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Status Quo of Comprehensive Utilization of Red Mud

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Abstract

Red mud is a solid waste in the aluminum industry. It has the characteristics of complex material composition, small particle size, high alkalinity and radioactivity, and high heavy metal content. Large piles of red mud are prone to cause major environmental safety issues. At the same time, red mud also has a high use value. This article will examine the use of red mud in the recovery of valuable metals, construction, environmental protection, and agriculture, as well as its shortcomings. Conduct an overview.

Keywords

Red Mud; Comprehensive Utilization; Valuable Metals; Building Materials; Environmental Protection; Agriculture.

1. Introduction

Red mud is a very fine-grained strong alkaline industrial solid waste produced during the production of alumina from bauxite as raw material. Depending on the type of bauxite, 1-1.5t of red mud is produced for every 1t of alumina produced. In 2015, the total global red mud was about 160 million t. As the largest red mud producer, China's total red mud production in 2016 was about 88 million. As of 2017, the global reserves of red mud have reached 3.9 billion tons, of which China has accumulated more than 350 million tons. A large amount of red mud is stored, which occupies land, wastes resources, and easily causes environmental pollution and safety hazards. In recent years, due to the lower grade of bauxite, the yield of alumina production has decreased, and the amount of by-product red mud has increased. However, the comprehensive utilization rate of red mud is very low, only 5.24%. A process commonly used to produce alumina, but due to some special properties contained in this production process, red mud will contain a large amount of heavy metal ions, fluorides and alkalis. These pollutants may enter the food chain by entering groundwater with rainfall or flowing into surrounding rivers, lakes and farmland. If animals or humans eat polluted water and food for a long time, it is bound to have a serious impact on health; the infiltration of water with high pH value into the soil farmland will cause the soil to compact and form dense clods, which will eventually turn into saline-alkali land with no grass. my country is a big country producing aluminum, which means that the annual discharge of red mud is as high as tens of millions of tons. The disposal of these waste residues has become a problem, so the utilization rate of red mud needs to be greatly improved.

2. Properties and Composition of Red Mud

2.1 Properties of Red Mud

The diameter of red mud particles is 0.088~0.25mm, the specific gravity is 2.7~2.9g, the bulk density is 0.8~1.0g/cm3, the melting point is 1200~1250℃, the specific surface area is 64.09~186.9m2/g, and the water holding capacity is 79.03%~93.23%. High, so the long-term stacking of red mud is difficult to unite, and it is in a state of soft plastic-flow plastic mud. [1-2] The composition of red mud

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is complex, in which metal oxides such as Al2O3, Na2O, SiO2, CaO, Fe2O3 and TiO2 are the main components.

3. Extract Valuable Metals

Red mud is rich in Al, Fe, Ti, V, etc. The recovery of valuable metals can not only reduce the metal content in red mud, reduce the impact and damage on the ecological environment, but also solve the problem of domestic metal mine raw materials to a considerable extent. To realize the sustainable development of the metal industry.

3.1 Recycled Aluminium

Since red mud contains a large amount of Al2O3 that has not been extracted, the recovery of alumina can alleviate the current situation of lack of bauxite resources in my country. The recovery of aluminum from red mud mainly includes sintering method and calcification-carbonization method. Kuang Chaohui[3] used the sodium roasting method to dissolve Al2O3. The results showed that the mass fraction of Na2CO3 was 15%, the roasting temperature was 1 100 °C, the clinker leaching temperature was 80 °C, the dissolution time was 20 min, and the liquid-solid ratio was 4:1. , under the condition that the roasting time is 60 min, the leaching rate of Al2O3 in red mud can reach 88.71%; Xiao-feng Zhu[4] et al. used the method of calcification-carbonation to recover alkali and aluminum in red mud, and the results showed that by carbonization Calcified slag, leaching alumina from carbonized slag with lye, can make 75% of alumina in red mud be recovered.

