

Beneficiation Tests of Gibbsitic Bauxite

Junwei Ma^{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 achieved was 16.69 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 Gibbsite Bauxite

Bauxite	Al₂O₃ (%)	SiO₂ (%)	Fe₂O₃ (%)	TiO₂ (%)	K₂O (%)	Na₂O (%)	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 gibbsite bauxite, comprising mainly Al₂O₃, Fe₂O₃, SiO₂, and TiO₂. Impurities such as K₂O, Na₂O, CaO and MgO were found to be present in small amounts.

2.2 Phase Analysis

Results from the initial X-ray analysis of Vietnamese gibbsite 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 gibbsite bauxite, with gangue minerals mostly comprising kaolinite and quartz, as well as iron minerals in the form of hematite, goethite and ilmenite. As gibbsite 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).

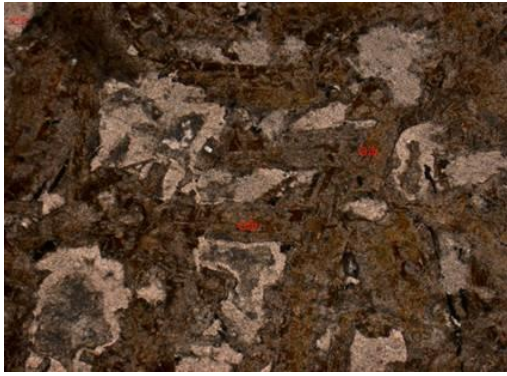


Figure 1. Lath gibbsite

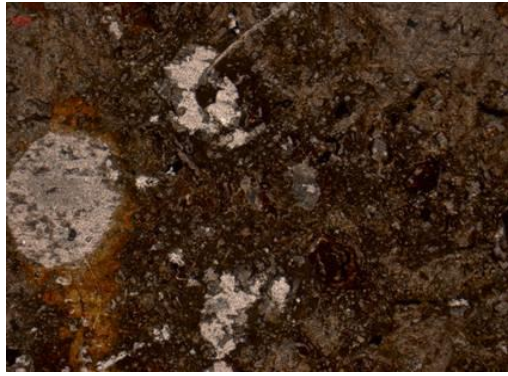


Figure 2. Pseudo-hexagonal flakes gibbsite

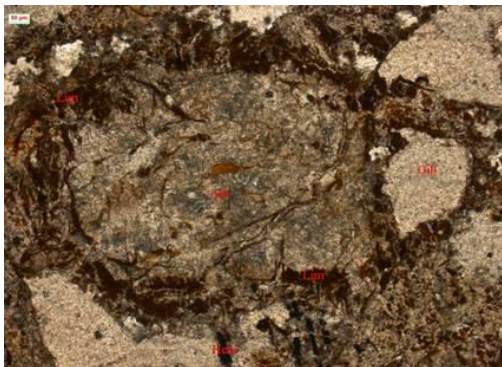


Figure 3. Oolitic structured gibbsite

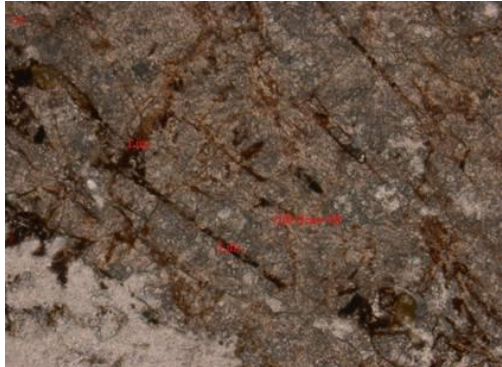


Figure 4. Gangue minerals

3. Laboratory Screening Tests

The laboratory screening process used to treat Vietnamese bauxite is presented in Figure 5, with 1mm, 0.5mm, 0.3mm, 0.1mm standard sieves used for screening tests. Each sieved sample was split, prepared and analyzed, in order to select the correct equipment for the proceeding step and to lay the foundations for technology choice and development. Screening test results are presented in Table 3.

