The main aim of this work was to optimize the proportions of vanadium and titanium ore from diverse sources in sinter mixture. Industrial V-Ti sinter was observed firstly, then 16 groups of sinter using different proportions V-Ti ore from diverse sources, designed through orthogonal method, were prepared by sinter pot, and their performances were determined. It showed that, V-Ti sinter had complex mineral compositions, particularly perovskite (CaO·TiO₂). V-Ti ores from diverse sources had different impacts on V-Ti sinter properties. V-Ti sinter should be sprayed with proper CaCl₂ to improving the lower reduction degradation index (RDI + 3.15). And the V-Ti sinter mixture with 5% DaBa (DB), 25% HengWei (HW), 25% YuanTong (YT), 45% JianLong (JL) ore was optimal.

Key word: sinter, vanadium - titanium iron ore, tumbler strength, RDI, orthogonal method

EXPERIMENTAL WORK

Raw materials

Industrial V-Ti sinter samples and the four vanadium - titanium ores from diverse sources DaBan (DB), HengWei (HW), YuanTong (YT), JianLong (JL), and two ordinary ores YinDu (YD), MaFeng (MF) used in this study are supplied by Chengde Jianlong Iron and Steel Group Company, China. The chemical compositions of iron ores for experimental work are listed in Table 1.

Experimental method

On the basis of raw materials supplied and industrial ore - matching scheme ( Table 2 ) in Chengde Jianlong Iron and Steel Group Company, experiments adopt orthogonal method with 3 factors and 4 levels (L₃₁⁴⁴), 3 factors were DB ore, HW ore, YT ore respectively, and 4 levels (The total V-Ti iron ore added in sinter mixture was set as 100 %, and the initial proportions of DB, HW, YT were 50%, 5%, 45% respectively. In addition, the proportions of DB and YT decreased in 15%, 10% respectively each time while HW rose in 10% and JL...
ore was used to fill the total proportion to 100%, the experimental schemes were shown in Table 3). And the sinter moisture maintained at 7.5 ± 0.3%, the coke content was 3.2%, basicity was 1.90. The metallurgical properties (tumbler strength (TI) and reduction degradation index (RDI)) were determined in accordance with ISO - 3271 and ISO - 4696 respectively.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Industrial ore - matching scheme of sintering / mas. %</th>
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<tbody>
<tr>
<td>V - Ti ore</td>
<td>YD ore</td>
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<td>45</td>
<td>5</td>
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</table>

Note: Basicity = \( \frac{\text{CaO}}{\text{SiO}_2} \)

RESULTS AND DISCUSSION

Optical microscopy analysis of Industrial V - Ti sinter

Optical microscopy photo for the mineralogical phase texture in the industrial V - Ti sinter was shown in Figure 1. The photograph showed the V - Ti sinter consisted of five key mineral phases and they were haematite, magnetite, silicate (dicalcium silicate), calcium ferrite and perovskite. And the noteworthy mineral should be pointed out for V - Ti sinter was perovskite for it just appeared in V - Ti sinter. In addition, due to Gibbs Free Energy of reaction between \( \text{TiO}_2 \) and \( \text{CaO} \) is far less than that of between \( \text{CaO} \) and \( \text{Fe}_2\text{O}_3 \), \( \text{CaO} \) prefers to react with \( \text{TiO}_2 \) to generating perovskite (\( \text{CaO} \cdot \text{TiO}_2 \)) (Figure 2), which consumed an additional part of basicity (\( \text{CaO} \)) and caused the decrease in liquid phase and calcium ferrite. Meanwhile, perovskite could distribute in some regions concentrated, which would weaken V - Ti sinter strength for its high fragility. Further, it dispersed in the slag phase (silicate), calcium ferrite and the iron minerals, which weakened the role of bonding phase and iron minerals and produced cracks easily when there was an external force. Thus, the V - Ti sinter with poor TI and RDI.

Orthogonal experiments results analysis by range method

TI and RDI of 16 groups of V - Ti sinter and the results of range analysis are shown in Table 3 and Figure 3.
The proportion scheme was 5% DB, 25% HW, 25% YT, and 45% JL ore in the view of TI. Similarly to the effect of TI, the sequence of effect on RDI+3.15 from high to low was HW ore, YT ore and DB ore for R(I) = 2.31 > R(II) = 1.02 > R(III) = 0.85. In addition, when the proportion of DB ore was 5%, the mean value of RDI+3.15 got a max value 43.97% (Figure 3 a) and when the proportion of HW ore was 15%, the mean value of RDI+3.15 got a max value 46.98% (Figure 3 b), and when the proportion of YT ore was 15%, the mean value of RDI+3.15 got a max value 46.43% (Figure 3 c). Therefore, the optimal proportion scheme was 20% DB, 15% HW, 15% YT, and 50% JL ore in the view of RDI+3.15. However, there was still a huge gap between V-Ti sinter and the requirements in RDI+3.15 for RDI+3.15 of sinter must be higher than 70% before smelted in blast furnace. Thus, V-Ti sinter should be sprayed with CaCl2 to improve RDI+3.15 to meet the requirements, and the effect of DB, HW, YT proportions on RDI+3.15 of V-Ti sinter could be neglected.

CONCLUSIONS

1. The properties of V-Ti sinters using V-Ti iron ore from diverse sources with different proportions are different, and V-Ti iron ores from diverse sources must not be used as the same kind of V-Ti iron ore in sintering.

2. The minerals in V-Ti sinter are complex especially perovskite (CaO·TiO2), which make the poor metallurgical properties particular RDI+3.15, and CaCl2 are needed to be sprayed to improve RDI+3.15 to meet the requirements in a blast furnace. Thus, V-Ti sinter should be sprayed with CaCl2 to improve RDI+3.15, to meet the requirements, and the effect of DB, HW, YT proportions on RDI+3.15 of V-Ti sinter could be neglected.

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Note: Mi Zhou is responsible for English language, Shenyang, China