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Original Research Paper

Briquetting Burnt Dolomite Powder for Recycling in Steel Plants

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ABSTRACT

Burnt dolomite powder is the by-product in preparing raw material in steel plants. It is treated as a solid waste in the steel industry case by its small particle size. This paper discusses the potential for utilizing burnt dolomite powder by briquetting with different binders include syrup, lime and ethoxyline resin. Burnt dolomite lumps of size 30mm could be used in slag splashing process. Moreover, compressive strength, curing time and effective MgO content in burnt dolomite lumps were considered in experiment. Experiments results found that the burnt dolomite lumps with 0.9% resin binder have the best compressive strength, 20.86Mpa. Additionally, the dolomite lumps with syrup or lime binder have an excellent chemical composition of high content of active MgO and low free water content.

INTRODUCTION

Burnt dolomite is one kind of the main raw materials for slag splashing process as slag conditioning reagent (Jian et al. 2000). Burnt dolomite is produced by calcining dolomite at 1000°C. During the dolomite burning, a part of dolomite will be pulverized. Burnt dolomite powder is the undersized product and consists of particles smaller than 5 mm. Because of its small particle size, burnt dolomite powder cannot be used in steel making. Therefore, burnt dolomite powder is considered as being a new solid waste in the steel industry. A common way to treat this mineral is by disposal to landfill, which results in wasting the land or soil, the most complex and valuable natural resources in the world (Adnan et al. 2013). This treatment not only destroys the environment but also wastes the limited resources. Aims to recycling burnt dolomite powder, several works have been carried out to prepare MgO or magnesium carbonate from it (Zhang et al. 2008, Xia et al. 2013). However, it is undeniable that both CaO and MgO are the main mineral resources in burnt dolomite powder (Table 1 and Fig. 1). Just reuse of MgO resources is not economical or comprehensive. Moreover, because of its individual chemical constituents, burnt dolomite powder has been studied as a desulphurizer and dephosphorization agent (Xiao-dong et al. 2010, Roques et al. 1991). However, the low activity of the powder, mainly the low activity of MgO and CaO, impedes the extension of this method. Thus, it is still an intractable issue to utilize and manage burnt dolomite powder.

On the other hand, slag splashing technology plays a significant role to improve life cycle of BOF (basic oxygen furnace) in steel making process. Slag splashing technology can not only reduce the furnace lining erosion, prolong the furnace life, but also decrease the manual intensity and the operating cost, thus enhances the productivity (Chigwedu & Kempken 2006). After steel tapping out from BOF, add slag conditioning reagent into BOF with the remnant molten steel slag. Main chemical content of slag conditioning reagent is MgO. A series of high melting point materials will be appeared after the reaction between MgO and steel slag (Yuan et al. 2013). Splashing the mixture slag by high-pressure nitrogen gas, the high melting point slag will adhere to brasque of BOF which is an efficient protective membrane of BOF.

Since the burnt dolomite powder is the by-product in burnt dolomite preparing process for slag splashing, recycle it as the raw materials of slag splashing should be one of the best choices to reuse this mineral resource.

In this paper, briquetting process was discussed to shape burnt dolomite powder, and then the burnt dolomite lump with size of 30mm will be offered to steel making plants as raw materials for slag splashing process. Three kinds of binders were compared in this study, and the cure time also considered. As the main index, compressive strength was tested. Moreover, the effective MgO content was measured to evaluate the burnt dolomite lump quality in this experiment.

MATERIALS AND METHODS

Materials were burnt dolomite powder, lime powder, syrup, ethoxyline resin and water. The burnt dolomite powder and lime powder were obtained from the Guanyinshan iron mine of the Shuicheng Iron and Steel Company, China. The syrup was from Guang Xi Province, China. The ethoxyline resin was produced by Chuandong Chemical Company, China. These three kinds of binders in burnt dolomite lumps are not harmful to the quality of steel. Syrup and resin will be decomposed into H_2O and CO_2 in BOF, and lime is another significant material of steel slag.

The chemical composition of the raw materials were tested by XRF (XRF-1800), made by SHIMADZU, Japan. The test results are given in the Table 1. CaO and MgO were the main components of the burnt dolomite powder at 50.46 and 36.07%, respectively. The main component of lime powder is CaO (83.84%).

Analysis of the main phase composition of dolomite powder was made by using Rigaku (Japan) D/max 2500PC equipment using Cu-Ká radiation at room temperature. Patterns are measured from 5° to 75° in 0.05°steps (Fig. 1).

Table 1: Main components of light burnt dolomite powder.

Material	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	MnO	Free H_2O
Burnt dolomite powder	50.46	36.07	7.69	3.48	1.12	0.03	1.15
Lime powder	83.84	1.36	3.78	0	0	0	0

Table 2: The scheme of the experiment.

Sample	Syrup %	Lime (%)	Resin (%)
A1	1	-	-
A2	2	-	-
A3	3	-	-
A4	-	1	-
A5	-	2	-
A6	-	3	-
A7	-	-	0.3
A8	-	-	0.6
A9	-	-	0.9
A10	-	-	-

Table 3: Burnt dolomite lumps components for 7days curing.

