
Research of the Effect of Different Dosage of Grinding Aids on Properties and Process Parameters of Steel Slag Power

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Abstract: Because of the high hardness and poor wear resistance of steel slag, the potential cementing property of steel slag can not be effectively exerted, and the utilization rate of steel slag is low. In order to improve the performance and grinding efficiency of steel slag powder, different grinding aids were added in the process of steel slag grinding in laboratory and production line respectively. The effects of different grinding aids on the performance and technological parameters of steel slag powder were studied. The results show that the specific surface area of steel slag powder is higher or lower, the fluidity and the activity index increased, the energy consumption of ball mill is reduced, the energy consumption of elevator and separator increased. The following conclusions can be drawn: (1) Steel slag properties: different grinding aids have no obvious effect on the grinding fineness of steel slag powder, but can effectively improve the activity index of steel slag powder. (2) Technological parameters: different dosage of grinding aids can reduce the power consumption of ball mill and improve the energy power consumption of elevator and separator. With the increase of dosage, the process parameters will be greatly affected, so the amount of grinding aids should be effectively controlled.

Keywords: Grinding Aids, Steel Slag Powder, Quality Characteristics, Process Parameters

1. Introduction

China is the largest producer of steel in the world [1]. According to the statistics of National Bureau of statistics, the cumulative output of crude steel increased by 5.7% in 2017, reaching 831 million 730 thousand T [2]. Steel slag is a by-product of iron and steel production, The yield is about 10% ~ 15% of the coarse steel [3]. At present, the comprehensive utilization rate of steel slag in China is about 50% to 60% [4], but only about 10% in building materials [5]. China's 70% steel slag is a converter steel slag with similar chemical composition and silicate clinker, and has potential cementitious properties [6]. The utilization rate of steel slag is relatively low. The main reason is that the steel slag has poor abrasive wear and high grinding energy consumption.

In recent years, with the attention paid by the cement and concrete industry to the saving, consumption and emission reduction, the slag powder made from steel slag has begun to be used as the active mineral admixture in the production of cement concrete [7]. And the research of steel slag grinding aids is becoming more and more. The traditional grinding aids

can be divided into liquid grinding aids and solid grinding aids. Most of their basic components belong to organic surfactant. They are mainly amines, alcohols, ethanolamines, lignosulfonic salts, fatty acids and their salts, alkyl sulfonates, etc [8-11]. Qin yumin found that different grinding aids can help the grinding of steel slag in Baosteel [12]. It can improve the effect of the specific surface area to the activity index, and the setting time has some influence, which can reduce the energy consumption of the production. Cheng zhou found that the optimization effect of grinding agent on the grain size of steel slag is mainly within 30min, and it can improve the strength activity index of steel slag and reach the standard of C type fly ash [13]. Wu Gang, Li Weifeng, Liusi, Joseph J, Zhu Xi and other studies show that the specific surface area, the activity index and the cementitious activity of steel slag with the grinding agent are improved with the addition of the grinding agent [14-18]. There is a lot of analysis on the influence of grinding aids on the grinding properties of steel slag in the laboratory, but there is still a big gap between the

test room environment and the large production. Some arguments still need to be tested in practice.

In this paper, the application effect of the same kind of grinding aids was tested under the test room and the actual production conditions. The double circulation grinding system of Shanghai Baosteel New Building Materials Technology Co., Ltd. was used, and the properties of the products were studied by the quality characteristics and technological parameters of the products. Influence of grinding process parameters.

2. Raw Materials and Test Methods

2.1. Raw Materials

Steel slag: taken from Shanghai Baoshan Iron and Steel Group, its chemical analysis data are shown in Table 1.

Cement: reference cement specified in GB 8076-2008 "concrete additive".

Grinding aids: ZM provided by A company.

Standard sand: GB/T 17671-1999 standard sand specified in "strength test method for cement mortar".

Mix water: tap water.

Table 1. Chemical composition of steel slag /%.

