Pretreatment Technology of Gibbsitic Bauxite with High Organic Matter Content

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Abstract

Organic matter in the alumina production process is the main technical problem that concerns the alumina refinery at present. This paper proposes to solve this problem by bauxite pre-treatment technology. The organic content can be reduced to 0.05 % by calcination at about 850 ℃. The roasted ore was digested using a conventional high temperature Bayer process, and the relative digestion rate of alumina reached about 98 %. By using this technology, the organics problem impacting the alumina process can be completely solved, the freight costs of bauxites transportation can be saved by one-third, and evaporation costs can also be significantly reduced by reducing water intake in the alumina production process, as water accounts for one-third of the weight of raw bauxites. This technical solution will be more competitive if low-cost energy is available at the mining sites of bauxite resources.

Keywords: Gibbsite, Organics, Roasting, Digestion.

1. Introduction

With the continuous expansion of China's alumina industry and the ongoing depletion of domestic bauxite resources, the country's bauxite imports have steadily increased, from less than 10 million tonnes in 2010 to 159 million tonnes in 2024. Due to the geological and climatic conditions of mineral formation, the organic content in bauxite has gradually increased [1, 2–6]. As a result, the organics issue has become one of the primary technical challenges faced by China's alumina industry. This leads to a series of problems, such as increased foam in the precipitation system, reduced precipitation rate, decreased product quality, and increased alkali loss [7, 8–11]. The presence of organics in the process severely affects the continuous and stable operation of alumina production.

Based on different treatment processes, the removal of organics is broadly categorized into two types, removal from the Bayer alumina production process and removal from the bauxite. The more extensively studied approach is the removal of organics from the Bayer production process. In the context of organics removal from the alumina production process, the main targeted organics are humic substances and sodium oxalate. Methods for removing sodium oxalate include solution causticization, salting-out crystallization, oxalate pellet method, and the common ion effect method, among others [12, 13]. Some of these methods have already been applied at various scales within alumina refineries. Research on the removal of humic substances is relatively limited. The primary methods include wet oxidation [14], cooling crystallization, liquid combustion, and activated carbon adsorption. An alternative approach involves reducing the organics entering the process through bauxite pretreatment. Compared to removing organics within the process, this method can remove organics before they enter the alumina production process, thus completely preventing their impact on production. Domestically, when dealing with high-sulphur diaspore bauxite, research and practical applications have explored the calcination of high-sulphur bauxite as a means of removing sulphur from the bauxite. During the desulphurization process, it is also possible to partially remove the organics from the bauxite [15].

This paper adopts the core technical approach for pretreatment of bauxite by calcination to remove organics. It presents preliminary research and analysis on the bauxite pretreatment process, the digestion effects of the calcined bauxite, and its techno-economic assessment (TEA). The research findings serve as a reference for alumina production enterprises using imported bauxites.

2. Test Material and Method

2.1 Test Material

The imported bauxite was used as the primary test material, and the chemical and mineral composition of the ore are shown in Tables 1 and 2.

Table 1. Chemical composition of the ore used for testing (%).

	Al_2O_3	SiO_2	Fe_2O_3	TiO_2	K_2O	Na_2O	CaO	MgO	LOI	C_{org}
Content, %	48.48	4.69	18.49	0.97	0.018	0.039	0.11	0.032	25.82	0.24

Table 2. Mineral composition of the ore used for testing (%).

	Gibbsite	Kaolinite	Quartz	Goethite	Hematite	Anatase
Content, %	66.50	8.20	0.90	15.40	6.60	1.00

The recycling spent liquor used in the digestion test was sourced from an alumina refinery, and its main chemical composition is shown in Table 3.

Table 3. Chemical composition of the recycling spent liquor (g/L).

	Na_2O_T	Al_2O_3	Na_2O_K
Concentration	253.72	122.39	232.00

2.2 Test Method

The main experimental procedures were divided into two parts, the bauxite calcination test and digestion test of calcined bauxites.

First, the tested bauxites were dried, then crushed and ground to a particle size (effective particle diameter, median diameter) of less than 15 mm, with particles in the range of 5–10 mm accounting for approximately 80 %. The grinding particle size was controlled by using a standard sieve. The ground bauxites were then subjected to static calcination in a muffle furnace, with a calcination temperature ranging from 600 to 900 °C and a calcination time of 10 to 20 minutes. The calcined bauxites were then digested using the traditional Bayer process. The digestion equipment used was a laboratory molten salt steel autoclave with a digestion temperature of 265 °C and a digestion time of 60 minutes. The concentration of recycling caustic soda was 232.00 g/L and the caustic ratio was 1.41.

The test process included testing and analysis of both solution and solid samples. The bauxite digestion performance under different conditions was evaluated to assess the effectiveness of technical solutions and the optimal process conditions were determined.

the actual alumina digestion rate of the tested ore was around 88 %, with a relative digestion rate of approximately 98 %. The addition of lime during the digestion process reduced the alumina digestion rate. Although it reduced soda consumption, the overall economic benefits were not significant. Therefore, it is not recommended to add lime during digestion.

After pretreatment, the organic content in the ore was reduced to around 0.05 %, with an organic removal rate of 79 %. This effectively eliminated the negative impact of organics on the alumina production process, preventing their adverse effect on output and the increased costs associated with subsequent organic removal. After low-cost calcination of high organiccontent bauxite at the mining site, 8–15 % of moisture in the ore will be removed and the loss on ignition will be reduced by 24–27 %. The bauxites weight would be reduced by about one-third compared to conventional wet bauxite transportation, approximately one-third savings in the transportation costs would be achieved. Compared to regular bauxites, through digestion of calcined ore, about one-third of the water that would have entered the alumina production process from the raw bauxites is eliminated, which will reduce steam consumption and significantly lower evaporation costs. However, the consumption of fresh water will increase.

This technology increases the cost of bauxites for alumina production due to calcination costs. However, the benefits are reflected in two aspects, firstly, after removing the organics, there will be no longer costs related to organic treatment in the alumina production process, reducing process disruption and cost. Secondly, if inexpensive energy is available at the mining site, calcination can be conducted there. Due to the reduction in weight of the roasted ore, the associated transportation costs will decrease accordingly. This reduction can largely offset the cost of the calcination process, thereby enhancing the overall economic viability and competitiveness of this technical solution

4. Research Conclusions

(1) After calcination pretreatment of gibbsitic bauxite with high organic content at 800–900 °C, the organic carbon in the ore is reduced to around 0.05 %, achieving effective removal of organics from the bauxites.

(2) The calcined bauxites should be digested using the high-temperature Bayer process. The alumina digestion rate of the tested ore was approximately 88 %, with a relative digestion rate of about 98 %. Lime should not be added during the digestion.

(3) After pretreatment, the organics in the ore were largely removed, eliminating the significant negative impact that organics would otherwise have on the alumina production process, thereby reducing processing costs. If low-cost energy is available for calcination at the mining site, one-third of the ore transportation costs can be saved. Due to the reduction of about one-third of the water fed into the alumina production process (by the weight of the raw bauxites), evaporation costs can be significantly saved, though the consumption of fresh water will increase.

By adopting this technology, especially when very cheap energy is available at the mining site, the ore calcination cost can be reduced. When this cost is lower than the sum of the organic's treatment costs (from the raw bauxites) and the savings from reduced transportation costs (of the calcined bauxites), this technical solution will have strong market competitiveness.

5. References

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