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Desilication and Flotation Techniques for Separating them from the Bauxite

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A R T I C L E I N F O

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A B S T R A C T

Magnesium aluminum silicate is composed of magnesium, aluminum, silica, and oxygen. Aluminum silicates like pyrophyllite, illite, kaolinite and chlorite are part of impure minerals that are found in diaspore bauxite that indicates the importance of the separation of silicate minerals in the early stage to enhance the volumetric ratio of Al2O3 / SiO2 from disapore bauxite. X-ray experiments on raw materials and products of flotation indicate that illite is separated much more difficult than other similar diaspore bauxite like pyrophyllite, kaolinite and chlorite. Closed-cycle flotation tests show us that disturbing agents of flotation for desilication are applicable with a regular program (MIBC, SFL, DTAL) and the result of it is bauxite concentrate (A / S> 10, Al2O3 (RGP)> 0.86) and economic production by primary technology Hydro garnet combinations are steadily present during the extraction of alumina with extremely high temperatures and the 30% of their compounds are converted into compounds of caustic soda. Alumina extraction will not have a great influence on the used mechanical - chemicals behavior.. In the present article the mechanical - chemical behavior of bauxite, along with lime has been studied at the time of processing. One of the notable items that during bauxite grinding and mixing of lime leads to serious damage to the mill is the existence of iron within the structure of constituent levels of slurry bauxite lime the can reach more than 9 percent of CaO composition. The results showed more than 90 percent of quartz content in the bauxite can be arrested by the interaction of the hydro garnet.

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INTRODUCTION

In the hydroxide minerals group the ion (OH) - or so called hydroxyl is in the atomic lattice. The presence of hydroxyl ions weakens the binding force between atoms. The main minerals of this group are: Brucite, Geothite, Diaspore, Bauxite, Lepidocrocite, Manganite, Groutite, Stainierite and Chalcopanite that this project discusses the diaspore minerals and processing of them from the diaspore minerals.

Bauxite mineral is formed form the mixture of multi-mineral isomporph of diaspore, Gibbsite, and Boehmite. So it has very complicated formula. Its hardness is 3-1 and its specific gravity is 2.55 to 2. Its color is white, gray, yellow and occasionally red. Basic color is like chalk paint. It has a matte polish. The main combination of the bauxite of aluminum oxides is hydrated. In some cases, the chemical formula of bauxite is closer to Gibbsite.Since bauxite is composed of several mineral it must be called stone. Bauxite is the most important mineral to produce aluminum. In Iran in the Zanjan and Kurdistan region there are small reserves of bauxite, so in Iran inevitably the alum is used to produce aluminum. In America, Turkey, Australia, France, Russia valuable reserves of bauxite has been found.

Bauxite and Alumina:

Bauxite is created naturally and initially compact homogeneous material are combined with one or more types of aluminum hydroxide minerals and finally, compounds such as silicon dioxide (SiO2) and iron oxide (Fe2O3), titanium oxide (TiO2) and aluminosilicate, and other detectable impurities can be observed within the bauxite. Aluminum hydroxide minerals in various proportions except bauxite are conventionally found in Gibbsite with the combination of [Al (OH) 3] and polymorphs like boehmite and diaspore [AlO (OH)]. The main sources of bauxite return to the materials which have non-metallurgical grade and the countries that have

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these resources are: Australia, China, Greece, Guinea, Guan and Italy that have been formed from the abrasive bauxite reserves. Among the countries that have been formed from very high bauxite grade, we can mention Brazil, China and Guan. Reported total global reserves of bauxite can cover the demand related to aluminum production in the 21st century in a way that will meet the needs[1]. These statistics can be seen in Table 1.

Table 1: The existing and outstanding status of bauxite.

