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EXPERIMENT STUDY ON THE EFFECT OF IRON ORE SINTER BEHAVIOR WITH ADDING BIOMASS

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This paper focused on the effect of sinter behavior with biomass.The changes of the relevant performance indexes of this sinter behavior, emission laws of harmful gases in flue gas emissions and the mechanism of emission reduction was studied in this paper.The results showed that, when the biomass amount is 0,28 %, the sinter index can meet production requirement, the porosity of sinter increased by 18,5 %, the sinter reduction degree increased by 2,66 %, the SO_2 emissions of harmful gases in the flue gas reduced by about 14 %, the amount of NO_x about 19 % lower.

Key words: sinter; biomass; porosity; reduction degree; harmful gas reducing

INTRODUCTION

Sinter has been playing an important role in the furnace charge structure of traditional iron and steel enterprises, however, it's not negligible that the annual energy consumption of sinter is about 9 % - 12 % of the total steel industry, of which solid fuel energy consumption accounted for about 75 % - 80 % [1-4]. In addition, the annual emissions of NO_x, SO_2 and other harmful gases in sinter production accounted for 40 % ~ 60 % of the total emission of steel industry [5]. Therefore, sinter enterprises become the main source of pollution of air pollution [6-8]. That's contrary to the policy of green production of energy conservation and emission reduction in China, therefore, the state has intensified the comprehensive treatment of the flue gas in sinter and other industries.With this as a background, seeking a new clean and cheap energy can't only improve the situation of environment pollution in China but also alleviate the dilemma of energy exhaustion. Biomass [9, 10] is widely concerned by scholars due to its resource rich, clean and renewable. Biomass energy is mainly derived from the photosynthesis of green plants.In theory, as long as solar energy is available, biomass energy can be continuously regenerated.

At present, foreign countries are still in the experimental research stage in this field, thoughForeign scholars began to explore and study the biomass energy earlier while China has started relatively late in this field, resulted few literatures are available.

This paper focused on the effect of sinter behavior with biomass as additive. By sintering cup experiment combined with the TG-DTG system, investigated the changes of the relevant performance indexes of this sinter behavior, explored the emission laws of harmful gases in flue gas emissions and analyzed the mechanism of emission reduction.

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EXPERIMENTAL

Sample

A metallurgical sinter materials which is utilized in actual production is selected the sample of this study, the proximate and ultimate analyses are shown in Table1.

Table 1 **Chemical composition of materials / wt%**

Type of raw material	TFe	FeO	SiO_2	CaO	MgO	S
ANQ	65,48	8,13	4,35	0,38	0,17	0,035
ZC	63,25	7,37	7,53	0,28	0,37	0,091
BAX	65,24	0,45	3,12	0,21	0,22	0,009
FK	55,58	7,84	6,17	12,15	1,75	0,019
Quicklime	—	—	1,68	87,13	0,58	—
Magnesite	—	—	2,75	1,60	44,73	0,028
Limestone	—	—	2,85	47,50	2,09	0,069

Thermogravimetric and Differential Thermogravimetric curves analysis

As Figure 1 shown, the biomass possess lower combustion temperature and burning time than pulverized coal. It has been completed combustion at 300 °C ~ 450 °C, after combustion, the biomass weightlessness rate is about 88 % and pulverized coal is about 80 %, which is caused by two different ash content.

Among three peaks in the DTG curve of biomass, 63 °C is caused by free water dissipation, and 326 °C corresponds to the volatiles heat precipitation, and 434 °C

