Reduction of Solid Waste at Source: High-Proportion Pellet Smelting of Chromium-Bearing Vanadium Titanomagnetite

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1 Introduction

China's ironmaking industry is currently dominated by blast furnace ironmaking. Historically, due to the characteristics of ironmaking raw material sources, the charge structure has been predominantly composed of sinter, with only a minor proportion of pellets and lump ore(Zhang Fuming & Xu meng, 2022; Xingdong Wang & Yonglong Jin, 2022). Pellets offer distinct advantages over sinter, including higher total iron content, lower pollutant emissions, and reduced energy consumption(Yuan Yu-xing et al., 2022; Xingdong Wang et al., 2019; Xingdong Wang & Yonglong Jin, 2021). Producing basic pellets and increasing the proportion of blast furnace charge pellets can enhance the quality of furnace charge, decrease the amount of blast furnace slag, and reduce pollutant emissions and energy consumption during the blast furnace ironmaking process. This approach also minimizes solid waste output and carbon emissions in the iron and steel industry.

Vanadium titanomagnetite, a multicomponent symbiotic iron ore primarily composed of iron with valuable elements such as vanadium and titanium, holds high economic value. The current process for utilizing vanadium titanomagnetite in blast furnaces, however, results in low sinter strength and poor quality due to the formation of perovskite(Tang W D et al., 2018; Tang W D et al., 2021; Hanlin Song et al.,2021). To address these issues and increase the proportion of blast furnace charge pellets, it is crucial to study the preparation of vanadium titanomagnetite flux pellets while maintaining the slag's basicity. In the Panzhihua area of China, Honggeite—a chromium-bearing vanadium titanomagnetite with a chromium content of 0.55%—exhibits high comprehensive utilization value. This paper utilizes Honggebei ore from Panzhihua as a raw material to prepare fluxing pellets of chromium-bearing vanadium titanomagnetite. It examines the effects of pellet basicity on the quality, crushing strength, reducibility (RI), and reductive free-swelling index (VFS) of the pellets. The goal is to provide technical support for increasing the proportion of these pellets in blast furnace smelting, thereby reducing pollutant emissions and energy consumption in the process.

2 Results and discussion

As the basicity of the pellets increases, their quality significantly improves, with enhanced compressive strength and an increased number of drop cycles.

With the increase in basicity, the compressive strength of the pellets first increases and then decreases. Increasing the basicity is beneficial for reducing the oxidation burning temperature required by the pellets and enhancing their strength. SEM-EDS analysis shows that calcium and silicon elements combine to form a low-melting-point bonded phase silicate. Vanadium and chromium are distributed in the hematite phase. When the basicity of the flux pellets is 0.9, the required oxidation burning temperature is the lowest, and the Crushing strength of the pellets is the highest.