	1998	1999	2000	2001	2002
United states					
Production,crude or e(dry equivalent)	NA	NA	NA	NA	NA
value	NA	NA	NA	NA	NA
Exports(as shipped)					
Crude and dried	83	115	133	67	27
calcined	16	34	9	14	15
Imports for consumption(as shipped)					
Crude and dried	11000	9890	8550	8300	7340
calcined	393	299	310	242	237
Consumption(dry equivalent)	12700	11700	10800	9770	9970
World production	123000	129000	136000	137000	14400

All bauxite reserves are scattered sporadically around the earth in a way that 90% of these reserves are located in the 12 countries which were mentioned and the amount of their reserves, can be estimated as 22 billion tones that this amount could be adequate for the future of the considered countries until 2003 [2] Aluminum production in America is mostly provided by the metallurgical bauxite reserves that are essentially used for the industries of country and no change has been made in terms of production compared to 2001. According to estimations, 91 percent of alumina shipped via cargo ship is created through initial smelters and refiners which are used to produce aluminum metal. Using these metals in industries such as abrasives, chemicals and refiners has exclusively lead to exportation of alumina to other regions. The estimation data of the production and transport of alumina in United States can be seen in table 2.

Table 2: Estimation of alumina production and transport in the United States of America.

YEAR	Calcined alumina	Other alumina	Total	
			As produced or shipped	Calcined equivalent
Production				
2001	3930	608	4540	4340
2002	3930	605	4540	4340
Shipment				
2001	4030	617	4650	4440
2002	3900	610	4510	4310

Global exportation of alumina in 2002 has increased 4 percent. The main countries producing alumina may include Australia, China, America and Brazil. These countries have accounted for a significant share of 60 percent of world output, while Australia has accounted for the largest share among the other countries.

Objective:

Separation of Diaspora bauxite from silicates by flotation method:

In trade and Industry of disturbing factors of flotation, granular magnesium carbonate is used to produce concentrate magnesium carbonate along SiO_2 with a volume less than 0.20 percent (Santana and Peres, 2001). In experiments for the flotation of quartz from Gibbsite / kaolinite, sulfates with pH = 2 were regularly used as a collector. Separation of kaolinite from Gibbsite is done by kaolinite flotation along with aluminum concentrate and 4/1 ammonium salt with a pH = 6 and causes the production of Gibbsite with high purity of 97.4 percent of Al_2O_3 and Altogether Gibbsite is recovered with a purity of 90% [3] In China diaspore bauxite is recognized with high volume of Al_2O_3 and SiO_2 and relatively low Al_2O_3 to SiO_2 (usually the amount is m (Al_2O_3) / m (SiO_2) = A / S (5-6)) and this ratio of Gibbsite bauxite and Boehmite bauxite is compared with other countries. The cost of production technologies of Aluminum oxides refractory bauxite that are produced by sintering and combining is much more than a basic production in a way that aluminosilicate tailings like pyrophyllite , illite and kaolinite largely are separated in bauxite and this has increased the ratio of A / S. Direct flotation shows us the useful and effective techniques for Desilication from diaspore bauxite [4]; Feng et al., 2001 Lu et al., 2002). Anyway disturbing factors of flotation with cationic collectors show us many advantages of this approach as compared to the direct flotation such as lower cost, easy squeeze, the less impact on metallurgy and diaspore flotation mechanism and aluminum silicates along with alkaline and sodium carboxy which were observed in studies conducted in China. Variability and floatation which are surface properties of aluminum silicate minerals and ease of reproduction of mud, unlike flotation method has made desilication difficult as compared to other common methods of flotation. Therefore, a new method of removing mud about disturbing factors of diasporas bauxite ore flotation has been studied[5].

MATERIALS AND METHODS

Flotation tests:

Ore flotation tests in the laboratory flotation devices XFD (1.51) is carried out in accordance with figure 1.

