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Effect of the sintering technology on the properties of fired brick from quartz sands

Jie-Guang Song[a,]*, Fang Wang[b], Xiao-Bo Bai[b], Da-Ming Du[a], Yin-Yan Ju[a], Ming-Han Xu[a] and Gang-Chang Ji[b]
[a]*School of Mechanical and Materials Engineering, Jiujiang University, Jiujiang, 332005 China*
[b]*Jiujiang Key Laboratory of Green Remanufacturing, Jiujiang University, Jiujiang, 332005 China*

River sands as low grade natural raw materials are used to prepare the fired brick to replace clay fired bricks, which aims to save land resources and use low grade natural resources to realize high cost performance. In this paper, the effect of sintering technology of bricks on their performance is discussed. The compressive strength of fired bricks is first increased and then decreased with an increase in the sintering temperature, the compressive strength of bricks prepared by the isostatic compaction shaping is higher than that of bricks prepared by the plastic shaping under the same conditions. The compressive strength of bricks reaches 28 MPa when sintered at 1150 °C by using a 20 MPa isostatic compaction shaping method. The compressive strength of bricks is first increased and then decreased by prolonging the holding time, the compressive strength of bricks reaches 28.9 MPa when sintered at 1150 °C for 2 h.

Key words: Fired brick, Quartz sands, Sintering technology, Compressive strength, Water absorption, Microstructure, Density, Shaping methods.

Introduction

With the development of modern industry, the demand for industrial raw materials is increasing, which depletes the raw material resources [1-2]. Many infant industries use both industrial waste or low grade raw material to manufacture high cost performance products [3-4]. High grade quartz sands as non-metallic minerals raw materials are extensively used in the foundry industry, for glass making, in the building industry and munitions industries [5-6]. However, low grade quartz sands are used as a mortar mixture in construction, which show a low cost performance [7-8].

With the development of town construction, the walling materials industry is quickly developing at home and abroad, the consumption of fired clay brick is very high, which consumes a mass of the clay resource. Many countries propose to save land resources for the sustainable development of human society [9-11]. River sands as low grade natural raw materials are being used to prepare quartz sand fired bricks to replace clay fired bricks [12], which aims to save land resources and use a low grade natural resource to realize a high cost performance. In this paper, the effect of sintering technology of bricks on the performance is discussed.

Materials and Experiment

River sands as the main raw materials were used to prepare quartz sands fired bricks. The component analysis of the river sands are shown in Table 1. Sintering additives (5 wt%CaO) were mixed with the river sands by a ball milling method, and then the composite raw materials were molded by different methods, drying, sintering under a normal atmosphere with a muffle furnace and tested. A process flow diagram of preparing the bricks is shown in Fig. 1.

The phase analysis was perfomed by X-ray powder diffraction (XRD) (Model: D/Max-RB, Japan). The compressive strengths of fired brick were tested by a universal mechanical tester (Model: AGS-5KNJ, Japan), and the microstructural analysis of the fired bricks was performed by scanning electron microscopy (SEM) (Model: JSM-5610 LV, Japan).

Results and Discussion

Effect of the sintering temperature on the performance of fired bricks

The effect of the sintering temperature on the water absorption of bricks is shown in Fig. 2, the water absorption of bricks is first decreased and then increased with an increase in the sintering temperature. The effect of the sintering temperature on the compressive strength of bricks is shown in Fig. 3, the compressive strength of bricks is first increased and then decreased with an increase in

Table. 1. The component analysis of the river sand

Chemical composition	SiO_2	Al_2O_3	CaO	MgO	Other	Ignition loss
Content (wt%)	84.21	6.69	1.47	1.01	2.04	4.58

*Corresponding author:
Tel : +86-792-8313632
Fax: +86-792-8313239
E-mail: songjieguang@163.com

