USE OF VALE HEMATITE PELLET FEED IN CHINESE PELLETIZING PLANTS[1]

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Abstract
Central South University and VALE has undertaken studies with the purpose to develop technological solutions for the Chinese pelletizing industry. The final result was optimized by using some technological solutions: (1) Blending hematite with different proportion of magnetite pellet feed (20 and 30%) and grinding it using ball mill, (2) Using 100% hematite pellet feed grinded by ball mill and adjusting basicity by adding limestone and (3) Blending hematite with 30% of magnetite and pre-treating the blended pellet feed with roller press. Good quality was reached on the fired pellets, highlighting: chemical properties, ballability, compressive strength and metallurgical properties.
Key words: Hematite; Magnetite; Pellets; Basicity; High-pressure roller press

O USO DE PELEET FEED DA VALE EM PLANTAS DE PELOTIZAÇÃO CHINESAS

Resumo
A “Central South Uiversity” e a VALE conduziram estudo para desenvolver soluções tecnológicas para o uso de pellet de feed hematítico da Vale na indústria de pelotização chinesa, que são: (1) O uso de pellet feed magnetítico, 20 a 30%, (2) O uso de calcário calcítico para ajuste de basicidade em misturas com 100% de pellet feed moído em moinho de bolas e (3) O uso de prensa de rolos para preparação de misturas com 30% de pellet feed magnetítico. Entre as melhorias obtidas destacam-se: a aglomerabilidade da mistura e a qualidade química, física e metalúrgica da pelota queimada.
Palavras-chave: Hematita; Magnetita, Pelotas, Basicidade; Prensa de rolos

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1 INTRODUCTION

With the fast development of steel industry in China, the production of pellets has been further expanded. Pellets are used as a high quality charge for blast furnace and the annual Chinese output is around 100Mt pellets.[1]

However, the steel industry of China has been confronted with a serious shortage of domestic pellet feed due to the low iron grade of Run-of-Mine ore despite of huge reserves of iron ores.[2] Therefore, more pellet feed, mainly hematite, has been imported to make pellets.

Brazil has abundance in iron ores reserves, especially hematite, and VALE is the major supplier of pellet feed of hematite type.[3] In this context, VALE has been developing important research activities together with customers/partners with CSU support to produce detailed studies by which remarkable technological solutions have been found, adding value for the Chinese pellet industry.

This presentation is aimed at demonstrating how far VALE has been prepared capable not only to supply pellet feed but also to develop technological solutions to the Chinese Pellet industry.

2 CASE STUDY: FIRING PELLETS FROM VALE HEMATITE AND DOMESTIC MAGNETITE PELET FEED BLENDS

As described before, Central South University and VALE has undertaken studies of hematite acid pellet with the purpose to develop technological solutions for the Chinese pelletizing industry.

In this paper, it is described 3 technological solutions to add value on rotary kiln pellet technology, as follows:

- ✓ Blending hematite with different proportion of magnetite pellet feed (20 and 30%) and grinding it using ball mill;
- ✓ Using 100% hematite pellet feed grinded by ball mill and adjusting basicity by adding limestone;
- ✓ Blending hematite with 30% of magnetite and pre-treating the blended pellet feed with roller press

2.1 Raw Materials

The chemical and physical properties of VALE hematite pellet feed and domestic magnetite pellet feed are shown in Tables 1 and 2, respectively.

VALE hematite pellet feed is characterized by higher iron grade (66.79%)$Fe_{(total)}$ and low silica content. The size of VALE hematite pellet feed is 91.14% passing 0.074 mm, with a specific surface of 520 $cm^2 \cdot g^{-1}$, but as we already know it is necessary to reduce the particle size even more, and adequate the blaine to 1500~1700 $cm^2 \cdot g^{-1}$ for the pelletizing process.

The grade of domestic magnetite pellet feed is 64.39% $Fe_{(total)}$ lower than hematite pellet feed content, and FeO content is 25.13%. Moreover, the specific surface area of domestic magnetite pellet feed is much higher than VALE hematite pellet feed, resulting in an excellent ballability.