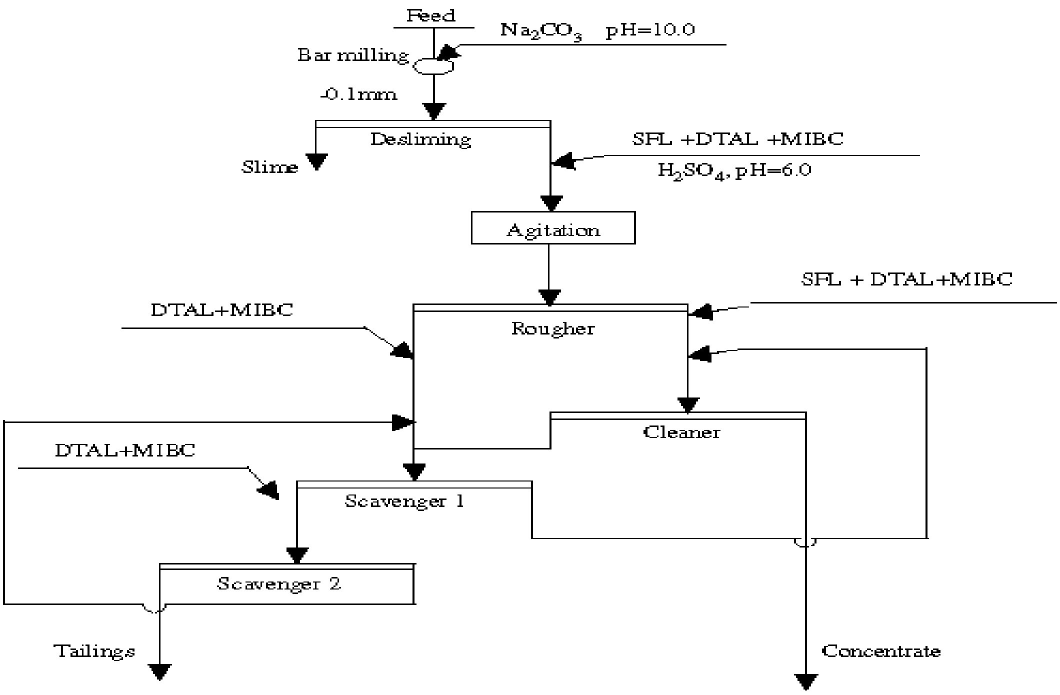

Fig. 1: Flowchart of disturbing factors of flotation with a closed-cycle.

Additional parameters in the flotation tests are shown in figure 1. To balance calculations, flotation products such as mud, tailings and concentrate are placed as thematic in chemical experiments in order to determine the amount of Al2O3 and SiO2[6].

Results:

Flotation tests using cationic collectors:

According to zeta potential measurement, minerals diaspore, kaolinite, illite and pyrophyllite, operating PZC diaspore, kaolinite, illite and pyrophyllite, were respectively about 6.68, 3.65, 2.88 and 2.51 [4]It was suggested to conduct the separation by using diaspore floatation method of kaolinite, illite and pyrophyllite, with a cationic collectors with a pH between 2 and 7. Flotation test samples 1 along with dodecylamine (DDA), Cetyl trimethylammonium bromide (CTAB) and especially 4/1 ammonium salts (DTAL) have been used as collectors, reagents inorganic SEL, 360 ppm, which is used as a reducer and additive that altogether perform the practice of removing mud in the pH range between 6 to 7. The open cycle test results are presented in the Figures 2 to 4[7].

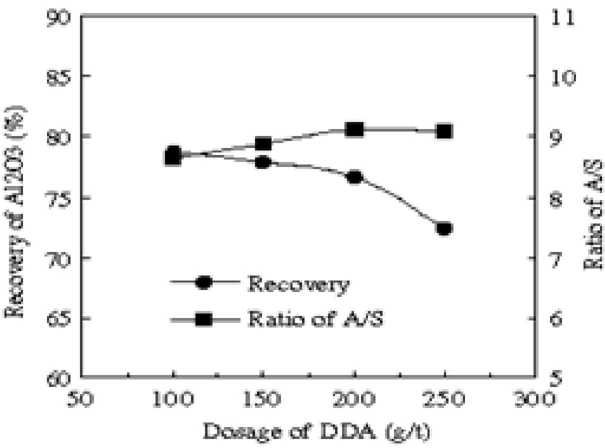

Fig. 2: Al2O3 recovery and ratio of A / S using the bauxite concentrates with the specified input of DDA.

