

## AA25 - Process Innovation and Technology Progress of Bayer-Sintering Series Method

Zhimin Yang

Professor

Zhengzhou non-ferrous metals research institute Co., Ltd. of CHALCO, Zhengzhou, China

Corresponding author: zyy\_ymz@rilm.com.cn

### Abstract

This article discusses innovation in the Bayer-sintering in series production of alumina technology, including new dry sintering technology, elimination of green liquor desilication and its downstream processes, joint processing of unpolished sinter extraction liquor with Bayer slurry, shortening of the sintering process. At the same time, the technical progress of High iron Red mud mix sintering and improving A/S of pregnant liquor was analyzed on the example of taking Shanxi bauxite whose A/S is 3.01, with the consumption figures of the new series method are compared with that of the Bayer process. The bauxite consumption of the new series method is lower by 26.42 %, the caustic consumption is lower by 84.07 %, and the process energy consumption is 15.35 GJ/ t-Al<sub>2</sub>O<sub>3</sub>, which is only 23.12 % higher than that of the Bayer process. The new series method will be an economical method to produce alumina by using low grade diasporic bauxite, and it has obvious effect on reducing the consumption of gibbsitic bauxite.

**Keywords:** Bayer-sintering series method, bauxite consumption, caustic consumption, process energy consumption, low grade bauxite.

### 1. Bauxite Resources in China

China's alumina production has increased more than tenfold since 2003. In 2019, the global alumina production is about 125960 kt, and China's alumina production is 72474 kt, with China accounting for 57.54 % of the global output. The major issue for Aluminium industry in China is a serious shortage of bauxite resources. According to the 2017 China land and mineral resources statistics bulletin of the Marine resources, by the end of 2017 China's bauxite resource identified as 5.01 billion tons, which shows duration of operation security is only 26 years. The reserve base is 1.01 billion tons, with security duration of only 6.8 years. Followed by resource depletion, alumina production enterprises in China are not only faced with the problem of scares bauxite resources.

More than 50 % bauxite reserves in our country are in Shanxi and Henan provinces. The A/S ratio > 5 bauxite is almost exhausted. Some of the alumina plants are using bauxite grade which has dropped to A/S < 4 or even as low as 3.8. This fact not only affects the supply of ore but is of high economic concern. China imported 687.6 million tons of foreign bauxite in 2017, and 826.2 million tons in 2018, accounting for more than 60 % of China's bauxite consumption in the same period.

At present, China's bauxite resources are facing the following problems: on the one hand, the only low-grade diasporic bauxite in China cannot be effectively used; on the other hand, there is a large quantity of imported bauxite. The fundamental reason why A/S < 4 low grade diasporic bauxite cannot be utilized effectively in China is that no ideal method to produce alumina by using the low-grade bauxite economically has been found at present. A large mass of imported ore is not only associated with high freight cost, but also has lower alumina concentration leading to relatively high bauxite consumption.

## 2. A Method for Producing Alumina from Low-Grade Bauxite

There are many methods to produce alumina by using low-grade bauxite, including Flotation-Bayer process, Bayer process and Sintering process, etc. These methods do not have technical bottlenecks, but their technical and economic differences are great. The Bayer process using lower grade bauxite, in which A/S has been down to  $< 4$ , that some alumina manufacturers use, leads to the ore loss and alkali consumption increase. The material flows increase leading to higher capital costs and the process, technical and economic indicators deteriorate badly.

Table 1 lists several ways in which alumina can be produced from low-grade bauxite.

**Table 1. Comparison of various methods.**

Methods	Suitable for bauxite grade	Advantages	Disadvantage
Flotation-Bayer	$A/S > 3.5$	The efficiency of Bayer method is improved; Process energy consumption is low.	The process is complex; Low alumina recovery; The lower the ore A/S is, the worse the economy will be
(Bayer-Sintering) Series process	$A/S > 2.6$	High alumina recovery and low alkali consumption; Sintering method has a small proportion.	The process is complex.
Soda-Lime Sintering process	unlimited	High alumina recovery, low alkali consumption and high whiteness; High carbon decomposition rate; Red mud has hydraulic properties.	Energy consumption is on the high side.

## 3. Innovation and Technical Progress of New Series Process for Alumina Production

In recent years, Zhengzhou non-ferrous metal research institute Co., Ltd. of CHALCO participates in "innovative series method of alumina production technology and equipment research projects" sinter dry sintering process and equipment technology research "project in soda-lime sintering, and the series method has made the important technological innovation and technological progress, formed a new series method. In the sintering process of the new series method, the processes such as desilication of the green liquor, carbonation decomposition of sodium aluminate liquor and evaporation are removed, and joint processing of unpolished sinter extraction liquor with Bayer slurry, thus greatly shortening the sintering process. The key techniques of sintering in the new series method include low A/S red mud mix sintering with high iron content, clinker dry sintering and green liquor desilication. At present, the new series method has more than ten years of successful experience in industrial practice. Thus, the energy consumption of alumina production by the traditional series method has been significantly reduced.

