

Experimental Study on Flotation Desilication of a High Iron Bauxite in Southwest China

Guo Xin¹, Tian Yingzhong² and Ren Peng³

1. Director

2. Researcher,

3. Assistant Researcher,

Institute of Comprehensive Utilization of Resources,

Zhengzhou Non-ferrous Metal Research Institute Co. Ltd of CHALCO, National Aluminum Smelting Engineering Technology Research Center, Zhengzhou, China

Corresponding author: zyy_gx@rilm.com.cn

Abstract

A bauxite mine in southwestern China is a high-iron bauxite ore. The alumina content and the mass ratio of alumina to silica (A/S) of the ore are relatively low. It is not possible to directly produce alumina economically and efficiently. Therefore, flotation desilication technology is needed to improve the alumina content of the ore, reduce the silica content and improve the ore quality. For the raw ore with an alumina content of 47.82 % and an A/S of 4.66, through the study of the fineness, the type of regulator, the amount of collectors and the closed-circuit test, the alumina content of the concentrate is 52.5 %, and the A/S is 8.37. The concentrate obtained is suitable for the production of alumina by the Bayer process.

Keywords: High-iron bauxite, Flotation desilication, Alumina.

1. Introduction

The bauxite resources in China are mainly diasporic ore. With the rapid development of domestic aluminum industry, the amount of domestic bauxite resources has decreased sharply. More particularly, high quality bauxite resources are insufficient [1]. The ore presents the characteristics of high alumina, high silica and low alumina to silica ratio, which is not suitable for the economic production of alumina by the Bayer process. With the depletion of resources, the mineral processing techniques used in the Bayer process will have a great influence on the development of alumina technology at home and abroad [2,3]. In recent years, the import volume of bauxite has been increasing gradually. In 2020, the import volume of bauxite in China was 120.25 million tons, and the domestic output will be 75 million tons [4,5]. The gap of bauxite is large, so the study of impurity removal and quality improvement of domestic low-quality bauxite can alleviate the tension of domestic ore supply. This paper mainly studies the removal of impurities from high iron bauxite and the improvement of ore quality. The concentrate obtained is suitable for the production of alumina by the Bayer process.

2. Analysis of Raw Ore Sample used in Testing

Chemical multi-element and phase analysis was carried out on the raw ore test sample, representative of the deposit mining area. The analysis results are shown in Table 1 and Table 2.

Table 1. Chemical multi-element analysis results of raw ore (%).

Element	Al ₂ O ₃	SiO ₂	Fe ₂ O ₃	TiO ₂	K ₂ O	Na ₂ O	CaO	MgO
Content	48.09	10.48	22.73	3.67	0.21	0.047	0.18	0.12

Table 2. Phase analysis results (%).

Mineral	Diaspore	Boehmite	Kaolinite	Illite	Hematite	Goethite	Anatase	Rutile
Content	42	4	20.5	2	10	15	3.2	0.5

According to the data in Table 1 and Table 2, the Al₂O₃ content in the raw ore is 48.09 %, the SiO₂ content is 10.48 %, the Fe₂O₃ content is 22.73 %, and the A/S is 4.59. The useful minerals in the ore are diaspore and boehmite, the gangue silica minerals are kaolinite and illite, the iron minerals are hematite and goethite, and the titanium minerals are rutile and anatase.

3. Testing Results and Discussion

3.1 Raw Ore Particle Size Composition Analysis

In order to investigate the selective crushing of the ore, the particle size composition of the raw ore crushed to -3mm was analyzed, and the analysis results were shown in Table 3.

Table 3. Analysis of the particle size composition of raw ore.