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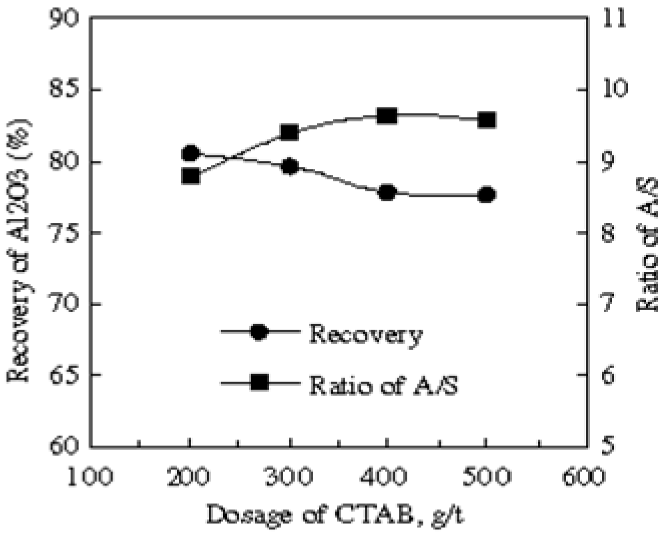

Fig. 3: Al2O3 recovery and ratio of A / S using the bauxite concentrates with the specified input of CTAB.

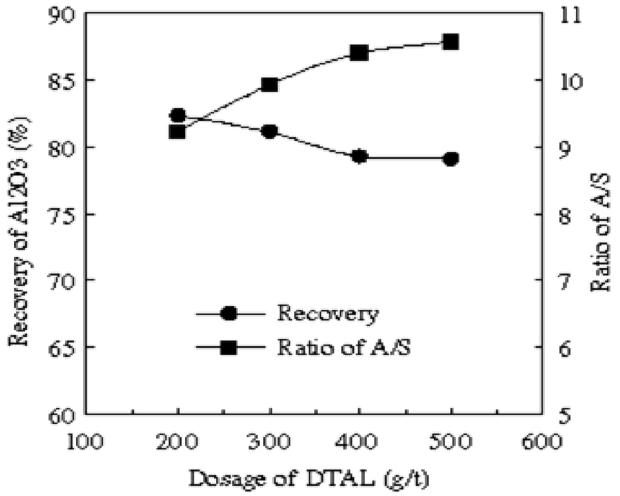

Fig. 4: Al2O3 recovery and ratio of A / S using the bauxite concentrates with the specified input of DTAL.

As can be seen in figure 2, Al2O3 recovery from bauxite concentrate reduces as the certain amount of DDA is increased, but ratio of A / S in bauxite concentrate increases slightly. The best result for Al2O3 recovery and ratio of A / S in the bauxite concentrate which are respectively about 75% and 9 percent, is achieved in certain amount of 200 ppm. Figure 3 shows that when certain amount of CTAB increases, ratio of A / S in bauxite concentrate makes progresses and the recovery of Al2O3 in bauxite concentrate is slowly reduced. Bauxite concentrate which is provided with a certain amount of 400 ppm, determines that the conscious choice of CTAB is better than DDA for mineral floatation of aluminum-bearing silicates. As can be seen in figure 4, by using DTAL, Al2O3 recovery and ratio of A / S concentration will find similar ascending designs in using CTAB but selection of CTAB is better than DTAL. Using a certain amount of 400 ppm, the ratio of A / S in the bauxite concentrate is about 10.5, and Al2O3 recovery is about 79% which implies that DTAL could be the right choice for cationic collectors for mineral floatation of aluminum-bearing silicates like pyrophyllite, illite and kaolinite and this choice makes possible the desilication of diasporic bauxite ore[8].

Discussion:

Desilication of disturbing factors of flotation for different diaspore bauxite:

Kaolinite, pyrophyllite, illite and chlorite are main tailings of diaspore mineral, this mineral aluminum-bearing silicates affect the disturbing factors of floatation in desilication and they are different like the possibility of suspension of three different aluminum-bearing silicates (Illite ~ kaolinite < pyrophyllite) . In this work, two different samples (samples 1 and 2) which have different combinations of aluminum silicate are used by present reagent to examine disturbing factors of flotation (DTAL, SFL, and MIBC), which is used for research on changes of current planned reagents. The results of tests on samples 1 and 2 are given in Table 3.[9]

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Table 3: Results of experiments conducted on disturbing factors of flotation on samples 1 and 2.

