THE STUDY ON ASSIMILATION OF IRON ORES AND ORE BLENDING OF ITS COMPLEMENTARY ACTION

Wu Shengli[1]
Chen Hui[2]
Pei Yuandong[2]
Hamilton Pimenta[3]
Dauter Oliveira[4]
Catia Casagrande[3]

Abstract
The assimilation of iron ores, which shows the ability of producing liquid phase during sintering process, has important effect on the quality and yield of sinter. 12 kinds of iron ores from Brazil, Australian, India, South Africa and China have been tested on their assimilation in this paper. Besides, the factors on assimilation of iron ores have been analyzed. And then, the method of iron ore blending is presented on the basis of the complementary action of assimilation, which will enrich the meaning of iron ore blending to guide the sintering practice and perfect the ore-blending theory of sinter.
Key words: Iron ores; Sintering; Assimilation; Complementary; Ore-blending

[1] *University of Science and Technology BeiJing, School of Metallurgical and Ecological Engineering, Xueyuan Road, Haidian District, Beijing, China 100083. Baosteel Research Institute (R&D Center), Shanghai, 201900, China.*
[2] *Baosteel Research Institute (R&D Center), Shanghai, 201900, China.*
[3] *Companhia Vale do Rio Doce S.A., Brazil.*
[4] *University of Science and Technology BeiJing, School of Metallurgical and Ecological Engineering, Xueyuan Road, Haidian District, Beijing, China 100083. Companhia Vale do Rio Doce S.A., Brazil.*

1 INTRODUCTION

In recent years, the sintering production technology of iron ore has advanced greatly. It is well known that Low temperature sintering technology, which can produce sinter ore with high quality possessing proper intensity and reducibility, has been accepted and applied well. However, the consolidation mechanism of sintering doesn't change in that agglomerate forms through solid phase coupling force by melting of low melting point substance and solidification with unreacted particles.[1] Therefore, the sufficient liquid phase under sintering temperature is still the basis of consolidation for low temperature sintering production.

The formation of liquid phase starts from low melting point mineral due to reaction between iron ore and flux. Therefore, the reaction between iron ore and flux directly affects the formation of liquid phase and the liquid phase characteristics. the reaction between iron ore and flux has been studied abundantly by former researchers,[2-9] besides, the concept of assimilation and reactivity of iron ores have been advanced, with the same essence actually. In china, represented by research on sinter basic characteristics developed by USTB, plentiful study has been processed in steel enterprise for the assimilation of iron ore with the purpose of guiding actual production.[6-9] However, reports on ore blending based on the complementary characteristics of the assimilation are few. Therefore, it is necessary to research thoroughly the blending method based on iron ore assimilation according to its complementary characteristics.

In present study, the assimilations of iron ores are measured by micro sintering device. Then, factors influencing iron ore assimilation are analyzed. At last, blending method based on assimilation is put forward following the low temperature sintering principle to guide the optimizing ore blending in actual sintering practice and perfect the ore blending theory during sintering process.

2 ASSIMILATIONS OF IRON ORES AND ITS MEASURED RESULTS

2.1 Assimilation of Iron Ore

Assimilation of iron ore is the ability of reaction between iron ore and CaO during sintering process, and the assimilation refers to the ability of liquid forms during sintering process, which is the basis of efficient bonding of sinter, measured by the lowest assimilating temperature when the melt begins to form at the reaction interface between iron ore and CaO.[4]

Generally speaking, If the lowest assimilation temperature (LAT for short) of one ore is low, it indicates that this ore has high assimilation ability, which enables more liquid forming and bonding phase with high-quality like CF achieving, resulting in improvement of sinter in intensity and reducibility. However, ore assimilation is not good when too high, in the reason that too high assimilation makes sintering materials over-fuse, which deteriorates the permeability of sinter bed, so the quality and yield of sinter is affected. Therefore, it needs the iron ores with proper assimilation in sintering process.

2.2 Experimental Materials

12 kinds of ores are selected in this study. OCSD-A is Laiwu magnetite concentrate, being used commonly in steel plant of Shandong province. The other ores belong to hematite ore limonite types. Among five ores from Brazil, OBR-D is concentrate, and the other four ores are fines, in which OBR-A is from the north of Brazil, and OBR-B is from the south of Brazil, and OBR-C is a new ore into business, while OBR-E is coarse ore from MBR company formerly. Among the four fines from Australia, OAU-A belongs to limonite, and OAU-B is standard sintering fine, and OAU-C is a new ore using in China, while OAU-D has high SiO2 content. OIN-A is Indian fines, and OSA-A is the familiar South African fines. The chemical compositions of 12 types of iron ore are listed in Table.1.

