BX02 - Dry Beneficiation of Bauxite Minerals Using a Tribo-Electrostatic Belt Separator

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Abstract

The ST Equipment & Technology LLC (STET) tribo-electrostatic belt separator is ideally suited for beneficiating very fine (<1 µm) to moderately coarse (500 µm) mineral particles, with very high throughput. Experimental findings demonstrated the capability of the STET separator to beneficiate bauxite samples by increasing available alumina while simultaneously reducing reactive and total silica. The STET technology is presented as a method to upgrade and pre-concentrate bauxite deposits for use in alumina production. Water-free processing with the STET separator will result in a reduction in operating costs of refinery due to lower consumption of caustic soda, savings in energy due to lower volume of inert oxides and a reduction in volume of alumina refinery residues (ARR or red mud). In addition, the STET technology may offer bauxite producers or alumina refiners other benefits including increased quarry reserves, extension of red mud disposal site life, and extended operating life of existing bauxite mines by improving quarry utilization and maximizing recovery. The water-free and chemical-free by-product produced by the STET process is usable for manufacture of cement clinker in high volumes without pre-treatment, in contrast to red mud which has limited beneficial reuse.

Keywords: Electrostatic, beneficiation, separation, bauxite, reactive silica

1. Introduction

Aluminum production is of central importance for the mining and metallurgy industry and fundamental for a variety of industries [1–2]. While aluminum is the most common metallic element found on earth, in total about 8 % of the Earth's crust, as an element it is reactive and therefore does not occur naturally [3]. Hence, aluminum-rich ore needs to be refined to produce alumina and aluminum, resulting in significant generation of residues [4]. As the quality of bauxite deposits globally decline, the generation of residue increases, posing challenges to the alumina and aluminum-making industry in terms of processing costs, costs of disposal and the impact on the environment [3].

The primary starting material for aluminum refining is bauxite, the world's main commercial source of aluminum [5]. Bauxite is an enriched aluminum hydroxide sedimentary rock, produced from the laterization and weathering of rocks rich in iron oxides, aluminum oxides, or both commonly containing quartz and clays like kaolin [3,6]. Bauxite rocks consists mostly of the aluminum minerals gibbsite ($Al(OH)_3$), boehmite (γ-AlO(OH)) and diaspore (α-AlO(OH)) and is usually mixed with the two iron oxides goethite (FeO(OH)) and hematite (Fe_2O_3), the aluminum clay mineral kaolinite ($Al_2Si_2O_5(OH)_4$), small amounts of anatase and/or titania (TiO_2), ilmenite ($FeTiO_3$) and other impurities in minor or trace amounts [3,6,7].

The terms trihydrate and monohydrate are commonly used by industry to differentiate various types of bauxite. Bauxite that is totally or nearly all gibbsite bearing is called a trihydrate ore; if boehmite or diaspore are the dominant minerals it is referred to as monohydrate ore [3]. Mixtures of gibbsite and boehmite are common in all types of bauxites, boehmite and diaspore less common, and gibbsite and diaspore rare. Each type of bauxite ore presents its own challenges in terms of mineral processing and beneficiation for the generation of alumina [7,8]. Normally, the beneficiation or treatment of bauxite is limited to crushing, sieving, washing, and drying of the crude ore [3]. Flotation has been employed for the upgrading of certain low-grade bauxite ores, however, it has not proven highly selective at rejecting kaolinite, a major source of reactive silica especially in trihydrate bauxites [9].

High-grade bauxite contains up to 61 % Al_2O_3, and many operating bauxite deposits - typically referred as non-metallurgical grade- are well below this, occasionally as low as 30–50 % Al_2O_3. Because the desired product is a high purity Al_2O_3, the remaining oxides in the bauxite (Fe_2O_3, SiO_2 and TiO_2) and organic material are separated from the Al_2O_3 and rejected as alumina refinery residues (ARR) or red mud via the Bayer process. In general, the lower quality the bauxite (i.e., lower Al_2O_3 content) the more red mud that is generated per tonne of alumina product. In addition, even some Al_2O_3 bearing minerals, notably kaolinite, produce undesirable side reactions during the refining process and lead to an increase in red mud generation, as well as a loss of expensive caustic soda chemical, a large variable cost in the bauxite refining process [3,6,8].

Red mud or ARR represents a large and on-going challenge for the aluminum industry [4,10–11]. Red mud contains significant residual caustic chemical leftover from the refining process, and is highly alkaline, often with a pH of 10–13 [12]. It is generated in large volumes worldwide – according to the USGS, estimated global alumina production was 121 Mt in 2016 [13]. This resulted in an estimated 150 Mt of red mud generated during the same period [4]. Despite ongoing research, red mud currently has few commercially viable paths to beneficial re-use. It is estimated that very little of red mud is beneficially re-used worldwide [4,11,14]. Instead, the red mud is pumped from the alumina refinery into storage impoundments or landfills, where it is stored and monitored at large cost [3]. Therefore, both an economic and environmental argument can be made for improving the quality of bauxite prior to refining, in particular if such improvement can be done through low-energy physical separation techniques.

While proven reserves of bauxite are expected to last for many years, the quality of the reserves that can be economically accessed is declining [1,3]. For refiners, who are in the business of processing bauxite to make alumina, and eventually aluminum metal, this is a challenge with both financial and environmental implications.

Dry methods such as electrostatic separation may be of interest of the bauxite industry for the pre-concentration of bauxite prior to the Bayer process. Electrostatic separation methods that utilize contact, or tribo-electric, charging is particularity interesting because of their potential to separate a wide variety of mixtures containing electrically conductive, electrically insulating, and semi-conductive particles. Tribo-electric charging occurs when discrete, dissimilar particles collide with one another, or with a third surface, resulting in a surface charge difference between the two particle types. The sign and magnitude of the charge difference depends partly on the difference in electron affinity (or work function) between the particle types. Separation can then be achieved using an externally applied electric field.

The technique has been utilized industrially in vertical free-fall type separators. In free-fall separators, the particles first acquire charge, then fall by gravity through a device with opposing electrodes that apply a strong electric field to deflect the trajectory of the particles according to sign and magnitude of their surface charge [15]. Free-fall separators can be effective for coarse particles but are not effective at handling particles finer than about 0.075 to 0.1 mm [16–17]. One of the most promising new developments in dry mineral separations is the tribo-electrostatic belt separator. This technology has extended the particle size range to finer particles than conventional

6. References

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