Al ₂ O ₃	MgO	Fe ₂ O ₃	SO ₃	MnO	CaO	SiO ₂	S	P ₂ O ₅
1.38	9.94	28.17	0.70	1.86	43.73	12.07	0.037	2.14

2.2. Test Methods

2.2.1. Addition of Grinding Aids, Sampling of Steel Slag Powder and Testing of Physical Properties

The same batch of stable steel slag was used for grinding test, and the output of ZM1 was 0.05%, 0.06%, 0.075% of the output of 34t/h. The steel slag was directly added before the ball mill was sent to the ball mill. After running 2h, the physical properties of the powder were tested.

2.2.2. Determination of Properties of Steel Slag Powder

- (1) The specific surface area was determined according to GB/T 8074-2008 method for determination of specific surface area of cement.
- (2) The determination of water consumption, setting time

and stability of the standard consistency of slag powder-cement is carried out according to GB/T 1346-2011 "test method for water consumption, setting time and stability of cement standard consistency".

- (3) The strength of mortar is determined according to GB/T 17671-1999 test method for strength of cement mortar.
- (4) Determination of activity index and fluidity ratio of steel slag powder according to GB/T 20491-2006 steel slag powder used in cement and concrete.

3. Test Results and Analysis

The influence of 0.1% admixture grinding aid ZM on the performance of steel slag powder was tested in the laboratory. The test data are shown in Table 2.

Table 2. Comparison of flow rate of mortar and activity index of steel slag powder in laboratory.

Number	Specific surface area of steel slag powder/ m ² .kg ⁻¹	Dosage of grinding aids/%	Fluidity/mm	compressive strength/ MPa			Active index/%		
				3d	7d	28d	3d	7d	28d
Cement mortar *	-	-	215	21.0	38	53.4	100	100	100
GZ1	394	-	212	7.9	24.7	42.7	37	65	80
GZ2	445	-	212	7.0	25.8	43.3	33	68	81
GZ11	404	0.1	215	9.7	25.8	45.4	46	68	85
GZ21	440	0.1	214	8.2	25.8	47.0	39	68	88

Note: GZ1 is a small mill grinding 45min slag powder in the test room, GZ2 is a small grinding powder of 60min steel slag powder in a test room, GZ11 is a small grinding 45min steel slag powder with 0.1% grinding aids, and GZ21 is a small grinding slag powder of small grinding mill with 0.1% grinding aids.

*Cement mortar is used for calculating the activity index of steel slag powder and made of pure cement.

It is visible from table 2,

- (1) Specific surface area. In the laboratory, the specific surface area of the slag powder with 0.1% grinding aids is more than that of the non admixture, and the specific surface area of the GZ11 adding grinding agent is 10m²/kg and the GZ21 specific surface area of the admixture is 5m²/kg lower than that of the non admixture, and the surface area of the additive is lower than that of the non admixture GZ2.
- (2) Intensity activity index. The 28d intensity activity index of the steel slag powder mixed with 0.1%

grinding aids in the laboratory is higher than that of the non doped agent. The GZ11 intensity activity index of the grinding aids increased by 5% compared with that of the non doped GZ1, and the GZ21 activity index of the grinding aids increased by 7% compared with that of the non doped GZ2.

The quality characteristics and technological parameters of the steel slag powder after grinding were compared and analyzed. The quality characteristics include the specific surface area and the intensity activity index of the steel slag powder.

3.1. Effect of Different Dosage of Grinding Aids on the Specific Surface Area and Grinding Efficiency of Steel Slag Powder

Table 3 shows the specific surface area of steel slag powder produced by grinding with different amounts of grinding aids.

Table 3. Comparison table of specific surface area of slag powder.

Number	Kinds of grinding aids	Dosage of grinding aids / %	Grinding time	Specific surface area of steel slag powde/ $m^2.kg^{-1}$
A0	-	-	8:00~9:50	435
A1	ZM	0.05	9:50~12:50	440
A2	ZM	0.075	12:50~13:20	435
A3	ZM	0.06	13:20~15:30	435

It is visible from table 3,

In actual production, the specific surface area of the slag powder containing ZM is different from that in the test room, and there is no obvious change, even a downward trend, compared with those in the non admixture.