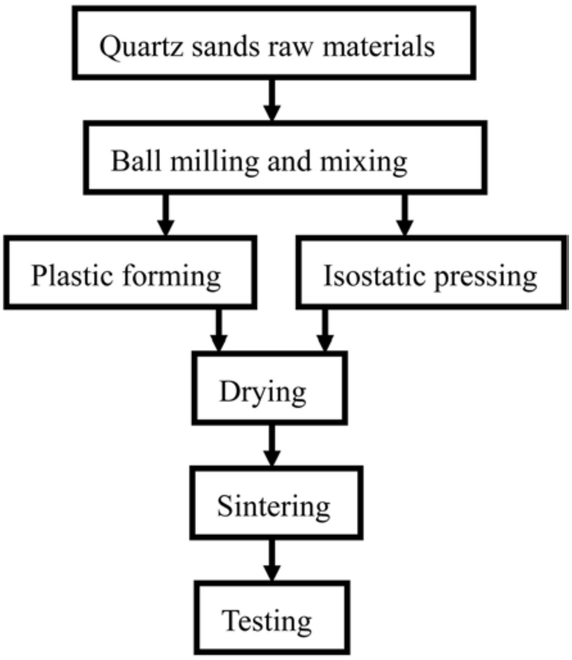

Fig. 1. A process flow diagram of preparing quartz sand fired brick.

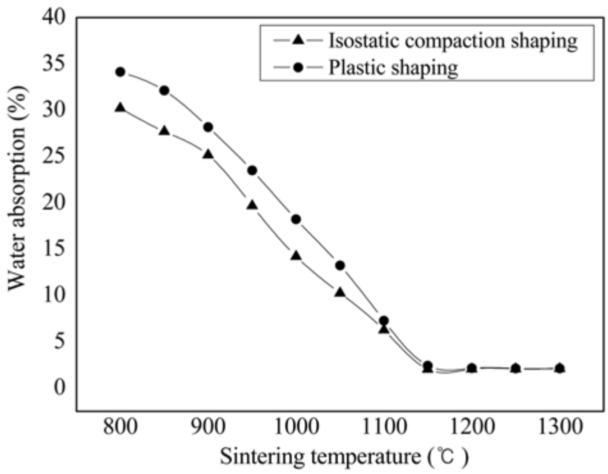

Fig. 2. Effect of sintering temperature on water absorption of fired bricks.

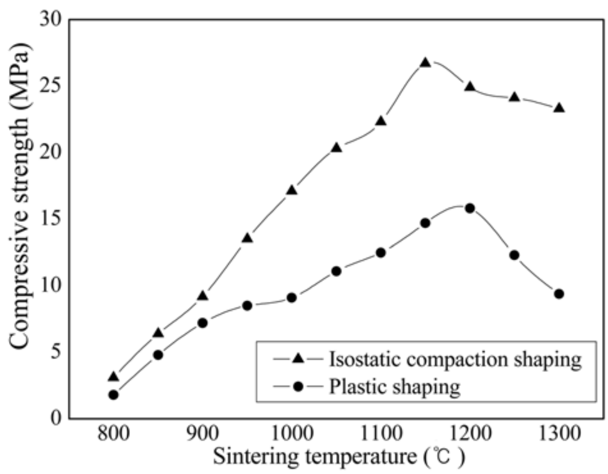

Fig. 3. Effect of the sintering temperature on the compressive strength of fired bricks.

the sintering temperature, the compressive strength of a brick reaches 28 MPa at 1150 °C using the 20 MPa isostatic compaction shaping method. Fig. 4 shows the phase analysis of raw materials and fired bricks at different temperatures, the quartz sands include quartz, potassium feldspar and white mica. The main crystalline phase is quartz, the second crystalline phase is potassium feldspar in the brick sintered at 1100 °C, and it shows a small amount of a glass phase because of the melted part of potassium feldspar. The main crystalline phase is quartz with a mass of a glass phase in the brick sintered at 1150 °C. Liquid is produced in increasing amount in the brick body with an increase in the sintering temperature [13-15], the voids in the brick are then filled by the liquid glass phase to decrease the porosity, which increases the density (Fig. 5) and compressive strength. But the liquid glass phase is increased gradually in the brick body with a further increase in the sintering temperature, which creates some gas in the liquid, when the sintering temperature reaches a certain temperature, some gas is entrapped to form the open pores on the surface of brick, which increase

