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TURKEY MORCUKUR BAUXITE PROCESSNG AT ETI ALUMINIUM

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Abstract

ETI Aluminium can process nearly 550.000 tons of bauxite and produce 250.000 tons of alumina per year. The south region of Turkey produces boehmitic bauxite at various alumina/silica ratio. The reserve of Morcukur Bauxite in this region is about 6.000.000 tons of high reactive silica content.

ETI started producing bauxite from the Morcukur deposits in 2007 because of easy handling and lower cost. 60,000 tons of Morcukur bauxite have been produced from this mine but could not be used because of red mud settling problems. After XRF, XRD, Goethite/Hematite ratio, Organic content (TOC) analysis, autoclave efficiency (Parr Reactor) and settling performance tests,10 % -40 % Morcukur bauxite has been processed in 2011 with a strict laboratory and process control. Results from grinding, digestion and red mud settling performance in the process and laboratory are discussed in this paper.

Key Words: Morcukur, boehmitic bauxite, high silica, settling test, autoclave efficiency

Introduction

Boehmitic bauxite have been using in ETI Aluminium from plant established (1978). Plant and equipment capacity was determined using 7– 7.5 % silica and 7-8 alumina /silica ratio content to produce 250.000 tons of alumina per year. South of Turkey has different silica and alumina content. Bore tests indicate the following: Boehmite (AlOOH) content: 55-65 %, Kaolinite ($Al_2Si_2O_5(OH)_4$) content : 7,5- 17 %. Mixing these bauxites and preparing a target alumina/silica ratio for an operational and profitable process is very important.

Twenty six tests bore were made in 1978 of the Morcukur mine which is located 50 km from ETI Aluminium Alumina plant. Nearly six million tons of Morcukur bauxite reserve was determined by these test bore results. 2 million tons of Morcukur bauxite is suitable for using in the alumina production process. The results for two million tons of Morcukur bauxite were determined in 1978 as follows:Al_2O_3:52.91 % ,SiO_2 : 11.24 %, CaO :1.76 %.The other 4 million tons of Morcukur bauxite has high SiO_2 and high $CaCO_3$ content.Morcukur bauxite mining is easier and less expensive than other bauxites in southern region of Turkey. Nearly 150.000 tons of Morcukur bauxite was delivered to ETI Aluminium Bauxite stock-piles area between 2007-2009. When Morcukur bauxite started feeding the process, mud settling problems occurred .Then, Morcukur bauxite usage was decreased to 2 % in the process. 60.000 tons of Morcukur bauxite remaining the stock-pile area as of May 2011.

Laboratory autoclave and settling tests work was started to examine the increase in usage of Morcukur bauxite in the process. Different percentage of Morcukur and other bauxites to feed the process were combined in the laboratory and their analysis compared for settling characteristics, autoclave efficiency, total available alumina, XRD and XRF.

Once the laboratory results were known a process trial with different percent of Morcukur bauxite was started. Autoclave efficiency, autoclave caustic/alumina ratio, settler over flow solids, autoclave mud, XRF, XRD analysis results were checked during this trial.

Experimental Procedure

Sample Preparation:

Different percentage of Morcukur bauxite samples were prepared .High silica and low silica bauxites from the plant stockpile were used to prepare 10%,20%, 30%,40% Morcukur bauxite samples. The bauxite blend was crushed with a jaw crusher and grinded with a disc mill to produce particles of less than 53 μm.In this experiment the target bauxite module (Al_2O_3/SiO_2) was the same of that feeding the process. Using chemical composition of high silica, low silica and Morcukur bauxite , each sample amount was calculated for 10 %,20 % ,30 %,40% percent Morcukur bauxite. Nearly 500 g of different blends of Morcukur were prepared for 75 ml Parr Autoclave and a 1 liter autoclave.

Autoclave Reaction

1 liter laboratory autoclave (bomb digest) pulp was used for settling performance of 5 different bauxite test samples. Process test tank liquor was used and analysed. Al_2O_3 and Na_2O (caustic) content as g/L was determined with a Metrohm -809. The amount of liquor for 150 grams of bauxite was calculated and the bauxite and test tank liquor was then put in to a 1liter autoclave vessel. The reaction was allowed to proceed for 250 °C and 2 hours. After the reaction the vessel was cooled and the autoclave pulp was poured in to 500 ml cylinders.A 50 ml sample was taken and filtered for solids (XRF; chemical analysis) and liquid (Metrohm :Al_2O_3 and Na_2O) analysis .

75 ml stainless steel parr reactor vessels were used for autoclave efficiency. 6 gram of bauxite sample and 50 ml of synthetic liquor (165 g/L NaOH) was mixed in the 75 ml vessel. The reactor program was adjusted for 250°C and 2 hours reaction time .After the reaction was completed the pulp was filtered and washed. The autoclave efficiency and the total available alumina was calculated using solid (mud) after autoclave reaction (mud) and bauxite (before reaction) Fe_2O_3-Al_2O_3 analysis from XRF results.