Table 1 composition of iron ore /%

SN.	TFe	SiO_2	CaO	MgO	Al_2O_3	LOI
OCSD-A	65.60	4.30	0.88	1.02	0.88	1.23
OBR-A	66.53	1.32	0.04	0.03	0.79	1.63
OBR-B	65.83	3.35	0.05	0.04	0.64	0.81
OBR-C	64.05	4.35	0.05	0.04	0.73	1.75
OBR-D	67.53	1.14	0.03	0.01	0.39	0.40
OBR-E	66.21	1.72	0.13	0.03	1.73	1.64
OAU-A	57.87	4.18	0.01	0.05	1.59	10.71
OAU-B	64.00	3.92	0.01	0.05	1.73	2.57
OAU-C	62.66	3.40	0.01	0.04	2.26	4.31
OAU-D	59.50	6.83	0.26	0.12	3.07	4.42
OIN-A	60.35	6.13	0.13	0.07	2.65	4.00
OSA-A	65.50	3.86	0.09	0.04	1.43	0.90

2.3 Experimental

Micro sintering method is adopted in this experiment with the mirco sintering device developed by USTB mainly [4]. The LAT, which means the reaction and melt forming on the interface between iron ore and CaO, is measured, and the assimilation of iron ore is gotten.

2.4 Results

Results of the lowest assimilation temperature of 12 kinds of ores are listed in Table 2 and the comparison is shown in Figure 1.

Table 2 The LATs of iron ores /℃

SN.	LAT	SN.	LAT
OCSD-A	1318	OAU-A	1227
OBR-A	1362	OAU-B	1228
OBR-B	1373	OAU-C	1237
OBR-C	1337	OAU-D	1263
OBR-D	1392	OIN-A	1247
OBR-E	1322	OSA-A	1251

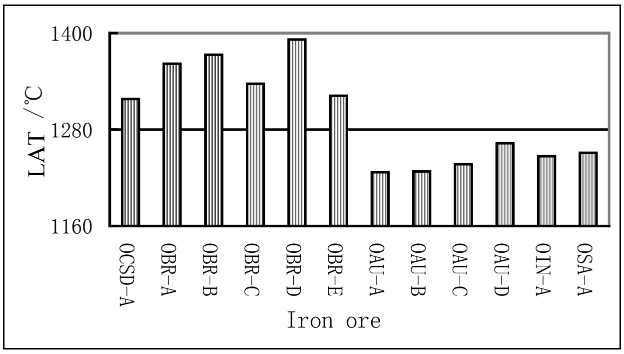

Figure 1 Comparison of LATs of ores

From results it can be found that five Brazilian ores and domestic ores have relatively high LAT, which means relatively low assimilation, while ores from Australia, India and South Africa have relatively low LAT lower than 1280℃, which means relatively high assimilation.

The order of assimilation of 12 kinds of ores from low to high is as follows: OBR-D＜OBR-B＜OBR-A＜OBR-C＜OBR-E＜OCSD-A ＜OAU-D＜OSA-A＜OIN-A ＜OAU-C＜OAU-B＜OAU-A.

3 FACTORS AFFECTING ASSIMILATION

As one of the self-characteristics of iron ores, factors affecting assimilation contain mainly iron mineral type, crystal size and pattern of iron mineral, SiO2 and Al2O3 content, existing state of gangue mineral, crystal water content and dense extent of iron ore, and so on. For one ore, the assimilation usually affected by some special factors mentioned above.

Combining above properties of iron ore, analyze is put up to research on the assimilation as follows.

3.1 Laiwu Concentrate

OCSD-A belongs to magnetite, so it has lower assimilation than ore of hematite type. However, compared with Brazilian ores, the assimilation of OCSD-A is higher for more SiO2 content. In addition, the crystal size is coarse and the texture is dense with a few pores, so the mineralization extent between ore and CaO is restrained, resulting in low assimilation.

3.2 Brazil Ores

Among five kinds of Brazil ores, although hematite is the main iron mineral, assimilations of Brazil ores are low, for the reason that the existing state of gangue mineral is the leading quartz with a few gibbsite, besides relatively big crystal size of iron ore and dense texture with few pores.

