Journal of Iron and Steel Research, International 24 (2017) 1007－1015

Contents lists available at ScienceDirect

Journal of Iron and Steel Research, International

journal homepage: www.chinamet.cn

Comparison of sintering performance of typical specular hematite ores with distinct size distributions

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ARTICLE INFO

Key words:
Sinter
Specularite
Iron ore
Size distribution
Granulation
Goethite

ABSTRACT

The sintering performance of three typical specular hematite ores (coarse SO-A, intermediate SO-B and ultrafine SO-C) was compared in an industrial ore blend through pilot-scale sinter pot tests. The effect of particle size of specular hematite ores on their granulation and sintering performance was revealed. Compared with the coarse SO-A fine and ultrafine SO-C concentrate, the intermediate SO-B showed inferior granulation and sintering performance characterized with poorer bed permeability and productivity, lower sinter strength and higher fuel rates. A new material preparation method was hence proposed and verified at both pilot and industrial scales. The proposed method by mixing SO-B with a high amount of goethite-type iron ore fines was found to be an effective way in improving the granulation and assimilative characteristics of ore blend comprising 31% intermediate SO-B, leading to improved sinter productivity and lowered fuel rates. The metallurgical properties and microstructure of sinters were also investigated. The sinters obtained through the proposed preparation method were generally stronger and more reducible on account of better sinter structure with more relict hematite ultimately connected with needle-like silico-ferrite of calcium and aluminum and lower porosity.

1. Introduction

The specular hematite ore has become a mainstream feed material for sintering and pelletizing in China on account of its high iron grade, low impurities (e. g., Al_2O_3 and phosphorus, etc.) and significant economic efficiency[1]. The specular hematite, also known as specularite, is a variety of hematite and usually occurs with silvery colour, dense and smooth surface. This type of iron ore can be found widely distributed all over the world, for example the Minas Gerais region in Brazil and the Queber-Labrador region in Canada, both of which have become the biggest specular hematite ore suppliers for China[2]. However, considerable work reported that the specular hematite ores generally possessed poor ballability and low chemical reactivity, which not only largely affected the granulation or balling efficiency, but also had great impact on their high temperature behaviors of sintering and induration[3-7]. Consequently, the amount of specular hematite ore was restricted to below 20% in the ore blend to achieve acceptable productivity and quality of products[8-11].

As mentioned, the predominantly detrimental effect of specularite concentrates for sintering lies not only in the deterioration of bed permeability responsible for lower productivity, but also in the decreased assimilation capacity of iron ore blend with fluxes, leading to less formation of liquid phase and higher energy consumptions[5,12]. Zhu et al.[13,14] found that both the damp milling and high pressure grinding rollers (HPGR) pretreatments were capable of drastically improving the sintering performance of specularite concentrates by improving the ballability and surface reactivity of specularite particles. Furthermore, in order to raise the amount of specularite concentrates in the ore blend, a series of selective granulation processes, namely composite agglomeration process (CAP)[15], POSCO process[16],

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Received 26 October 2016; Received in revised form 19 December 2016; Accepted 20 December 2016
Available online 15 October 2017
1006-706X/

separated granulation-sintering process[17] and pre-briquetting process[18,19], were developed. These processes may have different selective granulation equipments and morphologies of products, but they share almost the same idea that the fine specularite concentrate is selectively balled or briquetted with a part of fluxes, and then mixed and granulated with the rest coarse materials in a traditional granulating drum. And generally, the pellets or briquettes made from specularite concentrate are given a lower basicity than total basicity acting as nuclear skeleton to increase the sinter strength and reducibility, while the other granulated materials will have a higher basicity to generate more liquid phase to hold ore particles together. Through selective granulation processes, the amount of specularite concentrates can be raised to 30% or even higher in the ore blends.

