

Application of Refractory Hematite in Pellets

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Abstract: With the progress of the beneficiation technology, the problem difficult to separate poor miscellaneous hematite can be solved, iron powder with finer grain size. In order to reduce the import of iron ore powder, reduce the cost of raw materials, and make full use of domestic iron ore resources. Do the experimental study that uses the refractory hematite to product pellets. The results show that the hematite ratio should not be too high, when the hematite ratio is 30%, `calcination temperature should be 1240°C, green-ball quality and metallurgical properties of the pellets can meet the requirements of blast furnace smelting. Therefore, it is feasible to use this kind of refractory hematite in the pellets.

Introduction

At present, iron and steel enterprises are facing the double squeeze which from upstream raw materials and fuels and the downstream product market[1], "the beneficiated burden material" policy has been transformed into "the economical material", using a large number of cheap hematite to product pellets will become a trend [2]. Xuanhua area is rich in iron ore resources, magnetite is easy to select with the high grade of iron, but the magnetite resource is reducing day by day; hematite are much of refractory hematite, with the progress of the beneficiation technology, poor, miscellaneous hematite mine selection problem can be solved, iron powder granularity is fine for balling. This can fit into the hematite to produce pellets, and make resource utilization reach to maximize has become the focus of attention.

Test Materials and Methods

Iron Powder

Iron powder is Xuanhua with lower grade of iron and Xuanhua hematite powder with lower grade of iron. The hematite powder is smaller than the magnetite powder, but SiO₂ content is higher. The hematite is irregular xenomorphic granular and is cemented by gangue which base on SiO₂ and consists of fine aggregate. The chemical composition and particle size of iron powder is shown in tab. 1.

Tab. 1 Chemical composition and Size of iron powder (%)

Iron powder	TFe /%	SiO ₂ /%	-0.073mm /%
magnetite	65.60	6.50	70
hematite	51.21	10.4	81.0

Bentonite

Bentonite is the most common a binder in pellets production, has a great influence on the green pellet properties, and its performance in tab. 2.

Tab. 2 Performance index of Bentonite (%)

Swelling capacity [ml g ⁻¹]	Colloid index [ml ·15g ⁻¹]	Montmorillonite content [%]	Blue suction quantity [%]
13	420	75	30

The Test Method

Take 7kg mixed iron powder to pellet in disc pelletizer .The size of qualified ball are 10~12.5 mm and moisture is at 8% around.Roasting is done in shaft electrical furnace.

Bentonite dosage is 2%, Xuanhua magnetite pellets as a standard sample, gradually adding Xuanhua hematite, adding the proportion of followed by 10%, 20%, 30%, 40%, 50%.The mixing proportion are shown in tab. 3.

Tab. 3 Scheme of test (%)

sample	magnetite	hematite
benchmark	100	0
1#	90	10
2#	80	20
3#	70	30
4#	60	40
5#	50	50

The Experimental Results

The Influence on Fresh Pellets Quality

The results are shown in tab. 4.

Tab. 4 The performance of green-ball

Sample	Compressive strength /N one ⁻¹	Drop strength /times one ⁻¹	Cracking temperature /°C
Standard	12.5	5.0	550
1#	12.7	5.4	540
2#	13.8	6.2	534
3#	14.7	6.8	520
4#	13.5	6.4	520
5#	12.9	5.8	520

With the increase of hematite, the compressive strength of green ball increases first and then decreases, when the hematite is allocated to 30%, reache to the maximum value. This is because the compression strength is determined between particles in solid - liquid surface tension caused by the capillary force and the granularity are finer ,the specific surface area are larger, the porosity are smaller, the produced capillary force are greater. The grain size of the hematite is finer than that of magnetite, so the compressive strength of the green pellets increases with the increase of the ratio of hematite. But increase to 30%, the compressive strength of the green pellets began to decrease. This

is because the hematite is irregular xenomorphic aggregate and is cemented by gangue, with the increase of hematite and gangue increased gradually, in small change of water, capillary water saturation deficiency caused by capillary force decreases, and it makes the green pellets ball compressive strength decreased, but still are greater than 9N/one, meet the requirement of pellet production. The change rule of drop strength to be in conformity with compressive strength.