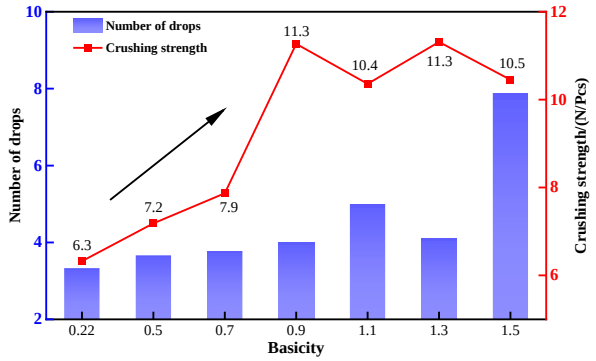

Fig.1 Crushing strength and drop number of green pellets

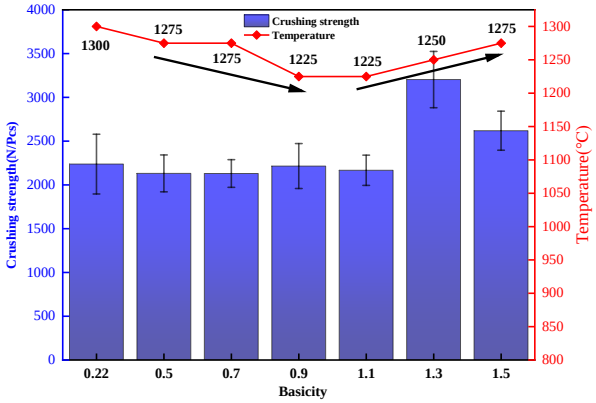

Fig.2 Crushing strength of flux pellets

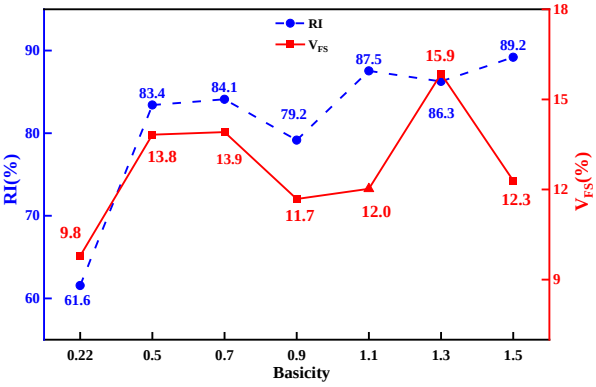

Fig.3 Reducibility(RI) and reductive free-swelling index(V_{FS}) of the flux pellets

The addition of calcium carbonate led to a significant enhancement in the reducibility of the pellets, although there was a minor deterioration in the reduction expansion index. Notably, no catastrophic expansion was observed. An increase in the basicity of the pellets resulted in an upward trend in their reducibility. The optimal basicity for the pellets was determined to be 1.1, at which point the reducibility reached 87.5%, and the reduction expansion index was 12%. At this basicity level, both the reducibility and the reduction expansion index were found to be favorable.

References

[1] Zhang Fuming, Xu meng. (2022). Development of Green and Low-Carbon Ironmaking Technology at Shougang. Ironmaking.

[2] Xingdong Wang, & Yonglong Jin. (2022). Prospect on high ratio pellet utilized in blast furnace under thebackground of carbon peaking and carbon neutrality. The Chinese Journal of Process Engineering, 22(10), 1379-1389.

[3] Yuan Yu-xing, Yan Tian-yi, Na Hongtao, & Du Tao. (2022). Intergrated optimization and analysis of energy consumption and cost in ironmaking system. China Matallurgy, 32(1), 97-103.

[4] Xingdong Wang, Jianxin Li, Qichen Hu. (2019). Application practice of source and process sulfur-nitrate reduction technology based on optimization of blast furnace charge structure. Iron and Steel, 54(12), 8.

[5] Xingdong Wang, Yonglong Jin. (2021). Strategy analysis and testing study of high ratio of pellet utilized in blast furnace. Iron and Steel, 56(5), 10.

[6] Tang W D, Yang S T, Cheng G J, et al. (2018).Effect of TiO_2 on the sintering behavior of chromium-bearing vanadium–titanium magnetite. Minerals, 8(7): 263.

[7] Tang W D, Xue X X, Yang S T, et al. (2018). Influence of basicity and temperature on bonding phase strength, microstructure, and mineralogy of high-chromium vanadium–titanium magnetite. International Journal of Minerals, Metallurgy, and Materials, 25(8): 871-880.

[8] Tang W D, Yang S T, Xue X X. (2021). Effect of titanium on the smelting process of chromium-bearing vanadium titanomagnetite pellets. JOM, 73(5): 1362-1370.

[9] Hanlin Song, Jinpeng Zhang, Gongjin Cheng, Songtao Yang, and Xiangxin Xue. (2021). CO_2 Injection Improves the High-temperature Performances of Cr-bearing Vanadia-titania Magnetite Smelting in Blast Furnace. Journal of CO_2 Utilization, 43:101363.