Sample	Binder	Addition amount, %	$Mg(OH)_2$ %	MgO %	Free H_2O %
A3	Syrup	3	2.84	31.34	1.83
A6	Lime	3	2.53	31.55	2.18
A9	Resin	0.9	3.02	31.22	2.84
A10	-	-	3.17	31.11	2.31

XRD results show that the main content phases in burnt dolomite powder are CaO, MgO and $Mg_xCaO_{(1-x)}CO_3$. The results also show that dolomite did not decompose completely in the calcining process.

Burnt dolomite powder was shaped by briquetting machine (07-I), made by ZheTYN Company, China. The briquette press is 15MPa. Three gradients of syrup and lime powder were used: 1, 2 and 3%. Three resin gradients were used: 0.3, 0.6 and 0.9%. In briquetting process, 5% of water was added into the dolomite powder. Moderate water addition in briquetting process is necessary because water can improve the bonding power efficiently (Table 2).

After the briquetting process the burnt dolomite lumps with particle size 30mm were cured indoor at room temperature for 1, 3 and 7 days respective.

Performance Index: ***Compressive strength*****:** The compressive strength of burnt dolomite lump was tested by universal test machine, WDS-5A made by San Si Company, China.

$$P=N/(\pi R^2) \quad ...(1)$$

In eq. 1, P is compressive strength (Mpa); N is the maximum pressure of the burnt dolomite lump (N); R is the radius of the test-contact area (m). In this study, the R is 0.006m.

Compressive strength of green burnt dolomite lumps and cured lumps was tested.

Chemical analysis**:** Free water in raw materials for steel making is controlled strictly. The free water content was tested by calculating the mass lost of lumps at 100°C.

$$R_w = \frac{m_0 - m_1}{m_0} \times 100\% \quad ...(2)$$

In eq. 2, R_w is the free water content in burnt dolomite lumps, %; m_0 is the original mass of lumps, g; m_1 is the mass of lumps after 4 hours baking at 100°C, g.

The main effective component of the burnt dolomite lumps is MgO. Excessive $Mg(OH)_2$ raise the energy consumption in steel making process. At 400°C, just the $Mg(OH)_2$ will be decomposed (Rat Ko et al. 2011). So it is feasible to test the $Mg(OH)_2$ content by measuring the mass loss of burnt dolomite lump at 400°C.

$$R_M = \frac{m_b - m_e}{m_b} \times 100\% - R_S - R_w \quad ...(3)$$

In eq. 3, m_b and m_e are the pellet masses before and after baking, respectively. R_S is the mass loss ratio of the powder at 400°C with the same addition of syrup as the pellets. R_w is the free water content.

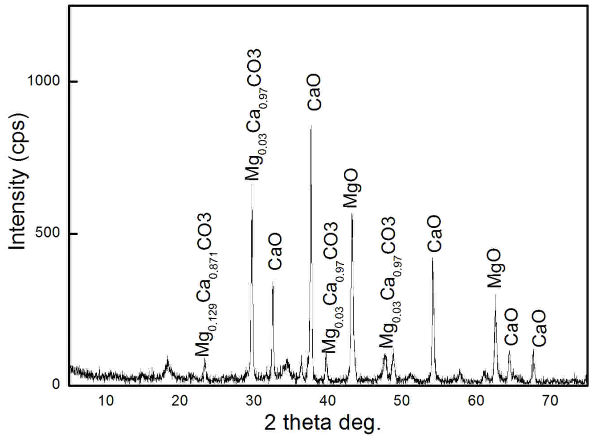

Fig. 1: XRD results of burnt dolomite powder.

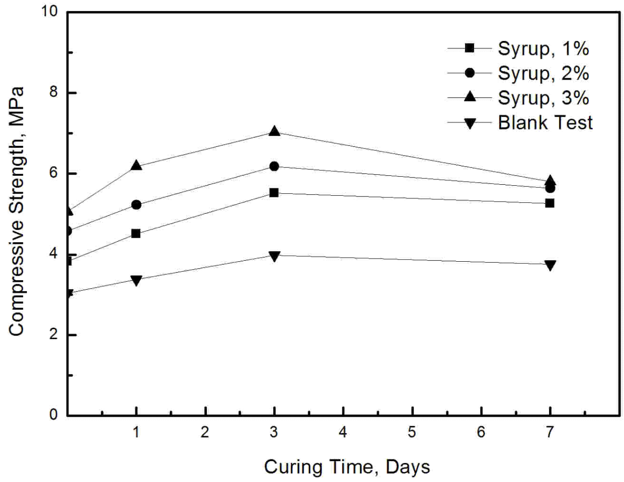

Fig. 2: Burnt dolomite lumps compressive strength with syrup binder.