Compared with OBR－A, OBR－B has more SiO2 content and denser texture and less pores, so the assimilation of OBR－B is lower than that of OBR－A; OBR－C, with high SiO2 content and crystal water, has higher assimilation than OBR－B; the assimilation of OBR－D is the lowest in the Brazil ores, due to the low SiO2 content and crystal water, besides the dense texture of iron ore; OBR－E has the highest assimilation in five Brazil ores, due to relatively high crystal water, Al2O3 content and porosity.

3.3 Australia Ores

Belongs to limonite type or hematite type with loose structure, four kinds of ores from Australia have high assimilation.

OAU-A is the typical limonite, with goethite as the main iron mineral, has small crystal diameter with size about 2μm and loose structure with lots of pores, and the crystal water is 10.71%. Therefore, the degree of mineralization between ore and CaO improves, resulting in high assimilation.

OAU-B is the typical hematite, with hematite as the main iron mineral, has low crystal water, while SiO2 content is relatively high and crystal diameter is small with the size about 5μm. Therefore, the mineralization extent between ore and CaO is not low, and assimilation of OAU-B is still high.

OAU-C is a new ore put in China market since July 2007, with the iron mineral of coexisting form of hematite and limonite, and the average diameter of crystal size is about 4μm, and the crystal water content is also high, so the assimilation of OAU-C is also high. However, the value of assimilation is smaller than that of OAU-B, because the former has lower SiO2 content.

OAU-D has high SiO2 content, with the iron mineral of coexisting form of hematite and limonite and the gangue mineral of coexisting form of quarts and kaolinite, and the average diameter of crystal size is about 4μm. The SiO2 content is the highest in Australia ores, not in accordance with the lowest assimilation, for the reason that too high SiO2 content that increases the amount of CaO· SiO2, resulting in increase of temperature of liquid phase melting.

3.4 Indian and South African Ores

OIN-A and OSA-A have hematite as their iron mineral. OIN-A has high SiO_2 content and Al_2O_3 content with crystal size of about 8μm in diameter, and the gangue mineral is mainly clay, which possesses high assimilation. Compared with OIN-A, OSA-A has relatively low SiO_2, Al_2O_3 and crystal water content with larger crystal size of about 11μm in diameter, so the assimilation of OSA-A is lower than that of OIN-A. Actually, OSA-A belongs to ores of high assimilation.

4 BLENDING METHOD BASED ON THE COMPLEMENTARY OF ASSIMILATION

As mentioned above, reactivity between iron ore and CaO is not good for sintering production and obtainment of sinter with high quality and yield when it is too high or too low. Therefore, arranging ores with different assimilations in pairs or groups to get the complementary effect should be paid attention, e.g., arrange the ores of high assimilation with the ores of low assimilation, so as to make reactivity between iron ore and CaO is proper, getting sintering blend with proper synthetical assimilation.

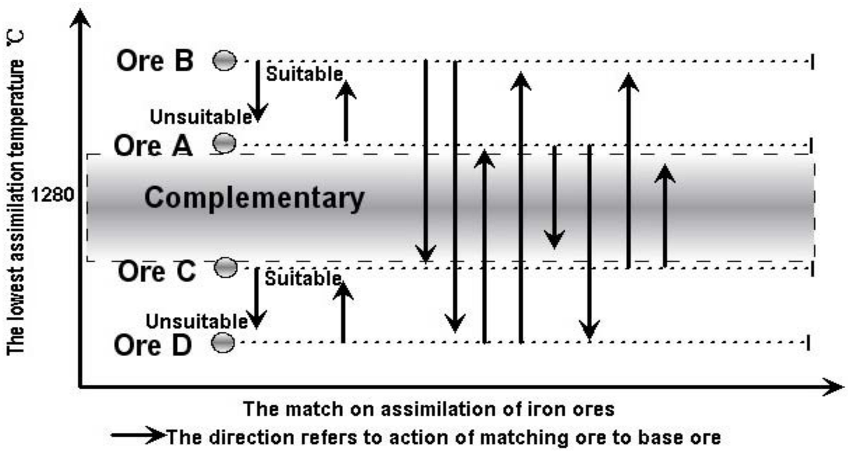

Figure 2. the sketch map of blend principle of ores based on assimilation

Figure 2 shows the sketch map of blend principle of different kinds of ores based on assimilation. In Figure 2, T means the LAT, it can be found that 1280℃ is the temperature which is assumed as the proper temperature existing in sintering process; ore A, ore B, ore C and ore D are the representation of 4 kinds of ores with different LAT; the sign '→' means the direction of putting 'matching ore' into 'base ore'. In the map, there are 12 kinds of matching patterns.