Nevertheless, in previous literatures, few studies were conducted to reveal the effect and importance of inherent particle size distributions of specular hematite ores on their granulation and sintering performance. Therefore, the present study particularly took a comparison of the sintering performance of three typical specular hematite ores that possessed distinct size distributions. And by comparison, the appropriate size distribution of specular hematite ore for sintering was revealed. This work also put forward a new material preparation method to strengthen the granulation and sintering process of ore blends containing a high amount of intermediate specularite concentrate.

2. Experimental

2.1. Raw materials

There are ten iron ores, i. e., three typical specularite ores (SO-A and C from Brazil, SO-B from Canada), a magnetite concentrate (O-D) from South America, four typical goethite-bearing iron ores from Australia (O-E, F, G and H) and two hematite ores (O-I from South Africa and O-J from Brazil). Besides, two under-sized materials (i. e., lump ore and pellet), three recycled materials (RM-A, B and C), four fluxes (i. e., limestone, dolomite, serpentine and burnt lime) and a fuel (coke breeze) are used. The chemical composition and size distributions of raw materials are shown in Tables 1 and 2, respectively.

It is noteworthy that all three specular hematite ores bear evidently lower Al_2O_3 content than Australian ores, which is beneficial for the sintering process[20]. Among three specular hematite ores, SO-A has the highest SiO_2 content of 6.60% corresponding to a lowest iron grade of 62.18%, while SO-C has the highest iron grade of 67.00% and lowest SiO_2 content of 2.29%.

As can be known from Table 2, SO-A is a fine ore with 55.89% passing 1 mm, 43.45% passing 0.25 mm and 28.63% passing 0.063 mm, while SO-C bears the finest granularity with 99.49% passing 0.063 mm. In contrast, the size distribution of SO-B falls in between that of SO-A and SO-C, spe-

Table 1
Main chemical composition of raw materials (mass%)

Raw material	TFe	FeO	CaO	SiO_2	MgO	Al_2O_3	S	P	LOI
SO-A	62.18	1.14	0.12	6.60	0.07	0.98	0.019	0.056	2.34
SO-B	64.74	5.97	0.45	5.65	0.10	0.85	0.035	0.026	0.17
SO-C	67.00	0.00	0.12	2.29	0.03	1.08	0.005	0.036	0.76
O-D	67.58	28.45	0.44	1.76	0.97	0.83	0.032	0.020	0.87
O-E	60.96	0.35	0.17	3.52	0.12	2.32	0.091	0.100	6.31
O-F	58.59	0.00	0.03	5.30	0.06	2.58	0.032	0.069	7.98
O-G	57.60	0.00	0.13	4.57	0.09	1.44	0.021	0.059	11.09
O-H	56.92	0.14	0.35	5.46	0.20	1.24	0.070	0.044	11.04
O-I	64.39	0.00	0.03	4.33	0.03	1.96	0.004	0.025	1.00
O-J	61.62	0.00	0.17	5.31	0.12	0.44	0.000	0.000	2.69
USM-Lump ore	61.90	0.44	0.27	2.57	0.09	1.55	0.028	0.120	6.37
USM-Pellet	63.82	0.00	1.80	3.14	0.18	1.55	0.070	0.054	1.02
RM-A	22.16	14.28	34.93	10.03	7.73	0.97	0.056	0.830	5.34
RM-B	39.67	3.97	3.65	6.33	0.54	2.40	0.340	0.006	29.31
RM-C	57.15	8.95	9.07	5.32	1.72	1.86	0.016	0.062	0.56
Limestone	0.62	0.00	51.23	3.86	0.64	1.51	0.010	0.020	40.88
Dolomite	0.60	0.00	30.53	1.17	19.76	0.05	0.032	0.003	45.93
Serpentine	5.06	2.89	3.18	37.25	35.46	0.82	0.044	0.006	14.16
Burnt lime	0.18	0.00	81.55	3.60	2.04	0.66	0.001	0.001	11.72
Coke breeze	0.20	0.00	0.55	5.81	0.28	3.98	0.620	0.043	86.58

Note: LOI—Loss on ignition.