AusIMM

MOLTEN2024

DETOXIFICATION OF STAINLESS STEEL SLAG BY HIGH TEMPERATURE MODIFICATION-CRYSTALLIZATION CONTROL APPROACH

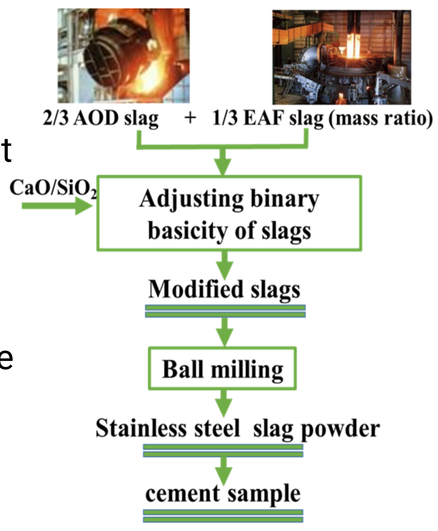
Min Guo[1], Xiangtao Huo[1], Peng Diao[2] and Mei Zhang[1]
1. School of Metallurgical and Ecological Engineering, University of Science and Technology Beijing, Beijing 100083, China
2. School of Materials Science and Engineering, Beihang University, Beijing 100191, China

1 INTRODUCTION

- Chromium (Cr) slag from stainless steel smelting poses significant environmental risks due to the lack of effective disposal methods.
- High-temperature modification-crystallization control is a promising detoxification process, but most studies focus on synthetic slag systems rather than actual industrial slag, limiting practical application.
- Regulating binary basicity and cooling conditions to optimize the formation of large Cr-containing spinel is crucial for minimizing Cr leaching. In this study, the effects of binary alkalinity and temperature regime on the occurrence state and Cr enrichment degree in spinel were investigated, which provided experimental basis for detoxification and comprehensive utilization of resources of industrial stainless steel slag.

2 METHODS

EAF and AOD slags were mixed 1:2 by mass, with CaO and SiO_2 added to adjust alkalinity. The effects of binary alkalinity and temperature regime on Cr enrichment and growth of Cr-containing spinel were studied, and the kinetic mechanism of crystal growth was revealed. Cr toxic leaching experiments were conducted on modified slag powder and cement sample powder according to Chinese standard HJ/T 299–2007 and US EPA TCLP standard.



3 RESULTS AND DISCUSSION

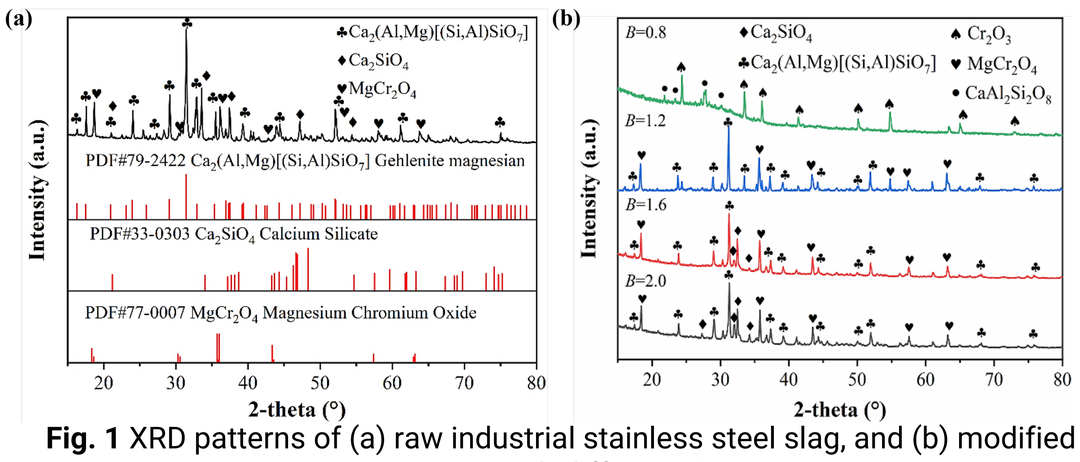


Fig. 1 XRD patterns of (a) raw industrial stainless steel slag, and (b) modified slags with different *B*

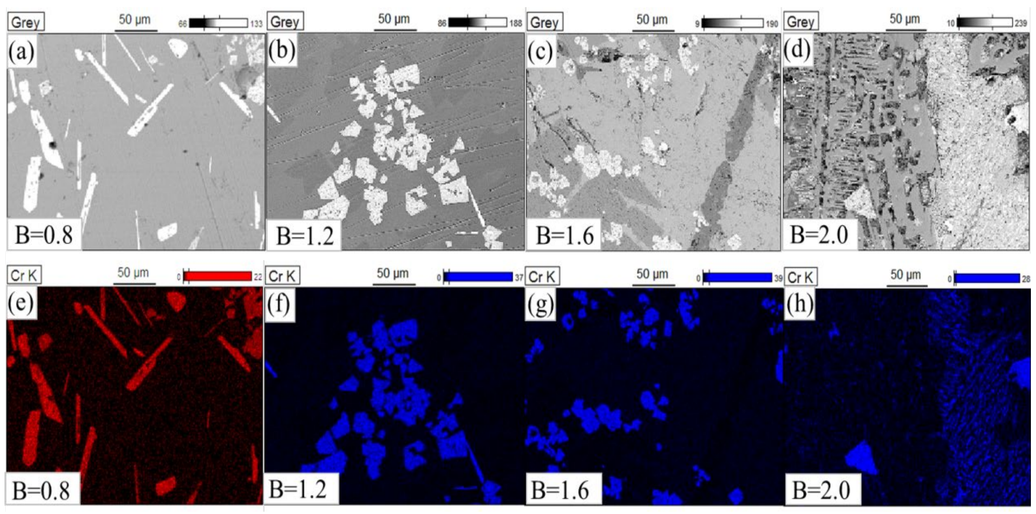


Fig. 2 SEM images of the modified slags (a-d) and their EDS-mapping images of Cr element (e-h) under different *B*