The cracking temperature of green pellet significantly reduces with the increase of hematite, but when the hematite reach to 30%, no significant change in the cracking temperature. This is because the gradual addition of hematite reduce the porosity of the ball, the steam cannot be diffused to the surface in a timely, resulting in the internal steam pressure increases, so the cracking temperature decrease. But because the hematite is irregular xenomorphic aggregate and is cemented by gangue, molecules bound water becomes larger, which reduces the dehydration rate in the drying process, so when the hematite content is more than 30%, there is no obvious change in the cracking temperature.

The Compressive Strength of Pellets with Different Mixing Quantity of Hematite at Different Calcination Temperature

Roasting the standard 1#, 3#, 5# samples to determine the reasonable roasting temperature. The compressive strength at different roasting temperature is shown in Tab. 5.

Tab. 5 The compressive strength under different roasting temperature (N one -1)

Sample	Roasting temperature /°C			
	1180	1210	1240	1270
Standard	2400	2550	2702	3420
1#	1175	1850	2570	3400
3#	1070	1150	2320	3160
5#	990	1000	1314	2280

Tab. 5 shows that at the same temperature the compressive strength of pellets decrease gradually with the increase of hematite. This is mainly because the consolidation mechanism of hematite pellets are very different from magnetite pellets.

Magnetite is mainly oxidized and re crystallized, the atoms at the crystal surface of generated Fe₂O₃ have higher activity, it easy to crystallize and then grow up; On the other hand, Magnetite oxidation can provide heat for the consolidation of the pellets; so the compression strength can reach to the production requirement at lower roasting temperature.

But hematite consolidation is a simple process, in which grain grow and recrystallize at high temperature. In the roasting process, the activity of native Fe₂O₃ was lower than generated Fe₂O₃, diffusion rate of particle is slow, resulting in the crystallization ability of Fe₂O₃ become poor [3]. Especially 5# pellets, the consolidation between the particles is not obvious even at 1240°C, the compressive strength is only 1314°C N one -1. In addition, the increase of SiO₂ content leads to increase slag phase. So the compressive strength of pellets decreases significantly with the hematite ratio increasing at the same temperature. The compressive strength of pellets can meet the production requirements, which must need higher roasting temperature with the hematite ratio increases.

When the roasting temperature is 1270°C, the microstructure of the standard sample and the 5# pellet are respectively shown in Figure 1 and fig. 2.



Fig.1 Mineral composition photo of the basic pellets

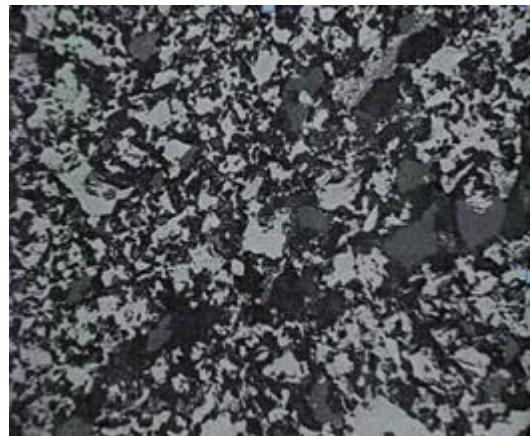


Fig.2 Mineral composition photo of the 5# pellets

As the figure1 shows, In magnetite pellets, oxidized to form Fe_2O_3 recrystallization and grain growth, the crystal growth is good even connect to be a large area with a high compressive strength. Figure 2 shows the 5# pellets, Fe_2O_3 grains become small and silica slag phase increases and Fe_2O_3 grains are surrounded by silicate slag, so the compressive strength decrease significantly.

When the proportion of hematite is the same, the compressive strength of pellets increased with the increase of roasting temperature, because temperature is conducive to the consolidation of pellets.

The Chemical Composition of Pellets

Chemical component is one of the basic indexes which measure pellet quality, containing iron grade and the content of SiO_2 is the main content and the chemical composition of pellets are shown in Table 6.