Grain grade (µm)	Yield (%)	Al ₂ O ₃ (%)	SiO ₂ (%)	A/S	Al ₂ O ₃ distribution rate (%)
+500	47.20	48.59	9.88	4.92	48.06
-500 ~ +150	25.10	47.97	10.41	4.61	25.23
-150 ~ +75	8.10	47.34	10.75	4.40	8.04
-75 ~ +38	5.38	47.03	10.79	4.36	5.30
-38 ~ +23	3.88	47.81	10.41	4.59	3.89
-23	10.34	43.75	15.88	2.76	9.48
Total	100.00	47.72	10.77	4.43	100.00

According to the data in Table 3, it can be seen that the raw ore presents certain selective fragmentation in particle size distribution. Coarse-grained ores have high alumina content, low silica content and higher A/S, while fine-grained ores have low alumina content and high silica content and lower A/S.

3.2 Grinding Fineness Test

The effect of grinding fineness on flotation index was investigated. Grinding fineness testing was carried out on the raw ore. The test process is shown in Figure 1, and the test results are shown in Table 4.

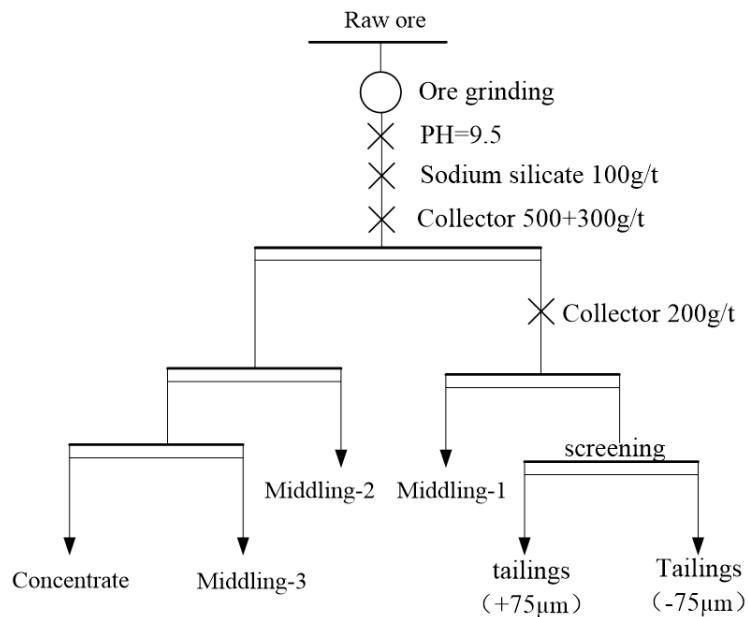


Figure 1. Experimental flow chart of effect of grinding fineness on flotation index.

Table 4. Test results of effect of grinding fineness on flotation index.

Grinding fineness (%) (-75 µm)	Product	Yield (%)	Al ₂ O ₃ (%)	SiO ₂ (%)	A/S	Al ₂ O ₃ Recovery Rate (%)
84.30	Concentrate	36.83	63.13	3.69	17.11	48.42
	Middling-3	8.40	45.16	9.80	4.61	7.90
	Middling-2	13.93	38.75	15.01	2.58	11.24
	Middling-1	4.70	44.38	9.69	4.58	4.34
	Tailings	36.14	37.33	17.13	2.18	28.10
	Raw ore	100.00	48.02	10.92	4.40	100.00
	Tailings +75µm	12.86	44.38	12.92	3.43	11.89
	Tailings -75µm	23.28	33.44	19.46	1.72	16.21
90.23	Concentrate	43.44	63.44	3.61	17.57	57.07
	Middling-3	13.57	43.75	9.12	4.80	12.29
	Middling-2	14.46	35.94	16.00	2.25	10.76
	Middling-1	5.12	36.88	13.41	2.75	3.91
	Tailings	23.41	32.94	21.00	1.57	15.97
	Raw ore	100.00	48.29	10.72	4.50	100.00
	Tailings +75µm	4.03	36.56	17.29	2.11	3.05
	Tailings -75µm	19.38	32.19	21.77	1.48	12.92
95.17	Concentrate	50.64	61.69	3.96	15.58	64.04
	Middling-3	9.16	40.09	13.59	2.95	7.53
	Middling-2	14.85	37.03	15.73	2.35	11.27
	Middling-1	4.13	38.63	11.72	3.30	3.27
	Tailings	21.22	31.94	21.00	1.52	13.89
	Raw ore	100.00	48.78	10.53	4.63	100.00
	Tailings +75µm	2.79	38.13	16.07	2.37	2.18
	Tailings -75µm	18.43	31.00	21.75	1.43	11.71

