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Study on Sintered Wall Materials Made Use of Iron Tailings and Waste Rock

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Key words: iron tailings; waste rock; sintered wall materials

Abstract. Iron ore tailings and waste rock are solid waste during mining in the steel industry. This paper presents the study on sintered wall materials made use of iron tailings and waste rock. The process parameters through chemical analysis and thermal analysis to determine the feasibility of using iron ore tailings and rock on sintered wall material. Plasticity index, firing shrinkage, water absorption, apparent porosity and bulk density are tested, and the proportion of these two materials are also determined. The results show that iron tailings and waste rock can be used to sinter MU15 wall materials, with the sintering temperature ranges 850-950℃, but shrinkage of the specimen (diameter and height shrinkage) of 2.5%-5.0%, and the apparent porosity 42% or more. This technology not only use both waste as raw material, furthermore, because of the higher iron content in iron ore tailings and waste rock, the products reduce the sintering temperature, decreased energy consumption. The technology uses waste as raw material, furthermore, due to the high iron content in the ore tailings and waste rock, the sintering temperature is decreased, which saves energy.

Introduction

With the rapid development of steel industry, iron tailings, waste rock and other solid volume increase rapidly. Statistics shows that the total iron ore tailings in China is over 20 billion tons[1] and it has been a widespread concern in society, not only taking up a lot of land, but also causing serious environmental pollution[2-3]. The using of Iron Ore Tailings as new wall material, has become the preferred technology for comprehensive utilization of iron ore tailings consuming large amount of waste and causing no secondary pollution,. Specifically, the current domestic and international researches in this area focus on using iron ore tailings unburned brick, fired brick, etc. [4] and using in sintered iron tailings insulation board are also reported, but there are still many technical problems to be solved.

Since silicon, aluminum, iron and other elements are the main components of iron ore tailings and waste rock, instead of part of iron ore tailings clay, mixed with appropriate amount of plasticizer, which can meet the …. requirements of sintered wall materials[5-6], but also by controlling the iron tailings ash, made of bricks of different intensity levels of the tailings, such as Benxi Waitoushan Jinzhong successfully developed iron ore tailings fired brick. In this paper, iron ore tailings and the surrounding waste rock was studied with physical and chemical properties, the results showed that all the iron tailings, waste rock for the sintered materials is feasible.

2. Experimental

2.1 Raw Materials

Raw materials come from Xingning Rising Limited include: Tailings(A) and Rock (C). The source of the tailings ore by dry magnetic pulley end of the waste thrown B3500 in the magnetic field

strength，named tailings A. Rock C is associated with some clay ore composition. Chemical composition of the two materials are list in Table 1.

Table 1 Chemical composition of raw materials / Wt%

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	TiO_2	SO_3	Other	Loss
Tailings A	36.1	27.72	20.64	0.38	0.16	0.24	1.95	0.2	0.54	12.07
Wall rock C	34.01	25.72	25.36	0.045	0.13	0.24	3.85	0.12	0.515	10.01

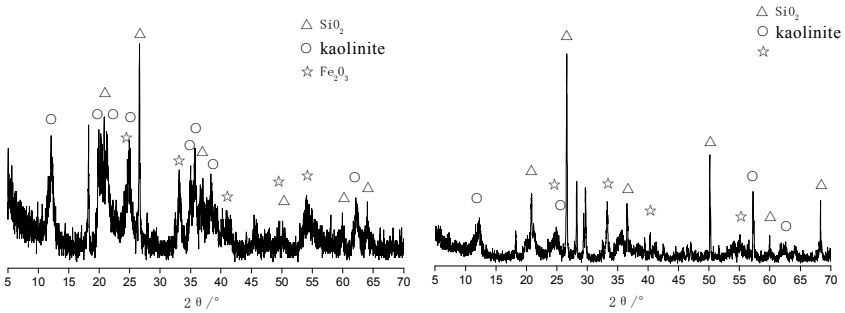


Fig 1 XRD of tailings(A), rock (C)

XRD results of Tailings A and Rock C are shown in Figure 1. The figure shows that the Tailings A are major composed with quartz, kaolinite and hematite (Fig. 1); the main mineral composition of C and a small amount of kaolinite hematite (Figure 2).

2.2 Test Methods

The equipments used in the experiment include electronic balance(weighing Yamato Co., Ltd.) Shanghai ACS-15Ad card balance (range 5Kg, precision 1g; Shanghai Instrument Co., Ltd.) JA5003 Ryohei electronic balance (range 510g, precision 0.001g); AUY120 type Shimadzu balance (the largest range 180g, accuracy 0.1mg). Fahrenheit balance Cone: Geotechnical Instrument Factory Shaoxing Yu Kan cone liquid limit device. Oven: Hysen letter DGG-9620A test instrument Co., Ltd. constant temperature blast type electric oven. High-temperature furnace: Shanghai Guangyi Technology Co., Ltd. hot ECF7-55-13-type high-temperature furnace, the rated power 55kw. Vacuum: SHZ-95 type rotary vane vacuum pump Direct. Compressive strength testing machine: Wuxi East building materials plant JES-2000A-type strength machine.

