Influence of Different Digestion Process Conditions on Digestion Rate of Impurity Elements in Guinea Bauxite

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Abstract

In recent years, the import volume of bauxite from China has been increasing year by year, with Guinea bauxite having the largest import volume. Currently, more and more Chinese alumina plants are using Guinea bauxite for alumina production. Through chemical composition analysis of Guinea bauxite, it was found that in addition to conventional elements such as aluminium, silicon, iron, and titanium, Guinea bauxite also contains trace elements such as phosphorus, vanadium, and gallium. These three elements enter the sodium aluminate solution during the digestion process, and then enter the aluminium hydroxide through seeded decomposition, seriously affecting product quality. Vanadium and gallium are both high-value metal elements. Improving their digestion rate in alumina production process and recovering them from sodium aluminate solution are of great significance for the economic and efficient utilization of bauxite resources. Therefore, this article focuses on the impurity elements phosphorus, vanadium, and gallium in Guinea bauxite, outlining an experimental study on the influence of different digestion process conditions on their digestion rates. The results show that different digestion process conditions have a significant impact on the digestion rates of alumina, phosphorus, vanadium and gallium in Guinea bauxite. By optimizing the digestion process conditions, the digestion rate of alumina can be increased by 4–5 percentage points and the bauxite consumption decreases by more than 100 kg per tonne of alumina, and the phosphorus digestion rate has significantly decreased to 12–15 %, with a decrease of about 75 %. The digestion rates of vanadium and gallium significantly increased to 50 % and 80 %, with an increase of over 50 % and 30 %.

Keywords: Guinea bauxite, Phosphorus, Vanadium, Gallium.

1. Introduction

China is the world's largest producer and consumer of alumina, with both production capacity and output ranking first in the world. In 2023, China's alumina production reached 82.27 million tonnes, accounting for 58 % of the world's total production [1]. However, China's bauxite resources are limited, with bauxite reserves accounting for only 3 % of the global bauxite reserves. With the increasingly severe situation of environmental inspections and mine rectification and management, bauxite production has sharply decreased, and the supply-demand contradiction of bauxite resources has become increasingly apparent. More and more alumina companies are using imported bauxite to produce alumina, and the import volume of bauxite is increasing year by year. Since 2019, China's annual import volume of bauxite has continued to exceed 100 million tonnes, reaching 141 million tonnes in 2023. The current layout of China's alumina industry is gradually shifting towards coastal areas, and the import volume of bauxite in China will continue to grow in the future.

At present, China's bauxite imports come from countries such as Guinea and Australia, with Guinea bauxite having the largest import volume, reaching 99.13 million tonnes in 2023, accounting for 70.3% of the total import volume. Compared with China's diasporic bauxite, Guinea bauxite has the characteristics of medium aluminium, low silicon, and high iron in chemical composition. In terms of phase composition, Guinea bauxite is gibbsite or gibbsite-boehmite mixed bauxite, which is easily digested at low temperature. Therefore, low temperature or medium-high temperature digestion processes are commonly used to treat Guinea bauxite [2–6]. In terms of the occurrence of trace elements, the content of phosphorus and vanadium in Guinea bauxite is relatively high, about 0.08 % and 0.07 % respectively, while the content of gallium is slightly lower, about 0.007 %. In the Bayer process of production, trace elements phosphorus, vanadium, and gallium in bauxite partially react with caustic soda to form sodium phosphate, sodium vanadate, and sodium gallate, which enter the sodium aluminate liquor [7], therefore the phosphorus content in sodium aluminate solution is relatively high. During the security filtration process, hydroxyapatite is easily generated, causing clogging of the filter cloth and making security filtration difficult. At the same time, the continuous accumulation of phosphorus content in sodium aluminate liquor can easily lead to excessive phosphorus content in aluminium hydroxide, affecting alumina product quality.

Vanadium and gallium are both rare metals with extensive applications in high-tech cutting-edge fields. At present, the demand for vanadium and gallium is constantly increasing. If vanadium and gallium can be extracted from the alumina production process from Guinea bauxite, it can not only purify the sodium aluminate liquor, improve the quality of alumina products, but also achieve comprehensive utilization of bauxite resources.

