Specifics of Alkali Recovery from Bauxite Residue of Different Alumina Refineries

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Abstract

To promote re-use of bulk amount of bauxite residue (BR) as an additive in Portland cement production the following two issues shall be solved: reducing total alkali content (Na_2O+K_2O) below 0.5 % and reducing moisture content below 25 %. Na_2O in BR of different refineries varies from 3.5 % to 8 %. BR contains alkali in three forms: up to 80 % of alkali is chemically bound in desilication product (DSP) - $Na_7[AlSiO_4]_6(OH,SO_4,CO_2)\times nH_2O$; up to 30 % of alkali can be sorbed on the surface of BR fine particles; up to 30 % of alkali is dissolved in the liquid phase. Upon completion of the laboratory tests, parameters to recover the alkali as NaOH and return it to the Bayer process have been established for three European refineries. Based on the experimental results, the design data for the construction of a mobile pilot plant have been developed.

Keywords: waste valorization, DSP, alkali removal.

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Figure 8. Logo of Horizon 2020.

2. Introduction

In the production of one tonne of alumina using the Bayer process, 0.65 to 2.5 tonnes of bauxite residue (depending on bauxite quality and process used) are deposited in the bauxite residue disposal area (BRDA). BR contains both useful, for other industries, components (SiO_2: 7 – 12%; Fe_2O_3: 40 - 52 %; TiO_2: 2 – 7 %; CaO: 4 – 9 %), and other components (Na_2O: 2.5 - 7%; K_2O: 0.1 – 1 %). Additionally, the liquid phase of bauxite residue contains alkaline aluminate liquor at pH $\geq$ 12.

To re-use bauxite residue (BR) in considerable amount as construction material (bedding of roads, filler in production of paving slabs), complex additive for production of Portland cement, it

is necessary to solve two technical problems: to reduce Na_2O content to ≤ 0.5 % and humidity to ≤ 25 %.

In the slurry of bauxite residue sodium compounds are presented in three forms:

- bound in the structure of hydroaluminosilicate (up to 80%);
- sorbed on the surface of BR fine particles (up to 30%);
- component of sodium aluminate in a liquid phase (up to 30%).

To provide maximum extraction of sodium from BR slurry with minimum "disturbance" of alumina production process from bauxites and to reduce the impact on ecology, the option of processing the slurry with lime (milk of lime) was studied. Sodium aluminosilicate contained in bauxite residue is decomposed with formation of alkaline-earth compounds, such as $3CaO{\times}Al_2O_3{\times}nH_2O$ and $2\ CaO{\times}SiO_2{\times}mH_2O$ [1, 2].

Alkali from DSP as caustic alkali passes into solution by reaction:

$$Na_2O{\times}Al_2O_3{\times}2SiO_2{\times}xH_2O + 7Ca(OH)_2 \rightarrow 3CaO{\times}Al_2O_3{\times}nH_2O + \\ + 2(2CaO{\times}SiO_2\ mH_2O) + 2NaOH \quad (1)$$

If sodium aluminate is not available in the liquor in significant amount, an additional reaction occurs, and alumina contained in bauxite residue is precipitated:

$$2NaAlO_2aq + 3Ca(OH)_2 \rightarrow 3CaO{\times}Al_2O_3{\times}nH_2O + 2NaOH \quad (2)$$

With addition of carbonate alkali such as sodium carbonate or potassium carbonate to the residue from these reactions, decomposition of alkaline-earth aluminates occurs by reaction:

$$3CaO{\times}Al_2O_3{\times}nH_2O + 3Na_2CO_3 \rightarrow 3CaCO_3 + 2NaAlO_2 + 4NaOH + XH_2O \quad (3)$$

By combination of these two processes it is possible to extract alkali from bauxite residue into solution.

This method was tested on BR samples from European alumina refineries:

- Aughinish Alumina Ltd, Ireland (AAL);
- Aluminum of Greece, Greece (AOG);
- Alum Tulcea, Romania (Tulcea)

3. Experimental

To perform the laboratory work, a unit was mounted and prepared for tests enabling to resist required temperature condition over extended period at continuous mixing of slurry, to feed and select samples directly in the course of the experiment.

The laboratory unit (Figure 1) comprises:

- reactor equipped with an external source of heating (thermostating);
- mixing device;
- submerged sampler (a tube for sampling).

7. References

1 Alexander Suss and Anatoly Lapin, Development and assessment of technology of Bayer bauxite processing with alkali recovery from red mud, VAMI report № 026-05-НГ, Saint Petersburg, 2005

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