Manufacture procedure(1) mixture: mixing raw materials with mixer in accordance with the designed ratio; (2)water granulation: accurate weighing 13% of the dry weight ratio of water to the raw materials with a watering can spray the surface of the water to fully mix, which aimed to raw material fails block, were spherical, loose soil; (3)curing: wet material wasplaced in a specific curing room (20 ± 1℃ and relative humidity 100%;) for 72h, (4)Specimen process by extrusion. Followed with dried in the air for 48h, specimen was placed in the blast electric oven dried at 105±1 ℃ for 24h. Specimen dimension and weight were measured with a vernier caliper and precision analytical balance weighing 0.01g of sample quality. After that, specimen will be placed in the uniformly dispersed ECF7-55-13 hoist high temperature furnace for sintering. After sintered the samples were cooled down to room temperature within the closed furnace.

AXIOS advanced wavelength dispersive X-ray was used to quantitative analyse the chemical composition of raw material, with the operating voltage of 30-60kV. operating current 50~100mA. Bulk density, water absorption and porosity of bulk density and porosity testing were tested by Shimadzu balances (AUW220H). Phase analysis was produced by Japan Rigaku (Science) Company D / Max-RB rotating anode X-ray diffraction analysis, with the power of 12kW, angular accuracy of $\Delta 2\theta \leq \pm 0.02$, scan range of 5~65 °, scanning rate of 10°/min. Microscope microstructure analysis was produced by Japan JSM-5610LV scanning electron, with the/an accelerating voltage of 30kV.

TG-DTG-DTA analysis was produced by Germany (NETZSCH) NETZSCH Simultaneous Thermal Analyzer 449C thermal analysis instrument, using air as the test atmosphere and the test temperature range is room temperature to 1200and the heating rate is 5/℃min.

3 Results and discussion

3.1 Determination of sintering regime

Preparation sintering process was determined by thermal analysis, (TG-DTG-DTAresults are shown in Figure 2). Corresponding to the three DTA endothermic peaks, three mass vary points were found in the TG curveduring the whole temperature rising process. DTA curves of 67.5℃ and 281.1 ℃ two endothermic peaks corresponding to the mass change and loss of 4.47% to 2.41%, respectively, which are resulted from the evaporation of free water and bound water. 491.2℃ at the endothermic peak corresponding to the mass loss 6.75%, of the structure of water. As the temperature keeps rising, the TG curve is nearly get a value(mass loss 0.43%), 700℃ began to decline after the DTA curve, indicating that liquid phase appears, and in 850℃-950℃ within the steepest curve.

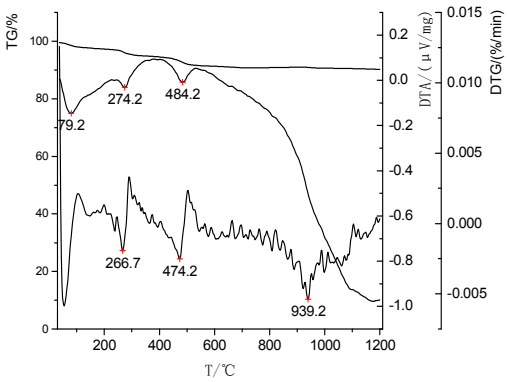


Fig.2 Sintering by thermal

The results of thermal analysis show that the sintering temperature range of the wall rock and tailings materials prepared is within 850℃-950℃.

3.2 Plasticity index

Plasticity index of mud samples are shown in Figure 3. It can be seen that all these samples have the distribution of mud plasticity index in the liquid limit between 65 to 68. Plastic limit of 42 to 45 are located in between the range of plasticity index greater than 15, distributed in 21 to 25, is a high plasticity clay material, the method can be vacuum extrusion molding. The liquid, plastic limits and plasticity index of A100 and C100 change little pug Group 5, but it should be noted that, AC series mud samples of the liquid and plastic limits of the high sintering dried green body will also see more time-consuming and energy, otherwise it will lead to shrinkage cracking green body and firing cracks.

