Lime Use Alternatives and Impacts on Processing Boehmitic Bauxites

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Abstract

ETI Aluminyum A.S has its own bauxite mines, and has been extracting from two mines out of five to feed its alumina refinery since the 1970's. The refinery was designed to process boehmitic bauxite with a reasonable A/S (Al_2O_3/SiO_2, w/w) ratio of 8.2. Over the years, bauxite quality has decreased and current reserves show an average A/S ratio of 7.0. On the other hand, the characterization studies for the other three mines, which ETI will exploit in a few years, indicate that diaspore and goethite content of these bauxite are significantly higher than current ones. In these circumstances, ETI needs to prepare for bauxite quality changes which can adversely affect operating cost and product quality. The first and most interesting option for examination is lime utilisation, and ETI has focused on studying lime addition in laboratory and plant trials. In the study discussed in this paper, the impacts of lime addition on boehmite/diaspore solubility, goethite conversion, titanium behavior, caustic soda consumption, as well as red mud settling properties and product quality, have been investigated. It has been observed that both the lime dosing point and quantity play an important role on desired process result.

Keywords: Boehmitic Bauxite; Soda Consumption; Lime Addition; Digestion.

1. Introduction

Due to its economics, the Bayer process is still the preferred and most used process globally for producing alumina. Bauxite is the main feedstock of Bayer process. Progressive bauxite quality deterioration is one of the main challenges to the alumina industry. Bauxite mineralogy affects process efficiency through the chemical reactions in the process. Alumina to silica mass ratio (A/S), along with total available alumina and reactive silica contents are the amongst the most economically important parameters describing bauxite quality.

Operating cost was discussed for varying A/S ratios on diasporic bauxite by Z. Baiyong and L. Xinqin [1] and it was found that 8.0 was an inflection point for economic Bayer process application. An A/S ratio lower than 7.0 was considered to be low grade bauxite. L. Zhijian et al. [2], recommends lime addition to the Bayer process when processing low grade bauxite which has an A/S higher than 5.0 and the Sinter process for A/S ratios lower than 5.0.

Lime is widely used in the Bayer process for different purposes and in different forms. Digestion, side stream causticisation and filter aid are the main applications stated by L.A.D. Chin [3]. Digestion lime charge by adding burnt lime (or milk of lime) to the bauxite, bauxite slurry or feeding it directly to one of the digesters are also common uses. The proper selection of the feeding point(s) for digestion lime charge has very high importance [4]. Lime is effective in not only increasing alumina extraction efficiency, but also increasing liquor productivity in the high temperature digestion of diasporic bauxites [5]. Furthermore, significant improvement in caustic soda consumption can be achieved by applying optimum CaO doses (3-4 %) [6] for monohydrate bauxites.

The reactive silica minerals in bauxite react with caustic soda in liquor to form desilication products (DSP) resulting in undesired caustic soda losses. Addition of lime during pre-desilication or digestion can minimise soda losses by forming a new DSP phase with soda content lower than that of sodalite (sodium silicon aluminium hydrate). The soda-free hydrogarnet (HG) or low-soda calcium-cancrinite (Ca-CAN) can both have Na_2O/SiO_2 ratios lower than sodalite DSP and their formation as DSP is beneficial in minimising soda losses [7].

Goethite present in the bauxite adversely affects the settling properties of red mud due to finer particle size and larger specific surface area. Finer red mud can cause considerable caustic soda losses due to insufficient washing efficiency [8]. The addition of lime or calcium-containing additives, such as CaO, $Ca(OH)_2$ and $CaCO_3$, can improve the hydrothermal transformation of goethite to hematite in the Bayer digestion which reduces settling and washing problems [9].

The anatase in bauxite can impede the transformation of goethite to hematite in the Bayer process [9]. In addition, the titanium minerals react with caustic in liquor to form sodium titanates which cause soda losses. Sodium titanate also forms a gelatinous coating on boehmite particles which inhibits further boehmite extraction [10]. With lime fed to high temperature digestion, part of the available CaO reacts with TiO_2 generating perovskite ($CaTiO_3$), which considerably improves the recovery of alumina as well as the performance of goethite to hematite conversion [8].

Lime is an economical raw material generally used in the Bayer process for controlling impurities such as carbonate, phosphorus, fluoride and sodium organics [11].

Bauxite exploration studies were started early 1960’s in Turkey by MTA. As indicated in Table 1, 95 % of Turkish bauxite was formed around Taurus Mountain.

Table 1. Turkey bauxite reserves [12].

