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REACTION MECHANISM ANALYSIS OF THE TiO_2 IN VANADIUM - TITANIUM BLAST FURNACE (BF) SLAG

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The Blast Furnace hot metal constitute and performance were effect by fluidity and fusion of the slag, as a result, BF smelting course was influenced. In the paper, the titanium slag was researched on, one iron and steel enterprise BF slags were detected and analysis by Scanning Electron Microscope (SEM), Energy Disperse Spectroscopy (EDS) and X - Ray Diffraction (XRD), then the $CaO{\cdot}FeO{\cdot}2SiO_2$ and $CaO{\cdot}TiO_2$ were tested beside the TiC that is the production of the reduction, at the same time, the residue iron was found in slag. By the thermodynamic calculation with the Factsage, the liquid phase regions contain magnesium titanate were changed when the percent of TiO_2 was enhanced. The smelting rate of slag system can be accelerated when the viscosity of the slag can be decreased, so the content of TiO_2 and B_2O_3 should be controlled.

Keywords: blast furnace, TiO_2, vanadium - titanium slag, analysis by SEM, EDS, XRD, viscosity

INTRODUCTION

The storage vanadium - titanomagnetite is abundant and the price is low in China[1], which is a kind of polymetallic symbiosis complex ore with vanadium - titanomagnetite as the main form in the iron ore, vanadium and titanium are the main element [2 - 4],The content of TiO_2 is high, as a result, the smelting technology is different from the common iron ore, which was the difficult to select, sinter and smelt, meantime it have the residual iron in the slag, if the vanadium - titanomagnetite was used to BF, some problems can be happened, such as excessive reduction, viscosity increasing, slag iron separation difficult, high loss of the metal phenomenon and so on, when the content of TiO_2 more than 20 %, it was be named high titanium slag, from which the technical and economic index of BF can be effected seriously [5 - 7].

In the paper, several test method were used to analysis the spot vanadium - titanium slag, and the Factsage was used to calculate the slag thermodynamic performance, the relation between the component and the viscosity, in this way, theory support can be offered for the smelting of the BF.

TEST AND ANALYSIS

The chemical component of the vanadium - titanium BF slag was in Table 1, then the SEM and EDS were used to analysis the reaction and the microstructure.

From the Figure 1,Table 2 and Table 3, the C element can be tested in the sample, the TiC can be formed from the reduction reaction of the titanic, which is high melting point and the viscosity of the slag can be increased, it was suspended on the slag surface in the form of dispersion, as a result, the slag fluidity was became worse, the iron content can be reach 90,69 %, at the same time, the FeO can form the low melting point compound, from which the melting temperature can be reduced, and the viscosity also can be decreased, in fact, the slag - metal mixture in the slag can't be avoided during high titanium BF slag, which can be reduced by improving the BF slag performance[8]. From the Figure 2, there a lot of $CaO{\cdot}FeO{\cdot}SiO_2$, $CaO{\cdot}TiO_2$ and the $10CaO{\cdot}7MgO{\cdot}3Al_2O_3{\cdot}17SiO_2$ were formed in the BF slag.

Table1 The **slag chemical composition/wt,%**

CaO	SiO_2	V_2O_5	TiO_2	MgO	Al_2O_3	S
28,98	26,34	0,3	22,5	7,57	13,86	0,45

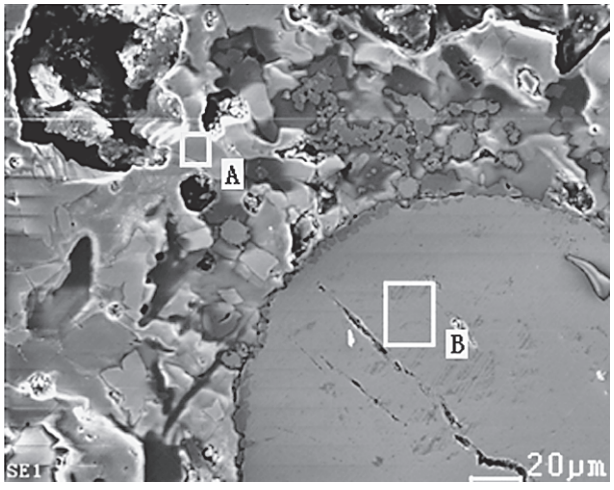

Figure 1 The SEM of the slag sample

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Table 2 **The area A EDS analysis/wt,%**