### 3.1 High Iron Content of Low Charge A/S Red Mud Formula

Low A/S of high iron red mud refers to Bayer red mud with  $A/S < 1.5$  and  $Fe_2O_3 > 10wt\%$ , and its ingredients are obviously different from ordinary red mud mix sintering.

At present, the low iron red clay furnace sintering is based on  $\text{Na}_2\text{O}\cdot\text{Al}_2\text{O}_3\text{-Na}_2\text{O}\cdot\text{Fe}_2\text{O}_3\text{-2CaO}\cdot\text{SiO}_2$  multi-element system to make the ingredients [1], For the high iron red clay furnace sintering, due to the formation of  $\text{Na}_2\text{O}\cdot\text{Fe}_2\text{O}_3$  content greatly increased, and amount of  $\text{Na}_2\text{O}\cdot\text{Al}_2\text{O}_3$  forming low temperature eutectic also greatly increased. The sintering temperature significantly decreased, and the formation of insoluble alkali ternary compounds resulting in the dissolution rate of alumina and sodium oxide has decreased. Therefore, for high iron red mud, ingredients should be made on the basis of  $\text{Na}_2\text{O}\cdot\text{Al}_2\text{O}_3\text{-Na}_2\text{O}\cdot\text{Fe}_2\text{O}_3\text{-2CaO}\cdot\text{SiO}_2\text{-2CaO}\cdot\text{Fe}_2\text{O}_3$  multi-element system, and the input amount of CaO should be increased, so that the part of  $\text{Na}_2\text{O}\cdot\text{Fe}_2\text{O}_3$  can be converted into  $2\text{CaO}\cdot\text{Fe}_2\text{O}_3$  to reduce the low temperature eutectic formed by  $\text{Na}_2\text{O}\cdot\text{Fe}_2\text{O}_3$  and  $\text{Na}_2\text{O}\cdot\text{Al}_2\text{O}_3$ . The input of CaO was determined by experiments, and the general principle was that the standard extraction efficiencies of sinter leaching should reach  $\text{Al}_2\text{O}_3 > 90\%$  and  $\text{Na}_2\text{O} > 92\%$ .

### 3.2 A Technique in which the Sintering Process is Changed from Wet to Dry

The technology of dry sinter sintering has been formed, such as the dry mixing of raw materials and granulation and drying with flue gas at the kiln end. At present, the industrial test of 1t/h sinter scale has been completed. The raw material moisture into the sinter kiln has decreased from about 40 % of the current wet method to < 12 %, the productivity of sinter kiln increased > 60 %, and the sinter sintering energy consumption decreased by 40 % [2].

### 3.3 Confluence of Unpolished Sinter Extraction Liquor with Bayer Slurry

Generally, the A/S of the Bayer digested bauxite slurry is 100–150, the A/S of the sintering green liquor is 5 – 20, and the solution after mixing requires A/S > 240.

At various mixing points, slurry temperature and residence time are different, and the resulting green liquor A/S is different. For example, the mixing point can be selected in the dilution tank, the final evaporation flash tank, or the previous evaporation flash tank. In this way, the mixing temperature will be higher and higher, and the residence time of the confluence will be longer and longer, which can significantly improve the confluence A/S. Therefore, the confluence point can be selected according to the confluence proportion. When the confluence proportion is small, the confluence point is selected in the dilution tank; when the confluence proportion is large, the confluence point is selected at the entrance of the final stage flash evaporation pipeline.

## 4. Technical and Economic Analysis of the New Series Process

### 4.1 The New Series Process

Figure 1 shows a simple process of new series method.

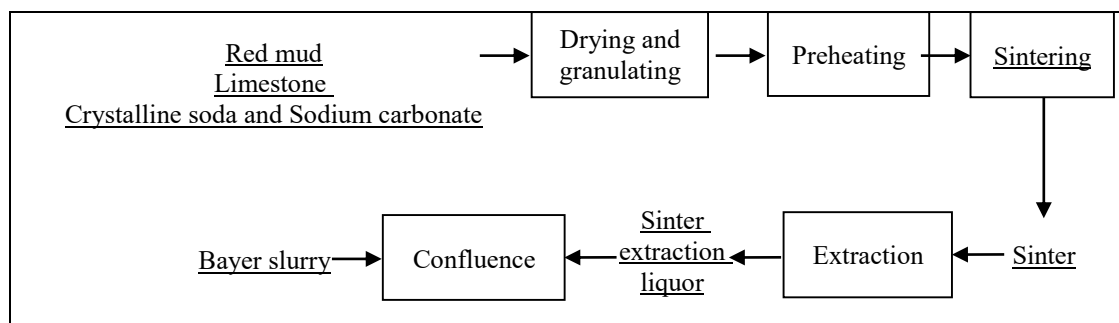


Figure 1. The new series simplified process.

