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STUDY ON INTERFACE REACTION CHARACTERISTICS BETWEEN DIFFERENT ACIDITY AND ALKALINITY SLAG

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In this paper, the interface reaction between different acidity and alkalinity of slag was explored by comparing the changing of wetting angle and viscosity in the interface between the binary slags. And the results indicated that, the reaction temperature range of Al_2O_3 and basic slag was relatively larger when the reaction interface was acid slag, and the fusion temperature would change when the content of calcium and magnesium were changed in the base slag. Al_2O_3, SiO_2 are prone to react with other components and formed the new silicate phase compared to CaO, MgO, what made interfacial diffusion relatively better.

Key words: molten slag wetting, acidity/alkalinity, viscosity, fusion temperature, scanning electron microscope (SEM)

INTRODUCTION

The molten slag refers to the multi component melt which is composed of oxide formed in thermo metallurgy, and the molten slag is another product of the process of valuable metal extraction and refining [1, 2]. The physicochemical property of the molten slag is closely related to the process of metallurgy reaction, molten slag performance has always been a research hotspot for metallurgical scholars [3]. And studying the molten slag has a significance for development of the theory of metallurgical reaction engineering [4, 5].

Compared the changing of wetting angle and viscosity in the interface between the binary slag and found that the interface reaction was affected by the acidity and alkalinity of the slag. To explore the influence degree, take the melting temperature as a reference, using Factsage thermodynamics software to calculate the viscosity, and the interface reaction characteristics of different slag system. Explored the melting behavior and interface reaction of different slag phase by the magnifying experiment.

EXPERIMENT

Experimental materials

The base matrix was made up of Analytical Reagent, the size of matrix were ϕ 3 × 1,5 cm, ϕ 2,5 × 0,3 cm, ϕ 1 × 0,6 cm, ϕ 0,2 × 0,5 cm with pressure were 25 Mpa, 10 Mpa, 10 Mpa, 5 Mpa. Selected Al_2O_3, SiO_2, CaO and MgO when prepared the binary slag, which the proportion was 1 : 1.

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Experimental methods

The viscosity of slag were calculated by the Factsage thermodynamics software firstly [6]. And the reaction temperature under different conditions were online detected. In interface reaction condition, the isothermal reaction was carried on to make slag complete wetting complete with the base slag while ensure the base slag can’t melt. Encapsulated sample and section cutting to detect and analyze the interface section with SEM. Etc.

Experimental methods

The viscosity of different acidity and alkalinity slag were calculated by the Equilib module of Factsage thermodynamics software firstly [6]. And the reaction temperature under different conditions in different reaction base were online detected. In certain interface reaction condition, the isothermal reaction was carried on to make slag complete wetting or reaction complete with the base slag while ensure that the base slag can’t melt. Encapsulated sample and section cutting to detect and analyze the interface section with SEM. Etc. and obtained the experimental parameters of melting process under different conditions.

INTERFACE-REACTION CHARACTERISTICS OF BINARY SLAG

Basic characteristics

The furnace slag was classified into acid slag and basic slag according property. And the acid slag include Al_2O_3 and SiO_2 while the basic slag includes CaO and MgO, and the fusion temperature of acid slags are much lower than basic slag [4-7]. To studied the interface melting behavior and reaction between acid slags or ba-

Table 1 **Fusion temperature of binary slag /°C**

Sample	Starting temperature	Hemispherical temperature	Complete temperature	Temperature range
$(Al_2O_3+SiO_2)$ - CaO	1 356	1 374	1 383	27
$(Al_2O_3+SiO_2)$ - MgO	1 453	1 479	1 482	29
(CaO+MgO) - Al_2O_3	1 440	1 468	1 521	81
(CaO+MgO) - SiO_2	1 378	1 397	1 416	38
$(Al_2O_3+SiO_2)$ - (CaO+MgO)	1 417	1 434	1 437	20

sic slag and bas slag, using the Melting Point and Melting Velocity device to detect the melting characteristic of the furnace slag, the results were listed in Table 1. And analyzed the photos during the melting process, the wetting angle results were obtained in Table 2.

As shown above, when set the acid slag of the binary slags as the reaction interface, SiO_2 and Al_2O_3 were prone to react with CaO easily during the melting process and the lower fusing point phase formed such as $CaSiO_3$, Ca_2SiO_4 and $CaAl_2(SiO_4)_2$, and react with MgO then generated the Mg_2SiO_4 which fusing point was relatively higher. Therefore, the fusing point could change due to the content changing of calcium and magnesium in the base slag. When the melting finished, the wetting angle of CaO was larger than MgO due to CaO and its corresponding compounds were poor fluidity and higher viscosity in high temperature. When the base slag was mixed calcium and magnesium, the component of interface section was changed, it's easy to generate $CaMgSiO_4$, Ca_2MgSiO_5, Ca_3MgSiO_6 what accelerated the reaction, as the result, the reaction temperature range was shorten. The reaction temperature range of Al_2O_3 and basic slag was relatively larger due to the fashioning point of Al_2O_3 and aluminate products were high. During the reaction, Al_2O_3 were easily react with CaO and generated $Ca(AlO_2)_2$, and the reaction and melting behavior were inhibited due to viscosity of slag were relatively higher caused by CaO and Al_2O_3 in the liquid slag. The solid MgO began to react and molten into the slag which improved the viscosity of slag, and the reaction was carried on further.

