Effect of CaO on Leaching Kinetics of Boehmite from Middle Timan Deposit Bauxites

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Abstract

The addition of lime has a positive effect on many aspects of alumina production, but its effect on the kinetics of the leaching process is not fully understood. This paper describes the investigation of the influence of lime on the kinetics of leaching of boehmite from Middle Timan bauxite deposits. It was found that the extraction of 80 % alumina in the presence of lime is achieved only after 1.5 – 2 hours of leaching, whereas in the absence of lime the same degree of extraction is achieved after 1 hour of leaching. The addition of lime in the leaching of currently processed bauxite of Middle Timan deposit leads not only to a decrease in the rate of the process but also to an almost twofold increase in the apparent activation energy. This indicates that the rate-limiting step is the chemical reaction. The cause of the limitations, apparently, is the formation of hydrogarnet, the presence of which in the red mud is confirmed by x-ray diffraction analysis.

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Keywords: bauxite, alumina, leaching, lime, kinetics.

1. Introduction

More than 90 % of alumina is produced from bauxite by the Bayer method [1], which consists of leaching alumina-containing minerals with an alkaline recycling solution. The solution, enriched with aluminum, is then sent to the deposition of aluminum hydroxide, which is calcined to produce alumina. The decomposed solution is recycled on the leaching of new portions of the bauxite. The solid residue from leaching (red mud), is sent to the sludge fields for storage [2]. The yield of the red mud is more than 50 % of the weight of the original bauxite

The output of red mud is strongly dependent on the quality of the used bauxite and the processing technology itself. Most harmful impurity in the bauxite is silica, which inevitably goes into solution and then precipitates in the form of desilication product. The number of generated red mud is also dependent on the method of desilication (the type of desilication product) [3]. In addition, the output of red mud depends on additional chemicals that are added with the purpose of intensification of extraction of alumina in solution.

For example, when using bauxite containing titanium in the form of anatase, it was shown that the addition of lime can significantly intensify the process of extraction of alumina by eliminating the formation of a film of sodium titanate on the surface of alumina-containing minerals [4]. In the presence of the titanium ii bauxite in the form of rutile, the necessity of Ca addition disappears, but the lime continues to be added to reduce the loss of alkali from red mud in the form of cancrinite. Because of the presence of lime, the silicon is bound in hydrogarnet, which is confirmed by x-ray diffraction analysis [5].

In addition, as shown in the recent work of Arikan et al. [6], the addition of lime contributes to a faster thickening of red mud, as well as obtaining better quality alumina by reducing the content of impurities in the aluminate solution. However, in their paper, the influence of lime on the degree of extraction of alumina was shown only in terms of the final extraction of alumina into the solution after 2 hours of leaching. And, as far as we know from the open literature, at the moment a little amount of works has been carried out to study the effect of lime on the kinetics of the leaching process of boehmitic bauxites.

Based on the above, this paper attempt to study the effect of lime on leaching kinetics of boehmitic Middle Timan bauxites at different temperatures of the process and to explain observed phenomena.

2. Experimental

The bauxite of the Middle Timan used in our experiments had the following chemical composition, mass. %: Al_2O_3 – 50,27; SiO_2 – 8,31; Fe_2O_3 – 24,60; S – 0,05; CO_2 – 0,30; CaO – 0,42; TiO_2 -2,90; H_2O. – 15,50; M_s = 6,06. Chemical analysis of raw materials and obtained red mud was carried out using the XRF-2000 spectrometer. Theoretical extraction of alumina from bauxite of this composition is 85% [7]. This parameter takes into account the losses of alumina with a complete transfer of the silica out of solution in insoluble desilication product. According to the X-ray difraction (XRD) in figure 1, the phase composition of Middle Timan bauxite is mainly represented by boehmite, hematite, rutile, kaolinite and chamosite.