Grinding fineness (%) (-75 μm)	Product	Yield (%)	Al ₂ O ₃ (%)	SiO ₂ (%)	A/S	Al ₂ O ₃ Recovery Rate (%)
98.32	Concentrate	53.09	59.15	5.72	10.34	64.44
	Middling-3	9.98	42.13	11.23	3.75	8.63
	Middling-2	18.72	36.28	15.21	2.39	13.93
	Middling-1	4.94	40.63	10.72	3.79	4.12
	Tailings	13.27	32.60	20.41	1.60	8.88
	Raw ore	100.00	48.73	10.24	4.76	100.00
	Tailings +75μm	0.95	40.35	15.13	2.67	0.79
	Tailings -75μm	12.31	32.00	20.82	1.54	8.09

According to the data in Table 4:

1. With the increase of grinding fineness, the rate of fine ore increases gradually, and the A/S of concentrate decreases gradually.
2. With the increase of grinding fineness, the rate of tailings decreases gradually, and the A/S of tailings decreases gradually at first and then increases.

The grinding fineness required by the ore monomer dissociation is relatively fine. When the fineness reaches 95.17 %, the monomer dissociation is relatively good. As the grinding fineness continues to increase, the ore will demonstrate slime phenomenon, thus affecting the flotation index. Therefore, the preferred grinding fineness was determined to be 95.17 %.

3.3 Adjusting Agent Type Test

The influence of the type of adjuster on flotation index was examined. The test process is shown in Figure 2, and the test results are shown in Table 5.

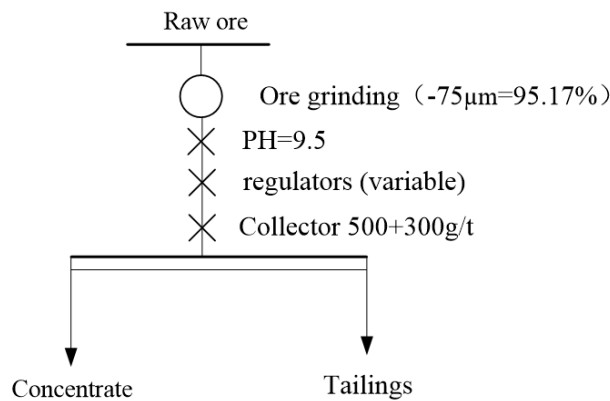


Figure 2. The test flow of flotation index influenced by the type of adjuster.

Table 5. Influence of the type of regulator on flotation index test results.

Regulators	Product	Yield (%)	Al ₂ O ₃ (%)	SiO ₂ (%)	A/S	Al ₂ O ₃ Recovery rate (%)
silicate	Concentrate	70.58	54.26	7.22	7.52	79.56
	Tailings	29.42	33.45	19.76	1.69	20.44
	Raw ore	100.00	48.14	10.91	4.41	100.00

Regulators	Product	Yield (%)	Al ₂ O ₃ (%)	SiO ₂ (%)	A/S	Al ₂ O ₃ Recovery rate (%)
hexametaphosphate	Concentrate	71.50	54.13	7.28	7.44	80.66
	Tailings	28.50	32.56	19.86	1.64	19.34
	Raw ore	100.00	47.98	10.86	4.42	100.00
hexametaphosphate: silicate	Concentrate	68.70	54.56	7.12	7.66	77.29
	Tailings	31.30	35.18	19.12	1.84	22.71
	Raw ore	100.00	48.49	10.88	4.46	100.00

According to the data in Table 5, when sodium hexametaphosphate was used as the regulator alone, the test indexes were better, with a refined mineral rate of 71.50 % and A/S of 7.44, the A/S of tailings is 1.64. Therefore, sodium hexametaphosphate was used as the regulating agent for experimental research.