3.2 Recycled Iron

The former Soviet Union, Japan, the United States, Germany, etc. have done a lot of research on the recovery of metallic iron. Although the time of foreign research is relatively early, mostly in the 1960s and 1980s, it is still in a large number of practical applications. At present, the research on iron recovery from red mud in my country mainly includes physical recovery and reducing agent method. He Pingbo[5] et al. used selective hydrophobic flocculation of magnetic seeds to magnetize iron to recover iron. The results showed that the separation of iron-bearing minerals and gangue components was increased by adding sodium hexametaphosphate, and the addition of oleic acid and kerosene emulsion made the iron containing The mutual attraction between iron minerals increases, and the iron concentrate obtained by magnetizing the treated red mud has a grade of 46.59% and a recovery rate of 56.88%. After roasting at 800℃ for 50min, and conducting weak magnetic separation under the condition of magnetic field strength of 160 kA/m, iron concentrates with a TFe grade of 55.40% and a recovery rate of 81.44% can be obtained. However, the recovery rate of iron by the physical method is low, the reduction method cannot achieve the optimal effect and the energy consumption is high, and further improvement is required.

3.3 Recovery of Scandium and Titanium

Scandium and titanium are elements of great recycling value. Although the content of scandium and titanium in red mud is not as high as that of other metal elements, they still have high recycling value. At present, the extraction of these two elements is mainly based on acid leaching. Agatzini-Leonardou[7] et al. 6mol/L dilute sulfuric acid, temperature 50℃, solid-liquid ratio as the optimal reaction conditions, the recovery rate of titanium can reach 64.5%; Zhang Jiangjuan[8] et al. extracted titanium by hydrochloric acid leaching solution, the results It was shown that scandium was extracted from the HCl leaching solution with 1% P507, washed with 6mol/L HCl and distilled water, and then used NaOH solution as the back extraction agent. The purity of Sc2O3 in the final scandium enrichment was 66.09%. Although the acid leaching method makes the leaching rate of scandium and titanium high, it also causes the dissolution and leaching of other metal ions, and the consumption of acid is large, so the cost is high and the follow-up treatment is troublesome, so it is difficult to be promoted on a large scale.

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4. Application in the Field of Construction

4.1 Application in Building Materials

Red mud has the characteristics of high compressibility and low shear resistance, so it can be added to cement as an admixture as a concrete raw material. When Yue Yunlong[9] et al. added less than 10% red mud into 3% alkali slag cement, the strength decreased not much, and when the red mud content was 10% to 20%, the strength decreased greatly, and after more than 20%. The tendency to decrease in strength decreases. Yan Zuxing [10] pointed out when using red mud instead of cement to make concrete, when the amount of red mud instead of cement is less than 1/3, the flexural strength of cement red mud concrete is equivalent to that of ordinary cement concrete. The strength of unburned bricks will be greatly affected, and once put into use, radioactive elements such as As in red mud will also cause harm to organisms. Therefore, red mud non-burning bricks have not been widely promoted to engineering applications.

4.2 Application in Road

Zhang Ning[11] used Bayer process red mud as the main material and used sulfate cement as the binder to prepare the roadbed filling material. The strength is 5.2MPa and the shrinkage rate is only 1.8%, which shows that it meets the basic needs of the roadbed filling project. If it is put into application, a large amount of red mud can be used to reduce environmental pollution. Liang Xu and Liang Naixing[12] conducted experimental research on the unconfined compression, splitting strength, elastic modulus and frost resistance of cement red mud. The results show that a certain amount of red mud is beneficial to changing the To improve the frost resistance of the mixture and improve the elastic modulus, the optimum amount of red mud is 10% to 16%. Although red mud cement can reduce the stacking of red mud, it is easy to cause soil and groundwater pollution when filling the roadbed. Therefore, if red mud is to be used on a large scale, it is necessary to realize the recycling and harmlessness of red mud, and reduce the amount of red mud. pollutants, and realize the comprehensive utilization of red mud resources.

5. Application in the Field of Environmental Protection

5.1 Application of Soil Remediation

Red mud has the properties of large specific surface area and high porosity, so it can adsorb heavy metal elements in soil. Shi Lizheng [13] used modified red mud and ferrous sulfate to treat heavy metal contaminated soil. The results showed that after 7 days of soil cultivation, the content of Cd and As decreased by 75.01% and 70.63%, and the content of Pb decreased by 55.6% after 60 days. %, which provides a good application prospect for soil lead, cadmium and arsenic pollution remediation. Moreover, red mud contains potassium, calcium, silicon and other trace elements needed by plants, which can increase the yield of crops lacking potassium, calcium, silicon and other trace elements. Groundwater polluti.

