Study on the Technology of Preparing Ceramsite from Coal Gangue

D.L. Zhang[1a], Y. Liu[1b], J.G. Song[2c], H.B. Wen[1d], R. Huang[1e], Z.K. Li[f], X.Y. Hu[1g]

[1] School of Materials and Chemistry Engineering, Pingxiang University, Pingxiang 337055, Jiangxi, China

[2] Sponge City Research Institute, Pingxiang University, Pingxiang 337055, Jiangxi, China

[a]1542543192@qq.com, [b]4151759@qq.com, [c]sjg825@163.com, [d]2842203249@qq.com, [e]huangrong154@qq.com, [f]2319670293@qq.com, [g]2319670293@qq.com

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Abstract. China's coal resources are extremely rich, and the degree of coal mining is high. During the formation of coal, a large amount of coal gangue will be produced, which not only accumulates land and wastes resources, but may also cause natural disasters such as fires. In this paper, coal gangue is used as the main raw material, and a certain amount of kaolin, steel slag and other auxiliary materials are added to prepare coal gangue ceramsite through a high-temperature sintering process. The research results show that as the sintering temperature increases, the porosity of the ceramsite decreases first. After increasing, the water absorption rate of ceramsite also decreases first and then increases with the increase of the firing temperature, while the compressive strength first decreases and then increases with the increase of temperature. With the increase of the holding time, the porosity of the ceramsite first decreases and then increases. The water absorption rate of the ceramsite also first decreases and then increases with the increase of the firing temperature, while the compressive strength decreases first and then increases with the increase of the temperature. Elevated. With the increase of coal gangue content, the porosity of ceramsite gradually decreases, the water absorption rate of ceramsite also gradually decreases, and the compressive strength gradually increases with the increase of coal gangue content. The optimization can be obtained, the coal gangue content (mass fraction) is 100%, the calcination process system is 1200℃, and the heat preservation time is 60min as the better parameters. At this time, the compressive strength is 29.57MPa and the porosity is 4.36%.

Introduction

Ceramsite is a spherical product prepared by high temperature sintering or sintering-free process [1]. Ceramsite also has good properties because of its light weight and high strength. The internal structure of ceramsite is also honeycomb [2]. Therefore, ceramsite is a high-quality material for making thermal insulation products, high temperature resistance, moisture resistance, sound absorption and noise reduction. The superiority of ceramsite concrete is even more vividly displayed in many large-span and high-rise buildings. Many public facilities and frequently exposed walls widely use lightweight reinforced concrete products produced with ceramsite as aggregate. The chemical composition of coal gangue is mainly silica and alumina, which are rich in elements such as Al and Si. The ceramsite can be prepared by adding other sintering aids and properly adjusting the proportion of raw silica and the oxidation process.

The seismic performance of ceramsite concrete is much better than that of ordinary concrete, because the relative seismic coefficient of ceramsite is much higher than that of ordinary concrete and brick masonry. And ceramsite has low water absorption, excellent frost resistance, durability, impermeability and alkali-resistant aggregate reaction ability. The excellent properties of ceramsite have laid a solid foundation for the wide application of ceramsite. Ceramsite is widely used in the field of construction, water treatment, flower cultivation and planting, etc. Especially in the field of construction, ceramsite, as a lightweight coarse aggregate, can reduce the weight of concrete, heat insulation, sound absorption and noise reduction, and has good application prospects. [5-7].

At present, the accumulated industrial solid waste in the country exceeds 60-70 billion tons. The amount of solid waste generated continues to grow, and the growth rate is relatively fast. In 2018, my country is at the peak of rapid industrialization development, and the amount of industrial solid waste has reached 3.656 billion tons. 90% of the total industrial solid waste increase is composed of waste ore resources such as coal gangue, tailings, and fly ash. Through green development, low-carbon development, environmental protection development and circular economy, it is urgent to improve resource utilization, realize efficient resource utilization of industrial solid waste, and achieve efficient environmental protection[11-12]. The use of industrial solid waste such as coal gangue as the main raw material to prepare ceramsite can not only meet the market's major demand for lightweight building materials, high-strength materials, and environmentally friendly materials, conform to the national development strategy, but also obtain excellent economic and social benefits [13-15].

At present, the accumulated industrial solid waste in the country exceeds 60-70 billion tons, and the amount of solid waste generated continues , obtain the properties of coal gangue ceramsite through performance test and analyze its mechanism, which lays the foundation for obtaining high-quality coal gangue ceramsite.

