RUSAL Alumochloride Technology – Efficient and Waste-Free Alumina Production from Non-Bauxite Resource

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Abstract

To reduce the costs for transportation of bauxites to alumina refineries and transportation of alumina to aluminium smelters RUSAL is currently developing an alternative technology for alumina production using abundant non-bauxite raw material from West Siberia. Upon successful completion of the laboratory experiments, the tests at the specialized demonstration mini-plant have been conducted. Consumption parameters and rates were determined for the following stages: acid digestion of kaolin, filtration and washing of silica residue, crystallization of aluminium chloride hexahydrate followed by calcination, rectification of hydrochloric acid. Respective chemical and physical processes were studied and the data required for technology industrial implementation were obtained. Research works are in progress to process the silica residue into valuable products thus bringing the technology closer to waste-free process.

Keywords: Non-bauxite ores, alumina, hydrochloric acid method, waste free production.

1. Introduction

At a new stage of development of aluminium industry, interest is growing in perspective sources of raw materials such as non-bauxite high-silica ores (e.g. kaolin clays) and coal fly ash. In fly ash processing the environmental problems are solved connected with their disposal. It is not expedient to process kaolin and ash from thermal power plants by conventional alkaline technologies due to high content of silica. However, they become rather attractive raw materials when acid processes are used [1] among which recently mostly developed are processes based on hydrochloric digestion of raw materials. In spite of higher capital expenditures as compared to widely known Bayer process, this method has noticeable advantages against other acid processes due to low silica solubility in hydrochloric acid; possibility of selective crystallization of aluminium hexahydrate (ACH) $AlCl_3 \cdot 6H_2O$ with removal of most of the detrimental impurities; and also simplicity of hydrochloric acid regeneration for the use in a closed cycle [2].

2. Modern Developments within Hydrochloric Method of Alumina Production

Previously a number of foreign companies repeatedly turned to hydrochloric processes of aluminium-bearing raw material processing. It is possible to distinguish investigations executed in1970 – 80 by Pechiney, Alcan, US Bureau of Mines (USBM), VEB Mansfeld Kombinat (GDR) as well as by Commonwealth Scientific and Industrial Research Organization, (CSIRO) Australia [3], that formed a basis for subsequent development of the process and equipment.

In 2004 Junggar Energy Resource Co., Ltd. opened a new period of activity in improvement of hydrochloric method in fly ash processing [4]. The process comprises preliminary beneficiation by magnetic separation to decrease iron content in raw material to < 1 %, hydrochloric leaching, sorption of impurities from aluminium chloride solution by ion-exchange resins, extraction of ACH residue and its calcination with subsequent recycling hydrochloric acid and hydrogen chloride from gas phase to the process [5]. On August 19, 2011 a 4,000 t/a pilot plant for alumina extraction by hydrochloric process from coal fly ash was successfully commissioned. The longest period of operation of the pilot plant was 5 months, which allowed to reach design capacity and, according to the company, gave an opportunity to select corrosion-resistant materials and to confirm the technology. A batch of 80 tons of produced alumina was tested at the cells of Yunnan Aluminium Co., Ltd. with satisfactory results on quality of metal. On the basis of the novel technology the company plans to construct an industrial complex including production of coal, electric power, alumina, primary aluminium and gallium, aluminium products, etc. The 1st stage of the complex will be commissioned before 2020 [6].

In 2007 Orbite Technologies Inc. (Canada) for the purpose of integrated processing kaolin argillite of Quebec yielding smelter grade alumina, reactive silica, pure iron oxide, rare and rare-earth elements (REs and REEs) , including scandium oxide and gallium developed a proprietary technology of acid processing. The process comprises a stage of hydrochloric leaching of raw material, separation of insoluble siliceous residue, selective extraction of aluminium chloride hexahydrate (ACH) by saturation solution with gaseous HCl, its cleaning and calcination to Al_2O_3. From the filtrate containing other soluble in hydrochloric acid metals, iron is extracted as hematite by means of low-temperature steam hydrolysis (PORI process), RE and REE are recovered by extraction methods, and the other non-hydrolysable impurities are removed at a pyrohydrolysis stage, at that HCl and water vapors obtained at different stages of the process are condensed and recycled to the production cycle [7]. Having originally set as the purpose construction of the 560 000 tpy "acidic" alumina refinery for SGA production, Orbite further focused on a small enterprise, 1000 – 5000 tpy, for production of high purity alumina (HPA, at least 99.999%). The product is meant for the production of leucosapphire monocrystals used for substrates of light-emitting diodes and special military optics. However, in developing the process, the company met serious technical difficulties in calcination of high-pure alumina. After modernization of ACH calcination unit, according to the press release of the company [8], is planned to begin a new stage of industrial tests.

Australian company Altech Chemical also developed the acidic technology of processing high purity Al_2O_3. As initial raw material, Altech Chemical considered kaolin clays of high purity from Meckering deposits in Western Australia, which after ore pretreatment are sent to hydrochloric leaching. Residue is neutralized and sold to local consumers such as brickworks and/or cement plants, and alumochloride solution is directed to crystallization, the obtained aluminium chloride hexahydrate is recrystallized for cleaning from impurities and calcinated at 1200 ℃ [9]. In September, 2015 Altech signed an exclusive distribution agreement in the Japanese market with Mitsubishi Corp, and in November of 2016 a 20 years lease agreement for the proposed construction site of HPA plant in Johor, Malaysia (Tanjung Langsat Industrial Complex, Johor, Malaysia). The planned enterprise capacity - 4,500 tpy 4N - high pure alumina (HPA). Altech Chemical is going to start the plant during 2020 – 21 [10].

Norwegian company Nordic Mining ASA and Institute for Energy Technology also took the tack of hydrochloric technology developing jointly a process of alumina production from the anorthosite ores with integrated use of carbon dioxide comprising crushing and leaching of aluminous materials in concentrated HCl; separation of unreacted material from chloride solution; ACH crystallization and calcinating in 2 – 3 stages to alumina with regeneration of the emitted hydrogen chloride. The technology comprises an ecological component, since mother

7. References

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