5.2 Applications of Contaminated Water Remediation

In recent years, with the acceleration of the industrial process, the generated wastewater is difficult to treat. If it is not treated, it will easily cause environmental pollution. The good adsorption performance of red mud can remove heavy metal ions in industrial wastewater. Lu Aihua[15] under the conditions of red mud dosage of 6g/L, p H=4, room temperature, adsorption time of 45min, the adsorption rate of Cu2+ can reach 99.73%, which opens up a new way for the treatment of copper-containing wastewater. Lei Xiaoli [16] and others used modified red mud to adsorb heavy metal ions in wastewater. The results showed that the maximum adsorption capacity of Cd2+ by red mud/polypropylene (RM/PAA) composites was 96.15 mg/g; The treated wastewater containing Cr6+, the effluent can reach 0.1mg/L; the cations such as Na+, Ca2+ and Mg2+ in the red mud can exchange with Pb2+, and CO23- can also form precipitation with Pb2+, which can effectively remove Pb2+. The adsorption mechanism of heavy metal ions is still unclear, and the experimental process is complicated and the composition is difficult to control.

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5.3 Application of Waste Gas Treatment

A large amount of nitrogen sulfide harmful gas is produced in industrial production, which pollutes the environment. Compared with the application of red mud in other aspects, there is less research on gas purification. Zhu Tao[18] used red mud slurry to treat sulfur dioxide, and the results showed that when the reaction temperature was 20 °C, the liquid-solid ratio was 12:1, the red mud particle size was above 0.178 mm, and the pH value was above 4.5, the desulfurization rate was 95%. about. Wang Yue [24] used the BaZrO3/red mud catalyst to oxidize NO in flue gas in the experiment, using red mud: fly ash:. bentonite = 5:4:1 as the carrier of BaZrO3. The results show that when the catalyst content is 20%, the conversion rate of NO can reach up to 40% when the reaction is catalyzed at 350-380 ℃.

6. Conclusion

The treatment of red mud has always been a hot topic studied by scholars at home and abroad. A lot of research has been done on red mud dealkalization, non-ferrous metal extraction, environmental restoration, etc., and many results have been achieved, proving the feasibility of red mud utilization. However, in order to realize the further development and utilization of red mud, it is recommended to focus on the following directions in the future:

1) Develop low-cost, high-efficiency, zero-emission metal recovery technology, and find an efficient purification technology in the extraction process to improve the purity of metal products.

2) Improve the utilization rate of red mud in building materials, optimize the treatment process, solve the problem of the influence of alkali on building materials products, and promote the industrial utilization of red mud building materials.

3) The red mud that has undergone environmental restoration should find a reasonable treatment method to avoid more serious environmental pollution.

References

[1] Ma Hongkun, Yu Qizheng, Zhong Jingbo, Chen Yuexian, Shen Weiguo, Chen Min. Comprehensive utilization of red mud in building materials [J]. Building Materials World, 2012, 33(05): 9-12.

[2] Wanchao Liu et al. Environmental assessment, management and utilization of red mud in China[J]. Journal of Cleaner Production, 2014, 84: 606-610.

[3] Kuang Chaohui. Experimental study on recovery of iron and aluminum by sodium roasting of red mud [J]. Engineering Construction, 2021, 53(03): 64-69.J. Liu, E.L. Chen and Z.T. He: Journal of Shi Jia Zhuang Railway Institute (Natural Science), Vol. 22 (2009) No. 4, p.40-42.

[4] Xiao-feng Zhu, Ting-an Zhang, Yan-xiu Wang, Guo-zhi Lü, Wei-guang Zhang. Recovery of alkali and alumina from Bayer red mud by the calcification–carbonation method[J]. International Journal of Minerals Metallurgy and Materials, 2016, 23(03): 257-268.

[5] He Pingbo, Zhou Yanfei, Hu Yuehua. Experimental study on the separation of red mud from Pingguo aluminum by selective hydrophobic flocculation method [J].

[6] Wang Liming, Liu Tao, Bai Chunxia, Guan Di, Jia Jia, Li Hongjing. Experimental study on iron extraction from a red mud in Shandong [J]. Modern Mining, 2019, 35(11): 8-10.

