2O_3 Ratio. Ironmaking 38(2019)2, 22-26.

[5] G. P. Zhang, F. M. Shen, Q. J. Gao. Effect of Reducing MgO Content on Metallurgical Properties of High Al_2O_3 sinter. Journal of Iron and Steel Research 34(2022) 8, 749-757.

[6] X. L. Han, T. H. Si. Influences of MgO and Al_2O_3 on the Mineralogical Properties of Calcium Ferrite in Iron Ore Sinter. Earth Science Frontiers 27(2020) 5, 280-290.

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