Table 1 - Chemistry of raw material (mass %)

Ore type	Fe	FeO	SiO_2	Al_2O_3	CaO	MgO	P	S	LOI
VALE hematite	66.79	0.19	2.47	0.82	0.10	0.038	0.042	0.017	0.64
Domestic magnetite	64.39	25.13	4.31	0.86	1.86	0.78	0.007	0.066	0.77

Table 2 - Physical properties of VALE hematite pellet feed and domestic magnetite pellet feed

Ore type	-0.074mm (%)	-0.043mm (%)	Specific surface area ($cm^2 \cdot g^{-1}$)
VALE hematite	91.14	61.59	520
Domestic magnetite	80.40	40.70	1875

2.2 Experimental [4,5]

The pellet feed and bentonite were homogeneously mixed at a given ratio and prepared for balling. Green balls were made in pelletizing discs, and followed by drying and firing. The chief equipment of Rotary-Kiln, which roast pellet, is shown in Figure1.

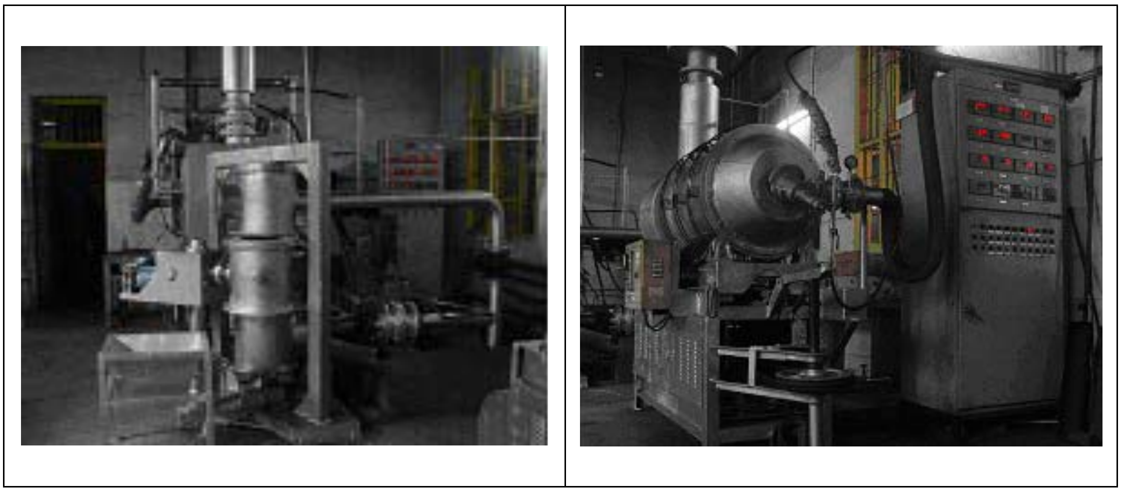

Figure 1 - The equipment of Traveling-Grate & Rotary-Kiln for drying, preheating and roasting pellets

Various characteristics of raw materials, green balls and fired pellets were determined, including size, particle morphologies, specific surface area compressive strength, drop number, thermal stability, metallurgical performance, mineralogy and chemistry of pellets. The specific surface area was measured by Blaine measurement device according to the standard of GB8074-87. The compressive strength of preheated and fired pellets was measured according to the standard of ISO 4700 (1996). The metallurgical performance, including reducibility, reduction swelling were determined according to the standard of ISO 7215 (1995), ISO 4698, respectively.

2.3 Results and Discussion

2.3.1 Test # 1: Blending hematite with magnetite pellet feed

VALE hematite pellet feed was blended with different ratios of magnetite pellet feed and then grinded on ball mill. The mixed and grinded pellet feed was blended with 1.0% to 2.5% of bentonite, pelletized for 15min at moisture of 10%, then dried and fired.

From Table 3, it can be seen the chemical specification of the fired pellets and the characteristics of pellets of VALE hematite blended with different ratios of domestic magnetite pellet feed.