Region	Reserves (x1000 tones)			Bauxite Type
	Proved	Potential	Total	
Seydişehir - Akseki	35,251	1,253	36,504	boehmite
Zonguldak - Kokaksu	5,900	3,400	9,300	boehmite
Yalvaç - Şarkikaraağaç	-	115,600	115,600	iron rich diaspore
Payas - Islahiye	-	215,500	215,500	iron rich diaspore
Tufanbeyli - Saimbeyli	5,500	6,000	11,500	diaspore
Muğla - Milas - Yatağan	9,400	11,200	20,600	diaspore
Bolkardağı	-	3,900	3,900	diaspore
Alanya	1,300	7,700	9,000	diaspore
TOTAL	**57,351**	**364,553**	**421,904**	

ETI Aluminium A.S. (ETI), the only alumina and aluminum producer in Turkey, owns the Seydisehir-Akseki region bauxite deposits and has been processing these ores since 1973. Although the initial A/S ratio for the alumina refinery design was around 8.20, it has decreased to 7.05 over the years. In the meantime, ETI has faced diaspore and goethite rich bauxite during the processing of new mines such as Arvana and Kaklıktas. Table 2 shows the current mines and their bauxite qualities.

Assuming the unit prices of lime, caustic and bauxite as 55, 400, 15 US dollars respectively, lime feed to bauxite looks more economic than the other feed points. While 6 % lime charge is sufficient to move into profit with lime feed to bauxite, 10 % and 14 % is necessary for mill and digestion feed respectively. Lime feed to desilication tank has the poorest economics.

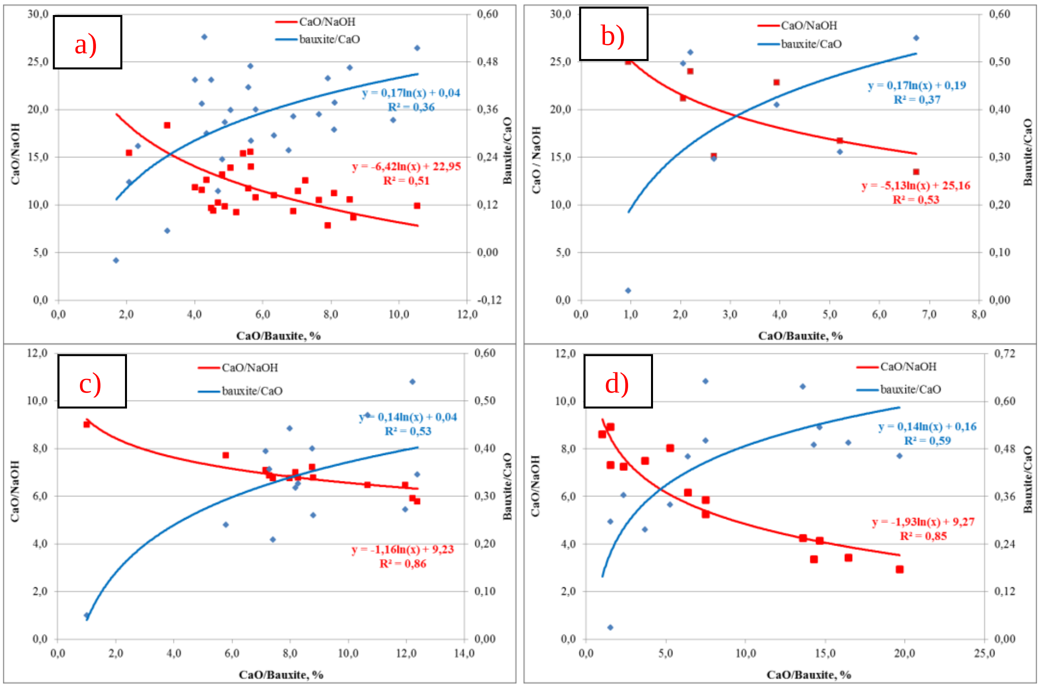

Figure 10. Lime efficiency when feeding to, a) Digestion, b) Dessilication tank, c) Mill, d) Bauxite

3. Conclusion

Lime is much more efficient when fed to boehmitic bauxite as burnt lime in terms of caustic savings. Due to high silica in bauxite, higher lime doses are needed. Diaspore dissolution during both plant trials and laboratory studies is enhanced, especially above 5 % lime charges. Katoite and SAS compounds were the main DSP products that increased substantially with lime feed. Tridymite and anatase contents of red mud were little changed in the presence of lime, while they interestingly decreased when lime was fed to the desilication tank. An explanation may be that lime fed to desilication promotes their dissolution and results in extra caustic losses. Lime has a big impact on goethite to hematite conversion. The lowest goethite content and highest H/G ratio were obtained with digestion lime feed. The lowest sodium titanate and the highest calcium titanate formation were achieved when lime was fed to digestion.

Lime feed to digestion looks the most efficient point according to clarification parameters. A significant decrease in both iron and titanium in alumina product was obtained wherever lime was dosed.

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