According to the effect of matching ore on basing ore, that is to say, the approaching or leaving extent of making the LAT of base ore toward the proper assimilation temperature (1280℃) by adding matching ore, matching patterns of 12 kinds of ores can be evaluated as the following types: 'unsuitable', 'suitable' and 'complementary', in which 'unsuitable' means there is not improvement of blend ore on assimilation when matching ore is put into base ore, and 'suitable' means there is improvement of blend ore on assimilation when matching ore is put into base ore, and ‘complementary’ means matching ore and base ore can improve each other for blend ore to obtain the proper temperature (1280℃).

From Figure 2, it can be found that, it is suitable for adding ore A to ore B as the LAT of blended ore is lower than that of ore B, that is to say, the LAT of blended ore heads toward the proper LAT (1280℃), while it is not suitable for adding ore B to ore A as the LAT of blended ore is higher than that of ore A. The match between ore C and ore D has similar condition as match between ore A and ore B. However, ore A and ore C, ore A and ore D, ore B and ore C and ore B and ore D all belong to the type of ‘complementary’, e.g., ore A and ore D, when adding matching ore A to base ore D or adding matching ore D to base ore A, the LAT of blended ore goes toward the proper LAT (1280℃).

Based on Figure 2, the evaluation on matching of 12 kinds of ores on assimilation is listed in Table 3, in which the value of first line means the ‘matching ore’, and that of first row means the ‘base ore’. The influencing effect of matching ore on base ore is listed in Table 3, in which the matching effect is expressed by ‘UNS’, ‘S’ and ‘COM’ that refers to ‘unsuitable’, ‘suitable’ and ‘complementary’ mentioned above, respectively.

Table 3 Influencing effect of matching ore on base ore for 12 kinds of ores

Matching ore / Base ore	OCSD-A	OBR-A	OBR-B	OBR-C	OBR-D	OBR-E	OAU-A	OAU-B	OAU-C	OAU-D	OIN-A	OSA-A
OCSD-A		UNS	UNS	UNS	UNS	UNS	COM	COM	COM	COM	COM	COM
OBR-A	S		UNS	S	UNS	S	COM	COM	COM	COM	COM	COM
OBR-B	S	S		S	UNS	S	COM	COM	COM	COM	COM	COM
OBR-C	S	UNS	UNS		UNS	S	COM	COM	COM	COM	COM	COM
OBR-D	S	S	S	S		S	COM	COM	COM	COM	COM	COM
OBR-E	S	UNS	UNS	UNS	UNS		COM	COM	COM	COM	COM	COM
OAU-A	COM	COM	COM	COM	COM	COM		S	S	S	S	S
OAU-B	COM	COM	COM	COM	COM	COM	UNS		S	S	S	S
OAU-C	COM	COM	COM	COM	COM	COM	UNS	UNS		S	S	S
OAU-D	COM	COM	COM	COM	COM	COM	UNS	UNS	UNS		UNS	UNS
OIN-A	COM	COM	COM	COM	COM	COM	UNS	UNS	UNS	S		S
OSA-A	COM	COM	COM	COM	COM	COM	UNS	UNS	UNS	S	UNS	

From Table 3, details on match of assimilation between two ores can be obtained, e.g., OCSD-A and OIN-A belong to ‘complementary’ type. Again, on the condition under 1280℃, the assimilation of OAU-C is lower than that of OAU-A, so when OAU-A acts as base ore, the assimilation of blended ore is lower than that of OAU-A, and this match belongs to ‘suitable’’. Again, the assimilation of OAU-B is higher than that of OSA-A, so when OSA-A acts as base ore, the addition of OAU-B as matching ore is ‘unsuitable’’, otherwise, when OAU-B acts as base ore, the addition of OSA-A as matching ore is ‘suitable’’, because the latter makes the assimilation of blended ore lower than that when the former exists singly, and toward the proper assimilation temperature.

5 CONCLUSIONS

（1）The assimilations of ores from different districts vary apparently, and those from Australia, India and South Africa are relatively high, while those from Brazil and China are relatively low;

（2）The main factors lead to difference in assimilation depend on individual characteristics due to influence of geological condition, which contains chemical composition, mineral composition and microcosmic properties of iron ore.

（3）The actual sintering process needs proper assimilation, so blending method based on complementary action of assimilation should be applied in sintering blend in order to meet the technological condition of low temperature sintering.

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