Materials and experimental

The coal gangue and steel slag used in this paper are obtained from a factory in Pingxiang, Jiangxi Province, and the composition analysis is shown in Tab.1. It can be seen from Tab.1 that the composition of coal gangue is mainly SiO_2 and Al_2O_3, and contains a small amount of other oxides. Fig.1 is the X-ray diffraction spectrum of coal gangue. According to Figure 1, it can be concluded that the main crystal phase of coal gangue is SiO_2, followed by Al_2O_3. In addition, coal gangue also contains some silicon-alumina compounds and a small amount of other substances.

First, prepare the waste coal gangue powder, kaolin, and steel slag required for the experiment. The obtained waste coal gangue was put into a constant temperature drying box with a temperature of 60° C. for drying, and the dried coal gangue powder was sieved with a 100-mesh sieve. Determine the proportion of various components of coal gangue ceramsite prepared by using different content of coal gangue raw materials; through comparative analysis of multiple experiments, finally, the best proportion of coal gangue, kaolin, and steel slag is obtained, and then in the water chestnut type pelletizing machine Ball in the ball. After drying the sample, according to the sintering temperature range, put the sample into the energy-saving box-type resistance furnace for high-temperature sintering. By testing the compressive strength, water absorption, porosity and other properties of the samples, the performance differences of the samples under different processes were explored. D8 Advance X-ray powder diffractometer was used to test the phase of the powder, SU8010 scanning electron microscope was used to test the microstructure of ceramsite, and AGS-X 10KN universal chemical testing machine was used to test the compressive strength of ceramsite.

Tab.1 The main chemical composition of gangue

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	K_2O+NaO	V_2O_5	P_2O_5
Content（wt%）	52	35	5.2	0.8	1.86	2.85	2.13	0.01	0.15

Results and discussion

Fig.2 shows the porosity and compressive strength of coal gangue ceramsite obtained at different calcination temperatures when the content of coal gangue is 100%, holding for 60min, and Fig.3 shows the gangue ceramsite obtained at different calcination temperatures when the content of coal gangue is 100%, holding for 60min of water absorption. It can be seen from Fig.3 that when the gangue content is 100% and the holding time is 60 minutes, the compressive strength increases significantly before 1200 °C, while the water absorption and apparent porosity decrease. When the calcination temperature exceeds 1200 °C, the compressive strength gradually decreases, while the water absorption and apparent porosity gradually increase. Therefore, as the calcination temperature increases to 1200 °C, the compressive strength increases sharply to 29.57MPa, while the porosity drops sharply to 4.36% and the water absorption decreases to 1.71%.

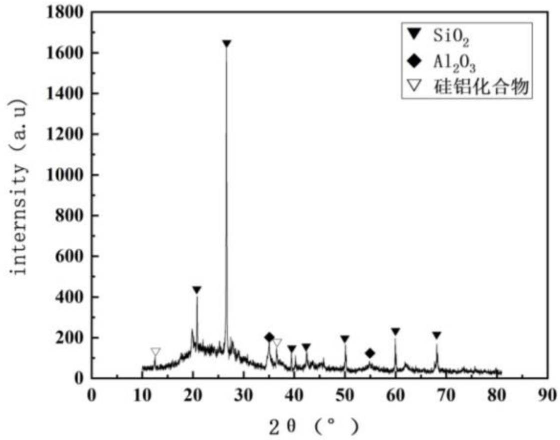

Fig.1 XRD pattern of coal gangue

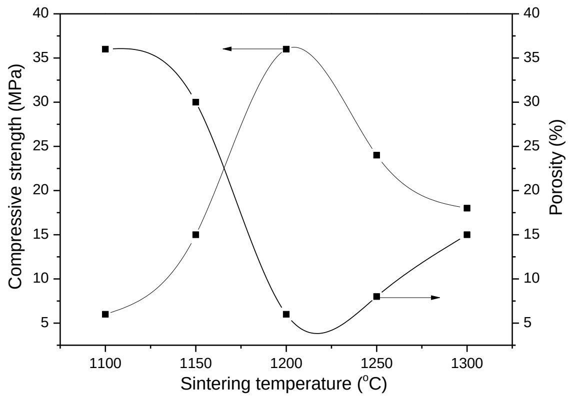

Fig. 2 Effect of sintering temperature on porosity and compressive strength of gangue ceramsite

Fig.4 and 5 show the effect of calcination temperature on the micro- and macro-morphology of ceramsite respectively. From the SEM photos and macro photos of coal gangue ceramsite at different calcination temperatures in Fig.4 and 5, it can be seen that with the increase of temperature, SiO_2 and Al_2O_3 form a glass phase at high temperature, forming a ceramsite skeleton, which provides strength for the ceramsite as a stress frame, reducing pores, porosity, and water absorption. Excessive glass phase is melted out, and some pores are formed. With the drilling of gas, the compressive strength of ceramsite is reduced, and the porosity and water absorption rate are increased. The results show that when the calcination temperature reaches 1200 ℃, the calcination process of the ceramsite is completed and the density is increased, thereby improving the compressive strength of the gangue ceramsite.