Tab. 6 Chemical constitution of pellets (%)

Sample	TFe	SiO_2	FeO	CaO	MgO
Standard	63.20	7.10	0.97	0.72	0.54
1#	62.80	8.25	0.75	0.65	0.51
3#	60.66	9.33	0.70	0.66	0.58
5#	56.24	11.76	0.72	0.71	0.60

From Tab. 6, it can be known that, iron content decrease and SiO_2 content increase gradually with the increase of hematite content. This will not only increase slag-iron ratio iron slag in blast furnace, and will worsen the economic and technical index of blast furnace smelting. When the proportion of hematite reaches to 50%, the iron grade down to 56.24%, the SiO_2 content increase to 11.76%, from pellet chemical component should not add proportion of hematite. As far as the chemical composition is concerned, should not increase the hematite proportion.

The Metallurgic Performance of Pellets

Pellets should not only have a good cold state performance, but also should have the metallurgical properties to adapt to the smelting in blast furnace. Metallurgical properties of pellets are shown in tab. 7.

Tab. 7 Metallurgic performance of Pellets

Sample	RDI _{+3.15} /%	RI /%	RSI /%	T _{10%} /°C	T _{40%} /°C	Δ T /°C
Standard	85.45	80.36	16.78	1165	1209	44
1#	86.05	79.40	15.26	1124	1189	65
3#	87.10	77.63	13.82	1084	1175	91
5#	88.50	75.98	10.42	1055	1160	105

The RDI + 3.15 increases with the hematite ratio increase, the main reason is that Fe₂O₃ grains became smaller and the connection is not tight enough. Low temperature reduction pulverization mainly occurred in the vicinity of large granular Fe₂O₃, Fe₂O₃ reduct into Fe₃O₄ with the change of the lattice (Fe₂O₃ is tripartite crystal hexagonal lattice, Fe₃O₄ is shaft cubic lattice), there is no enough pore to buffer the volume expansion around the large granular Fe₂O₃, so engender a great internal stress, which leads to the iron ore crush under the action of mechanical force. Fe₂O₃ grain size becomes smaller with the hematite increase and the connection is loose, there is enough pore to buffer the volume expansion, so the internal stress is small. Also with silica content increase with the hematite ratio increase, the slag can limit the stress destruction, thereby inhibiting the reduction pulverization of pellet.

The reduction degree decrease with the hematite ratio increase, because the SiO₂ content increase, the grains are coated with silicate slag, which is not conducive to the reducing gas diffuse to the interface and reduct.

The reduction expansion ratio of pellets decrease with the hematite ratio increase, because the SiO₂ content increase, the slag phase bonding increase which is conducive to accelerate ion transfer and diffusion, but also to fill in lattice defects, can restrain reduction expansion of the pellets to some extent^[4].

The softening temperature of pellets decreases with the hematite ratio increase, because the slag phase bonding easy to soften. SiO₂ can improve the viscosity of slag phase, lead to softening interval become wide.

Conclusion

Comprehensive indicators, the hematite ratio should be 30% and the roasting temperature is 1240°C, the green ball quality and metallurgical properties meet the requirements of blast furnace smelting. Therefore, it is feasible to use this kind of refractory hematite in the pellet.

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References

- [1] Dai-jun Wang, Wei-tian Chen. Analysis of Blast Furnace Burden Structure and Raw Material[C] Large Blast Furnace Conference. Beijing: The Chinese Society for Metals, 2012: 122.
- [2] Xiao-Qin LI. Behaviores of Carbonin PreParation of oxidized Pellet from Hematite Concentrate [D].Changsha: Central South University, 2009, 12.
- [3] Chang Liu Research on the effect of Hematite Ratio on Oxidation Pellets [D]. Changsha: Central South University, 2011, 30
- [4] Ju-ying Fu, De-qing Zhu. Basic principle, technology and equipment of iron oxide pellets [M]. Changsha: Industrial Press of Central South University.2005: 227-233.