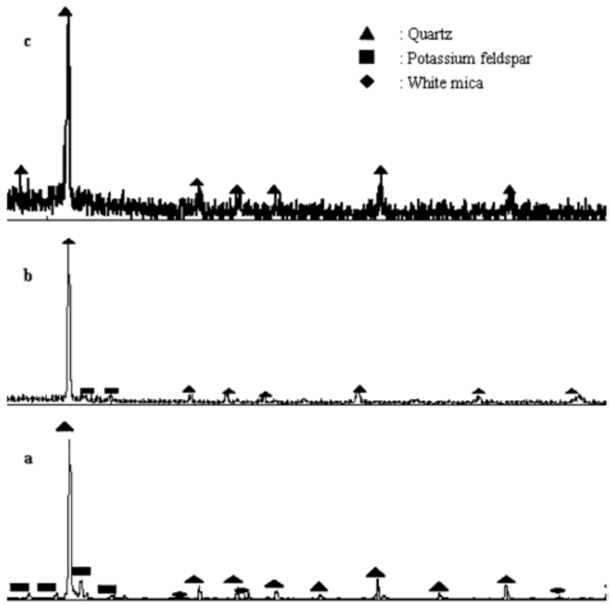

Fig. 4. Phase analysis of raw materials and fired bricks (a-raw materials, b-sintering at 1100 °C and c-sintering at 1150 °C).

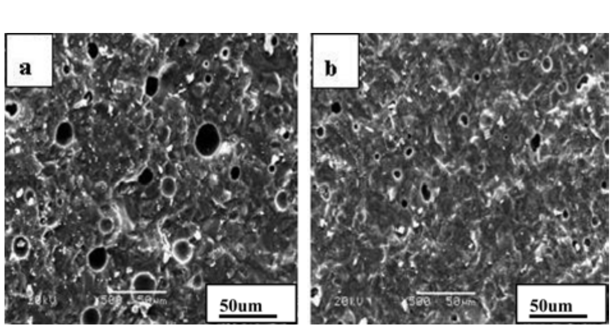

Fig. 5. Effect of the sintering temperature on the microstructure of fired bricks made by the 20 MPa isostatic compaction shaping method (a-1100 °C and b-1150 °C).

the water absorption and decrease the density. Because the liquid is retained as the glass phase during the cooling process, the glass phase matter reduces out the brittleness, when the glass phase fills the void spaces of the bricks, the bricks show the best compressive strength, but if the glass phase is too much, the bricks show the character of the brittle material to decrease the compressive strength.

Fig. 3 shows the compressive strength of bricks prepared by isostatic compaction shaping is higher than that of bricks prepared by plastic shaping under the same conditions. Because the shaping pressure creates the impingement conditions among the raw material particles, which decreases the resistance to diffusion and the migration distance of particles is decreased to help in the sintering densification [16-17]. The pressure for isostatic compaction shaping is higher than that for plastic shaping, which makes the remaining air content in the green brick molded by isostatic compaction lower than that by plastic shaping. This result shows that the sintering densification of bricks molded by isostatic compaction is easier than that of bricks molded by plastic shaping.

Effect of the holding time on the performance of fired bricks

The effect of the holding time on water absorption of fired bricks is shown in Fig. 6, the water absorption of fired bricks is first decreased and then increased by prolonging the holding time. The effect of the holding time on the compressive strength of fired bricks is shown in Fig. 7, the compressive strength of bricks is first increased and then decreased by prolonging the holding time, the performance of a prepared brick reaches 28.9 MPa sintered at 1150 °C for 2 h. Because the liquid glass phase is increased gradually by prolonging the holding time at a certain sintering temperature, the glass phase fills the void spaces of the bricks to decrease the void space quantity and the pore diameter (Fig. 8(a) and (b)), which increases the density of bricks to decrease their water absorption and increase their compressive strength. When the holding time is prolonged excessively, some gas bubbles are expanded and formed the large pores (Fig. 8(c)). When the holding time is optimum, the liquid produced suitable to form the glass phase which fills the void spaces of brick to give the best performance.

