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Research on mineral processing technology of bauxite based on Banzhuyuan deposit in the Central Guizhou

Guizhou has a rich bauxite resources, including a part reserves of poor bauxite. Based on a series of the past positive flotation and reverse flotation condition test, we found the reverse flotations are better to improve alumina-silica ratio. In this study, we collected the fresh ore samples in several mining areas in Central Guizhou. And bauxite sintering dissolution tests show that $A1_2O_3$ dissolution rate is high after the bauxite ingredients sintering, 1# sample and 2# sample dissolution rates are much higher than the flotation recoveries, and because aluminum silicon ratio of 2# sample is a little higher, the dissolution rate can reach 75.64%. The test results show that positive flotation is not fit for poor bauxite, reverse flotation process can obtain a certain effect, and the sintering aluminum process can fully recycle the useful minerals.

Keywords: *Guizhou, equipment, bauxite, Al-Si ratio.*

1. Introduction

There is an abundant supply of bauxite in China, such as Guizhou, Shanxi, Henan, Guangxi, Yunnan provinces having large reserves, in the amount of 3 billion tonness. The overall level of China's bauxite resources endowment was not high, main ore type is diaspore, ores whose Al-Si ratio are over 8 rich accounted for about 12%, the vast majority of resources belong to Al-Si ratio is under 6 and medium grade bauxite, Al-Si ratio between 4 to 6 of them accounted for about 40%, Al-Si ratio between 2 to 4 super poor bauxite accounted for about 30%. With the development of the expansion of the alumina industry in China, the rich aluminum (aluminum silicon ratio is over 8) resources is fewer and fewer, such as bauxite is being largely consumed in Shandong province, therefore our country needs to import a large number of high grade alumina resources from abroad every year. Guizhou is one of the important bauxite production and resource development bases in our country. Due to the shallow burried, large scale and a lot of reserves, quality is currently the main types of exploitation and utilization. Such major ore minerals are aluminum and silicon minerals, iron ore, titanium minerals of four categories, aluminum are given priority to diaspore, then hematite, gibbsite and so on, silicon mineral was kaolinite, chlorite, illite and quartz, etc. Ore structure is mainly lenticular, eolithic, disseminated and massive.

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As an important raw material of alumina industry, low Al-Si ratio in bauxite ore is a bottleneck restricting to the development of alumina industry in China. At present, the main user abroad is Bayer process to produce alumina; it can shorten the production process, reduces energy consumption and reduces production costs. But for situation of the aluminum resources of our country, we must carry out effective processing desilication, produce high Al-Si ratio of concentrate, which might use Bayer process or the joint method to produce alumina. The existing ore dressing desilication method mainly include physical separation method, chemical processing and biological processing method. For our country the micro granular disseminated, composition complex diaspore mineral, desilication are carried out by physical separation and chemical beneficiation method which can obtain a high-quality aluminum ore concentrate, to meet the requirements of the alumina production process. .In this paper, in view of the Yunfeng in Guizhou bauxite, we carried out the related exploration from two aspects.

2. Ores characteristics

There are two kinds of ore samples, they are taken from the same mine of different spots, marked as 1# sample and 2# sample. Chemical analysis results show that $A1_2O_3$ content of 1# sample is 40.94%, the SiO_2 content is 33.89%, Al-Si ratio is 1.25; $A1_2O_3$ content of 2# sample is 46.09%, SiO_2 content is 24.03%, Al-Si ratio is 1.92. Aluminum-silicon ratio of 2# sample is a little higher, but still less than 2, two kinds of samples are super poor bauxite. The XRD analysis results of samples is shown in Tables 1 and 2. X-ray diffraction analyzing results show that the ore samples mainly contains

Table 1: Mineral content of the sample l#

Name	Diaspore	Pyrophyllite	Illite	Hematite	Kaolinte
Conetent /%	25-30	42	5	5	10-15
Name	Gibbsite	Plagioclase	Potash flespar	Quartz	Not detected
Conetent /%	2	3	2	/	1

Table 2: Mineral content of the sample 2#

Name	Diaspore	Pyrophyllite	Illite	Hematite	Kaolinte
Conetent /%	30-35	41	10-15	5	2
Name	Gibbsite	Plagioclase	Potash flespar	Quartz	Not detected
Conetent /%	3	1	2	/	1

diaspore which is accounted for 25%-35% of the total mineral. Also contain a lot of aluminum silicate minerals, such as pyrophyllite, kaolinite and illite etc. Most of these minerals are gangue minerals containing silicon, a large number of their existence, which led to a run of mine ore Al-Si ratio is extremely low. There experiments mainly through beneficiation methods to make diaspore and gangue minerals containing silicon separates effectively, achieves the goal of increasing the ore Al-Si ratio.