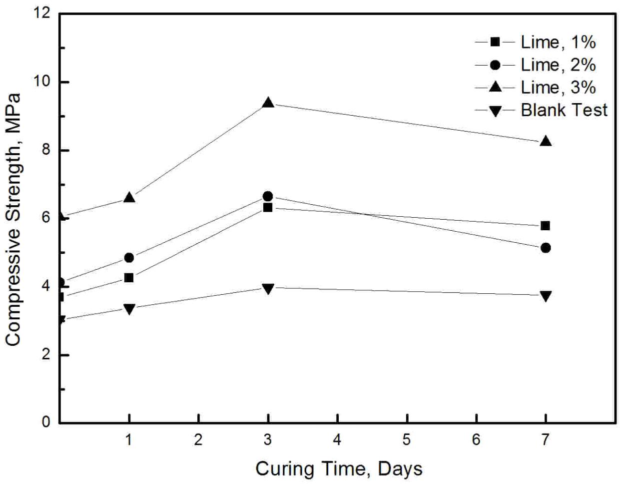

Fig. 3: Burnt dolomite lumps compressive strength with lime binder.

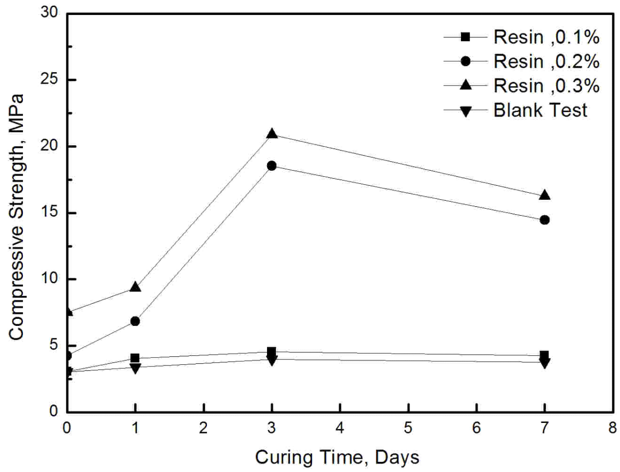

Fig. 4: Burnt dolomite lumps compressive strength with resin binder.

RESULTS AND DISCUSSION

Compressive strength: Compressive strengths of burnt dolomite powder lumps with different binders are shown in Figs. 2, 3 and 4.

Fig. 2 shows that in first 3 days of curing, the compressive strength increases with a steady speed. With the rise of syrup addition, the compressive strength grows too. However, while the curing time arrives 7 days, compressive strength has an obvious reduction. Compressive strengths of all the samples are almost similar. Unlike syrup binder, it can be seen in Fig. 3 and Fig. 4 that increasing rate of compressive strength in second and third curing day is much higher than the first curing day.

From Fig. 2 to Fig. 4, it can be found that the compressive strength is increasing with the addition amount of each binder. Moreover, compressive strength of all the lumps with binders is higher than the blank test. All this proves that the binders improve briquetting of burnt dolomite powder. In addition, ethoxyline resin shows the best binding power in the three binders and lime has more binding power than syrup in this experiment.

With the increase of curing time, the compressive strength of lumps initially increases and then decreases. The highest compressive strength appeared when cure time is 3 days. The highest compressive strength of each binder is 7.03Mpa, 9.37Mpa, 20.86Mpa respectively. When the cure time exceeds 3 days, the compressive strength becomes deteriorating. By the hydration expansion of CaO and the expansion rate of lime is nearly 150 % (Hai-zhen & Chun 2010). The increasing internal stress and voids volume in burnt dolomite lumps have responsibility for the strength decrease.

Chemical analysis: Analysis of the chemical components of the samples with the best compressive strength was made. In addition, the blank samples were also tested for comparing. The chemical components of A3, A6, A9 and A10 are listed in Table 3.

In Table 3, all the four samples have a low free H_2O content. In comparison, the samples with lime and syrup as binders have a lower free H_2O content than samples A9 and A10. On the other hand, the MgO content of samples A3 and A6 is higher than samples A9 and A10. The reason of this phenomenon is that the syrup and lime absorb more water than resin as briquetting binders. The main content of lime is CaO which is a high reaction activity material with H_2O. So the lime binder expands part of addition water. In addition, because of the presence of hydrophilic hydroxyl group in syrup, the syrup has a strong attraction to water (Alanazi 2010). The sample A3 and A6 have lower free water content and higher efficient MgO content in burnt dolomite lump than samples A9 and A10, due to the special character of these two binders.

So syrup and lime as the binders of burnt dolomite briquetting process are beneficial to the chemical quality of burnt dolomite lumps.

CONCLUSIONS

Experiment results found that the reuse of burnt dolomite powder for slag splashing by briquetting with binder is feasible.

1. Ethoxyline resin shows the best binding power in burnt dolomite powder briquetting process and the highest compressive strength is 20.86Mpa.
2. With 3 days indoor curing at room temperature, the burnt dolomite lumps have the highest compressive strength.
3. Lime powder and syrup are beneficial to the chemical quality of the burnt dolomite lumps.

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