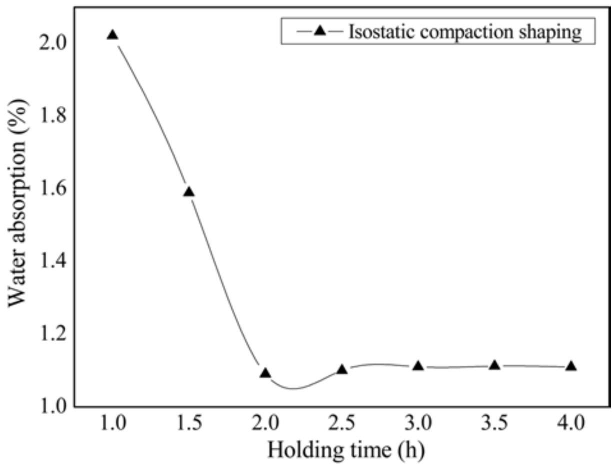

Fig. 6. Effect of the holding time on the water absorption of fired bricks.

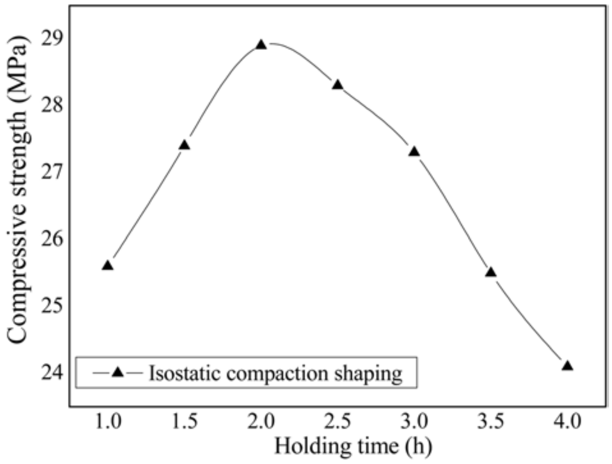

Fig. 7. Effect of the holding time on the compressive strength of fired bricks.

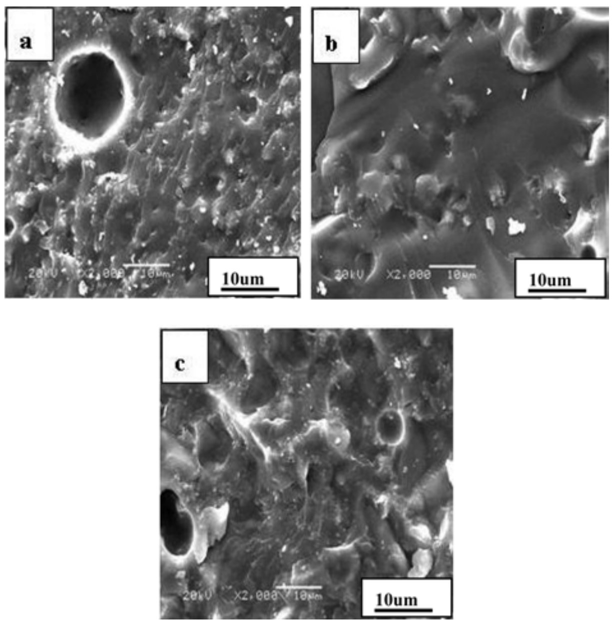

Fig. 8. Effect of the holding time on the microstructure of fired bricks (a-1 h, b-2 h and c-3 h).

Conclusions

(1) The water absorption of fired bricks is first decreased and then increased a little with an increase in the sintering temperature. The compressive strength of fired bricks is first increased and then decreased with an increase in the sintering temperature, the compressive strength of a sintered brick reaches 28 MPa when sintered at 1150 °C by the 20 MPa isostatic compaction shaping method.

(2) The water absorption of fired bricks is first decreased

and then increased a little by prolonging the holding time. The compressive strength of brick is first increased and then decreased by prolonging the holding time, the performance of a prepared brick reaches 28.9 MPa when sintered at 1150 °C for 2 h.

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