3. Results and discussion

3.1 Direct flotation experiment

Flotation process is one of the main methods of bauxite physical separation, and the positive flotation is one of the most widely used methods. Flotation of bauxite mainly used oleic acid as collector, with sodium hexametaphosphate as inhibitors of gangue minerals containing silicon, using sodium carbonate as slurry pH adjustment. Positive flotation method mainly adopts to explore the development and utilization technology of lean bauxite.

3.1.1 Direct flotation tests using collector of oleic acid

To study the performance of conventional collector oleic acid collecting bauxite, 1# samples are tested through positive flotation to ensure collector dosage, grinding fineness for 92% 200 mesh, inhibitor dosage of sodium hexametaphosphate is 40 g/t, roughing collector oleate dosage is 200 g/t, 400 g/t, 600 g/t, 800g/t, test process is shown in Fig.1, the results are shown in Fig.2. It is shown from the above test results that, when there is low dosage of oleic acid, no matter what the concentrate Al-Si ratio is, $A1_2O_3$ recovery rate is very low. When oleic acid consumption is 800 g/t, concentrate Al-Si ratio reaches 1.36, $A1_2O_3$ recovery is 24.27%, compared to the condition of low dosage, achieves a relatively good level, so the primary roughing collector oleate dosage is 800 g/t.

3.1.2 Desliming flotation test

Gangue minerals in the ores, such as pyrophyllite, kaolinite, illite whose hardness are less than diaspore, under the same grinding conditions are more likely to be ground.

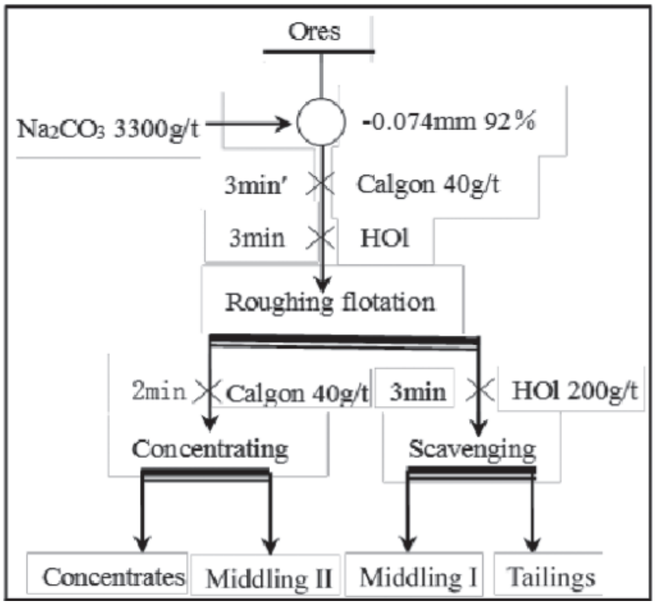

Fig.1 Flotation collector dosage test process

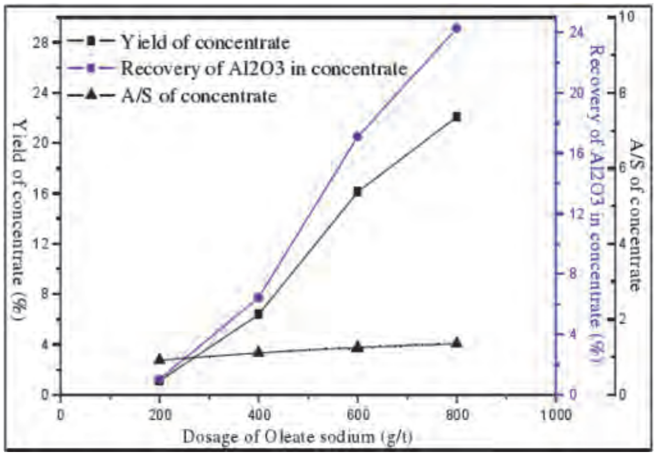

Fig.2 Effects of collector dosage on direct flotation tests

Because we need fine grinding ore (content more of 200 mesh over 90%) can make useful mineral monomer dissociation, therefore it is easier to containing silicon gangue gathered in the fine level, leading to higher silicon content in the fine mud. l# sample for desliming flotation test; test process is shown in Fig.3, the test results are shown in Table 3.

