Beneficiation Tests of Gibbsitic Bauxite

JunweiMa[1,3] and Jianqiang Zhang[2,4]
1. Senior engineer
2. Assistant director of the institute
Zhengzhou Non-ferrous Metals Research Institute Co. Ltd of CHALCO, Zhengzhou, China
3. Senior engineer
4. Assistant director of the institute
National Aluminum Smelting Engineering Technology Research Center, Zhengzhou, China
Corresponding author: 33623290@qq.com

Abstract

Vietnamese gibbsitic bauxite was the subject of laboratory beneficiation testing for the purpose of developing a technique to improve recoveries. Mineralogy studies, laboratory screening tests and pilot beneficiation tests were conducted to develop a suitable beneficiation technology process. The purpose was to develop a technical prototype, along with technical support, for the processing of Vietnamese gibbsitic bauxite. The process developed, called ‘Cylinder Screening-Spiral Scrubbing Classification’. According to pilot-scale results, the final concentrate alumina to silica (A/S) ratio achievedwas16.69 with an alumina recovery of 72.14% using a flotation separation technique, compared with the raw ore A/S ratio of 5.15.

Keywords: Gibbsitic bauxite, mineralogy, spiral scrubbing classification.

1. Introduction

Bauxite deposits can be divided into three major groups depending on their means of formation: sedimentary diaspore, accumulation diaspore, and lateritic gibbsite. From a global perspective, commercially significant bauxite deposits can be categorized as lateritic and sedimentary [1, 2]. Lateritic bauxites are the most important bauxite deposits, accounting for approximately 92% of total global reserves and comprising mainly gibbsitic bauxite, which is characterized by low silica, high iron, and high A/S ratios. Vietnam has abundant bauxite resources, with a reserve estimated at approximately 3.7 billion tonnes [3], ranking it third in the world. Specifically, the bauxite resource reserves of DakNong province are rich of mainly gibbsitic bauxite.

Gibbsitic bauxite deposits are typically treated using beneficiation processes including washing [4,5], which remove fine grained silica minerals as tailings, as well as coarse ore as alumina mineral. However, typical beneficiation processes can have their disadvantages: complex technology, high production costs, low recoveries, tailings disposal issues and high backwater consumption rates [6,7]. This paper considers the beneficiation options for treating Vietnamese bauxite through direct washability research and provides a technical solution to successfully treat Vietnamese bauxite.

2. Mineralogy Research

2.1 Chemical analysis

Results from the initial chemical analysis of Vietnamese gibbsitic bauxite are presented in Table 1.

Table 1. Analysis of Vietnamese Gibbsitic Bauxite

Bauxite	**Al_2O_3 (%)**	**SiO_2 (%)**	**Fe_2O_3 (%)**	**TiO_2 (%)**	**K_2O (%)**	**Na_2O (%)**	**CaO (%)**	**MgO (%)**
Content	40.99	8.20	27.18	3.96	0.02	0.05	0.09	0.12

Results presented in Table 1 confirm the chemical composition of Vietnamese bauxite as a typical gibbsitic bauxite, comprising mainly Al_2O_3、Fe_2O_3、SiO_2、and TiO_2. Impurities such asK_2O、Na_2O、CaO and MgO were found to be present in small amounts.

2.2 Phase Analysis

Results from the initial X-ray analysis of Vietnamese gibbsitic bauxite are presented in Table 2.

Table 2. The main minerals content of the sample

Mineral	**Gibbsite (%)**	**Kaolinite (%)**	**Quartz (%)**	**Hematite (%)**	**Goethite (%)**	**Ilmenite (%)**	**Others (%)**
Content	52.4	11.0	3.0	16.0	12.0	2.8	2.8

From the X-ray analysis results presented in Table 2, we can conclude this to be a high-grade gibbsitic bauxite, with gangue minerals mostly comprising kaolinite and quartz, as well as iron minerals in the form of hematite, goethite and ilmenite. As gibbsitic bauxite and gangue minerals have complex disseminated relationships and small sizes, it is difficult to separate the gibbsite and gangue monomer during a washing test.