Samples	Conditions	Product	Weight (%)	Grade (%)		Recovery (%)		$m(Al_2O_3)/m(SiO_2)$
				Al_2O_3	SiO_2	Al_2O_3	SiO_2	
Sample I	De-slime,	Concentrate	80.46	68.55	6.33	86.63	45.56	10.83
	pH – 6 7, SFL	Slime	12.59	45.15	28.46	8.93	32.05	1.59
	360 g/t, DTAL	Tailings	6.95	40.68	36.02	4.44	22.39	
	450 g/t, MIBC 70 g/t	Feed	100.0	63.67	11.18	100.0	100.0	5.69
Sample II	De-slime,	Concentrate	79.59	68.03	6.88	84.81	48.37	9.89
	pH – 6 7, SFL	Slime	11.21	45.57	30.62	8.00	30.32	1.49
	360 g/t, DTAL	Tailings	9.20	49.80	26.22	7.19	21.31	
	450 g/t, MIBC 70 g/t	Feed	100.0	63.48	11.32	100.0	100.0	5.64

As can be seen in Table 3, current reagent shows the best variations about disturbing factors of flotation on samples 1 and 2. Al2O3 recovery and ratio of A / S in concentrate in the two samples are 85 percent and 10 percent, respectively. Due to the high volume of illite and lack of pyrophyllite in the raw materials, sample 2 has a volume ratio of Al2O3 / SiO2 and Al2O3 recovery is low.

X-ray experiments on soil of flotation products:

Disturbing products of flotation which are obtained from samples 1 and 2 have been placed thematically in the X-ray analyzes in order to determine the amount of aluminum-bearing silicates particularly pyrophyllite, kaolinite, illite and chlorite in flotation products. The results of samples 1 and 2 are respectively given in Figure 5 and 6.

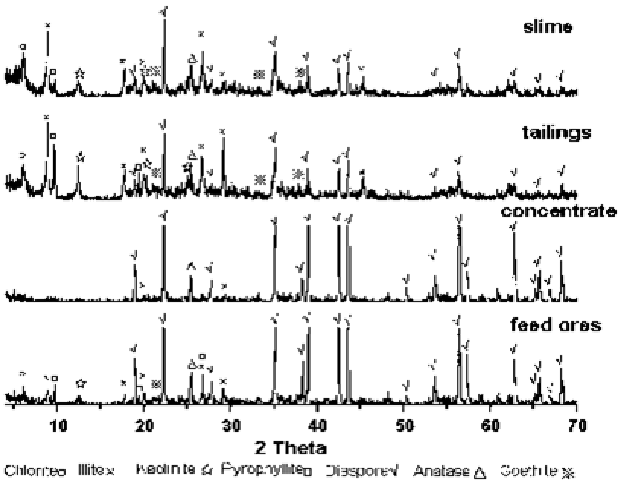

Fig. 5: Results of X-ray experiments on flotation products - Sample Number 1.

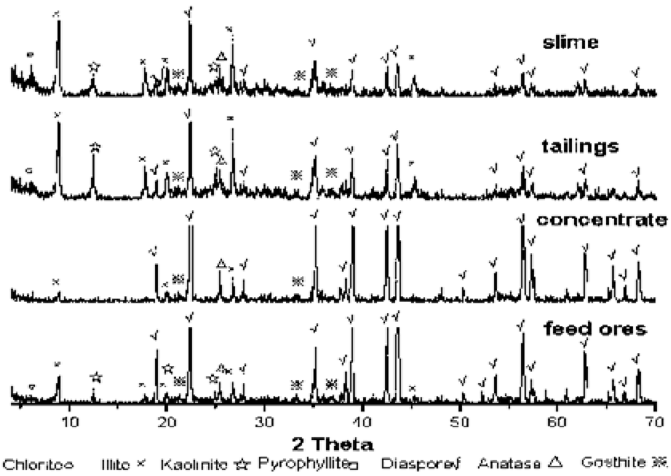

Fig. 6: Results of X-ray experiments on flotation product-- sample 2.

