Short Research Article

Research progress in the preparation of ceramsite from solid waste

ABSTRACT: A large number of solid waste stockpiles produce pollution and harm to the atmosphere, soil, water bodies, and biosphere. Ceramic pellets are an emerging material with excellent performance and wide application. Part of solid waste and ceramic pellets have a degree of compatibility, which is an excellent ceramic pellet matrix material, and the use of waste to prepare ceramic pellets products can be used on a large scale while forming good social and environmental benefits and considerable economic benefits. This paper the national standard index requirements of ceramic pellets; lists and summarizes the status of ceramic pellets; introduces the general situation of industrial solid waste generation and treatment in China in recent years.

Keywords: Solid waste; ceramic pellets; resourcefulness; process

0 INTRODUCTION

As a new lightweight, thermal insulation, high-strength multi-functional artificial light aggregate, ceramic pellets are a part of the "Industrial Structure Adjustment Guidance Catalogue (2019)" encouraged category of building materials for assembly-type buildings, and is also a multi-functional product in the "Thirteenth Five-Year Plan" and "Building Materials Industry Development Plan (2016 ~ 2020)". Materials. The Ministry of Industry and Information Technology issued on May 15, 2018, to implement the "Interim Measures for the Evaluation and Management of Comprehensive Utilization of Industrial Solid Waste Resources" and "National Catalog of Comprehensive Utilization of Industrial Solid Waste Resources", the main products of which include ceramic granule products. This has a significant significance and promoting effect on the resource utilization of industrial solid waste preparation ceramic pellets and the ceramic pellet industry itself. With the rapid development of green ecological circular economy construction, the production of raw materials of ceramic pellets has been shifted from traditional clay and shale to industrial tailing sludge, construction sludge, and other solid wastes, which is an important factor for the sustainable development of ceramic pellet industry. It has been found that most industrial solid wastes have a good fit with ceramic pellets' raw materials and are excellent basic materials for ceramic pellets.

1 OVERVIEW OF SOLID WASTE

1.1 Red mud overview

Red mud is mainly composed of oxides or hydroxides of aluminum, iron, calcium, and titanium, and fine particles of silica. Due to its inherently high calcium and sodium hydroxide content, red mud is relatively toxic and has the potential to cause serious contamination. The main mineral composition of Bayer red mud is desilication products (DSP) and residual minerals such as hematite and quartz in bauxite; the main component of sintered red mud is dolomite, with a mass fraction of 50%. The main characteristics of the Bayer process are low energy consumption, but the loss of aluminum metal is high, and the impact on water bodies and soil is large; the sintering process has high energy consumption and carbon emissions, and there is much room for reducing energy consumption; the combined method has the highest resource utilization rate of aluminum, and among these three processes, the Bayer process has a long history of red mud emissions for the development of the aluminum industry. In the process of extracting alumina from aluminum ore by the Bayer process, about 70 million tons of dry red mud is produced annually. A large amount of red mud generated required proper disposal, and the most common method of handling red mud at the time was simply to store it in the dike sediment adjacent to the alumina processing plant. On the one hand, the recycling of red mud can reduce its negative impact on the environment, and on the other hand, it is of great research significance to turn red mud into a treasure and to make secondary use of red mud, which can be applied in a comprehensive way to generate more value in environmental management. At present, the utilization of red mud mainly includes the production of ceramics, construction, adsorption, new functional materials, metal recycling, and application in environmental pollution control. From a comprehensive point of view, it is urgent to improve the current situation of red mud stockpiles and promote the resourceful reuse of red mud.