3.4 Collector Dosage Test

The effect of collector dosage on flotation index was investigated. The test process is shown in Figure 3, and the test results are shown in Table 6.

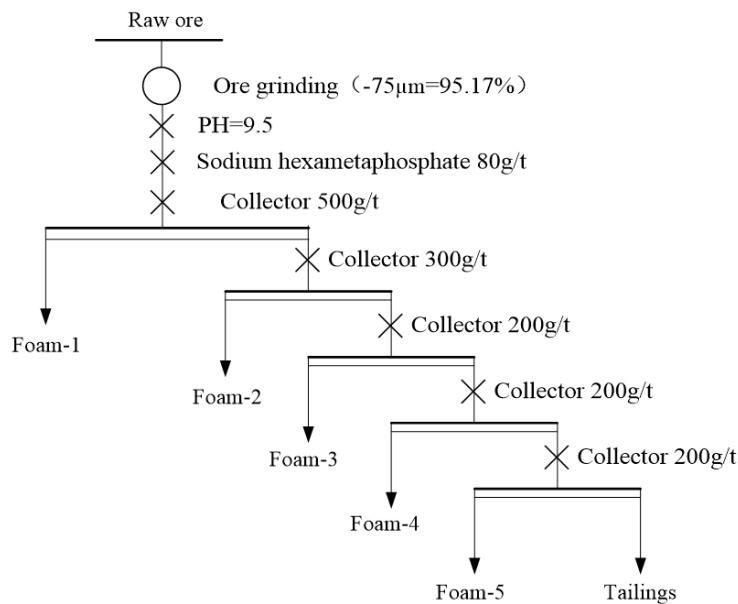


Figure 3. Collector dosage test flow.

Table 6. Collector dosage test results.

Product	Yield (%)	Al ₂ O ₃ (%)	SiO ₂ (%)	A/S	Al ₂ O ₃ Recovery rate (%)
Foam-1	58.43	55.24	6.42	8.60	67.64
Foam-2	10.70	43.81	10.37	4.22	9.82
Foam-3	5.66	41.13	11.58	3.55	4.88
Foam-4	4.50	39.78	12.29	3.24	3.75
Foam-5	3.00	36.75	14.66	2.51	2.31
Tailings	17.71	31.25	23.19	1.35	11.60
Raw ore	100.00	47.72	10.62	4.50	100.00

According to the data in Table 6, with the increase of the amount of collector, the A/S of tailings gradually decreases. When the amount of collector is increased to 1400 g/t, the yield of foam 5 is 3.00 %. If the amount of collector continues to increase, the foam yield will be low and the contribution to the reduction of tailings will be small. Therefore, the test of further increasing the amount of collector is not carried out. When the amount of collector is 1400g/t, the rate of tailings is 17.71 % and A/S is 1.35. Therefore, the amount of collector in the test was determined to be 1400 g/t.

3.5 Closed-circuit test

According to the results from the flotation desilication test conditions, the preferred grinding fineness was 95.17 %, the adjusting agent was sodium hexametaphosphate, and the collector dosage was 1400 g/t. The closed circuit test process is shown in Figure 4, and the test results are shown in Table 7.