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As shown in Figure 5 and 6 we can see that chlorite, pyrophyllite and kaolinite are separated almost completely diasporic bauxite ore and there are no signs of chlorite, pyrophyllite and kaolinite in samples 1 and 2, which were obtained from bauxite concentrate. Signs of illite can be seen in samples 1 and 2 which were obtained from concentrate. This result makes it clear that the presence of illite minerals makes progress difficult in a volume ratio of Al2O3 / SiO2 in concentrate. In sample 2 there are no signs of pyrophyllite, but there is plenty of illite in these samples with the volumetric ratio of Al2O3 / SiO2 and Al2O3 recovery is very low [10].

Processing gained experiences:

The materials used in this study are about bauxite with enormous silicates and reagent CaO. Bauxite compounds used in this study can be seen in Table 4.

Table 4: Compounds of used bauxite.

	wt%
Al_2O_3	55.1
Fe_2O_3	11.3
SiO_2	5.7
TiO_2	2.6
H_2O, trace elements	Balance

Grinding operation has good stability and horizontal capacity of destruction of this mill is 1 meter per mill length. Weight of the bullets used to charge mill is 3 kg, which has a thickness of 6 mm and rotation rate of bullets of this mill is 600 rpm. There were 4 type of consumption ratio for bauxite and CaO (lime) at the time of grinding and the ratio of lime consumption can be observed in Table 5.

Table 5: The ratio of lime consumption.

Sample	wt% CaO
QA1	4.0
QA2	5.9
QA3	9.1
QA4	14.3

According to operation, grinding is performed; slurries are recovered by adding water to grinding and after the operation ends slowly from 2 to 5 minutes. Slurry and bullets enter into a container for screening and ultimately they will be washed by distilled water. Finally, after filtration the intended slurry will be used to retrieve bauxite. After drying the samples for routine tests, the element analysis test (XRD) will be used to measure the amounts of various elements and then (XRF) testing will be used for chemical analysis and measurement of metal oxides in bauxite. The amounts of inactive quartz can be measured at the time of bauxite grinding through routine standard analysis and methods of acid solution. The milled samples of bauxite will be used in Bayer process at temperatures of 250 ° C for 10 minutes.

Immediately after the operation, the solution is cooled and centrifuged to separate the red mud and other compounds. Caustic soda and aluminum levels in solution were analyzed by the extremely accurate analyzer. Contaminated solution will be measured by XRF analysis. Solids (red mud) form about 10% of the solution and before analysis by XRF, XRD analysis is used for measuring metal oxides in red mud and to detect and measure the ingredients.

Conclusion:

Element analysis experiment or XRD is used for bauxite and samples QA3 QA2 which are not milled, and the results of it, indicated that the amount of lime is approximately 5.9% in the sample QA2 and about 9.1 percent in the sample QA3, that the considered amounts can be seen in Figure 7.

In addition, highest existing levels of these minerals can be searched by Gibbsite and Boehmite and in the case of the lowest forming levels we can mention hematite, kaolinite and anatase. By comparing the pattern of constituents in the sample QA2 which are provided from bauxite samples without grinding, it can be concluded that the severity and extent of broadband components of the mill are significantly reduced. Part of this sample can be used to reduce the peak of intended components such as calcite and the absence of any new discovery from the surface of the sample QA2 after the operations of the mill, can be observed. Pattern of components for sample QA1 (4% lime) is exactly similar to the sample QA2 [10].

Examinations related to pattern of components for sample QA3 after the operations of grinding indicated that the maximum number of new values has been formed that levels of iron hydro garnet and the combination of Ca3 Al Fe (SiO4) (OH) 8 can be mentioned as the major ones. As can be seen in figure 7, curve (C), Gibbsite

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and hydro garnet are the main levels of the grinding after the operation is performed. The experiments showed that the amounts of hematite, Goethite in the samples are extremely low, so the increase can be observed for short-chain kaolinite. The same pattern of components can be observed for sample QA4. Measuring the effects of lime concentrate on the remaining amount of quartz in the grinding samples can be seen in Figure 8.