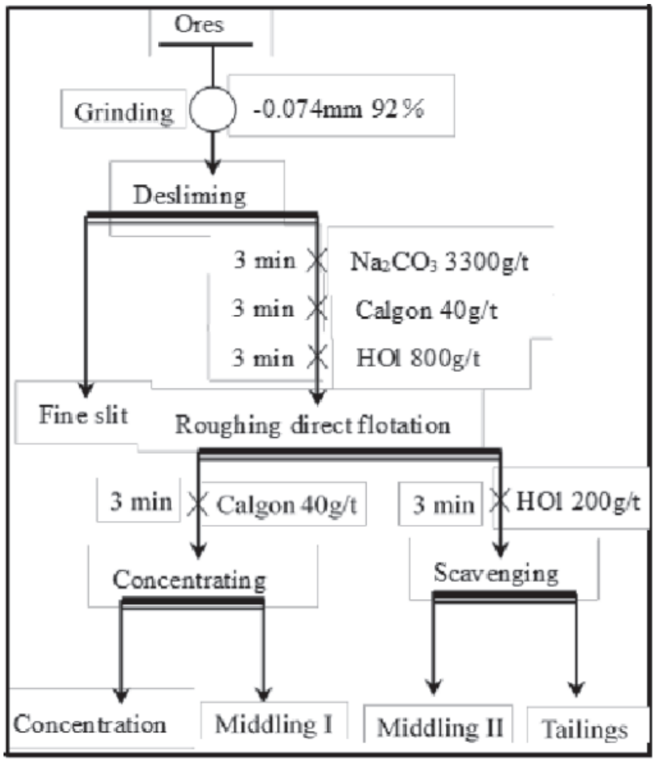

Fig.3 Desliwing.flotation test.flow chart

As can be seen from the above results, even though SiO_2 content and recovery rate of the removal of fine mud is higher, in line with the previous inference, but the process also has the problem of concentrate Al-Si ratio and is not high, and the problem of low recovery rate of $A1_2O_3$, analyses the reason of the problems; it may be because of inhibitors effect in gangue minerals containing silicon inhibition not strong or collector to diaspore selective collecting ability is weak.

3.1.3 The new collector flotation test

XY-1 is a new type of bauxite collector, suitable for diaspore bauxite, compared to oleic acid has strong selective collecting effect, and the dosage is relatively small. So 1 # sample as shown in Fig.4; process validation tests of which is carried out, mainly inspects the XY-1 of the bauxite flotation effect, the results are shown in Table 4.