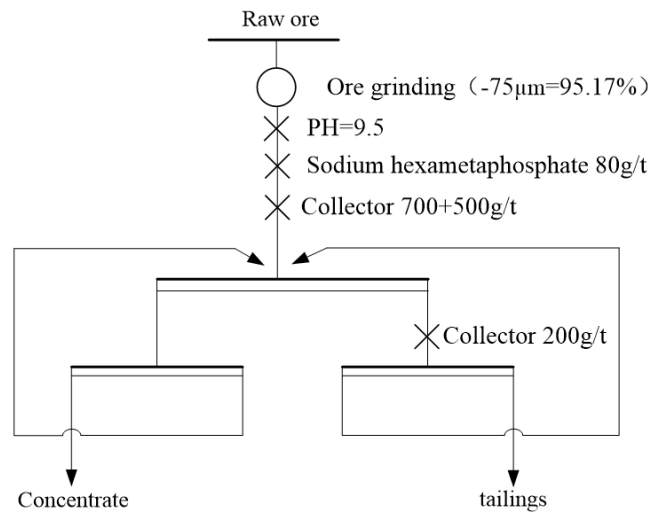


Figure 4. Closed circuit test flow of flotation desilication.

Table 7. Closed circuit test results of flotation desilication.

Product	Yield (%)	Al ₂ O ₃ (%)	SiO ₂ (%)	A/S	Al ₂ O ₃ Recovery rate (%)
Concentrate	77.29	52.50	6.27	8.37	84.86
Tailings	22.71	31.88	23.83	1.34	15.14
Raw Ore	100.00	47.82	10.26	4.66	100.00

According to the data in Table 7, through the test process of one roughing, one cleaning and one scavenging, the refined ore rate obtained was 77.29 %, A/S was 8.37, and the recovery rate of Al₂O₃ was 84.86 %. The rate of tailings was 22.71 %, and A/S is 1.34. Under the condition of stable raw ore properties, repeated flotation desilication tests were carried out, and the test results showed that the test scheme was repeatable and effective.

4. Conclusion

1. The useful minerals in the ore are diaspore and boehmite, the gangue silica minerals are kaolinite and illite, the iron minerals are hematite and goethite, and the titanium minerals are rutile and anatase.

2. A representative sample of raw ore with an alumina content of 47.82 % and an A/S of 4.66 was tested and a grinding fineness of 95.17 % passing 75 μm was selected for monomer dissociation without sliming. During test sodium hexametaphosphate was used as a regulator, along with a collector dosage of 1400 g/t. Through the "one roughing, one cleaning and one scavenging test process, an alumina concentrate with a yield of 77.29 %, an A/S of 8.37, and an Al_2O_3 recovery rate of 84.86 % can be obtained.
3. The beneficiation tests of the ore demonstrated the impurity content of the alumina production feed can be effectively reduced, enabling the economic benefit of alumina production to be improved. After flotation desilication, the A/S of the ore is increased from 4.59 to 8.37, which reduces the alkali consumption of 53.7 kg/t of alumina produced. At the same time, the output rate of red mud per ton of raw ore dropped by about 0.19 t. the results provide better technical guidance for the efficient production and utilization of this type of bauxite.

5. Reference

1. An Pengyu, Analysis and suggestions on the prospect of bauxite supply overseas investment for chinese enterprises [J]. *China Resources Comprehensive Utilization*, 2018(12):76-81,86.
2. Ling Shishengand Liu Siqing, A review of reagents on desilication of bauxite ores by reverse flotation [J], *Conservation And Utilization Of Mineral Resources*, 2008(3):49-53.
3. Jiang Yuehua, Development of alumina production new process and new technology and its application [J], *Light Metals*, 2007, (2), 11-13.
4. Zhang Zhihua, Yang Zhuo, Huang Hongjun, et al. Experimental study on flotation and desilication of a bauxite in Yunnan [J], *Light Metals*, 2017, (12), 6-10.
5. Xie Haiyun, Jiang Yaxiong, Ye Qunjie, et al., Study on removal silicon from high alumina and silicon bauxite by sectional flotation desilication [J], *Light Metals*, 2014, (4),1-5.