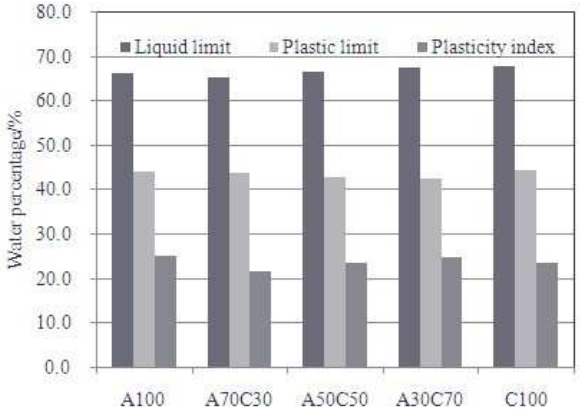


Fig.3 Plasticity index

3.3 Shrinkage

Firing shrinkage of specimens are shown in Figure 4. Firing shrinkage of the specimen (diameter and height shrinkage) are within 2.5% ~ 5.0% and it increases with the increasing of using C (A content decreases). So the specimen relative to the C100, A is helpful to control the size of the specimen; mass loss rate of AC series samples are between 11% and14%, and its variation with the size line shrinkage due to sample AC series high rate of mass loss, mass loss when a higher temperature range (500 ℃) the heating rate should be slow down to avoid excessive stress crackings on products.

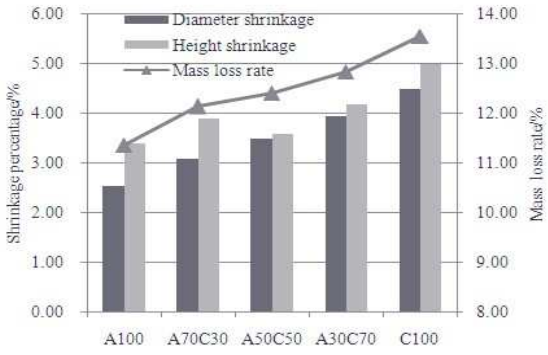


Fig.4 Shrinkage of specimens

3.4 Water absorption, apparent porosity and bulk density

Specimen water absorption, apparent porosity and bulk density are shown in Figure 3.5, it can be seen that water absorption and porosity of A100 specimen are 28.60% and 47.24%; while those of C100 specimen are 25.67 and 42.75%. With the increasing of C content in the specimen, water absorption and porosity are slightly decreased. Apparent porosity of specimens are more than 42%, indicating that they can achieve a good thermal insulation purpose. If the products are used to make bricks, the fineness of raw materials and the process must be controlled to reduce the water absorption. Bulk density of the specimens are relatively stable around 1.65g/cm^3, slightly lower than that of the clay brick, up to reduce the load bearing structure.

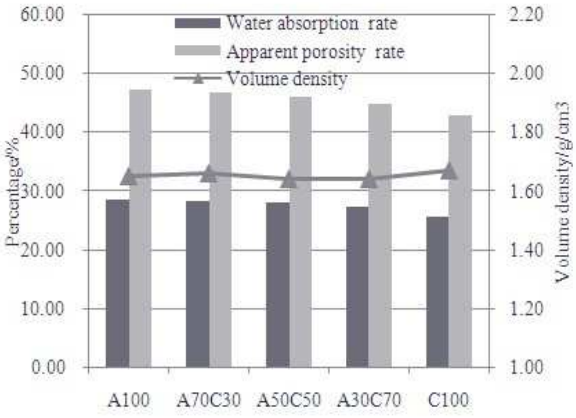


Fig.5 Water absorption, apparent porosity and bulk density of specimen

3.5 Compressive strength

Compressive strength of specimens are shown in Figure 3.7. Compressive strength of all these samples have achieved the MU15 level. The minimum strength is 15.56MPa from the A100 specimens, while the maximum strength is from C100 22.86MPa. With the increasing of C content, the compressive strength is increased significantly.

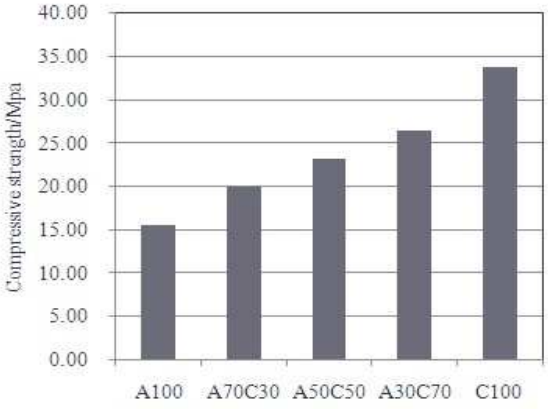


Fig.6 Compressive strength of specimen

3. 6 Performance and Mechanism of Micro

A) XRD

XRD analysis of chosen specimens are shown in Figure 7. It can be seen from the results that the main phase of the specimens are quartz, iron oxide and calcium aluminum garnet.in which three kinds of specimen A100 crystalline phase of a larger peak intensity, while the C100 specimens more in phase, calcium aluminum garnet, iron oxide peak intensity is relatively large, with the increase of C content, the specimen in Grossular, weak iron peak, are relatively little, C100 of the XRD patterns of quartz has been no obvious, so C, is helpful to reduce the test piece in the quartz and iron oxide content, and promote the sintering reaction, an increase of the specimen within the connection between particles tightness, to some extent play the role of the binder.