1.2 Overview of coal gangue

Coal gangue is the waste discharged in coal production, according to estimates, every Production of 10t coal will produce 1t coal gangue. Coal gangue not only occupies a lot of lands but also caused a waste of land resources and serious environmental Pollution, coal companies have to pay high costs for this, and more and more coal gangue has become a burden on the enterprise. Coal gangue and stone coal, are poor-quality fuels, its low heat content, low carbon content, hardness, high mineral content, and low organic matter content. Digging gangue generally has low carbon content, and calorific value is correspondingly low; coal gangue contains high carbon content, a certain calorific value, often mixed with coal and coal sludge, which is characterized by concentrated emissions, smaller particle size, higher availability, but more sulfur and iron content; self-combustion gangue for years of accumulation caused by natural after gangue, because it has been a certain burning process, and has a certain volcanic ash activity and chemical activity, but its calorific value is not high.

The coal gangue contains carbon, and has a certain calorific value, especially the selected coal gangue heat is generally more than 6270kJ/g, it is processed into 13mm particle size, moisture 10% of the coal gangue, and the washing process produced

by the lower calorific value of poor quality coal together with the configuration of the heat of 10000 ~ 13000kJ/g coal, can be used as fuel for power plant fluidized bed boiler, can also be used for small fluidized bed boiler for heating. Since the coal mine pit power station uses a fluidized bed boiler, all can use this fuel, for the country to save a lot of high-quality coal, and greatly reduce environmental pollution.

1.3 Overview of fly ash

Fly ash is mainly used in coal-consuming processes such as thermal power generation, metal smelting, and heating, which can be harmful to human life and production if not used effectively. For example, fly ash requires a lot of lands, and open piles will cause ash, pollute the atmosphere, damage the soil structure and pollute water bodies, etc. In the 1920s, overseas research on the comprehensive utilization of fly ash has been carried out, and by the 1990s, many countries have more mature comprehensive utilization technology of fly ash. However, the utilization rate of fly ash varies greatly from country to country due to the differences in the level of science and technology, economic level, natural conditions, and the nature of fly ash. In China, the fly ash production is huge, but the regional distribution is uneven and there are seasonal differences, resulting in a low utilization rate of fly ash and large regional differences.

Fly ash has active, morphological, and micro aggregate effects, which can improve the weak interface between newly mixed cement mortar and recycled coarse aggregate, thus improving the mechanical properties of recycled aggregate concrete. In addition, the glass beads contained in fly ash have homogenizing and water-reducing effects, which can improve the rheological properties of concrete and its permeability after hardening. The chemical properties of fly ash are similar to those of red clay and kaolin, but it contains higher Al 2O3 and has better refractory properties, which can effectively avoid the cracking of billets during the sintering process and thus increase the success rate of sintering. Therefore, fly ash can replace some red clay and kaolin as raw materials for brickmaking.

The mullite component of fly ash improves the compressive capacity and toughness of ceramics, which in turn improves the brittleness of ceramic products and makes them less susceptible to damage. In modern interior wall and floor decoration, the application of fly ash ceramics is not only beautiful but also can play a role in sound and heat insulation. However, the application of fly ash ceramics also has the problems of a complex preparation process, large investment, and small amount of admixture.

2 OVERVIEW OF CERAMSITE

2.1 Proceedings of the academic conference on ceramic pellets

The fourth national light aggregate and light aggregate concrete academic discussion meeting held in 1994, the National Light Aggregate Society and related experts proposed to accelerate the development of high-strength ceramic pellets, the fifth National Light Aggregate and Light Aggregate Concrete Conference in 1997 again stressed the acceleration of the development of high-strength ceramic pellets. Ltd. and Yichang Baozhu Ceramics Development Co., Ltd. two ceramics production enterprises and the application of

several typical projects, greatly promoted the development of high-strength ceramics: Nanjing Sun Palace Square, Guangdong International Conference Center, Tianjin New Yongding River Bridge, Beijing North Fourth Ring Jianxiang overpass, Beijing Jingzhou Highway Yongding River Bridge, Nanjing International Exhibition Center, Nanjing Bridge South Road Viaduct, etc.

