Research Progress on Green Utilization of Red Mud

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Abstract Based on the research at home and abroad in recent years, this paper summarizes the recycling of metals in red mud, the preparation of cement and concrete with red mud, and the preparation of cementitious materials with red mud, so as to achieve the purpose of efficient utilization of waste and turning waste into wealth, make positive contribution to environmental protection, and ensure the green and sustainable development of various industries.

Key words Low carbon cycle, Red mud, Green utilization

1 Introduction

Red mud is the waste of alumina production, and according to relevant investigation and research, every ton of alumina produced will generate about 0.8 to 1.5 t of red mud[1], or even more. According to the data, the stock of red mud in China has exceeded 700 million t, and there is a large amount of red mud accumulated in the dam area, which not only occupies land, wastes resources, but also easily causes environmental pollution and potential safety hazards. In 2022, the green utilization amount of red mud was only 8 million t. According to the development requirements of China's 14th Five-Year Plan, the construction of ecological civilization and industrial green and low-carbon production play an increasingly important role in promoting the deep integration of green and low-carbon and ecological environment protection, and promoting the sustainable development.

In order to make green and comprehensive utilization of red mud, relevant scholars at home and abroad have explored and studied the utilization of red mud. At present, red mud is widely used, and as a building material, it can be used to prepare cement and concrete, and a certain amount of red mud can be used instead of cement for pavement construction. The compressive strength of bricks can meet the requirements of national standards by using waste red mud mixed with a certain quantity of admixtures at the same time. The vegetation cultivation technology with red mud is to firstly carry out ecological restoration of red mud and cultivate a variety of plants on phase III red mud. Red mud also has great potential in the application of new alkali-activated cementitious materials, and can be used in the preparation of cementitious materials. It is an urgent need for industrial green sustainable development to improve the green comprehensive utilization rate of red mud and reduce the potential risks to the environment caused by long-term storage of red mud.

2 Green utilization ways

2.1 Recovery of metal elements Red mud contains a large number of metal elements, especially ferric oxide, and its main chemical components include aluminium sesquioxide, silicon oxide and calcium oxide. If red mud is piled up, it will not only pollute the environment but also waste resources. Therefore, scholars at home and abroad have done a lot of experimental research and analysis on how to efficiently recover iron elements from red mud. Zhao Zi[2] *et al.* used many methods including physical separation, roasting, smelting and hydrometallurgy to recover iron, each of which has its own advantages and disadvantages. Physical separation involves relatively less pollution, but the amount of treatment is large, and the extracted iron contains impurities, so it is suitable for raw material pretreatment or tailings treatment. Other treatment methods are complicated, but they can be used to effectively extract iron to different degrees. Fan Yanqing[3] carried out relevant experimental research and analysis on Australian red mud, and concluded that iron oxide in red mud was completely reduced at about 1 200 ℃. At present, extracting useful components from red mud and recovering valuable metals such as iron, gallium and scandium is one of the more effective methods.

2.2 Preparation of cement and concrete Red mud can be used as raw material to produce cement materials with excellent properties, but the alkali content in red mud is slightly high, and the main method to solve this problem is to carry out dealkalization pretreatment on red mud to meet the requirements of cement production, and then increase the use level of red mud in cement. It is of great significance to develop a new economical and efficient method for red mud dealkalization for comprehensive green utilization of red mud. Singh[4] used a certain amount of red mud to re-

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place limestone and clay. The main components of red mud are iron oxide, alumina and silica, so red mud can be used as raw materials for cement and concrete, which can consume a part of red mud and reduce environmental pollution. The limestone and clay need to be mined in the production of cement, which will produce a lot of pollution and carbon dioxide emissions. They come to the conclusion that the cement produced by red mud reaches the test strength, and red mud will not change the mineralogical characteristics or affect the final quality when used as cement raw material, so it can be well applied to the preparation of cement. Zhang Junyi[5] analyzed the production of sulphoaluminate cement by mixing admixture with red mud. The cement slurry comprehensively utilizes two kinds of waste materials, and reasonably and scientifically applies red mud to the preparation of cement. After testing, the cement clinker prepared with red mud has good mechanical properties. Red mud as raw material for preparing cement clinker can effectively utilize its main components, and the cement produced will not change its original characteristics, and its compressive strength and flexural strength can meet the basic requirements.

2.3 Preparation of cementitious materials Red mud is the industrial solid waste discharged when extracting alumina[6]. Its main chemical components are calcium oxide, silicon dioxide and aluminum oxide, and the main components of alkali-activated cementitious materials are also these. After being treated by related technologies and sintered at high temperature, it still has high potential cementitious activity, so it is suitable for application in a large amount in the preparation of cementitious materials. Chinalco Shandong and Shandong Expressway Group have realized the preparation of low-carbon solid waste-based cementitious materials from Bayer red mud to completely replace cement in the whole country and it can be directly used to prepare cementitious materials. Only the free alkali in it can be used, and most silicon-aluminum phases cannot undergo hydration reaction. Some enterprises also make red mud into a high-quality geopolymer cementitious material, which can effectively consume a large amount of red mud and form low-carbon products that can replace traditional cement. Red mud-based cementitious materials can be used in pavement base stabilized macadam, subgrade improved soil, prefabricated components of traffic engineering and goaf filling, *etc.* The proportion of red mud in red mud-based materials can exceed 60%.

3 Discussion

At present, the main green comprehensive utilization of red mud includes iron recovery, preparation of ceramsite, preparation of building materials and preparation of road materials[7]. At the same time, there are many ways of red mud resource utilization being developed. First, red mud is used as the main raw material and combined with other solid wastes to prepare 3D printing ink. This process can not only effectively consume red mud and other solid wastes, but also turn waste into wealth and reduce cement consumption, which meets the development requirements of "dual carbon (carbon peaking and carbon neutrality) economy" and brings new opportunities for future economic development. Second, it can also produce economic benefits, which meets the requirements of sustainable development. With the attention of the country to the red mud problem, more and more enterprises and related units also actively participate in the research and development of new comprehensive treatment methods of red mud, and the large-scale green resource utilization of red mud will become a reality. According to the requirements of sustainable development of green building materials, people's awareness of ecological environment protection and green building materials is getting higher and higher. The comprehensive utilization technology and green application of various wastes are also rapidly advancing, and the treatment technology of red mud is also constantly improving. The exploration of the new idea of multi-coupling utilization of red mud has greatly expanded the ways of comprehensive utilization of red mud, such as realizing the technologies of recovering iron resources from red mud and using red mud in building materials, preparing cementitious materials with red mud, *etc.*, which can help to realize the integrated solution and industrialization idea of "solid waste treatment-gas purification-resource recovery".

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