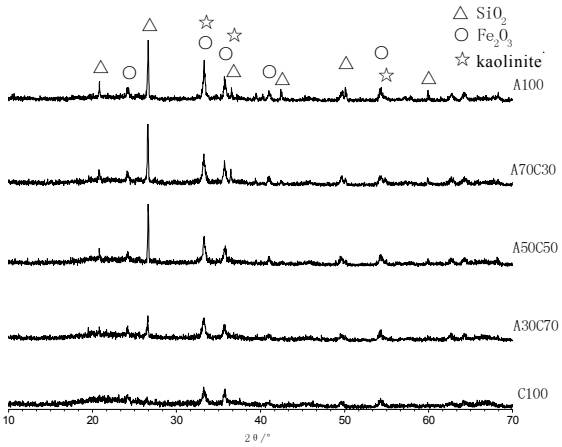
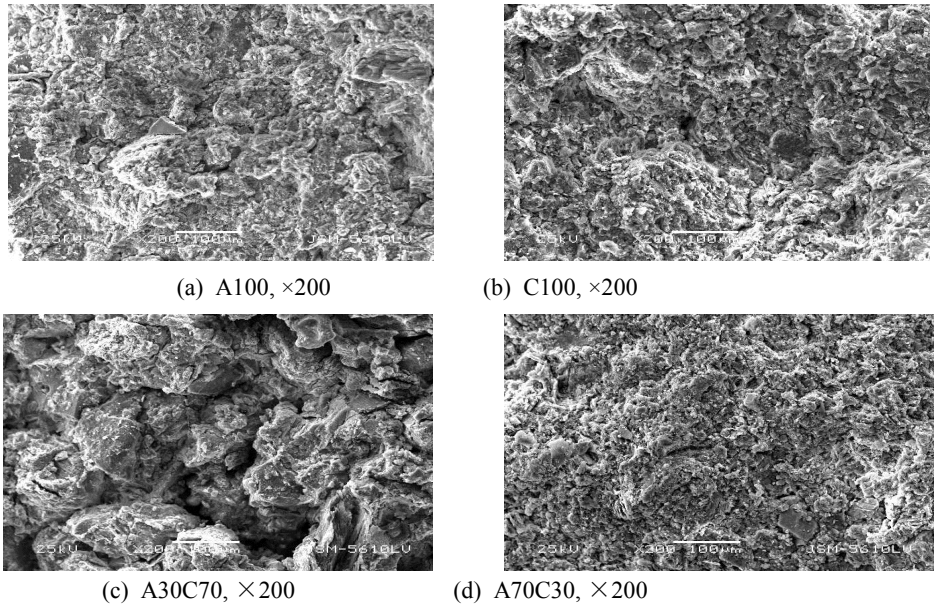


Fig.7 XRD of specimen

B)SEM

SEM comparison of different samples as shown in Figure 8（200 times). Picture (a) and (b) show that A100, C100 have a tight connection between the sample particles; From the pictures (d) and (e) A70C30 connection between the degree of sample particles; by the (f), (g), (h) 200 times the SEM graph shows, add C after the specimen between the density of particles increased significantly, so, C to join the role played tight bond; from the (i), (j), (k), (l), (m) 5000 times the SEM graph shows that, within the specimen there is still a large number of pores, which and sample performance was consistent with high porosity. A100, A50C50, C100 under this factor structure do not change significantly, with consistent bulk density; by a (n) 2000 times the

SEM graph shows, A100 specimen of white flocculent material and there are a large number of pores and many columnar crystals appear.



(a) A100, ×200 (b) C100, ×200

(c) A30C70, ×200 (d) A70C30, ×200

Fig.8 SEM of specimen

4 Summary

1. Plasticity index of mud is a high plasticity clay material(greater than 15), which matchs the method of vacuum extrusion molding. The high liquid and plastic limit indexes could lead to shrinkage cracking, including both the green body and the sintering cracks.

2. Dimension shrinkage of the specimen (diameter and height) and the mass loss rate increases with the increasing of rock content: the heating rate should be slown down to avoid excessive stress when sintering at the higher temperature range (500℃ or so). Specimen water absorption, apparent porosity and bulk density did not change significantly; take control of the fineness of raw materials and improve the burning process would reduce the water absorption.

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