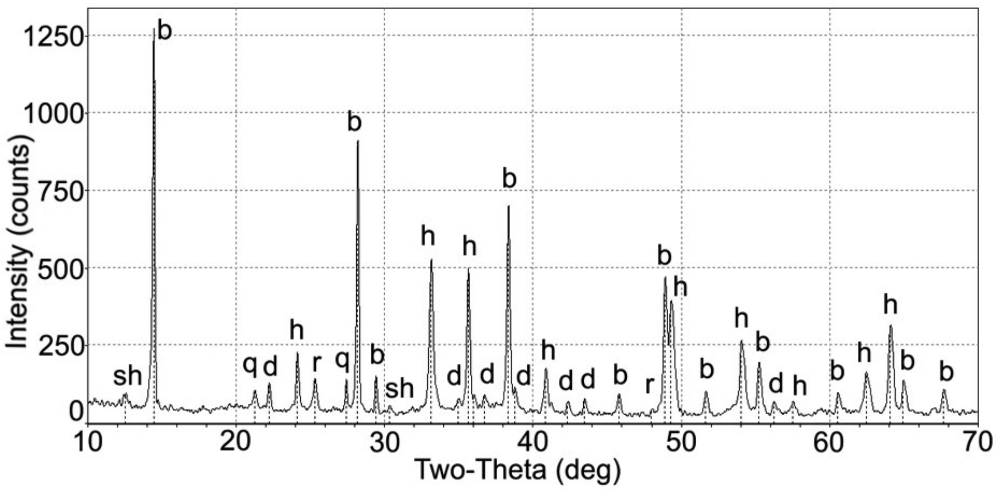

Figure 1. XRD pattern of the phase composition of Middle Timan bauxite: b – boehmite; h – hematite; d – diaspore; q – quartz; r – rutile; sh – chamosite.

For the experiment, bauxite was previously ground to a size of 75 µm more than 90%. As a reagent, a factory circulating solution of the branch of JSC RUSAL Ural in Kamensk-Uralsky with the Na_2O_k concentration 260 g\L and α_k module 3.55 units was used. The dosage of the solution during leaching of the bauxite sample was carried out to obtain a final α_k module equal to 1.64 units. Experiments with lime were carried out by adding the CaO of the chemical purity in an amount of 3 % of the mass of the initial bauxite.

Leaching of bauxite was carried out in an autoclave of Parr company with a volume of 1000 ml. The pulp after leaching was diluted to Na_2O_k concentration 130 g\L with distilled hot water and then filtered with subsequent repeated washing of the resulting red mud, which, after drying at 80 °C to a constant mass, was subjected to various physical and chemical methods of analysis.

The XRD in figure 5 shows that the addition of 3 % lime by weight of the starting bauxite decreases the amount of cancrinite (desilication product), and significantly increased the number of katoite (hydrogarnet), which reduces losses of caustic alkali, however, increases the loss of alumina. Also at the initial moment, the formation of tricalcium aluminate is possible, and the addition of lime, among other things, can affect changes in the structure of the aluminate solution, which is confirmed by almost complete inhibition of the decomposition process with a large amount of lime in the pulp.

4. Conclusions

As a result of the experiments and the study of the kinetic features of the leaching of bauxite of Meddle Timan deposit in the presence and without lime additives, it was found that even a small addition of CaO (3 %) leads to a change in the mechanism of dissolution of boehmite with caustic alkali. Extraction of 80 % alumina in the presence of lime is achieved only after 1.5 – 2 hours of leaching, whereas in the absence of lime the same extraction is achieved after 1 hour of leaching. According to the calculations of the apparent activation energy, both processes apparently proceed in the diffusion regime, since the apparent activation energy was 30 and 15.7 kJ/mol for the dissolution of boehmite with caustic alkali in the presence and without lime, respectively. However, the value of the apparent activation energy in the presence of lime was almost two times higher, which indicates the appearance of difficulties in the chemical reaction itself, which causes a slowdown in the leaching process. The mechanism of slowing, apparently, associated with the formation of hydrogarnets in the initial time of the process.

5. References

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