In this process, the crystallized soda comes from the Bayer evaporation process, and the red mud is also dehydrated by pressure filtration.

#### 4.2 Comparison of Main Technical and Economic Indexes of Different Methods

Taking the low-grade diasporic bauxite from Shanxi Province as an example, technical and economic analysis was carried out on different production methods, and the main consumption results were shown in Table 5. The chemical compositions of bauxite, limestone and lime are shown in Tables 2–4, respectively.

**Table 2. Chemical composition of bauxite.**

Chemical composition	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	K <sub>2</sub> O	Na <sub>2</sub> O	CaO	LOI	A/S
Content (%)	55.90	18.23	7.68	2.48	0.19	0.026	0.47	13.94	3.07

**Table 3. Chemical composition of limestone.**

Chemical composition	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	CaO	MgO	Fe <sub>2</sub> O <sub>3</sub>	S	LOI
Content (%)	0.93	0.72	53.34	0.83	0.53	0.03	43.16

**Table 4. Chemical composition of lime.**

Chemical composition	CaO	CaO <sub>f</sub>
Content (%)	91.80	87.20

**Table 5. Comparison of main technical and economic indicators of alumina production by different methods.**

Methods	Bayer process	Sintering process	Series process	The new series process
Bauxite consumption (t/ t-Al <sub>2</sub> O <sub>3</sub> )	2.65	1.95	1.95	1.95
Caustic consumption (kg-Na <sub>2</sub> CO <sub>3</sub> / t-Al <sub>2</sub> O <sub>3</sub> )	361.85	57.66	57.66	57.66
The molar ratio of CaO to SiO <sub>2</sub> in the ingredients [C/S]	0.84	1.95	0.96	0.98
Process energy consumption /GJ/ t-Al <sub>2</sub> O <sub>3</sub>	12.48	33.31	21.27	15.35

It can be seen from Table 5 that for bauxite with A/S of 3.07, the main consumption indexes of the comprehensive analysis include ore consumption, alkali consumption, lime consumption and process energy consumption, etc. The energy consumption of the new series process is reduced to 15.35 GJ/t-Al<sub>2</sub>O<sub>3</sub>, which is the primary energy and coal, although the process energy consumption of Bayer process is relatively low, only 12.48 GJ/T-Al<sub>2</sub>O<sub>3</sub>, as the steam consumed belongs to secondary energy, so the actual cost of the two is not significantly different. However, the ore consumption of the series method is 0.7t/ t-Al<sub>2</sub>O<sub>3</sub>, which is lower than that of the Bayer method, and the alkali consumption is reduced by more than 0.3/t-Al<sub>2</sub>O<sub>3</sub>. Therefore, when the price of low-grade bauxite is lower and the price of caustic soda is higher, the consumption index and actual production cost of the new series method will have certain advantages.

## 5. Conclusions

In view of the current shortage and serious dilution of bauxite resources in China, it is necessary to adopt a more economical method to produce alumina by using low-grade diaspore bauxite, while it is necessary to reduce the bauxite consumption of gibbsitic bauxite.

The new series method developed in China has formed the key technologies such as Low A/S of high iron red mud is sintered into kiln by dry method and joint processing of unpolished sinter extraction liquor with Bayer slurry desilication, which is of great significance for the economic utilization of low grade diaspore bauxite to produce alumina and to reduce the bauxite consumption of gibbsitic bauxite.

Taking Shanxi bauxite whose A/S is 3.01 as an example, the consumption index of the new series method is compared with that of the Bayer method. The bauxite consumption of the new series method is lower by 26.42 %, the caustic consumption is lower by 84.07 %, and the process energy consumption is 15.35 GJ/ t-Al<sub>2</sub>O<sub>3</sub>, which is only 23.12 % higher than that of the Bayer method.

## 6. References

1. Hong Wang, Jingsong Wang, Jiang Liu and Qingguo Xue, Experimental research on comprehensive utilization of the high iron red mud based on direct reduction and melting by RHF iron bead technology, *Journal of Light Metals*, 2013, No. 1, 19-22.
2. Zhimin Yang, The improved Bayer process - red mud sintering method can be used economically to produce alumina from low-grade bauxite, *Catalogue of China Aluminum Industry Environmental Protection Technology Development Forum*, Zhengzhou, China, 19- 21October 2019, 114-116.