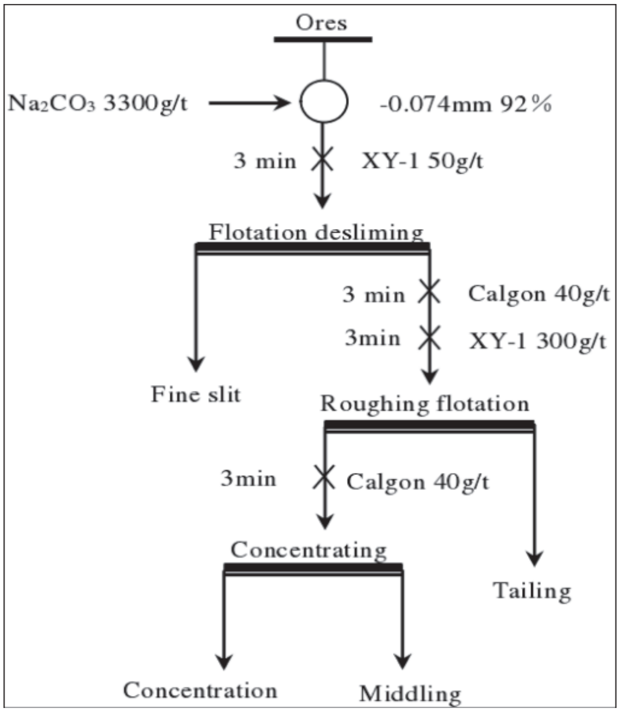

Fig.4 New collector were flotation test process

TABLE 3: DESLIWING FLOTATION TEST RESULTS

Name	Yield (%)	Grade (%)		Recovery (%)		A/S
		Al_2O_3	SiO_2	Al_2O_3	SiO_2	
Concentrate	12.26	40.33	35.92	12.1	12.79	1.12
Middling 1	19.3	43.01	31.4	20.32	17.6	1.37
Middling 2	6.67	42.72	32.01	6.97	6.2	1.33
Tailings	25.99	47.85	23.34	30.44	17.62	2.05
Fine mud	35.78	34.45	44.06	30.17	45.79	0.78
Total	100	40.86	34.43	100	100	1.19

TABLE 4: NEW COLLECTOR WERE FLOTATION TEST PROCESS RESULTS

Name	Yield (%)	Grade (%)		Recovery (%)		A/S
		Al_2O_3	SiO_2	Al_2O_3	SiO_2	
Concentrate	6.89	40.48	36.18	6.82	6.99	1.12
Middling 1	37.86	44.82	33.41	41.5	35.5	1.34
Tailings	31.2	39.35	36.27	29.83	31.56	1.08
Fine mud	24.05	37.14	38.44	21.85	25.95	0.97
Total	100	40.86	34.43	100	100	1.19

As can be seen from the above results, in this condition, Al-Si ratio of concentration is lower than undressed ore, the recovery rate of $A1_2O_3$ is low, it shows that the new collector agent XY-1 was not fit for bauxite. The positive flotation test result shows that either direct flotation, desliming flotation, or used a new regulators or new collector for positive flotation, due to Al-Si ratio of undressed ore is extremely low, large gangue mineral content, fine granularity, leads to more concentrate containing silicon gangue mixed into the stream, Al-Si ratio of concentrate is improved not very much. Generally speaking, the positive flotation process affects bauxite which is not very ideal.

3.2 Reverse flotation experiment

In view of the low characteristics of gangue ore grade of mineral content $A1_2O_3$, is much higher than mineral products, depending on "float less restrain more" in the flotation principle is carried on the reverse flotation experiment.

3.2.1 Reverse flotation inhibitor dosage test

In the condition that grinding fineness of -200 orders, accounting for 92%, used sodium hexametaphosphate as depressant, dodecyl-trimethyl ammonium chloride (1231) as the collector, diaspore for 1 # samples of starch dosage test, test process as shown in Fig.5, the test result is shown in Fig.6.

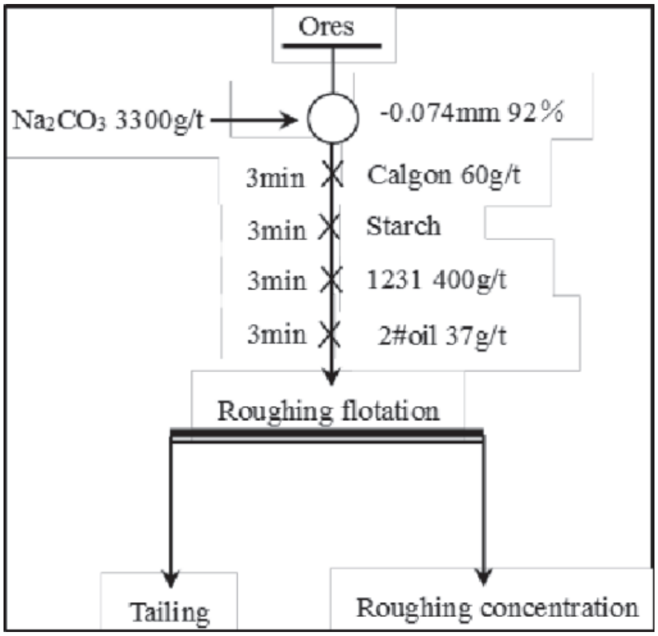

Fig.5 Reverse flotation inhibitor dosage of starch test flow chart

From the above results we know that inhibitor dosage of starch in the test within the scope of the test index changes little, tailings Al-Si ratio stable at around 1, concentrate Al-Si ratio are close to 2, comprehensively consider concentrate Al-Si ratio and recovery rate, choose the starch dosage is 600 g/t.