3.2. Effect of Different Dosage of Grinding Aids on Fluidity and Activity of Steel Slag Powder Sand

Under the same water binder ratio, the steel slag powder obtained by grinding is equivalent to 30% cement instead of the same cement. The fluidity and intensity activity index of the mortar are tested, and the results are shown in Table 4.

Table 4. Comparison of fluidity of mortar and activity index of steel slag powder.

Number	Dosage of grinding aids/%	Fluidity /mm	compressive strength/ MPa		Intensity active index/ %	
			7d	28d	7d	28d
Cement mortar *	-	215	38	53.4	100	100
MA0	-	212	24.7	42.7	65	80
MA1	0.05	215	27.4	47.0	72	88
MA2	0.075	216	27.0	47.5	71	89
MA3	0.06	214	27.4	47.0	72	88

*Cement mortar is used for calculating the intensity activity index of steel slag powder and made of pure cement.

It is visible from table 4,

- (1) Compared with the flow degree data of the blank MA0 group, the flow degree of the slag powder obtained by the grinding agent grinding is increased to a certain extent, and the increase of MA2 is the most obvious (the flow degree of 0.075% grinding aids is increased by 1.9% than that of the non admixture). The increase of fluidity of mortar is due to the dispersion of fine particles in steel slag powder. Because of the effect of grinding aids, the proportion of fine particles in the slag powder obtained by grinding is larger. The fine slag powder particles will quickly adsorb on the surface of cement particles when mixed with water and hinder the formation of the flocculation structure of the cement slurry. Furthermore, the fine slag powder particles are filled in the accumulation of cement particles, which can help to open the cement particles and improve the fluidity of the slag powder - cement mortar.
- (2) compared with the steel slag powder obtained without grinding aid powder grinding, the activity index of steel slag powder mixed with grinding agent powder was

improved, while the 7d and 28d activity index of MA2 group were increased by 6 and 9 percentage points respectively.

3.3. Effect of Different of Dosage of Grinding Aids on Process Parameters of Steel Slag Grinding

The grinding process is shown in Figure 1. The steel slag is pulverized into the slag powder through the pre grinding cycle system (the first pressure of the roller press), and is fed into the slag powder by the hoist to the intake port. The fine powder is finished under the collection of the dust collector, and the coarse powder is returned to the mill to be continued to be grinded. Therefore, the current of the pulverist, the ball mill current and the external circulation hoist are 3 important parameters to measure the operation condition of the process.

When the raw material is the same, the feed volume is 34t/h and the production is stable, the grinding aids are added to the ball mill before grinding. The addition and adding time are shown in Table 5.

Table 5. addition time and addition amount of ZM grinding aids.

Grinding time	9:50~12:50	12:50~13:20	13:20~15:36
Dosage of grinding aids/%	0.05	0.075	0.06

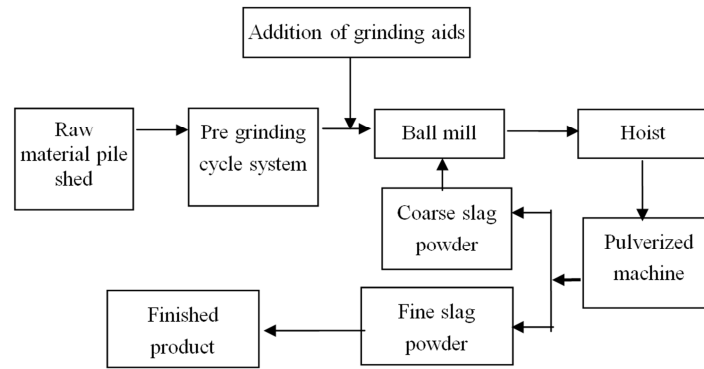


Figure 1. Process flow chart of slag grinding production.

3.3.1. Influence of Different Dosage of Grinding Aids on the Electric Consumption of Ball Mill

The data of ball mill current, outer loop hoist current and separator current are shown in figures 2, Figure 3, and Figure 4.

