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Effects of high pressure roller grinding on size distribution of vanadium-titanium magnetite concentrate particles and improvement of green pellet strength

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ABSTRACT

The vanadium-titanium magnetite concentrate from Panxi region of China was pretreated by high pressure roller grinding (HPRG) and then used in pelletization. Size distribution change of the vanadium-titanium magnetite concentrate after HPRG and the improvement of its green pellet strength were investigated. The results indicated that, besides the increase of fine particles, the vanadium-titanium magnetite concentrate after HPRG had a smaller size ratio of fine particle to coarse particle of 0.126, meaning a lower porosity, compared with the size ratio of raw material of 0.157. The concentrate particles were more closely packed when there was a smaller size ratio of fine particle to coarse particle. The particle packing in the green pellets was closer after HPRG, which strengthened the green pellets with an average drop number of 5.1 (drop height of 0.5 m) and average compressive strength of 13.1 N per pellet of 11 mm in diameter.

1. Introduction

Pelletization is one of the agglomeration methods widely used to utilize iron ore concentrate, and it plays an increasingly important role in the iron and steel industry. Green pellets with a high drop number and high compressive strength, are required in pellet production to meet the requirements of pellet transport on rubber conveyor belts and charging into grate-kiln. Thus, the production of high-quality green pellets with high strengths is of great significance to the smooth running and efficient production of the grate-kiln.

A previous research[1] on the production of green pellets and experience in industrial pelletization showed that the pelletizing properties of iron ore concentrates were good when 60% of the concentrate particles were smaller than 45 μm or 90% were smaller than 75 μm or the specific surface area of the concentrate was above 1500 cm^2/g. An empirical conclusion was obtained that the strength of green pellets was improved by increasing the amount of fine particles in the raw concentrate. Thus, a number of pretreatments of iron ore concentrate are applied in pelletization to utilize the concentrate with large particle sizes. There are mainly three methods currently used: ball milling, damp milling and high pressure roller grinding (HPRG); they are adopted to crush large particles and increase the specific surface area of concentrate with the aim to improve the pelletizing properties.

HPRG used in pellet production is attracting increasing attention in the iron and steel industry, because it not only is energy-efficient and of great capacity but also can efficiently improve the strength of pellets and decrease the bentonite dosage. The ground particles in HPRG can be directly used as the raw materials in pelletizing without drying process in the ball milling, thus greatly decreasing energy consumption. Besides, HPRG has a larger processing capacity to deal with the iron concentrate compared with the damp milling. Furthermore, the grinding mechanism of HPRG is whole layer grinding, so that concentrate particles are crushed with the interactions of adjacent particles in the whole layer between two rollers under high pressure, in which particles with more cracks and crushes are obtained. Whereas, individual particles are milled among steel

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balls both in ball milling and damp milling, and even particles are obtained with less angles and cracks. Selective crushing occurs in HPRG as those cracks and crushes generally form and grow in the interfaces of crystal faces in the particles. Thus, it is significant to research the effect of HPRG on pellet production to improve pellets properties and decrease energy consumption in pellets industry.

There are many relevant studies[1-12] on the effect of HPRG on pellet production. Some researchers[2-4,6-9] pointed out that lattice imperfection of iron ore concentrate was developed by HPRG when iron ore concentrate was crushed to fine particles with an increasing part of the mechanical energy being converted to surface activation energy, which is called mechanical activation. The mechanical activation of HPRG has been found to be beneficial to improve the pelletizing and roasting properties of iron ore concentrates, and it is proven that iron ore concentrate particles become finer and many fresh surfaces are exposed by HPRG. However, there are few studies emphasizing the entire particle size distribution change of iron ore concentrate after HPRG and its effect on the pellets properties. It is reported[1,13] that particle size distribution of iron ore concentrate is one of the key factors to influence the pellets properties, especially for the green pellets as the particles size distribution affects the cohesive forces between particles in the green pellets. Thus, the improvement of green pellets strength after HPRG pretreatment was researched in this work from the perspective of particle size distribution change by HPRG.

Vanadium-titanium magnetite concentrate from the Panxi region of China is refractory and hard to be pelletized, which always needs to be pretreated before pelletization. This vanadium-titanium magnetite concentrate was pretreated by HPRG to crush the large particles, and the effect of HPRG on the size distribution change of vanadium-titanium magnetite concentrate and the improvement of green pellet strength was systematically investigated in this work.

2. Materials and Methods

2.1. Properties of raw materials

The vanadium-titanium magnetite concentrate used was from Panxi region, Sichuan, China. The chemical composition of this vanadium-titanium magnetite concentrate is presented in Table 1. Its specific surface area was 940 cm^2/g. Its cumulative value of size smaller than 75 μm accounted for 60.4 wt.% and that of size smaller than 45 μm accounted for 42.9 wt.%, which did not meet the size requirements for pelletization.

Bentonite used in the pelletization in this work was from Weiyuan Steel Co., Ltd., China.

Table 1
Chemical composition of vanadium-titanium magnetite concentrate (wt.%)

TFe	FeO	SiO_2	Al_2O_3	CaO	MgO	K_2O	Na_2O	MnO	S	P	V_2O_5	TiO_2
54.70	26.58	4.09	4.16	0.37	2.53	0.03	0.07	0.25	0.12	0.03	0.62	11.75

2.2. Experimental procedure

Samples of as-received vanadium-titanium magnetite concentrate and after pretreatments were analyzed by a laser particle size analyzer to obtain their size distribution. Meanwhile, the concentrate with and without pretreatments were pelletized in a disc pelletizer with a diameter of 1000 mm, a height of 250 mm and a rotation speed range of 0－40 r/min. A 5 kg batch of the concentrate was mixed with bentonite at a suitable ratio and pelletized with the rotation speed of 22 r/min. Green pellets with diameters from 10 to 12 mm were chosen as the green pellets after pelletization for 12 min, and used for drop number and compressive strength analyses.

2.3. Pretreatments via high pressure roller grinding

The machine for high pressure roller grinding was a high-pressure grinding roller mill with the rollers of 250 mm in diameter and 120 mm in length, and the pressure range of 0－50 kN. The pressure was fixed at 31.4 kN to make the intensity of pressure on the cross section of the roller being 1 MPa. This high pressure was used to pretreat the concentrate with a water content of 6.5 wt.%. It takes several times for the concentrate passing through the roller mill to reach the target specific surface. Fig. 1 shows the schematic diagram of high pressure roller grinding.

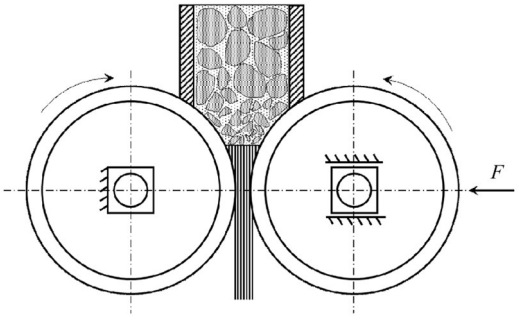

Fig. 1. Schematic of high pressure roller grinding.