[7] Wang Lu, Hao Yanzhong, Hao Zengfa. Progress in the extraction and comprehensive utilization of valuable metals in red mud [J].

[8] Zhang Jiangjuan, Deng Zuoguo, Xu Tinghua. Extraction of scandium from red mud hydrochloric acid leaching solution [J]. Light Metals, 2006(07):16-18.

[9] Yue Yunlong, Lu Lingchao, Chang Jun, Cheng Xin. Research on red mud alkali slag cement and its products [J]. Bulletin of Portland, 2001(01):46-49.

[10] Yan Zuxing. Research on the development and application of cement red mud concrete [J]. Concrete, 2000 (10):18-20.

[11] Zhang Ning, Gao Yifan, Li Zhaofeng, Zhang Jian. Experimental study on filling materials of high content red mud foundation roadbed [J]. China Comprehensive Utilization of Resources, 2020, 38(11): 10-13.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202205_8(5).0102

[12] Liang Xu, Liang Naixing, Zeng Jianmin, Mei Yingjun, Yu Wei. Research on the performance of cement red mud stabilized graded gravel base [J]. Journal of Chongqing Jiaotong University (Natural Science Edition), 2008, 27(06): 1086-1089.

[13] Shi Lizheng, Chen Huikang, Wu Chuan, Huang Liu, Cui Mengqian, Xue Shengguo. Stabilization effects of red mud and its composite passivators on soil lead, cadmium and arsenic [J]. Journal of the University of Chinese Academy of Sciences, 2018,35(05) :617-626.

[14] Li Dong, Pan Lixiang, Zhao Liangqing, Shi Lifang, Wu Xuan. Research progress on comprehensive utilization of red mud [J]. Environmental Engineering, 2014, 32(S1): 616-618+625.

[15] Lu Aihua. Study on the adsorption properties of red mud on copper-containing wastewater [J]. Shandong Chemical Industry, 2017, 46(14): 178-181.

[16] Lei Xiaoli, Wu Youe, Zeng Wei, Yang Di, Qian Wenmin, Li Bin. Research progress of typical heavy metals in modified red mud adsorption wastewater [J]. Environmental Science Guide, 2021, 40(04): 1- 8.

[17] Li Bin, Zhang Baohua, Ning Ping, He Liwei, Zuo Xiaolin. Current Situation and Prospects of Red Mud Resource Utilization and Safe Treatment [J]. Progress in Chemical Industry, 2018,37(02):714-723.

[18] Zhu Tao, Wang Ruonan, Jin Xinrui, Song Yuhan, Lv Yirong, Zhang Gengyuan. Treating Waste with Waste: Application Research on the Treatment of Industrial Waste Gas Sulfur Dioxide with Solid Waste Red Mud from Aluminum Plants [J]. Nonferrous Metals Engineering, 2019,9(07):109-114.

[19] Li Yanjun, Zhang Hao, Han Yuexin, Liu Xiao, Yuan Shuai, Gao Peng. Red mud resource recycling research progress [J]. Journal of metal mine, 2021 (04) : 1-19. DOI: 10.19614 / j.carol carroll nki JSKS. 202104001.

[20] Li Yiwei, Fu Xianghui, Li Li, Zeng Juan. Research progress and prospect of comprehensive recycling of red mud [J]. Rare Earth, 2020,41(06):97-107.

[21] Liu Qingling, Jin Xiuqi, Yang Yujia, Liu Jin, Zhang Junjun. Research progress on the application of red mud in environmental pollution remediation [J]. Environmental Science and Technology, 2019, 25(05): 56-60.

[22] Jiang Wenyan, Zhang Linye, Long Jianyan, Zhou Changxi, Liao Zhifei, Wei Guangtao. Advances in the preparation and application of red mud-based environmental remediation materials [J]. Modern Engineering, 2018, 38(05): 29-33.

[23] Yang Jiakuan, Hou Jian, Qi Bo, Liu Wei, Guo Huaisheng, Xiao Bo. Pilot production and industrialization of red mud unburned bricks for aluminum industry [J]. Environmental Engineering, 2006(04):52-55+4.

[24] Wang Yue. Preparation of BaZrO_3/red mud catalyst and its catalytic oxidation of NO in flue gas [D]. Beijing University of Chemical Technology, 2013.