In the 7th National Symposium on Light Aggregate and Light Aggregate Concrete in 2000, some of the above-mentioned projects applying high-strength ceramic pellets were reported, which set off a small climax of research, production, and application of high-strength ceramic pellets and their concrete in China. Ltd. (shale grinding process), Jiangsu Jintan Haifa New Building Material Co., Ltd. (shale grinding process), Daqing Petroleum Administration Electric Power Company Fly Ash Ceramic Granule Plant (introduction of British sintering machine technology), Yunnan Kebao Coal Mine Ceramic Granule Plant (coal mine stripping soil granulation process), Liaoning Chaoyang Hualong Kejian Ceramic Granule Company (coal gangue grinding process) as representatives of several production High strength ceramic pellets manufacturers and more engineering applications.

At present, the national production capacity of ceramic pellets is about 15 million m3, of which the proportion of high-strength ceramic pellets is less than 10%, and its main varieties are shale gravel-type high-strength ceramic pellets, fly ash sintered ceramic pellets (rotary kiln process and sintering machine (box) process), and silicate autoclaved light aggregate, which is far from meeting the needs of the current stage of comprehensive utilization of solid waste and the construction market, especially the market of PC components for assembly-type buildings. Thus, the use of solid waste production of high-strength ceramic pellets will become one of the main development directions in the coming period.

2.2 Application of ceramic pellets

At the beginning of the research and production of ceramic pellets, they were used as aggregates in the field of building materials. As a building material, pottery pellets generally require lightweight and high strength; corrosion resistance; thermal insulation, earthquake resistance, and seepage resistance. The mechanical strength of the clay brick is best when the sludge is added at 2.5%, which can reach 30 MPa. The compressive strength of concrete is the highest (28 MPa) at 12 mm particle size. The addition of 25% (mass fraction) of sludge ceramic pellets to the concrete can improve the thermal insulation properties of concrete. It has been shown through research that concrete hollow blocks made by adding sludge ceramic pellets have a significant energy-saving effect and are suitable for new wall construction in hot summer and cold winter regions. Nowadays, as the research related to ceramic pellets continues, it is understood that the application of ceramic pellets is no longer limited to the single field of building materials.

The nutrients (N, P) and trace elements (K, Mg, Ca, etc.) contained in the sludge ceramic pellets can supply the required elements for plants and promote their growth. When the sludge ceramic pellets are used as the soilless substrate, they have good water permeability and air permeability, and at the same time can play a certain buffering effect on pH. Low leaching toxicity is the basic requirement for the use of ceramic pellets as a soilless substrate.

Water-treated pottery pellets contain alkaline components such as calcium phosphate hydrate, calcium phosphate triplicate, and sodium hydrogen phosphate, which can react with acidic substances and improve the pH of the soil; the effective phosphorus and total phosphorus mass fraction in soil with added pottery pellet waste (350 g pottery pellet waste:1.2 kg soil) are increased by 27.6% and 16.0%, respectively, which can promote the accumulation of dry matter in corn plants. The addition of pottery pellets to the soil surface not only effectively increased the water in the substrate, but also reduced the variation of water content between different soil layers and months, thus keeping the growing environment of plants in a stable state. The addition of straw-fly ash pellets with a mass fraction of 20% and 40% in the soil can enhance the moisture retention effect of the soil.

When used as a substrate for cultivation, ceramic pellets mainly increase plant yield, facilitate plant survival and growth, and promote dry matter accumulation. When homemade ceramic pellets were used as cultivation substrates for agricultural research, it was found that the appropriate amount of ceramic pellets (20% mass fraction) could increase the yield of Chinese cabbage (59.69%) and the plant's resistance to pests and collapse. The pottery pellets after treating sewage water were used as cultivation substrate, which is rich in nutrients such as N, P, and K required for plant growth and is beneficial to plant germination. The highest germination rate and faster sprouting of cabbage seeds were achieved when the number of ceramic pellets applied was 20% (mass fraction), and the yield of cabbage tended to increase as the number of ceramic pellets applied increased. Covering the soil surface with ceramic pellets not only had a significant effect on the photosynthesis of plants but also improved the survival rate and growth rate of plants. The results showed that the application of ceramic pellets increased plant height by 23.3% and 14.5%, and leaf area by 75.9% and 64.6%, respectively, and promoted the accumulation of plant mass in two different maize plants.