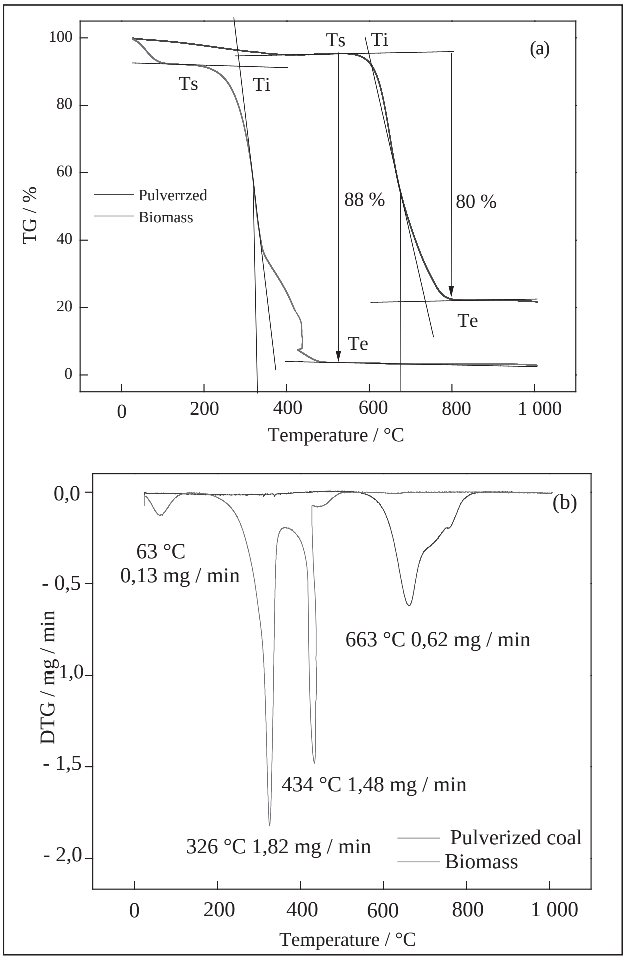

Figure 1 TG (a) and DTG (b) curves of nonisothermal combustion of pulverized coal and biomass

is because of the carbon combustion reaction of biomass. The moisture and volatiles of the pulverized coal are lower, so that only one peak in the DTG curve is generated at 663 °C due to the combustion of carbon. The DTG curve of pulverized coal is relatively gentle while the DTG curve of biomass is mainly spikes and the peak value fluctuates greatly.

Porosity and reducibility of sinter

Due to the porous structure of the sinter, so analysed the effect of porosity on the sinter reduction degree by Porous Body and Reaction Model,

$$D_{Ae} = \frac{1}{\frac{1-\alpha N_A}{(D_{AB})_e} + \frac{1}{(D_{KA})_e}} \quad (1)$$

In the formula, $\alpha \equiv 1+J_B/J_A$, J_B and J_A represent the diffusion flux of element A and B, N_A is the number of molecules of A, $(D_{AB})_e$ and $(D_{KA})_e$ represent Fick diffusion coefficient and Knudsen diffusion coefficient of AB binary system.

$$(D_{AB})_e = (D_{AB}) \times \frac{\varepsilon}{\zeta} \quad (2)$$

$$(D_{KS})_e = (D_{KA}) \times \frac{\varepsilon}{\zeta} \quad (3)$$

$$D_{KA} = 3,068r\sqrt{\frac{T}{M}} \quad (4)$$

In the formula, M_A is the molecular weight of A, r is the pore radius, D_{AB} could calculate enough accurate values by gas dynamics theory of Enskog and Chapm, ε is porosity, ζ represent maze degree.

Eliminating the influence of the shape of the sinter porosity and the pores distribution, the temperature and the gas property are constant in each experiments. So the porosity of the sinter becomes the limiting part of the effective diffusion coefficient of CO. Increased the porosity of the sinter and optimized the kinetic conditions of the diffusion of CO, which is beneficial to the sinter internal diffusion of the reducion. Due to the increasing of porosity, the contact area of gas-solid phase also increased, which promoted the sintering reduction degree.

Analysis of influence on SO_2 emission process

After added biomass, can be seen from Figure 2, the the concentration peak value and SO_2 emission time of sinter were significantly reduced, the total emissions of SO_2 in sinter flue gas was on the decline. In the experimental group, when 0,56 % of the biomass is added, the emission reduction of SO_2 is 23,71 %.