Area	Fe	C	V	Si
A	90,69	6,33	2,30	0,67

Table 3 **The area B EDS analysis/wt,%**

Area	C	Ti	Ca	Al	O
B	4,02	35,41	30,30	0,60	29,93

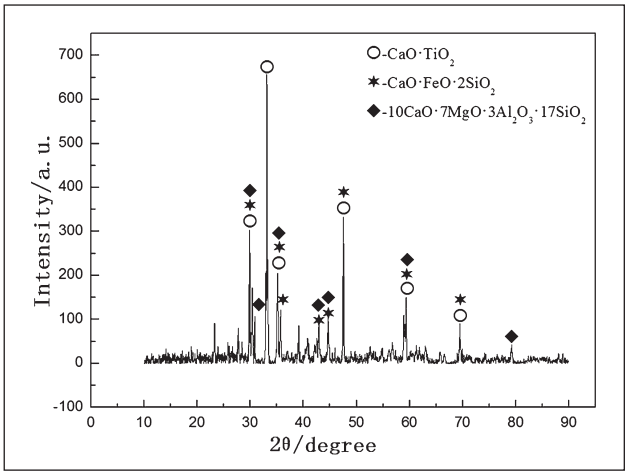


Figure 2 X-ray diffraction of the slag sample

THERMODYNAMIC CALULATION

Phase diagram analysis the reaction of the vanadium - titanium slag

The slag samples were made up by chemical analytical purity on the basis of enterprise BF slags. As Table 4 showed, viscosity was calculated by Factsage when the basicity (CaO/SiO_2) were 1, 1,1, 1,15, 1,2.

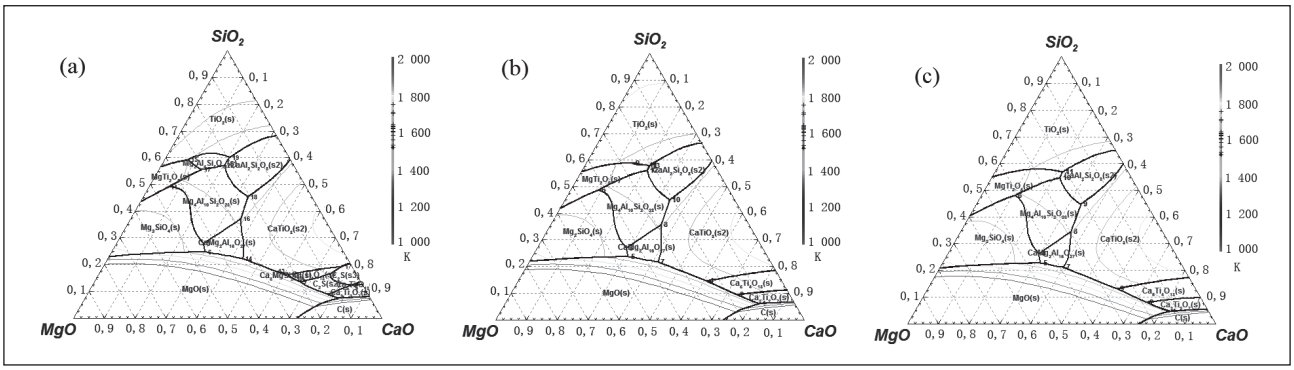
Table 4 **Chemical composition of the calculating vanadium - titanium slag/wt,%**

R	CaO	SiO_2	TiO_2	MgO	Al_2O_3
1,1	30,02	27,3	20,5	7,57	13,86
1,1	28,98	26,34	22,5	7,57	13,86
1,1	27,93	25,39	24,5	7,57	13,86
1,15	30,66	26,66	20,5	7,57	13,86
1,15	29,59	25,73	22,5	7,57	13,86
1,15	28,52	24,8	24,5	7,57	13,86
1,2	31,27	26,05	20,5	7,57	13,86
1,2	30,17	25,15	22,5	7,57	13,86
1,2	29,08	24,24	24,5	7,57	13,86

From the Figure 3, the TiO_2 was added into CaO - SiO_2 - MgO - 13,86 % Al_2O_3 slag system, from which the five slag system can be gained, and then there were $Mg_2Al_2Si_5O_{18}$, $Mg_4Al_{10}Si_2O_{23}$, $CaMg_2Al_{16}O_{27}$, $MgTi_2O_5$ and the other slag phase in the vanadium - titanium BF slag system, at same time, the liquid phase region which can be mainly formed by $Mg_4Al_{10}Si_2O_{23}$ and $CaMg_2Al_{16}O_{27}$ including the little other matter, which can be changed by the increasing content of the TiO_2, and the total liquid phase region can be decreased with the temperature especially with the content of the TiO_2. The liquid phase region was increased with the $CaO·TiO_2$, which had been seen from the XRD in the Figure 2. From the Figure 3 (c), it can be saw that the TiO_2 can not be the liquid if there was not reaction that was carried out with it when the content was reach to 24,5 % in the BF slag. At the same time, the $MgTi_2O_5$ can be formed with the reaction in the vanadium – titanium blast furnace slag system, and from which the solid solution produced and the normal decomposing of aluminate can be controlled in the more high temperature, in this way, the melting of the aluminate can be promoted effectively, and the fluidity of the slag can be increased with the melting performance improved in the BF.

Slag viscosity calculation and analysis

From the data of the Table 4, how the viscosity was effected by increasing of the TiO_2 with the different basicity was calculated in Figure 4, the viscosity was decreased with adding the more TiO_2, meantime the viscosity was decreased largely when the basicity was changed from 1,1 to 1,2 in the titanate slag. As Figure 5 showed, the viscosity may be different in the low temperature, but the viscosity was reduced quickly with the increasing of the temperature, so the fluidity of the slag was effected by temperature is more obvious than the basicity or the different content of the TiO_2, meantime the chemical reaction may be carried out quickly when the temperature of the BF was during 1 300 °C to 1 400 °C, then the viscosity was changed a little when the temperature was more than the 1 600 °C, meantime the viscosity is changed below 0,6 Pa·s, from which the fluidity can be improved quickly.