This article focuses on the influence of different digestion processes on the digestion rates of the trace elements phosphorus, vanadium, and gallium in Guinea bauxite, and recommends suitable digestion processes. While ensuring a high alumina digestion rate, it can not only inhibit the digestion of phosphorus, but also promote the digestion of vanadium and gallium, laying a foundation for the extraction of valuable elements in bauxite and the comprehensive utilization of resources.

2. Experiment

2.1 Raw Materials

The chemical composition and phase composition of the Guinea bauxite used in this study are shown in Tables 1 and 2, while Figure 1 shows the X-ray diffraction pattern of the experimental bauxite.

Table 1. Chemical composition of Guinea bauxite (%).

Al_2O_3	SiO_2	Fe_2O_3	TiO_2	K_2O	Na_2O	CaO	MgO	LOI	A/S	P	V	Ga
43.38	2.55	26.67	2.53	0.023	0.034	0.035	0.024	24.73	17.01	0.081	0.067	0.0071

Table 2. Phase composition of Guinea bauxite (%).

Gibbsite	Boehmite	Kaolinite	Quartz	Hematite	Aluminium goethite	Anatase	Rutile
59.5	1.5	2.0	1.6	11.8	18.9	1.0	1.53

From Table 1, it can be seen that the contents of Al_2O_3, SiO_2, and Fe_2O_3 in the bauxite are 43.38 %, 2.55 %, and 26.67 %, respectively. The contents of phosphorus, vanadium, and gallium are 0.081 %, 0.067 %, and 0.0071 %, respectively. From Table 2 and Figure 1, it can be seen that the bauxite is a gibbsite-boehmite mixed bauxite, with a content of 59.5 % and 1.5 % for gibbsite and boehmite, respectively. The siliceous minerals are mainly kaolinite and quartz, with contents of

From Figure 5, it can be seen that when the digestion temperature is 145 °C, as the digestion time increases from 30 to 60 minutes, the digestion rate of gallium in Guinea bauxite is about 60 %. As the digestion temperature increases, the digestion rate of gallium shows a slight upward trend. When the digestion temperature is 240 °C, the digestion rate of gallium is about 64 %. When the digestion temperature continues to rise to 260 °C, the digestion rate of gallium increases to about 65 %. The digestion time has little effect on the digestion rate of gallium. By adopting the new Guinea bauxite high-efficiency digestion technology, the digestion rate of gallium in Guinea mine significantly increased to over 80 %, and as the digestion time increased from 10 to 60 minutes, the digestion rate of gallium in Guinea mine increased from 80% to 82.89 %.

4. Conclusion

At a low temperature of 145 °C, the gibbsite from Guinean bauxite is completely digested after a digestion time of 30 minutes. Extending the digestion time slightly reduces the alumina digestion rate. When raising the digestion temperature to 240 °C, in addition to gibbsite, some boehmite also digested, and the digestion rate of alumina increases by 1–2 percentage points. Raising the digestion temperature to 260 °C, allows both gibbsite and boehmite to be completely dissolved in about 10 minutes. Compared with the digestion temperature of 240 °C, the digestion rate of alumina increased again. The new Guinea bauxite high-efficiency digestion technology developed by Chinalco's Zhengzhou Non-ferrous Research Institute significantly increases the alumina digestion rate after a digestion time of more than 30 minutes. Compared with the low temperature of 145 °C, the alumina digestion rate increases by 4–5 percentage points and the bauxite consumption decreases by more than 100 kg/t Al_2O_3.

When the conventional low temperature of 145 °C is used for digestion in Guinea bauxite, the digestion rates of phosphorus, vanadium, and gallium are 55 %, 23–26 %, and 60 %, respectively. As the digestion temperature increases, the digestion rates of phosphorus, vanadium, and gallium all show an increasing trend. By using the new Guinea bauxite high-efficiency digestion technology, the phosphorus digestion rate has significantly decreased to 12–15 %, with a decrease of about 75 %. The digestion rates of vanadium and gallium significantly increased to 50 % and 80 %, respectively, with increases of over 50 % and 30 %, respectively.

The new Guinea bauxite high-efficiency digestion technology can effectively improve the digestion rate of alumina and valuable metals such as vanadium and gallium in Guinea mine, while significantly reducing the digestion rate of phosphorus, which is beneficial for reducing bauxite consumption, promoting the extraction of valuable elements in the alumina production process, and avoiding excessive phosphorus content in alumina products. This is of great significance for the economic and efficient utilization of Guinea bauxite.

5. References

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