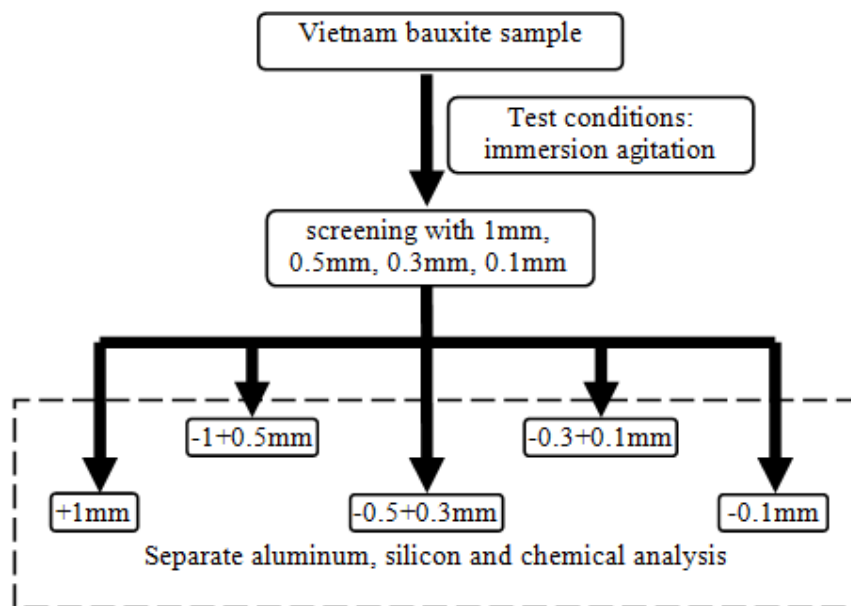


Figure 5. Laboratory Screening Flowchart

Table 3. Results from laboratory screening tests

Size fraction (mm)	Yield (%)	Al ₂ O ₃ (%)	SiO ₂ (%)	A/S
Feed	100.00	42.12	8.02	5.25
+1	55.00	50.80	3.20	15.88
-1+0.5	1.82	45.26	4.26	10.62
-0.5+0.3	1.83	39.96	8.54	4.68
-0.3+0.1	4.71	38.07	11.06	3.44
-0.1	36.64	29.57	15.02	1.97

Results presented in Table 3 indicate the bauxite size fraction in the sample required to meet the economical requirements of the Bayer process (grade above 0.5mm) to be relatively high. However, the A/S ratio of the 0.1-0.5 mm sized fraction was in the range 3-5, indicating it contained an amount of bayer-treatable mineral, which needed to be further treated to recover, so as to improve the overall recovery from the bauxite resources.

4. Pilot Beneficiation Tests

In order to verify the laboratory results and support industrial process design and development, further pilot beneficiation tests were carried out in the area of beneficiation and equipment design specifically for Vietnamese bauxite, developing the most suitable combination of process and technology to treat high silica gibbsitic bauxites.

4.1 The Beneficiation Technical Flowsheet and Equipment

The flowsheet selected for the pilot test was a "Cylinder screening-Spiral scrubbing classification" process, with the major equipment and instruments comprising the feeder, cylinder beneficiation machine, spiral classifier, thickener box, mortar pump and flowmeter. The flowsheet is presented in Figure 6.

Raw ore and flushing water enter the cylinder beneficiation machine at a feed rate of 250kg/h. The +3 mm size fraction is designated as concentrate 1, with -3mm size fraction fed into the spiral classifier and underflow from the classifier by high-pressure flushing water designated as concentrate 2. This enters the thickener box, with the underflow from the thickener box designated as the concentrate tails, with the overflow used as the recycling water.

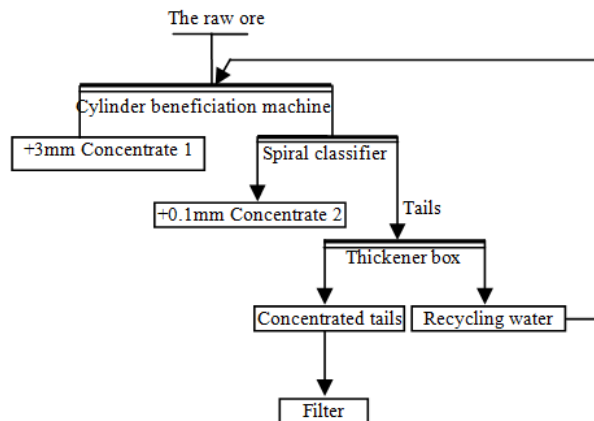


Figure 6. "Cylinder screening--Spiral scrubbing classification" flowsheet

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 ₂ O 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

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