T.A.A % = [[$(Al_2O_3)B*(Fe_2O_3)m$]-[$(Al_2O_3)m*(Fe_2O_3)B$]]/(Fe_2O_3)m

Autoclave Efficiency % = [1-[(Al_2O_3)m*((Fe_2O_3)B/ (Al_2O_3)B*((Fe_2O_3)m]]*100

B: Bauxite m : Mud

Picture 1: 1 Liter Laboratory Autoclave

Picture 2: 75 ml Multiple Parr Reactor System

Settling Test

After the 1 liter autoclave reaction the slurry pulp was transfered into a 500 ml cylinder maintained at 96 °C in a water bath. Autoclave pulp and first washer over flow were mixed to achieve 130 g/l Na_2O before settling test. 100 ml diluted pulp was taken for solid and liquid analyses.500 ml pulp was put in to 96 °C water bath and 0,1 % Nalco 9779 (prepared with 10 g/l NaOH) flocculant was used for mud settling. Flocculant was also added and its dosage targeted to nearly 150 g/ton mud. The settling time was observed and the settling rate was calculated.After the mud level reached the 350 ml mark (about 20 minutes) a sample was taken from the clear zone for turbidity and suspended solid analysis.

Results and Discussion

Table 1 shows different silica and alumina content in the bauxite. The target silica content was 7.4 % (feeding bauxite to the mills)

Sample Name	Al2O3	SiO2	Fe2O3	TiO2	CaO	CO2	Module (Al2O3 /SiO2)
Feeding Bauxite	57,52	7,4	16,9	2,59	0,98	0,77	7,77
Low-Silica Bauxite	58,88	4,8	18,0	2,68	0,44	0,34	12,27
High-Silica Bauxite	55,09	11,3	17,1	2,43	0,56	0,44	4,87
Morcukur Bauxite	56,24	9,8	17,7	2,53	0,32	0,25	5,74

Table 1: Chemical Composition (XRF) of bauxite sample for test sample preparation

Three different sources of bauxite with different silica content were mixed using table 1. Analysis for different percentages of Morcukur bauxite is shown in table 2. Feeding bauxite in to the mill include 2 % morcukur bauxite. Nearly same silica and, alumina content bauxite were prepared for autoclave and settling tests. Morcukur bauxite has a high silica content and low total organic carbon.

Test Sample Name	Feeding Bauxite	Low Silica	High Silica	Morçukur
Feeding Bauxite (%2 morcukur)	100	-	-	-
10 % Morcukur	-	60	30	10
20 %Morcukur	-	55	25	20
30 %Morcukur	-	52	18	30
40 %Morcukur	-	50	10	40

Table 2: Test Sample bauxite % composition

Test Sample Name	Al2O3	SiO2	Fe2O3	TiO2	CaO	CO2	Module (Al2O3	Total Organic Carbon ppm
Feeding Bauxite	57,5	7,4	16,8	2,5	0,98	0,7	7,77	610
10 % Morcukur	57,7	7,3	17,7	2,6	0,47	0,3	7,84	470
20 %Morcukur	57,5	7,2	17,7	2,5	0,44	0,3	7,92	450
30 %Morcukur	57,5	7,3	17,7	2,5	0,42	0,3	7,85	410
40 %Morcukur	57,5	7,3	17,8	2,5	0,40	0,3	7,84	380

Table 3: XRF chemical composition %-Total Organic Carbon

Test Sample Name	Boehmite	Diaspore	Gibbsite	Kaolinite	Tridymite	Quartz	Hematite	Goethite	Rutile	Anatase	Calcite	Goethite /Hematite
Feeding Bauxite	60,5	1,69	0,91	10,2	2,0	0,6	16,7	0,1	0,3	2,2	1,7	0,01
10 %	62,3	0,63	0,14	10,3	2,0	0,5	17,0	0,8	0,6	1,9	0,8	0,05
20 %	61,5	0,69	0,69	10,6	1,4	0,8	16,4	1,3	0,6	1,9	0,8	0,08
30 %	62,1	0,62	0,1	10,7	1,9	0,5	15,3	2,7	0,4	2,1	0,8	0,18
40 %	62,7	0,42	0,21	9,5	2,7	0,1	16,0	2,1	0,6	2,0	0,7	0,13

Table 4: Mineralogical Analysis XRD Results %

Test sample's XRD results are shown in the table 3 for autoclave and settling test.

A D 5000 Siemens XRD was used with Bruker AXS-Diffract ^{plus} Basic software .Semi quantitative XRD analysis was made using XRF chemical composition. Nearly same mineralogical composition was detected in the test sample. Goethite (FeO(OH)) and Tridymite (SiO_2) content increased with increasing Morcukur bauxite percentage. Increasing Goethite content with increasing Morcukur amount can have a negative effect in settling rate.