3.2.2 Reverse flotation grinding fineness of validation test

Because under the experiment of grinding fineness, siliceous gangue minerals may not completely monomer dissociation, so it is also in other grinding fineness is verified under the condition of the above process, in order to find the best grinding fineness. Test process is shown in Fig.7, the results are shown in Table 5.

It can be seen from the above test results, with the increase of grinding fineness, concentrate Al-Si ratio increases

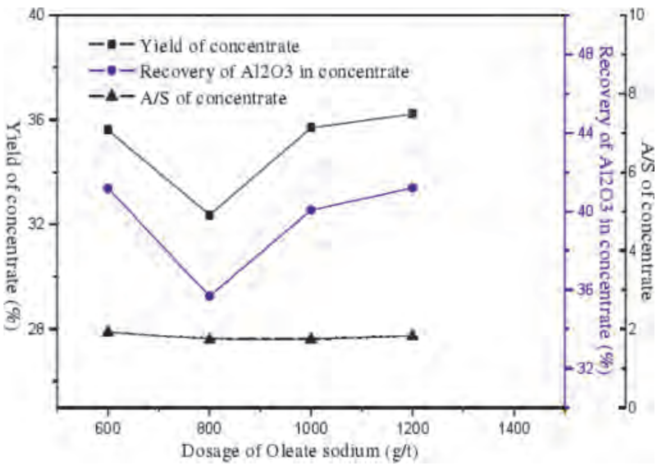

Fig.6 Effects of starch dosage on the reverse flotation tests

Table 5: Results of grinding fineness condition tests

Finenss (content of 0.074/%)	Product	Yield (%)	Grade (%)		Recovery (%)		A/S
			Al_2O_3	SiO_2	Al_2O_3	SiO_2	
82	Concentration	31.2	40.48	36.18	35.28	21.37	1.12
	Middling	7.31	44.82	33.41	41.5	35.5	1.34
	Tailing	61.49	39.35	36.27	32.14	31.56	1.08
	Ores	100	37.14	38.44	100	100	0.97
92	Concentration	27.11	40.48	21.87	21.47	17.03	1.13
	Middling	9.89	44.82	33.41	46.89	35.5	1.49
	Tailing	63	39.35	36.27	33.48	31.56	1.16
	Ores	100	37.14	38.44	16.85	25.95	1.16
95	Concentration	23.51	47.77	36.18	6.82	6.99	1.14
	Middling	12.82	44.82	33.41	40.88	36.9	1.42
	Tailing	63.67	39.35	35.54	29.74	32.14	0.9
	Ores	100	39.3	36.98	31.54	34.21	1.15
98	Concentration	21.44	40.48	18.17	24.68	11.44	2.61
	Middling	12.43	44.82	28.43	13.65	10.34	1.56
	Tailing	66.12	39.35	41.23	60.14	78	0.96
	Ores	24.05	37.14	38.44	100	100	1.17

TABLE 6: RESULTS OF REVERSE FLOTATION TESTS FOR SAMPLE II

Name	Yield (%)	Grade (%)		Recovery (%)		A/S
		Al_2O_3	SiO_2	Al_2O_3	SiO_2	
Concentrate	16.53	60.3	10.43	21.64	7.1	5.78
Middling III	1.89	58.77	11.89	2.41	0.93	4.94
Middling II	6.34	55.89	14.56	7.69	3.8	3.84
Middling I	14.44	50.14	15.09	15.72	8.95	3.32
Tailings	60.8	39.35	36.27	52.54	79.19	1.18