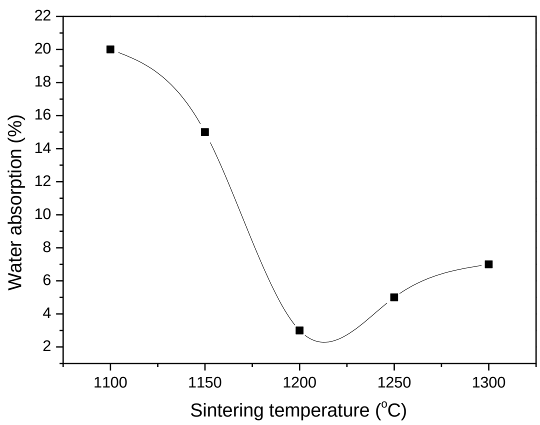

Fig. 3 Effect of sintering temperature on water absorption of coal gangue ceramsite

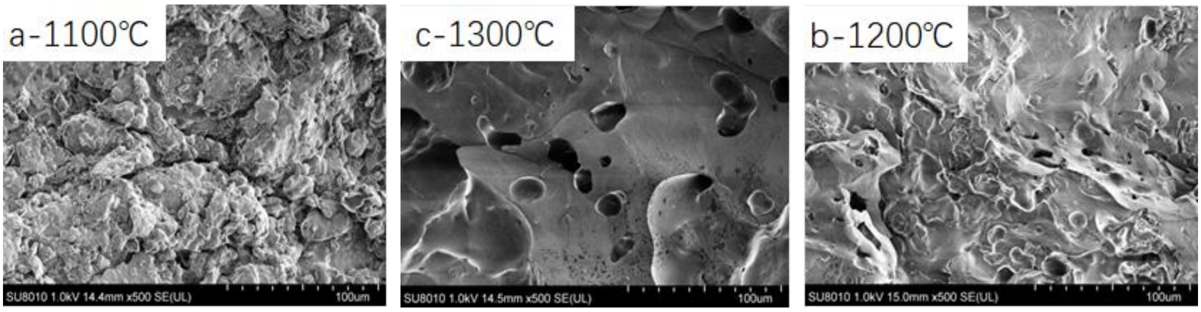

Fig.4 Effect of calcination temperature on the microstructure of ceramsite

Fig.5 Effect of calcination temperature on macroscopic morphology of ceramsite

Fig.6 shows the porosity and compressive strength of the coal gangue ceramsite obtained at a calcination temperature of 1200 ℃, a coal gangue content of 100%, and different holding times. Fig.7 shows the water absorption rate of the coal gangue ceramsite obtained at different holding times when the calcination temperature is 1200°C, the coal gangue content is 100%. It can be seen from Fig.6 that when the gangue content is 100% and the calcination temperature is 1200 °C, the compressive strength increases significantly before the holding time of 60 min, while the water absorption and apparent porosity decrease. When the holding time exceeds 60min, the compressive strength gradually decreases, while the water absorption and apparent porosity gradually increase. Therefore, as the holding time increases to 60min, the compressive strength increases sharply, reaching 29.57MPa, the porosity drops sharply to 4.36%, and the water absorption decreases to 1.71%.