Table 2 **Wetting angle of dual component slag / °**

Sample	Wetting angle
$(Al_2O_3+SiO_2)$- CaO	29
$(Al_2O_3+SiO_2)$- MgO	25
(CaO+MgO)- Al_2O_3	38
(CaO+MgO)- SiO_2	16
$(Al_2O_3+SiO_2)$-(CaO+MgO)	22

Table 3 **Changing in viscosity of different reaction bases / Pa·s**

Sample	Viscosity
$(Al_2O_3+SiO_2)$- CaO	2.716
$(Al_2O_3+SiO_2)$-MgO	1.869
(CaO+MgO)- Al_2O_3	1.807
(CaO+MgO)- SiO_2	2.928
$(Al_2O_3+SiO_2)$-(CaO+MgO)	2.214

Analysis of viscosity of slag with different acidity and alkalinity

There is a relationship between the viscosity and fashioning point in slag. Using the **Equilib module of** Factsage thermodynamics software to further study the changing in viscosity of the binary slag. Under the calculation condition were 1,500 °C and the reaction pressure was standard atmospheric pressure, the changing in viscosity of different reaction bases were listed in Table 3.

The viscosity of slag is a measure of the state of slag flowing. The acid slag was low melting point but maintained high viscosity in larger overheat interval. The viscosity of the slag could be enhanced due to basic slag component increased in slag system. As Table 3 shown, the changing in viscosity of binary slag was obeying the rule of changing in single component slag. The viscosity of liquid slag was relatively lower in the slag phase which contained more magnesium and the Mg_2SiO_4 was formed. The viscosity of liquid Al_2O_3 and CaO were bit higher when the SiO_2 was the highest. The main component of the slag were CaO and Al_2O_3 caused the viscosity of liquid slag increased which inhibited melting behavior. On the binary base slag were CaO and MgO, the viscosity of liquid slag were higher when add SiO_2 than Al_2O_3. The viscosity of (CaO+MgO) - SiO_2 was 2,928 Pa·s, and $CaMgSiO_4$, Ca_2MgSiO_5 and Ca_3MgSiO_6 were easily generated in this area. The viscosity of (CaO+MgO) - Al_2O_3 was just 1,807 Pa·s. Therefor the basic base slag was affected deeply by SiO_2. There was also influence on the acid base slag when added CaO and MgO. The $CaSiO_3$, Ca_2SiO_4 and $CaAl_2(SiO_4)_2$ were easily formed in the $(Al_2O_3+SiO_2)$ - CaO base slag and the viscosity was 2,716 Pa·s. The viscosity of $(Al_2O_3+SiO_2)$ - MgO was 1,869 Pa·s, therefore there was distinct influence of CaO on the viscosity of acid base slag.

Interface reaction behavior of slag with different acidity and alkalinity

According to the experimental results and analysis of the above, the magnifying experiment of interface reaction and wetting process were carried on to explore the diffusion trend of melting behavior and reaction process of binary slag in the interface section. Figures1, 2, 3 of interface behavior of slag with different acidity and alkalinity were listed below.

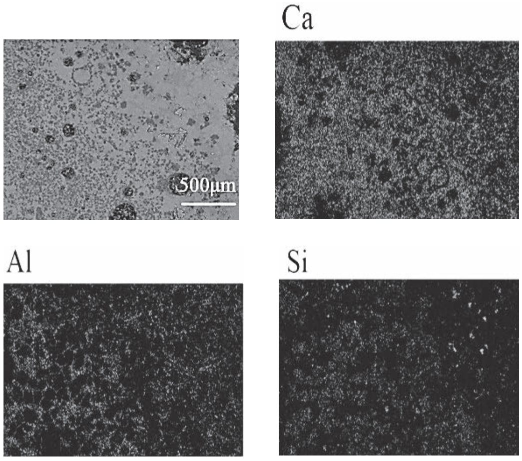

Figure 1 The SEM of the interface section in (Al_2O_3 + SiO_2) – CaO

As Figure 1 showed, due to the differences of the base slag and reaction, the interface melting behavior may cause different phase structure in the interface section of the base slag with different acidity and alkalinity. On the reaction between the CaO and acid base slag, the diosmose among different slag system was distinctly, and the none obvious boundary could be found. The low melting point phase such as $CaSiO_3$, Ca_2SiO_4 and $CaAl_2(SiO_4)_2$ could be generated.

According to the analysis of previous section, MgO owned better fluidity than CaO in acid base slag reaction process, and MgO were easily reacted with acid base slag and generated a new phase.

From the Figure 2, the diosmose phenomenon of SiO_2 was more obvious than basic slag system. According to the wetting angle analysis, the wetting angle of (CaO+MgO) - SiO_2 was 16 °, therefore the wetting behavior of SiO_2 in the interface section was fine, and contacted well with interface, which lead new phase such as $CaMgSiO_4$, Ca_2MgSiO_5 and Ca_3MgSiO_6 could formed, that could intensified the reaction and made diosmose phenomenon more obvious.