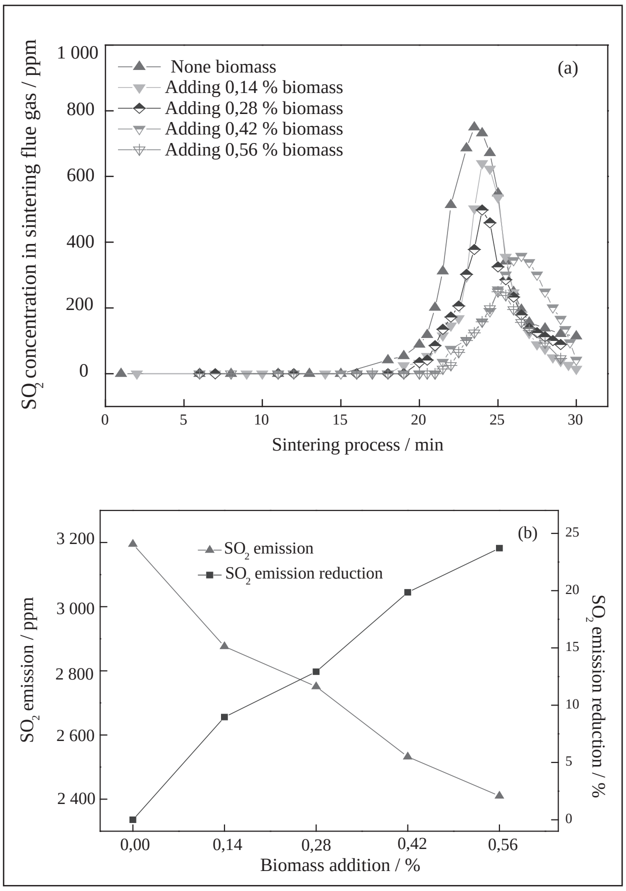

Figure 2 The effects of adding biomass on SO_2 concentration (a) and emissions (b)

Analysis of influence on NO_x emission process

In the sinter test after adding the biomass, the NO_x concentration and the peak value were slightly decreased which shown in Figure 3. When 0,56 % of the biomass is added, the emission reduction of NO_x is 24,32 %.

RESULTS AND DISCUSSION

Combustion characteristic of pulverized coal and biomass

Referring to Table 2 and Thermogravimetric and Differential Thermogravimetric curves analysis, it indicated that biomass doesn't have constant combustion velocity while being heating, and the biomass has a shorter combustion time. under the same conditions, the biomass has better combustion characteristics than pulverized coal.

Table 2 **Characteristic parameters of nonisothermal combustion of pulverized coal and biomass**

Fuel type	Ignition temperature / °C	Burnout temperature / °C	Maximum burning rate /min
Pulverized coal	600	850	0,62
Biomass	295	500	1,82

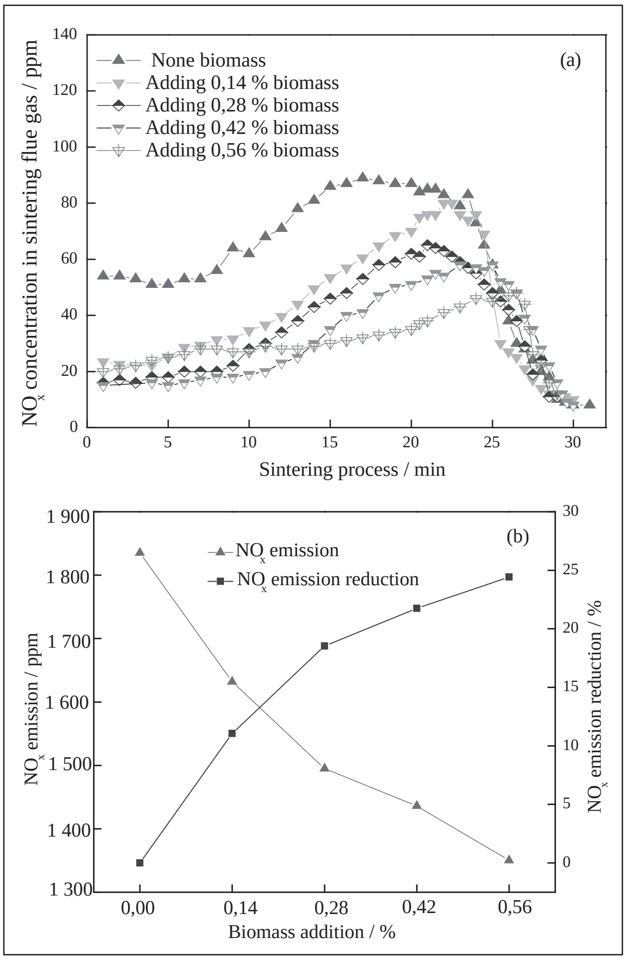

Figure 3 The effects of adding biomass on NO_x concentration (a) and emissions (b)

Porosity and reduction degree of sinter

Referring to Table 3, the addition of biomass to the sinter increased sinter internal porosity. Due to the combustion characteristics of biomass, it has a lower ignition point and a faster burning rate which lead the biomass in the layer is burned firstly and burned out before the arrival of the flame front, leaving a large number of pores. With the liquid phase gradually solidified, it caused a significant increase in the porosity of sinter, which is beneficial to the sintering internal diffusion of the reducion. Due to the increasing of porosity, the contact area of gas-solid phase also increased, which promoted the sinter reduction degree.