(a) TiO_2 content is 20,5 % (b) TiO_2 content is 22,5 % (c) TiO_2 content is 24,5 %

Figure 3 CaO-SiO_2 – MgO – 13,86 % Al_2O_3 - TiO_2 slag system phase diagram

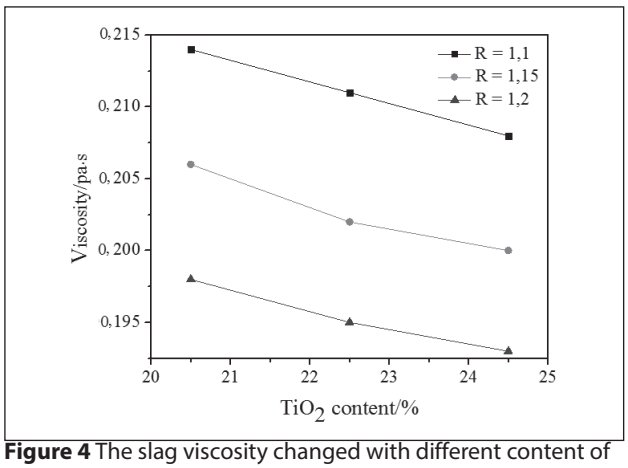


Figure 4 The slag viscosity changed with different content of TiO_2 at 1 500 °C temperature

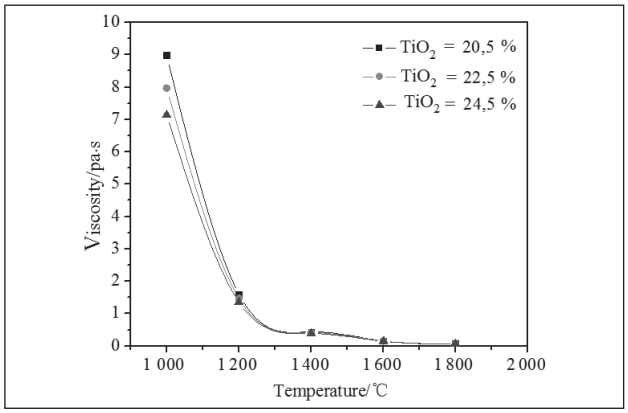


Figure 5 The slag viscosity changed with the increasing of the temperature

B_2O_3 influent on the viscosity of the high titanium slag

As Figure 6 showed, the slag viscosity can be decreased when the content of the B_2O_3 was increased, because the melting point of the B_2O_3 was low to 450 °C, and it can be reacted with the basic oxide, from which the low melting point matter can be formed, so the B_2O_3 can be used as the melting agent in the vanadium - titanium BF, in this way, the melting temperature can be decreased, and the fluidity can be improved, so when the B_2O_3 was added into the vanadium - titanium BF, the viscosity can be decreased and the desulfuration ability can be enhanced, then both smelting process and quality of the hot metal can be improved.

CONCLUSIONS

TiC can be formed from the reduction reaction of the titanic, which is high melting point and the viscosity of the slag can be increased, the fluidity was became worse, the FeO content can be high and the viscosity also can be decreased meantime.

From the analysis of CaO - SiO_2 - MgO - 13,86 % Al_2O_3 - TiO_2 slag system phase diagram, the total liquid phase region was decreased with the increasing content of the TiO_2, in this way, the melting of the slag can be promoted effectively.

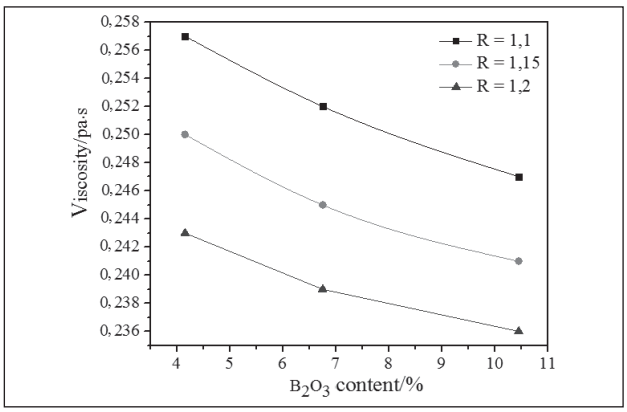


Figure 6 The slag viscosity changed with different content of B_2O_3 at 1 500 °C temperature

When the content of TiO_2 more than 20 %, the viscosity was decreased with the increasing of the basicity, meantime viscosity was effected by temperature more obviously.

Viscosity can be decreased with the adding of the B_2O_3, as a result, the content both TiO_2 and B_2O_3 can be controlled reasonably.

Acknowledgements

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Note: The responsible translator for language English is associate professor Y, Wu - University of Science and Technology LiaoNing, China.