2.3 Structure and Distribution of main minerals

1）Gibbsite

Gibbsite is the most important economic mineral in most Vietnamese bauxites; it occurs in several structures: a) Lath crystal structure (Figure 1), its size is typically 0.04 × 0.2mm to 0.2 × 0.8mm, in which the distribution of clay gangue minerals on the surface of gibbsite has a complex disseminated relationship. b) Pseudo-hexagonal sheet structure (Figure 2), typical slice diameter of 0.1 to 0.4mm, the crystal surface is relatively clean and non-disseminated by iron. c) Oolitic structure (Figure 3), the nucleus of this type of structure is mainly gibbsite, which is interspersed with iron minerals, with the outer shell mostly iron minerals.

2) Gangue minerals

Gangue minerals are mainly kaolinite, the main disseminated structures are a) kaolinite distributed in the gangue and surface of the gibbsite, the disseminated relationship is again complex (Figure 1b) the product of feldspar weathering and symbiosis with gibbsite (Figure 4).

4.2 Technical Index of Steady-state Operation

The Cylinder screening-Spiral scrubbing classification continuous pilot beneficiation tests on Vietnam bauxite were conducted in accordance with the flowsheet presented in Figure 6. The feed rate was stable at 250 kg/h, with the average technical index presented in Table 4.

Table 4. Pilot experiment average technical index of Vietnam bauxite

Product Name	Yield (%)	Grade (%)			Recovery (%)
		Al_2O_3	SiO_2	A/S	
Raw ore	100.00	40.64	7.89	5.15	100.00
Concentrate1	33.64	52.35	2.75	19.00	43.33
Concentrate2	24.38	48.04	3.93	12.22	28.81
Tailings	41.98	26.97	14.62	1.85	27.86
Total concentrate	58.02	50.53	3.03	16.69	72.14

Interpreting the data presented in Table 4, when considering the A/S ratio of the original bauxite at 5.15, passing the bauxite through the Cylinder screening-Spiral scrubbing classification process and operating under steady-state for 6 shift-groups, the average A/S ratio of the concentrate was found to increase to 16.69, with a concentrate yield of 58.02%. The A/S ratio of tailings was 1.85.

These results indicate that the Cylinder screening-Spiral scrubbing classification process better meets the technical washing requirements for a Vietnamese gibbsitic bauxite, providing a technical pathway for the commercial treatment of these bauxite resources in the future.

5. Conclusions

Most Vietnamese bauxite deposits are gibbsitic in nature, with associated gangue minerals comprising mostly kaolinite, quartz and iron minerals in the form of hematite, goethite and ilmenite. As gibbsitic bauxite and gangue minerals typically have complex disseminated relationships and, in this case, are mostly small-sized, it is difficult to economically separate all the gibbsite from the gangue minerals by washing alone.

Although laboratory screening results showed that most of the target bauxite met the sizing requirements for direct Bayer processing (size fraction above 0.5mm), the 0.1-0.5mm fraction grade did not meet the requirements and required further processing beyond simple washing.

This research concludes that development of the beneficiation technology process called "Cylinder screening-Spiral scrubbing classification", has the potential to increase overall recoveries of Vietnamese gibbsitic bauxites by recovering the smaller size fractions. The prototype process developed for this research was found to be simple, stable and reliable.

6. References

1. Shrn Hui, The world bauxite resources and alumina production [J], *Nonferrous Metals Industry*, 1996(4): 25-30.
2. Yang ZhongYu, The World bauxite reserves and distribution [J], *World Nonferrous Metals*, 1990(8): 7-11.
3. U.S. Geological Survey, Mineral Commodity Summaries, January 2021. https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-bauxite-alumina.pdf.

4. Huang Qing, Raises the ore washing efficiency and reduce the putty rate [J], *Nonferrous Metals Industry*, 2003 (11): 61-62.
5. Wang ZhenMin, Test in Hard Ore Washing Adding Chemical Agents [J], *Hunan Nonferrous Metals*, 2001(4): 10-12.
6. Ning MinXia, Water impact study on the dam's stability [J], Express Information of Mining Industry, 2006(5): 43-44.
7. Li JingFeng, Analysis of Factors influencing Safety of Tailings Dam and Countermeasures [J], 2006(01): 285~286.