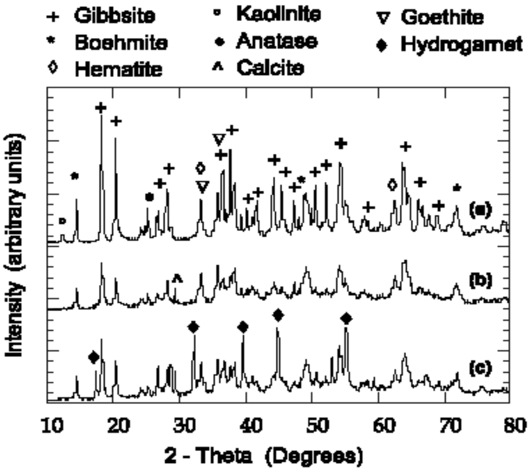

Fig. 7: XRD examination for Bauxite and samples QA2 and QA3.

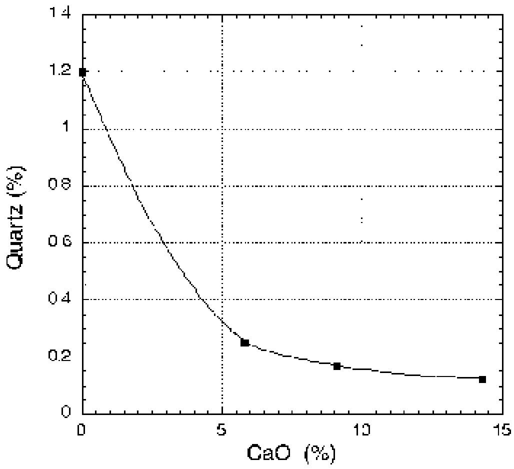

Fig. 8: Effect of lime concentrate on quartz in milled bauxite samples.

Increase of lime concentrates reduces the amounts of residual quartz in samples as 10% of the value of original combination. According to existing documents, main atomic weights in hydro garnet level and composition of bauxite refers to silicate transformation which exists within the bauxite and by increasing their amount from 26 percent to 100 percent, the amount of lime concentrate will be increases from 4 percent to 14 percent. It is not possible to make the necessary measurements for samples containing kaolinite after grinding and finally measure amounts of conversion of kaolinite to hydro garnet, thus the relative decrease in the amount of kaolinite in samples QA2 and its removal from QA3 and QA4 samples represents their conversion to hydro garnet samples. As shown in Figure 7, the maximum amount of CaCO3 in milled samples can be seen by performing incomplete reaction. Effects of lime concentrate on soda ash consumption during the reaction are shown in Figure 9.

The ratio of sodium to silica is defined according to current consumption of caustic soda compared to the amount of silica inside red mud. The maximum measured ratio of DSP in terms of formula is approximately 0.67. The ratio of sodium to silica which is lower than the amount shown in the figure will lead to a reduction in sodium consumption. As shown in Figure 9 because of increase in lime weight, the ratio of sodium to silica will be reduced. Qualitative impact of mill on soda and the ratio of soda to silica can be seen in Figure 9 where the comparisons required for grinding or not grinding of bauxite, which is similar to the presence lime concentrate, will be investigated. In this period, different bauxite and oils were used to perform two different experiments and as it is shown in figure, soda is consumed for each series of data, that normally limestone has not been used for bauxite samples. The main results of sodium consumption indicate estimation for reducing consumption by rising to 30% of the mechanical -chemical behavior of the particles. Theoretically if all silicates convert to hydro garnet, soda consumption can be removed during the solubility of bauxite. Increasing the degree of substitution of iron in hydro garnet combinations during grinding will lead to a reduction in the loss of alumina which will occur with the addition of lime in the Bayer process. This work is one of the investigations that in the future will need optimization in mentioned process. Other profitable possibilities in the mechanical - chemical behavior of the mentioned process are removing organic pollutants in the bauxite which will accelerate the problems solving [10].