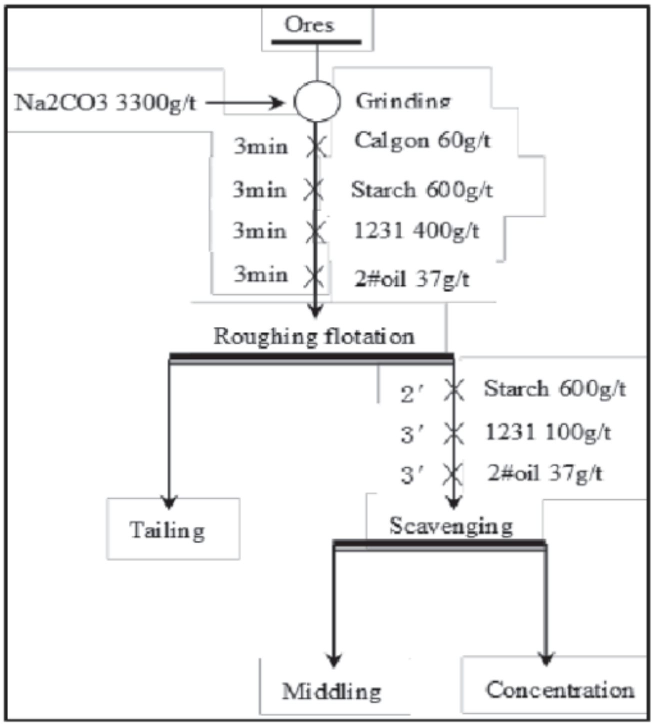

Fig.7 Flow sheets of reverse flotation tests when changing grinding fineness

gradually, but the recovery rate of $A1_2O_3$ is gradually reduced. Comprehensive consideration, choose grinding fineness of -200 orders, accounting for 98%.

3.2.3 Reverse flotation process validation test on 2# sample

In order to further confirm the effect of the reverse flotation technology, adopting the reverse flotation process of 2# ore sample verification test, the test process is shown in Fig.8, the results are shown in Table 6.

As can be seen from the above test results, 2 # sample Al-Si ratio increased range is very big, concentrate Al-Si ratio can reach 5.78, the main reason may be the 2 # sample ore Al-Si ratio is relatively high, close to 2, at the same time, the siliceous gangue mineral in 2 # sample is relatively small, less interference is also on the flotation.

We can draw from the reverse flotation test, undressed ore Al-Si ratio has great influence on ore sorting indicators, for Al-Si ratio is a little higher than 2 # sample, using the reverse flotation technology available in conformity with the joint method required to produce Al-Si ratio of concentrate. Therefore, in the actual process of development and utilization, the region's best bauxite ore matches processing, makes the ore samples meet or exceeds 2 # samples ore Al-Si ratio level, can obtain high quality bauxite ore concentrate.

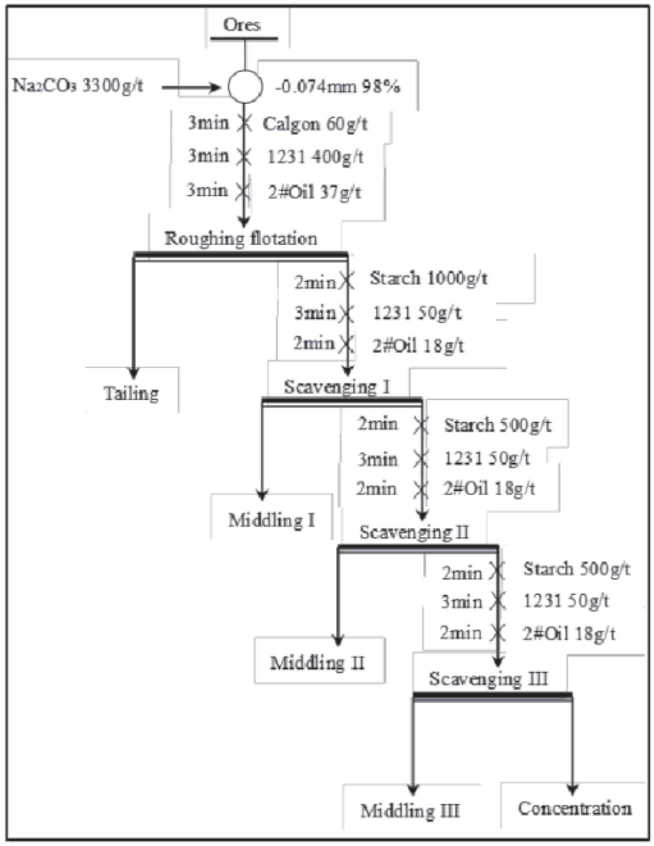

Fig.8 Flow sheet of reverse flotation tests for 2# sample

4. Bauxite sintering dissolution test

In order to further study the bauxite ore dressing performance, on the base of the above test, we used the method of chemical separation tested the samples. Chemical beneficiation desilication process mainly includes perorating, alkali leaching desilication, solid-liquid separation process, etc. The main advantages of chemical beneficiation desilication are: desilication process alumina recovery rate is high in desilication process; ore is processed at high temperatures, can be removed most of harmful impurities such as carbonate, sulfur, harmful impurities organic matter in the ore, are advantageous to the subsequent dissolution operation. Adjusting liquid is made up by pure sodium hydroxide and aluminum hydroxide in the process of dissolution, after adjusting liquid is compounded Na_2OK solubility are 51.40 g/L, $A1_2O_3$; solubility are 42.00 g/L, the coefficient of akwere equal to 2.0.