It can be seen that the drop number reached 3.4 times from 0.5m height. The compressive strength of fired pellet reached 2,906 N·pellet^{-1} with magnetite ratio of 30%. Magnetite pellet feed enhances the induration of hematite pellets.

The oxidation of magnetite is exothermic reaction, which contributes to good firing and lower fuel consumption. The newly formed hematite from magnetite oxidizing has higher reactivity during solid state reactions. In the meantime, exothermical reaction of magnetite oxidating into hematite can raise the temperature inside pellets.[4]

On the other side, it can also be seen that the RI and RSI of fired pellets blended with magnetite fall short of the quality standard. It was proposed to reproduce again test # 1, but using high pressure roller press instead of grinding ball mill aiming at increase balling property by way of improving iron ore surface character. The test # 3 describes the results.

2.3.2 Test # 2: Using 100% hematite pellet feed and adjusting basicity

The same methodology adopted on test # 1 was again used, but this time using 100% hematite and adjusting basicity by adding limestone. Table 3 shows the characteristics of 100% VALE hematite pellets at two different acid basicity levels.

It can be seen that the compressive strength of fired pellets increased from 2,228 N·pellet^{-1} to 2,624 N·pellet^{-1} with the basicity of pellets rising from 0.2 to 0.3. The additive accelerates solid state reaction, boosts up the intensity of induration and reduces bad effect on metallurgic performance of pellets[5]. But there is suitable basicity according to different SiO_2 content, it is very important to choose suitable basicity of pellets which can guarantee not only good compressive strength of fired pellets but also good metallurgic performance of pellets.

In conclusion, the method of adjusting basicity by adding some additive is propitious to improve the characteristics of hematite pellets.

Table 3 - Chemical, physical and metallurgical properties of fired pellets in different conditions

Test type	Chemical properties					Physical properties		Metallurgical properties		
	Tfe	FeO	SiO_2	Al_2O_3	CaO	Drop times Times/0.5m	CS (N/pellet)	RI (%)	RSI (%)	RDI -3.15mm (%)
# 1	66.18	0.47	4.04	1.86	0.47	3.2	2,741	63.44	35.86	2.74
	65.82	0.42	4.14	1.92	0.64	3.4	2,906	58.82	20.36	2.07
# 2	65.82	0.43	3.51	1.05	0.70	;3.3	2,228	64.36	25.96	2.67
	65.55	0.40	3.54	1.03	1.05	3.1	2,624	68.79	21.37	1.24
# 3	65.82	0.42	4.14	1.92	0.64	6.0	2,478	67.18	13.08	2.35

2.3.3 Test # 3: Blending hematite with magnetite and pretreating the blended pellet feed with roller press

For test # 3, 70% of hematite was blended with 30% of domestic magnetite and then pre-treated the mixed material by roller press. Table3 shows the characteristics of the pellets with the feed pretreated by the roller press. A roller press circuit with close recirculation circuit was tested.

It can be seen that the characteristics of pellets was improved because the pellet feed was pretreated by roller press before balling. Statistic ballability index achieved 0.798 for the recirculation circuit.The drop strength of green balls increased from 3.4 to 6.0 times from 0.5m height, at the same time, the bentonite dosage decreased from 1.5% to 0.7%. The finer the pellet feed pre-treated by press roller, the lower of reduction swelling degree of fired pellets, which is below than 15%. Reducibility of pellets also increased to 67.18% when the pellet feed is pre-treated by roller press.