when the binary basicity (*B*) was controlled between 1.2-2.0, Cr-bearing spinel phase was precipitated in the slag, however, the enrichment degree of Cr decreased with increasing *B*. When *B*=1.2, The amount of formed spinel was the largest and the enrichment degree of Cr was the highest, reaching 13.32 wt% and 98.62%, respectively.

Crystallization temperature (°C)	Holding time (min)	Cooling rate (°C/min)	Crystallization fraction (%)
1200	20	5	9.17
	45		12.72
	70		14.51
	95		15.37
1300	20	5	7.37
	45		11.38
	70		13.41
	95		15.33
1400	20	5	5.13
	45		9.62
	70		12.53
	95		14.78

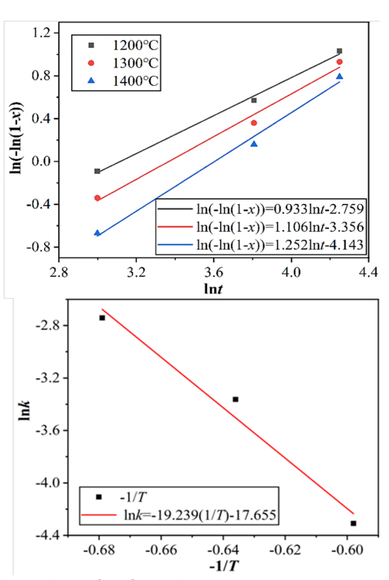


Fig. 3 Cr-containing spinel growth kinetics behavior

In the process of crystallization of Cr-containing spinel, diffusion process was the speed control step. When the temperature and holding time were controlled at 1200-1400° C and 95 min, the crystal area and size of the formed spinel nearly reached equilibrium. The crystal area were 15.37% (1200℃) and 14.78% (1400℃), and the crystal sizes were separately about 22.86 μm (1200℃) and 24.07 μm (1400℃).

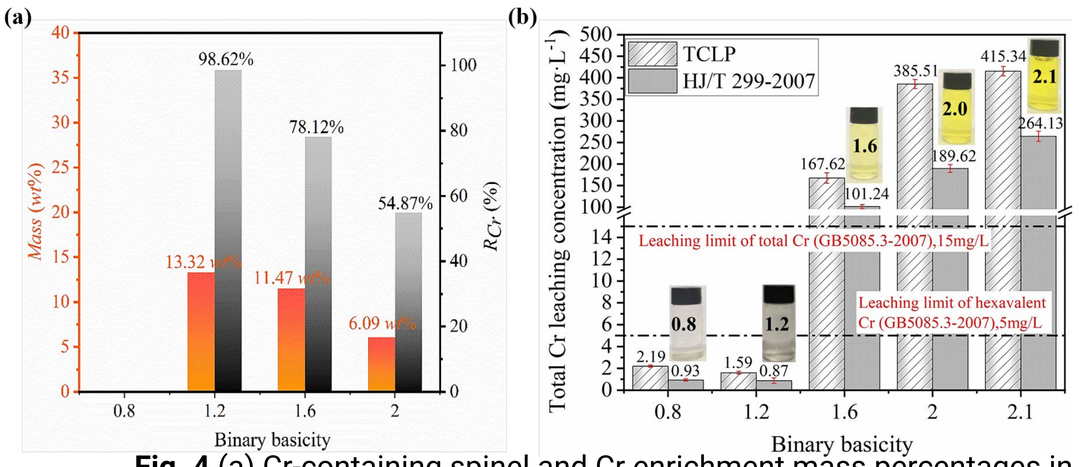


Fig. 4 (a) Cr-containing spinel and Cr enrichment mass percentages in modified slags with different *B*; (b) Total Cr leaching concentrations of modified slag powders.

With TCLP leaching method, the leaching concentration of Cr from stainless steel slag with *B*=1.2 was only 1.59 mg/L, which was far lower than the national limit of heavy metal leaching concentration of solid waste (15 mg/L). Notably, after the steel slag powder was prepared as concrete test block, the leaching concentration was even lower than the ICP-OES detection line, suggesting that the detoxified slag powder could meet the requirements of resource utilization.

5 CONCLUSION

The crystallization amount of $MgCr_2O_4$ in modified slag reached 13.32wt%, and the enrichment degree of Cr was up to 98.62% with B=1.2 at 1200℃. The average size of $MgCr_2O_4$ crystals could be increased to 20 μm when the cooling rate of the modified slag system was reduced from 10 to 2 ℃/min or the holding time was extended from 20 to 95 min at temperature of 1200℃. The modified stainless steel slag was effectively detoxified with leaching concentration of Cr element was only 1.59 mg/L (TCLP).

REFERENCES

- *Journal of Hazardous Materials*, 2023, 446, 130746.
- *Journal of Iron and Steel Research International*, 2018, 25(11): 1131-1139.