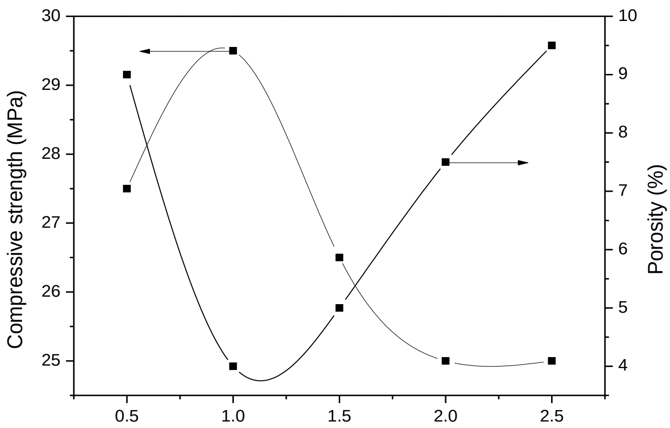

Fig.6 Effect of holding time on porosity and compressive strength of gangue ceramsite

Fig.8 and 9 show the effect of holding time on the micro- and macro-morphology of ceramsite, respectively. From Fig.8 and 9, it can be seen from the SEM photos and macro photos of coal gangue ceramsite with different holding times that with the increase of holding time , so that the sintering of ceramsite is more sufficient, thereby increasing the compactness of ceramsite and increasing the strength of gangue ceramsite, but the water absorption rate and apparent porosity are reduced.

However, if the holding time is too long, it may lead to over-burning, and too much glass phase precipitates on the surface, resulting in a decrease in compressive strength, an increase in porosity and an increase in water absorption. Comprehensive analysis shows that the optimal calcination process system for coal gangue ceramsite is 1200 ℃, holding for 60 minutes.

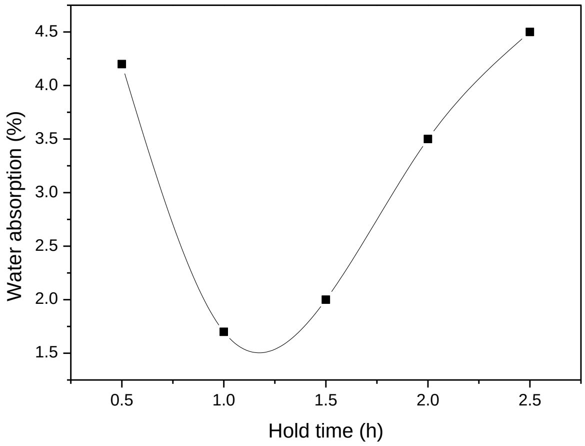

Fig.7 Effect of holding time on water absorption of coal gangue ceramsite

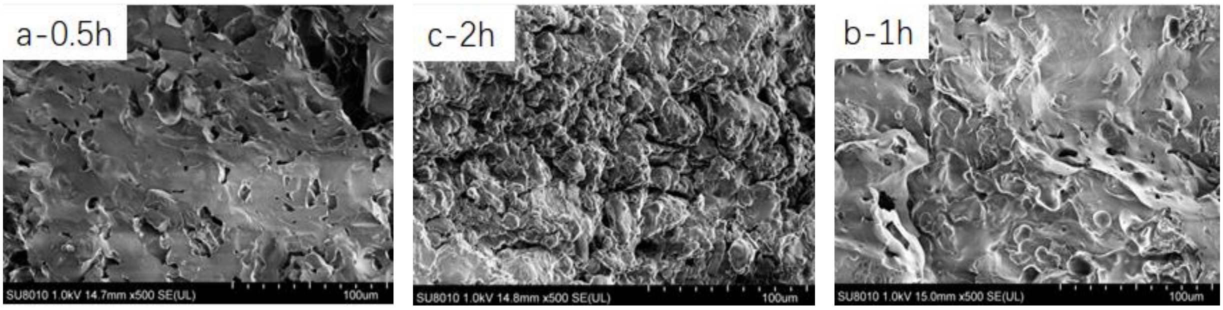

Fig.8 Effect of holding time on the micro-morphology of ceramsite

Fig.9 Effect of holding time on macroscopic morphology of ceramsite

Conclusion

In this paper, the process research of preparing coal gangue ceramsite from coal gangue powder is mainly studied from three aspects: sintering temperature, holding time and coal gangue content. The conclusion is as follows. With the increase of sintering temperature, the pores of ceramsite first decreased and then increased, the water absorption rate of ceramsite also decreased first and then increased with the increase of sintering temperature, while the compressive strength decreased first with the increase of temperature raised later. With the increase of holding time, the pores of ceramsite first decreased and then increased, the water absorption rate of ceramsite also decreased first and then increased with the increase of sintering temperature, while the compressive strength decreased first decreased and then increased with the increase of temperature. To sum up, the optimal calcination temperature for preparing coal gangue ceramsite is 1200℃, the holding time is 1h, and the coal gangue content is 100%. At this time, the porosity of coal gangue ceramsite is 4.36% and the water absorption rate is 1.71%. , the compressive strength is 29.57MPa.

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