3 RESEARCH PROGRESS OF SOLID WASTE-BASED CERAMIC PELLETS

The theory, technology, and equipment for preparing ceramic granules from solid waste are maturing. Solid waste pellets can be divided into five categories: fly ash pellets, waste rock and tailings pellets, sludge pellets, terracotta pellets, waste slag, and slag pellets by the different types of solid waste. The composition of the above-mentioned solid waste is close to the theoretical composition of ceramic pellets, and some other solid waste, shale, clay, or glass powder can be added to prepare qualified ceramic pellets. The ceramic granule preparation process and product testing formed a complete theoretical system, the preparation process of a ceramic granule with sintered ceramic granule process and no baking ceramic granule process two; released several ceramic granules related to national standard documents specify the indicators and testing standards of ceramic granule. Ceramic pellet production equipment has also been developed accordingly, there is much-advanced equipment, and more and more full-line automated production lines.

China in the use of clay, shale, and other natural mineral raw materials and the use of fly ash preparation of ceramic granule research has more mature technology, and for the use of coal gangue, all kinds of

tailings and other industrial solid waste burning ceramic granule technology is still in the research and development stage, mainly focused on the feasibility study of different industrial solid waste sources of raw material formulations, including raw material sources and formulation system on the product bulk density, cylinder compression strength, water absorption, porosity, etc. The impact of water absorption, porosity, and other performance indicators. In the production process of ceramic pellets, most of the industrial solid waste materials need to be mixed with other materials to obtain the appropriate ceramic pellets' raw material composition and the preparation of excellent performance of ceramic pellets. At present, more ideal development results have been obtained, and the amount of blending is> 30% Preparation of qualified ceramic pellets of industrial solid waste materials are: fly ash, coal gangue, copper tailings, gold tailings, iron tailings, vanadium tailings, sapphire tailings, nickel laterite tailings, red mud, sludge, etc...

The recent development is mainly concentrated in Shanxi and Shandong, using the "waterfall" rotary kiln developed by Shandong Hengyuan Company, and the fly ash pellets under construction and already in operation have an annual output of about 300,000 cubic meters. Sludge pellets are a recent industry development hotspot, the use of ceramic pellet kiln co-disposal of various industrial sludge, and even hazardous waste and sludge (such as chrome slag, vanadium tailings, leather sludge, electroplating sludge, stainless steel pickling sludge, oil sludge, etc.) and other aspects of rapid development. According to the incomplete statistics of the new sludge pellets project of China Concrete and Cement Products Association Light Aggregate Branch in 2018, there are more than 12 new and under-construction sludge pellets enterprises, with an additional capacity of nearly 2 million cubic meters, and the preparation of pellets has become a new and effective way to resourceful and harmless disposal of sludge. Compared to fly ash, industrial sludge preparation of ceramic pellets of mature technology applications, coal gangue, all kinds of tailings, smelting slag, and other industrial solid waste burning ceramic pellets of industrialization is relatively slow. It is understood that will be built in Huairen City, Shuozhou City, Shanxi Province, coal gangue ceramic pellets project to achieve 100% use of solid waste, coal gangue, and fly ash as raw materials, the use of international advanced special production line, through scientific proportioning, nucleation, ball formation, cross-roller screening, sintering and molding for ceramic pellets. The first domestic 50,000 cubic meters full coal gangue ceramic pellet production line developed by Huainan Dongchen Group completely independently has been put into production. The production line of Huayou Cobalt using cobalt tailings as raw material to produce pottery pellets is currently under intense construction and is expected to be put into operation in the first half of 2021. Ltd., Wuhan University of Science and Technology, and Guangxi Lvsheng Technology Co., Ltd. cooperate in the "harmless treatment of typical industrial slag and resource utilization engineering research" project, one of the results of "steel slag burning high-strength insulation ceramic granule technology "is based on full particle size utilization and full life cycle development

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