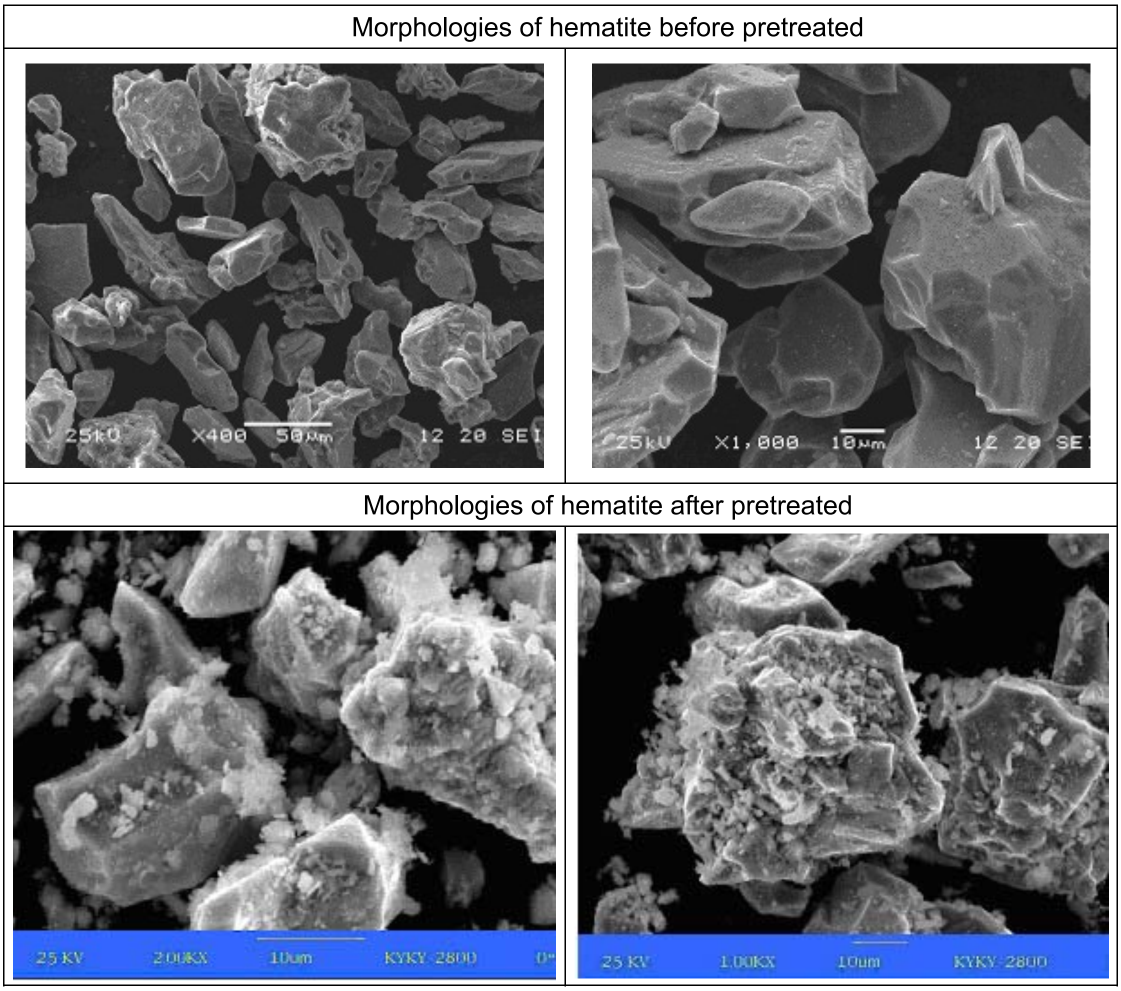

Figure 2 - Morphologies of hematite remodeled by roller press pretreating

After pre-treating pellet feed blend, the specific surface area reached around 1500 $cm^2 \cdot g^{-1}$, with much rougher surface and more super fine particles occurring, as shown in Figure 2. The activation of crystal lattice and an increase in specific surface area by roller press can enhance balling dynamics and speed of solid state reaction.[6,9] Pre-treating hematite is a good technique, which can wreck the disfigurement of crystalloid and activate the crystal. Note on figure 2 that the hematite after pretreated by roller press have good mineral composition and microcosmic structure, which can improve the quality of the pellets.