Sample Name	Al203 %	Sl02 %	Fe203 %	Na20 %	CaO %	Ton Mudule Ton bauxite	T.A.A %	Autoclave Efficiency %
Feeding Bauxite	16,47	17,93	39,77	10,9	2,06	0,424	50,54	87,87
10%	16,83	18,22	41,57	11,32	0,46	0,428	50,51	87,52
20 %	16,59	17,9	41,99	11,38	0,42	0,422	50,50	87,82
30 %	16,51	17,42	42,35	11,41	0,37	0,420	50,65	87,96
40 %	16,75	17,26	42,56	11,34	0,30	0,419	50,56	87,81

Table 5: Parr Reactor reaction solid phase (mud) chemical analysis, total available alumina and autoclave efficiency results:

Mud analysis after autoclave reactions was made using XRF. The results are shown in table 5.Silica and calcium content decreased with increasing Morcukur bauxite amount .Alumina and sodium content was nearly the same. Iron content increased with increasing Morcukur bauxite amount. The mud amount per bauxite for 40% Murcukur was lower than for 10% Murcukur. Total available alumina and autoclave efficiency results were nearly the same. Increasing Morcukur bauxite does not have an impact on autoclave efficiency. These results are very important for processing bauxite by the Bayer process.

	First washer over flow			Liquid from settling test pulp			
Sample Name	Al203 (g/L)	Na20c(g/L)	Modulec(Na20c / Al203)*1,645	Al203 (g/L)	Na20c(g/L)	Modulec(Na20c / Al203)*1,645	Solid Mud (g/L)
Feeding Bauxite to Mill	44	42,5	1,59	151,1	127,4	1,39	67,8
10% Morcukur	37,9	41,2	1,79	138,6	123,3	1,46	**51,58**
20 % Morcukur	45,3	44,9	1,63	145,9	128,1	1,44	64,40
30 % Morcukur	47,4	49,4	1,71	150,9	131,1	1,43	61,06
40 % Morcukur	37,7	41,1	1,81	142,5	124,4	1,44	61,4

Table 6: First washer over flow for dilution and diluted pulp liquid phase analysis

First washer over flow was used for dilution of autoclave reaction pulp as in the process. There was some difference in caustic concentration for the test sample. 10 % and 40 % Morcukur had low caustic concentration .Also 10 % Morcukur had low solids in the pulp. These results gave high settling rate and low suspended solids for 10 % Morcukur bauxite. Settling rate and suspended solids are shown in table 7.

Sample Name	Settling Rate (m/hr)	Suspended Solids (mg/L)	Turbidity (NTU)
Feeding Bauxite	30,3	195	333
10% Morcukur	48,5	57	180
20 % Morcukur	26,3	110	246
30 %Morcukur	25,9	82	296
40 % Morcukur	41,1	61	200

Table 7: Settling Performance Test Results

There were no significant change between 2 % morcukur (feeding bauxite) and 20-30 % morcukur usage.

Process Trial Results

Morcukur trial was started April 2011 with 10 % and increased 40 % in june 2011 after laboratory test results.

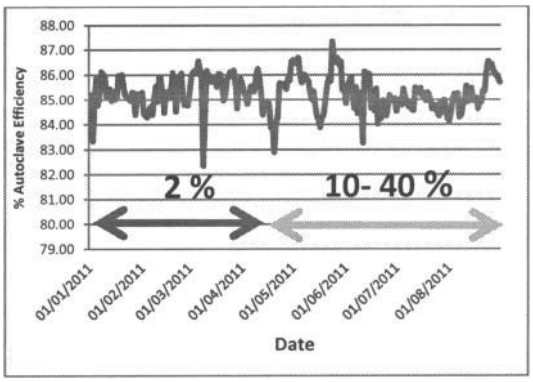
Morcukur% Usage	Date of the Morcukur usage period
% 2	≤ 14.04.2011
% 10	15.04.2011-04.05.2011
% 20	05.05.2011-20.05.2011
% 30	21.05.2011-20.06.2011
% 40	21.06.2011-22.08.2011

Table 8. Date Of the Morcukur usage in process

Morçukur %	Autoclave Efficiency, %	Red Mud ton/day	Settler Over flow solids mg/L	Settler Under Flow Solids g/L	Settler Clear Zone Level, m
2	85,40	678	95	384	3,40
10	85,30	684	107	381	3,25
20	85,10	673	90	385	3,65
30	85,53	668	86	379	3,60
40	85,30	675	98	379	3,45

Table 9: Process Parameter using Morcukur bauxite

Red mud ton /day and settler performance values were nearly same while increasing Morcukur Bauxite %.Settler over flow solids were below 100 mg/L and there was no clear zone problem at this period.Settler under flow solids were %25-26 percent.



Graph 1: Autoclave Efficiency and Morcukur %

Process Autoclave efficiency % with 10-40 % morcukur results are shown in graph 1.There was no significant change for autoclave efficiency between 2 % and 40 % morcukur bauxite.

Conclusions

- These tests indicate that there are no significant process performance differences between High Silica Bauxites and Morcukur.
- Morcukur can be use as high silica bauxite to prepare 7-7.5 % silica content bauxite blends.
- ETI Aluminum started using 10% Morcukur bauxite in the process there was no performance difference between 2 % and 10 % Morcukur blend.
- Morcukur quantity was increased slowly while checking autoclave efficiency and settler over flow solids.
- For a period of five months 40 % Morcukur bauxite was used in the process with no settling problems.

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