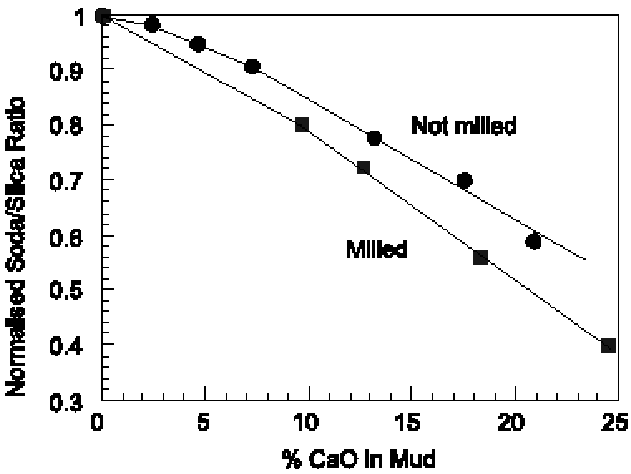

Fig. 9: Effect of lime concentrate on consumption of caustic soda through obtaining bauxite.

Suggestions:

1-In desilication of disturbing factors of flotation, from among the diasporic bauxite ore whose pH range is between 6 and 7, ¼ ammonium salts (DTAL) is the best choice as compared to the dodecylamine and Cetyl trimethylammonium bromide.

2- Mud granular with dimensions of less than 0.010 mm affect disturbing factors of flotation with cationic collectors, so there is a need to separate the mud granular with dimensions less than 0.010 mm using Na2CO3 as suspender.

3 - In both samples 1 and 2, the use of new reagents (MIBC, SFL, DTAL) shows us the best desilication fluctuations and bauxite concentrate (A / S> 10, Al2O3 (RGP)> 0.86).

4 - X-ray experiments on soil samples make it clear that presence of a small amount of suspended illite makes desilication of disturbing factors of flotation of despotic bauxite difficult that this causes the improvement of the ratio of A / S be harmful for diasporic bauxite and may cause great losses.

5 - Mechanical - Chemical behavior of bauxite and water solution along with lime, provide us with results in which there are information about the substitution of iron in hydro garnet combination for lime concentrate and approximately will contain 9% of the total weight of the solution.

6 - According to the analysis done on the quartz content of bauxite grinding it was found that reducing this amount by more than 90 percent will lead to the reaction of silicate quartz with lime.

7 - In the future, activities should be done to eliminate the need for greater understanding of chemical reactions and optimization of grinding operations and other common processes.

REFERENCES

[1] Alcan Inc., 2012. Alcan agreement on consultation process at its Burntisland facility ensures closure on November 30 , 2012 : Montreal , Quebec , Canada,Alcan Inc.press release , November 18,1 p.
[2] Alcoa Inc., 2002a. Alcoa,BHP Billiton sign letter of intent to explore further opportunities in Suriname: Pittsburgh , PA , Alcoa Inc.press release,October 17,1 p.
[3] Alcoa Inc., 2002b. Alcoa World Alumina and Chemicals and the Government of Jamaica to invest $115 million to expand Jamalco alumina re . nery Operations: Clarendon, Jamaica, Alcoa Inc. press release April 27,1 p.
[4] Alumina Plants Worldwide, 1993. U.S. Bureau of Mines.
[5] American Metal Market, 2002. Alcoa, Alinta Gas in power accord for W .Australia alumina reneries: American Metal Market, 110: 75-4 , July 5,p.6.
[6] Bauxite Mines Worldwide, U.S. Bureau of Mines, 1994. CRU. Alumina Monitor (monthly).
[7] Bittencourt, L.R.M., C.L. Lin, J.D. Miller, 2013. Flotation recovery of high-purity gibbsite concentrates from a Brazilian bauxite In: Advanced Materials - Application of Mineral and Metallurgical Processing Principles. Society of Mining Engineers of AIME, pp: 77-85.

[8] Baksa, G., F. Vallo, F. Sitkei, J. Zoldi, K. Solymar, 1986. Complex causticisation: an ective means for the reduction of NaOH losses in an alumina plant. Light Met. TMS,Warrendale, 75-80.
[9] Cao, X., Y. Hu, Y. Jiang, H. Li, 2001. Flotation mechanism of aluminum - silicate minerals with N – dodecyl – 1, 3diaminopropane. Chinese Journal of Nonferrous Metals, 11(4): 693-696 (in Chinese).
[10] Cooper, Mike, 2002. SUAL aims to begin Komi project in 2004: Metal Bulletin, no. 8731, December 9, p.4.