Bauxite Beneficiation at the Grinding Stage in Kazakhstan Alumina Production

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https://doi.org/10.71659/icsoba2024-aa008

Abstract

This paper presents information on the pre-processing of bauxite using two different flowsheets for the removal of iron and kaolinite components at the grinding stage at the Pavlodar Aluminium Plant (PAP) of Aluminium of Kazakhstan JSC. These solutions reduce input of impurities into the Bayer circuit: Fe_2O_3 by 35–40 %; CO_2 by 40–60 %; SO_3 by 50–70 % and SiO_2 by 12–15 %.

The removal of iron sand reduces the mass of Fe_2O_3 entering the sintering stage by ~ 20 %, partially debottlenecking the sintering furnaces, increasing the throughput capacity of both the Bayer and sintering circuits.

This in-house development of PAP is the main technological solution to increase the capacity of the "Bayer-Sintering in series" plant and was achieved while maintaining alumina product quality. Implementation of this flowsheet also solved the constraint faced from declining ore reserves, allowing lower quality ore to be processed and extend the life of operation.

Keywords: Bauxite, Iron-rich sands, Kaolinite, Impurities.

1. Introduction

To suite mineral and chemical composition of local bauxite from Kazakhstan, PAP is applying a quite rare technology of Bayer-Sintering in Series for its processing [1–6]. The technology consists of Bayer digestion of high silica bauxite and then sintering of resulting red mud to extract with high efficiency, the alumina and soda losses associated with it.

Currently, PAP uses bauxite from the Krasnooktyabrsky deposit, characterized by a very low mass ratio Al_2O_3/SiO_2 (silica ratio) of only 3.5 - 4 units, and a high content of harmful components: siderite, chamosite, hematite, pyrite, organics and other impurities. As the deposit is developed, the quality of bauxite decreases, which leads to increase of impurities in green liquor, an increase in the amount of red mud and a decrease in the technical and economic production performance.

The next to come ore reserves from the Krasnooktyabrsky deposit for alumina production at PAP are associated with lower-quality raw materials with a silica ratio below 3.5 units [7–11].

Lower quality raw materials require a constant search for innovative solutions to maintain recovery and product quality specifications, as well as research and development of new technological methods to improve and modernize existing production equipment.

Various methods of bauxite conditioning are known: flotation [12–13]; roasting (to remove CO_2, C and SO_3) [14]; magnetic separation [15–16].

Thus, there was a need to develop technology at PAP for impurities removal at the beginning of the technological cycle of alumina production.

As a result of the introduction of new process flow schemes, including the pre-processing of bauxite at the grinding stage, removing significant part of impurities from the Bayer cycle, PAP has achieved economically viable processing of low-quality bauxite from Kazakhstan.

2. Description of Problem

The plant was designed and constructed in 1964 for processing bauxite supplied 100 % from the Torgai deposit with a silica ratio of ~ 4.5 units (Al_2O_3/SiO_2).

As the deposit was developed, the reserves of Torgai bauxite deteriorated and were largely exhausted, and so bauxite from other deposits began to be involved in processing, which led to further degradation in the bauxite quality. By 2011, the share of Torgai bauxites was only 7 %, by 2020 4 %, and in 2022 this deposit, as well as the Belinskiy one, were completely consumed (Tables 1, 2, 3).

Table 1 – Blend composition of sourced bauxite over time.

Variant (average by year)	Source composition of bauxite by mine (%)			
	Torgai	Krasnooktyabrsky		
		Ayat	Belinskiy	Krasnogorsk
2011	7	15	36	42
2020	4	33	9	54
2022	-	32	-	68
2024	-	32	-	68

Since 2022, PAP has been processing bauxite from the Krasnogorsk mine at a level of 65–70 % and from the Ayat deposit at a level of 35–30 %, which differ in their impurity composition.

Table 2. Average chemical composition of bauxite by deposit.

Deposit	Chemical composition ((%)									A/S
	Al_2O_3	SiO_2	Fe_2O_3	SO_3	CO_2	C_{org}	Cl	TiO_2	FeO	
Torgai (beginning of mining)	45.7	10.2	16.0	0.20	0.20	0.1				4.48
Torgai (at the end of mining)	44.50	15.9	13.8	0.29	0.32	0.23	0.21	1.30	0.85	2.80
Belinskiy	41.40	10.3	21.2	0.60	1.79	0.16	0.84	2.15	2.88	4.02
Ayat	44.60	10.7	18.3	0.34	1.26	0.17	0.15	2.09	2.06	4.17
Krasnogorsk	42.00	10.9	19.4	0.70	3.70	0.35	0.41	2.01	5.41	3.85

The method is based on water washing of 20 % of the bauxite input feed in a grinding mill then classifying on a battery of hydro cyclones before the start of contact of bauxite with recycled alkaline liquors. This process serves for partial removal of kaolinite from the Bayer bauxite flow (~ 5–7 %) with transfer of the washed kaolinite phase to red mud disposal area or used in a mix for sintering.

From the data given in Table 5 it follows that due to the discharge of the kaolinite fraction in an amount of ~ 5 %, the alumina to silica ratio of the processed bauxite increases by ~ 0.13 units, while the amount of red mud decreases by 0.03 t/t bauxite. Mineralogical analysis also showed that the kaolinite fraction contains almost 2 times more finely dispersed kaolinite and has an increased content of goethite, compared to the original bauxite.

The kaolinite removal flowsheet made it possible to involve bauxite with lower quality in the process flow of alumina production at PAP. After 2012, the kaolinite removal circuit has not operated due to insufficient filtration, which caused high water content in cake and, subsequently, in the sintering mix.

Currently, options are being explored to improve the kaolinite removal scheme at the stage of bauxite grinding with dewatering in a decanter centrifuge/press filter to minimize the input of water into the sintering mix.

4. Conclusions

The bauxite beneficiation flowsheets at the Bayer circuit of Pavlodar Aluminium Plant allowed reduction of material flows and increased the productivity of the plant's processing areas, including increase in extraction of alumina, intensifying thickening processes and reduction of red mud volume, which allowed transferring part of the sintering kilns to stand-by. The technology also made it possible to optimize the plant's alkaline balance by reducing the formation of sodium carbonate in the process liquors and losses of alkali with red mud, while increasing ore reserves by operating on lower quality bauxites.

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