Experimental Research on Preparation of Ultra-Low-Density Ceramsite Proppant with Bauxite Waste Rock

JunweiMa[1,4], GuoliangWu[2,5] and Jianqiang Zhang[3,6]
1. Senior engineer
2. Director of the institute
3. Assistant director of the institute
Zhengzhou Non-ferrous Metals Research Institute Co. Ltd of CHALCO, Zhengzhou, China
4. Senior engineer
5. Director of the institute
6. Assistant director of the institute
National Aluminum Smelting Engineering Technology Research Center, Zhengzhou, China
Corresponding author: 33623290@qq.com

Abstract

In this work, the ultra-low-density ceramsite proppant was first prepared using bauxite waste rock as the main raw material. The effects of raw material pre-calcination, sintering temperature, sintering time and additive dosage on proppant performance were studied. The results indicated that the Henan bauxite waste rock was pre-calcinated at 750℃ for 2 hours, the additive dosage of CMC of 1.5%, and the raw meal granules were calcined at 1320℃ for 150min, the formed ceramsite proppant size was between 0.42 and 0.84 mm, its bulk density was 1.41g/cm^3, apparent density was 2.53g/cm^3, and breakage rate under 52 MPa closed pressure was 5.26%. The prepared ceramsite proppant can meet the SY/T 5108-2014 requirements according to the standard of proppant using for hydraulic fracturing and gravel packed.

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1. Introduction

In the mining process of bauxite, a large number of hard clay ores and low-grade ores stripped from mining roof and floor will be produced.Under the current market economic situation, they are discharged as waste residue, which not only wastes valuable mineral resources and causes economic losses of enterprises, but also occupies a lot of land and funds, which is not conducive to environmental protection[1,2]. The main contents of bauxite waste rock are SiO_2 and Al_2O_3. By reasonably controlling the contents of Fe_2O_3, K_2O and Na_2O in the waste rock, it can be used to produce low-density ceramsite proppant[3,4]. At present, the production capacity of medium density ceramsite proppant in China is seriously excessive, while the production capacity of ultra-low-density ceramsite proppant is seriously insufficient, which is an important development direction of ceramsite proppant in the near and future[5,6]. From the perspective of raw materials, the preparation of high performance ceramsite proppant from industrial solid waste represents the development direction of oil fracturing proppant, and the research of low cost and high performance ceramsite proppant will be highly valued and developed[7-10]. In view of the low comprehensive utilization rate of bauxite mining waste rock and the serious shortage of ultra-low-density ceramsite proppant productivity in China,the experimental research on the preparation of ultra-low-density ceramsite proppant from mining waste rock was carried out.

2. Test

2.1 Test materials

The bauxite waste rock used in the test came from a bauxite mining plant in Henan Province, , which was hard clay ore. The chemical composition analysis of bauxite waste rock is shown in Table 1, and the phase analysis results are shown in Table 2.

Table 1. The chemical composition analysis results of bauxitewaste rock.

Element	Al_2O_3	SiO_2	Fe_2O_3	TiO_2	K_2O	Na_2O	CaO	MgO
Content/%	40.26	42.33	1.30	1.95	0.11	0.01	0.16	0.07

Table 2. The phase analysis results of bauxite waste rock.

Mineral	Diaspore	Kaolinite	Illite	Hematite	Anatase	Rutile
Content/%	5.10	89.90	1.10	1.30	1.55	0.40

It can be seen from Table 1 and Table 2 that the waste rock sourced from Henan Province as raw materials, the main aluminum bearing minerals were diaspore, the main silicon bearing minerals were kaolinite and illite, the main iron bearing minerals were hematite, and the main titanium bearing minerals were anatase and rutile. Its chemical composition basically meets the requirements of ultra-low-density ceramsite proppant for main raw materials.

2.2 Experimental method

The bauxite waste rock was pre-calcined at 650℃ to 800℃. It was then mixed with a certain amount of carboxymethyl cellulose (CMC) as additive, and then crushed to a particle size less than 0.0374mm. The above-mentioned materials were granulated by forced stirring granulator to make 18-35 mesh semi-finished products. The semi-finished granules were dried to moisture content less than 3%, and then sintered in a high-temperature tubular rotary furnace. The sintering temperature was 1280℃to1360℃, and the sintering time was 1-3 hours, and the ultra-low-density ceramsite proppant with particle size of 20-40 mesh was prepared.

2.2.1 Pelletizing process

The highspeed stirring granulator was used for granulation. Before granulation, the powder and water were added into the container, and then the high speed mixing was carried out. The powder and water were fully mixed, and then the bulbar nucleus were slowly formed and gradually grew up. When the particle grows to a certain size, the needle rod on the stirring rod will smash the ball particles beyond the size again, and the process of ball growing again.After the particles grew to the target size, a small amount of reserved powder with the same formula was quickly put into use for surface coating and polishing, so that the surface of the particles will be smoother, the interior will be denser and easy to disperse.

2.2.2 Sintering process

A High temperature tubular rotary furnace was used to sinter the products. The qualified raw meal granules were dried and added into the automatic feeding bin. The heating curve was set, the inclination angle and rotation speed of rotary furnace were adjusted. Then the proppant sintering test was carried out. The sintered products were screened for 20-40 mesh size, and the properties of roundness, sphericity, bulk density and breakage rate of different closing pressure were measured.

Table 4. The test results of the ceramsite proppant from bauxite waste rock.

Test items	Detection result	Standard requirements	Result judgment
Bulk density, g/cm^3	1.41	≤1.65	Qualified
Apparent density, g/cm^3	2.53	≤3.00	Qualified
Breakage rate under 52 MPa closed pressure, %	5.26	≤9.0	Qualified
Roundness	0.9	≥0.80	Qualified
Sphericity	0.9	≥0.80	Qualified
Turbidity, FTU	55	≤100	Qualified
Acid solubility, %	3.2	≤5.0	Qualified

It can be seen from Figure 4 and Figure 5 that under the optimal conditions, the main phase composition of ceramsite proppant prepared from bauxite waste rock was mullite, corundum and cristobalite. Ceramsite proppant has dense internal structure and complete crystal development, mainly mullite phase, which improved the compressive strength of the product.According to the test results in Table 4, the product indexes prepared by bauxite waste rock met the requirements of low density and high strength ceramsite proppant standard.

4. Conclusions

The bauxite waste rock used as raw materials was sourced from Henan Province, which was pre-calcined at 750℃ for 2 hours, the additive dosage of CMC of 1.5%, the ultra-low- density ceramsite proppant was prepared after granulation and sintering. The raw meal granules were calcined at 1320℃ for 150min, the formed ceramsite proppant size was between 0.42 and 0.84 mm, its bulk density was 1.41g/cm^3, apparent density was 2.53g/cm^3, and breakage rate under 52 MPa closed pressure was 5.26%. The prepared ceramsite proppant met the SY/T 5108-2014 requirements according to the standard of proppant using for hydraulic fracturing and gravel packed.

Through the analysis of the micro morphology and phase of the sample, the main crystalline phase was mullite, corundum and cristobalite. The internal structure was dense and the crystal was fully developed, which improved the compressive strength of the product.

The ultra-low-density ceramsite proppant prepared by using bauxite waste rock, compared with using conventional raw materials to produce the low density ceramsite proppant, can realize the efficient utilization of bauxite waste rock.

This will effectively reduce the environmental and safety risks in the process of waste rock stacking, with low production cost and has significant economic and social benefits.

5. References

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