In Figure 3 the mixed state of aluminosilicate slag interface section, MgO could facilitate diosmose distinctly than CaO. The fluidity and activity of component were

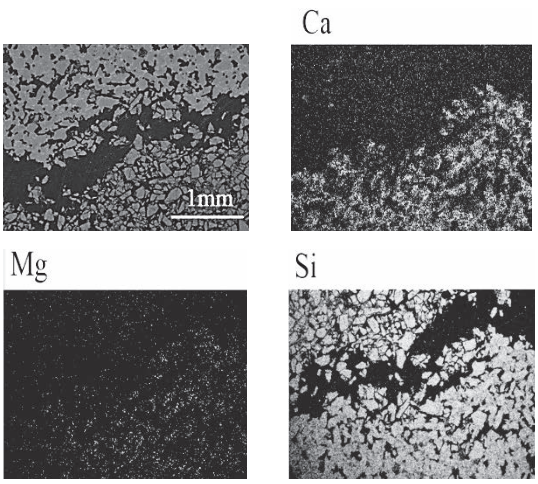

Figure 2 The SEM of the interface section in (CaO+MgO) - SiO_2

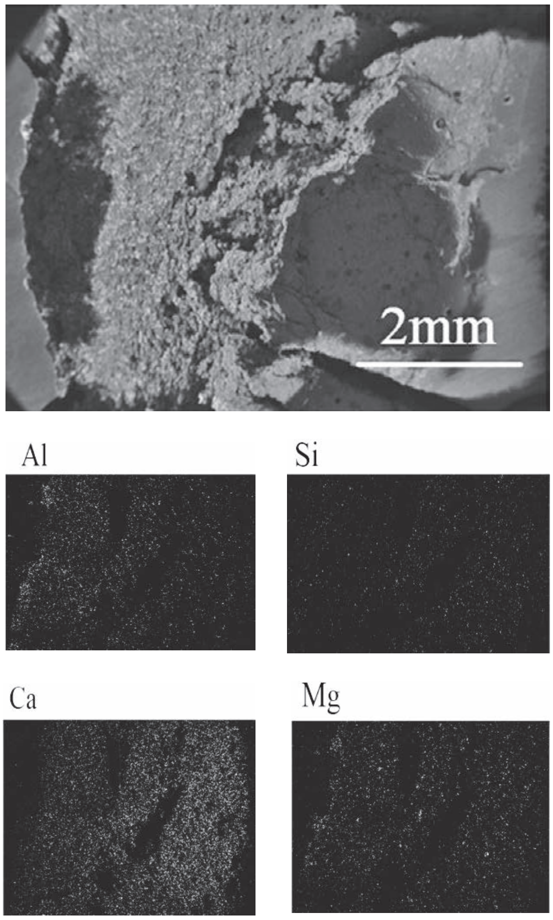

Figure 3 The SEM of the interface section in (Al_2O_3+SiO_2) - (CaO+MgO)

improved obviously along with Mg melting and diosmose, which accelerated interfacial diffusion and promoted melting behavior between the slag system.

When the base slag was mixed calcium and magnesium, the component of interface section was changed, it's easy to generate $CaMgSiO_4$, Ca_2MgSiO_5, Ca_3MgSiO_6 what accelerated the reaction, as the result, the reaction temperature range was shorten. The wetting angle between Al_2O_3, SiO_2 and base slag was decreased, this fine wetting behavior could contact interface well and facilitated reaction, generated new phase of molten slag.

Synthesized the surface scanning photos above, in the process of melting behavior and interface reaction of the binary slag, the phase structure may be changed due to component content changed, added multicomponent made the slag structure more complicated as well as decreased the fashioning point of the new molten slag phase. Al_2O_3 and SiO_2 could react easier with other components than CaO and MgO, which generated new molten phase of silicate, and promoted the diffusion behavior in the interface section.

CONCLUSION

(1) The reaction temperature range was larger between the Al_2O_3 and basic slag due to the melting point of Al_2O_3 and aluminate were relatively high. Al_2O_3 was

prone to react with CaO in basic base slag and generated $Ca(AlO_2)_2$ which lead the fashioning temperature would change when the content of calcium and magnesium changed in the base slag.

(2) When the melting finished, the wetting angle of CaO was larger than MgO due to CaO and its corresponding compounds were poor fluidity and higher viscosity in high temperature. The viscosity and wetting angle of (Al_2O_3+SiO_2) - CaO was 2,716 Pa·s and 29 °, while the viscosity and wetting angle of (Al_2O_3+SiO_2) - MgO was 1,869 Pa·s and 25 °. Therefore, acid base slag was affected by CaO much which promoted osmosis between the slag system.

(3) Al_2O_3 and SiO_2 could react easier with other components than CaO and MgO, which generated new molten phase of silicate, and promoted the diffusion behavior in the interface section.

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Note: The responsible translator for language English is associate professor W.L. Zhan - Univerisity of Science and Technology Liaoning, China.