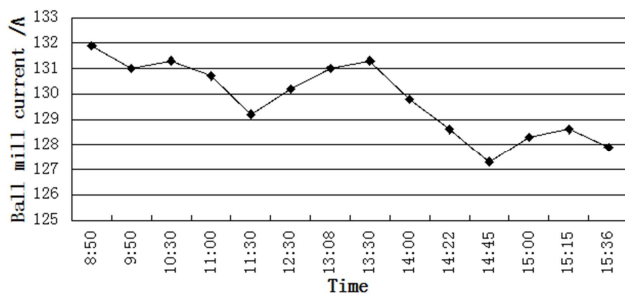


Figure 2. Current trend diagram of ball mill.

Note: the electricity consumption data at 8:50 is not added to the grinding agent.

From Figure 2, the current of ball mill is decreased and the flow velocity inside mill is accelerated after adding grinding aids. When the dosage of grinding aids is 0.05%, the current of the ball mill is more stable. The flow degree of the material in the ball mill increases and the velocity of the ball mill increases. The electric consumption of the ball mill is reduced, and the power consumption of the ball mill is reduced by 3.03% when the dosage of the grinding agent is 0.06%.

3.3.2. The Influence of Different Dosage of Grinding Aids on the Power Consumption of the Hoist.

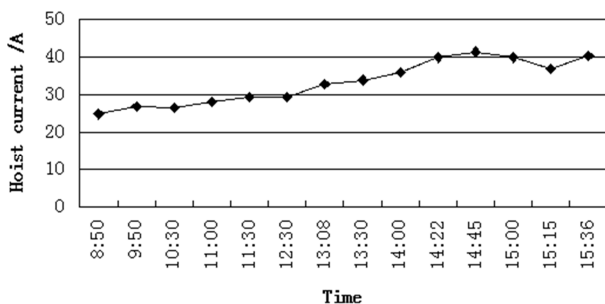


Figure 3. The current trend diagram of the hoist.

Note: the electricity consumption data at 8:50 is not added to the grinding agent.

As can be seen from Figure 3, with the addition of grinding aids, the current of the hoist increases with the increase of the dosage, and the material circulation increases and the load increases. The power consumption of the hoist increased by 66% when the grinding aids were added to 0.06%.

3.3.3. Influence of Different Dosage of Grinding Aids on Power Consumption of Powder Separator

From Figure 4, it can be seen that the current of the pulverized machine is on the rise after adding the grinding aids, and the mechanical and electrical consumption of the powder selection is more stable after adding 0.05% of the grinding aids. With the increase of the amount of mixing, the material in the powder separator is increased.

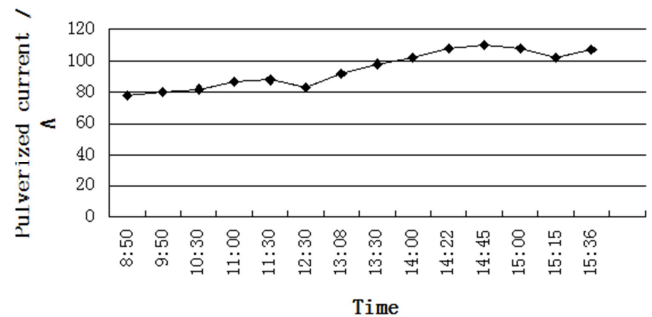


Figure 4. Current trend diagram of pulverized machine.

The volume of the finished product is coarse, the volume and speed of the coarse material increase, and the milling machine even appears the phenomenon of running ash.

4. Conclusion

- (1) The influence of the grinding agent on the grinding fineness of the slag powder in the test room is not obvious, the 28d intensity activity index is increased and the 0.1% grinding aids is increased by 7%.
- (2) The influence of different dosage of grinding aids on the grinding fineness of steel slag powder is not obvious in the pilot test. With the increase of the content, the intensity activity index of the slag powder is improved, and it is improved with the increase of the content of the slag.

- (3) with different grinding aids, the power consumption of ball mill is reduced, and the power consumption of hoist and separator is improved. With the increase of the dosage, the process has great influence. When the content is 0.075%, the production is difficult to control.
- (4) grinding aids; in the production process, we should preliminarily determine the content of the mixture through the laboratory, and then carry out the production line test to determine a reasonable amount.

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