This experiment uses pure sodium carbonate and analytical pure lime as the sintering materials. Lime comes from roasting under 650°C after 2 hours, the effective composition content of CaO in the experiment are in 100%.

Test firing condition control as in the following:

$[CaO]/\{[SiO_2]+[TiO_2]\} = 1.8$

$[Na_2O]/\{[A1_2O_3]+[Fe_2O_3]\} = 1.0$

Sintering temperature control at 1250°C the firing time for 1 h. In the firing process, the first raw material is preheated at 800°C for 15 minutes; then sintered at 1250°C high temperature furnace for 1 hour. Finally, the clinker cooler 15 minutes at 800°C then turns the power off with furnace cooling and then the clinker is subjected to the dissolution test, dissolution, control water bath temperature are 90°C dissolution time for 30 minutes, liquid-solid ratio of stripping correction liquor is 200 g/L.

After ingredients sintered bauxite, A1203 dissolution rate is high, much higher than the recovery rate of flotation test. Low aluminum-silicon ratio 1# sample dissolution rate reaches 59.62%, high Al-Si ratio 2# sample dissolution rate reaches 75.64%. For the super poor bauxite, through chemical beneficiation desilication process can get good effect.

5. Conclusions

(1) Chemical analyzing results show that the Al-Si ratio and $A1_2O_3$ content of the bauxite are extremely low, which is difficult to choose lean bauxite.

(2) In view of the mine Al-Si ratio is extremely low, after a series of positive flotation and reverse flotation condition test, found the reverse flotation for the improvement of the aluminum silicon ratio had good effect. Undressed ore Al-Si ratio had a large influence on the final concentrate Al-Si ratio, for high Al-Si ratio concentrate, ore Al-Si ratio had better reach or exceeding 2.

(3) Bauxite sintering dissolution test showed that the bauxite after ingredients sintering $A1_2O_3$ dissolution rate is higher, the 1# sample and 2# sample dissolution rate is far higher than that of the flotation recovery, 2# sample whose Al-Si ratio is a little higher dissolution rate can reach 75.64%, shows that raising ore Al-Si ratio can significantly improve the dissolution rate of the ore.

(4) The test results show that the bauxite from Guizhou used are not suitable for flotation process, joint method required to produce Al-Si ratio of concentrate can obtain by reverse flotation, and sintering dissolved aluminum process, can make full recovery of useful minerals.

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A MODELLING STUDY ON MULTI-MINE AND MULTI-PRODUCT IN GUIZHOU PROVINCE, CHINA

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inventory cost; the optimized annual profit is increased by RMB 980 million compared to the actual annual profit, where reduced inventory has led to a reduction of inventory cost by RMB 660 million; (3) there is a non-linear relationship between dynamic cost and production of raw bauxite mining in bauxite mine n=1, with an inflection production as 0.28 million tonnes; The optimal solution of this model has shown that under the premise that multiple bauxite mines produce a same type of bauxite, the pursuit of maximum profit of individual bauxite mine may not realize the maximum overall profit. This is of great significance for bauxite mine enterprises to be conscious of the irrationality of diluting per tonne bauxite cost through increasing production.

According to the optimization results, the optimal production decision model for multiple-mine and multiple-product portfolio constructed by this article is of a certain practicability and actual value, especially in the new normal of bauxite mine industry. bauxite mine enterprises shall transfer the decision focus from production to cost, instead of overemphasis of high and stable production and overlook of the actual market demand; secondly the bauxite mines should optimize the production plans based on market demand and enterprise inventory in time; lastly, bauxite mine enterprises during the production process shall also focus on information infrastructure construction, for example constructing a DSS (decision support system), to upgrade the data sharing ability for bauxite mine production decision.

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