That the surface is activated by the mechanical action of the HPGR can be further proved by the wetting enthalpy and pelletability index (Figure 3 and Table 4). It can be observed that wetting heat increases from 0.1813 to 0.1939 J/g for single VALE PF and 0.4443 to 0.5302 J/g for blends of VALE PF/Magnetite=70/30 by pretreating concentrates using HPRG. The higher surface free energy of the particles is thought to be due to the lattice deformation and defects by HPRG, with more wetting enthalpy released when these particles come in contact with water molecules.

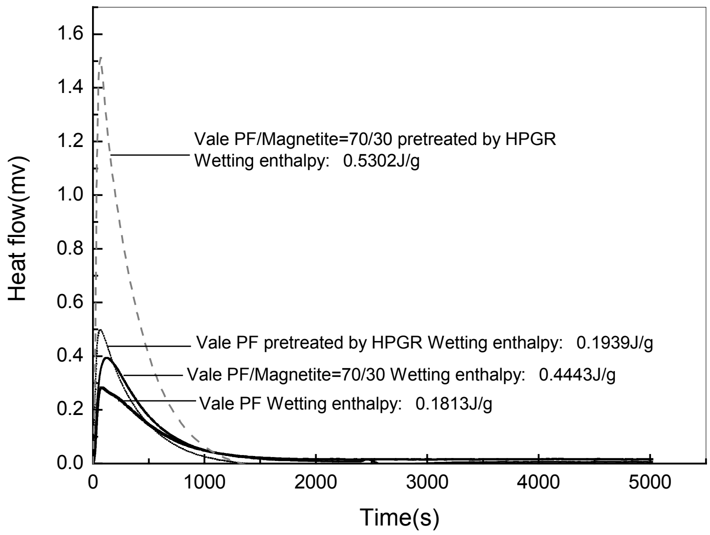

Figure 3 - The pretreatment of HPGR effect on wetting enthalpy of concentrates

It can also be noticed from Table 4 that the ballability index is increased from poor (0.150 and 0.230) to better (0.580 and 0.470) by pretreating the concentrates. There is agreement among results for the degree of lattice deformation, wetting enthalpy and strength of the green pellets. The improved surface activity of concentrate particles is ascribed to the mechanical activation of the HPRG, in which mechanical energy is transferred into chemical energy which is stored in the iron ore concentrates crystal grains, and resulting in higher lattice deformation and defects.

Table 4 - The pretreatment of HPGR effect on ballability of concentrates

Condition	Maximum molecule moisture (%)	Maximum capillary moisture(%)	Static ballability index
VALE PF	1.89	14.24	0.150
VALE PF pretreated by HPGR	4.62	12.55	0.580
VALE PF/Magnetite=70/30	2.84	15.27	0.230
VALE PF/Magnetite=70/30 pretreated by HPGR	5.37	16.12	0.470

In general, pre-treating hematite pellet feed using the roller press is an optimal technique to improve pellets quality.

3 CONCLUSION

(1) According to some studies undertaken from Central South University and VALE on hematite acid pellet, technological solutions were achieved for the Chinese pellet industry. Beneficial improvements on productivity and quality were achieved by using VALE Higher Value in Use pellet feed on rotary kiln technology. The final result

was optimized by using some technological solutions, such as:

- Blending hematite with different proportion of magnetite pellet feed (20 and 30%) and grinding it using ball mill.
- Using 100% hematite pellet feed grinded by ball mill and adjusting basicity by adding limestone.
- Blending hematite with 30% of magnetite and pre-treating the blended pellet feed by roller press is an optimal technique to improve pellets quality. Good quality was reached on the fired pellets, highlighting: chemical properties, ballability, compressive strength and metallurgical properties.

(2) VALE believes it is not only prepared to supply hematite pellet feed, based on superior quality, but to develop and offer customized technological solutions for the Chinese pellet industry. Moreover, VALE is quite confident that it will manage to consolidate our attendance in the Chinese market as a reliable supplier ready to establish long-term relationships. Thereby, VALE reaffirms its intention to continue strongly with the successful technical relationship developed with its customers and partners to proceed with the establishment of an open channel for interchanges.

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