Effect of adding biomass on the regulation of harmful gas emission

The lower temperature promoted the formation of $CaSO_4$, because when the temperature exceeds 900 °C, part of $CaSO_4$ decomposed and released SO_2, when the temperature exceeds 1100 °C, the decomposition reaction rate is further accelerated, and more SO_2 gas released, which reduced the sulfur removal efficiency of CaO.

The calorific value of the biomass itself is lower, which partially inhibits the decomposition of $CaSO_4$ and enhances the sulfur fixation efficiency of CaO. In addition, the addition of biomass in the sinter, created a large number of pores, which created a good dynamic conditions for the diffusion of SO_2, improved the surface diffusion conditions of SO_2 to CaO, increased gas-solid contact area of CaO desulfurization reaction and reaction time. That further strengthened the desulfurization reaction.

The nitrogen in the pulverized coal is easily released at higher temperatures.At temperatures above 1000 °C, the precipitation rate is significantly enhanced and the amount of NO_x generated increases.The biomass combustion process causes the local temperature of the sinter layer decreased instantaneously, inhibit the release of nitrogen in the pulverized coal and reduce the generation of fuel type NO_x.

The formation of NO_x is an oxidation reaction. As Figure 4 shown, added different amount biomass, the rate of CO/O_2 in the combustion zone would gradually increased, in addition, a reduction atmosphere of CO gas is formed in some areas of the sinter material layer, which suppressed the change of nitrogen element in the volatile matter, further reducing the generation of NO_x.

Table 3 **The effects of adding biomass on porosity and reduction index of sinters**

Additive amount / %	Porosity / %	Reduction index / %
0	21,12	85,06
0,14	23,38	86,01
0,28	25,03	87,32
0,42	27,32	88,33
0,56	28,85	89,88

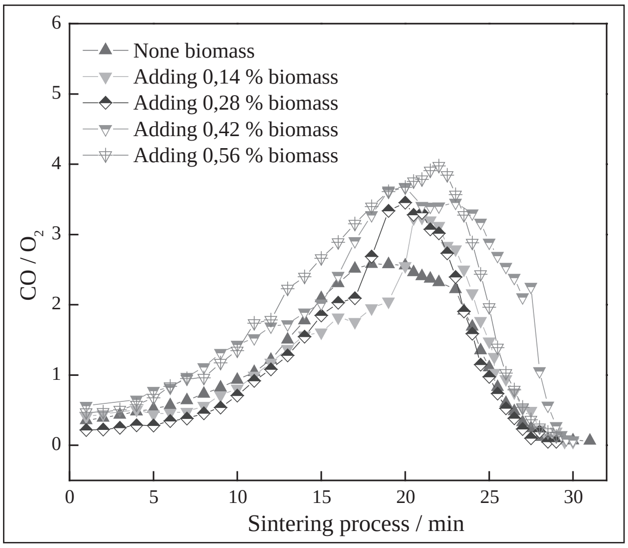

Figure 4 The effects of adding biomass on CO / O_2

CONCLUSIONS

The experimental results show that the biomass has good combustion characteristic, the combustion initiation temperature and the burning temperature are lower, and the burning rate is faster. So the addition of biomass, the porosity of the sinter has been significantly increased, the reduction degree of sinter has also corresponding improved. The results showed that, when the biomass amount is 0,28 %, the sinter index can meet production requirement, the porosity of sinter increased by 18,5 %, the sinter reduction increased by 2,66 %, the SO_2 emissions of harmful gases in the flue gas reduced by about 14 %, the amount of NO_x about 19 % lower.

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Note: The responsible translator for language English is doctor W.L. Zhan - Univerisity of Science and Technology Liaoning, China.