Bauxite Residue Reuse through Combined Operations: Industrial Pilot Modules

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Abstract

Bauxite residue' (BR) refers to the insoluble solid material, generated during the extraction of alumina (Al_2O_3) from Bauxite ore using the Bayer process. As the global demand for primary aluminium metal increases so does the BR production, currently in excess of 150 million tonnes per year (worldwide). This is generated at some 60 active alumina refining plants. In addition, there are at least another 50 closed legacy sites, so the combined stockpile of bauxite residue at active and legacy sites is estimated at between three and four thousand million tons. MYTILINEOS' since 1991 has been pioneering research on BR handling and reuse, focusing initially on massive low value applications such as use as a raw material for cement clinker production, iron production, bricks and tile production, soil and road substrate and others. From such approaches, only re-use in the cement sector has found industrial application leading to a current recycling of a 10 % of the annual BR production in various cement plants in Greece and Cyprus. To increase the BR reuse potential, MYTILINEOS and NTUA investigate BR-centric processes aiming to recover iron, aluminium, sodium and scandium from BR in a near-zero waste and break-even processing flowsheet which could be applied in a context of industrial symbiosis. To this end, lab-scale and industrial pilot scale research are combined to produce reliable data that will allow a comprehensive techno-economic evaluation that can lead to a viable solution. This paper will present several stand-alone processes and provide insight on the possibilities of interconnecting them.

Keywords: Bauxite residue, Metal recovery, Industrial pilot.

1. Introduction.

In the Bayer process for aluminium oxide production, bauxite ore is treated with caustic soda, causing the aluminium hydroxides/oxides (approximately 50 % of the bauxite ore mass) to be solubilized, while the remaining solid fraction is a by-product of the process, the Bauxite residue (BR). BR is produced as a red slurry (hence the common term "red mud") and contains iron minerals and other non-alumina bearing bauxite minerals as well as the liquor desilication product

(calcium and sodium alumino-silicate precipitates) from the Bayer circuit. It is estimated that for each tonne of alumina produced 0.9- 1.5 tonnes of solid residue is generated depending on the initial bauxite ore grade and alumina extraction efficiency. As the global demand for aluminium metal increases, so does the BR production. Current estimates indicate quantities in excess of 150 million tonnes per year (worldwide). This is generated at some 60 active Bayer plants. In addition, there are at least another 50 closed legacy sites. The combined stockpile of bauxite residue at active and legacy sites is estimated at between three and four thousand million tonnes.

Nowadays, many plants use high pressure filtration as a final step of slurry treatment, (the most efficient method of alkali recovery), in which the bauxite residue is pressed to remove the maximum remaining liquor and produce a compact filtercake with a moisture content of 25-30 %. The resulting filtercake, called "Filtered Bauxite Residue" (or ferroalumina), can be trucked or put on a conveyor belt, allowing for easy transport and further processing. The liquid filtrate from the filter-press, containing a small amount of caustic soda, is recycled to the washing lines, effectively re-entering the Bayer circuit [1].

The most significant difference between bauxite residue as a slurry and bauxite residue as a filtercake is the fraction of water and soda content in the final residue. The characteristics of filtered bauxite residue, (75-77 wt.% solids, 1-3 wt. % Na_2O) compared to bauxite residue slurry (30-50 wt. % solids, 4-6 wt. % Na_2O), drastically enhance its properties and its transportation either for disposal or for use (e.g., in cement industry or iron industry).

The large volume of waste produced during the Bayer process has been of concern to alumina producers since the early days of its adoption. In cases where land availability is becoming limited, the ever-growing demand for BR disposal space ultimately threatens the longevity of established alumina refineries. Stopping BR disposal or gradually reclaiming the legacy BR disposal sites is vital both for the industry and the society.

2. BR Re-Use potential.

The list of areas where bauxite residue could be used covers almost all areas of inorganic material science with particular focus on the recovery of elements present in the bauxite residue. Even Bayer himself in his 1892 patent describing the Bayer Process proposed the potential for iron recovery. Seeking effective solutions has attracted many researchers from industry, universities, institutes, and entrepreneurs to develop applications including construction of cement, bricks, roads etc., soil remediation as well as base metals and CRM metallurgical extraction.

In Europe, alumina refineries operate in Bosnia Herzegovina, France, Hungary, Germany, Greece, Ireland (AAL), Romania (ALUM), Spain and Ukraine, while significant BR deposits from refineries that have stopped their operations (legacy sites) exist in Italy, France (RT), Germany, Hungary and other countries. The current BR production level in the EU is 6.8 Mtpa (million tonnes per year); while the cumulative stockpiled level is a staggering >250 million tonnes (dry matter).

When seen as a potential mineral resource for reuse [2], the annual EU BR production, amounts to:

- With an average iron oxide content of 40 wt. %, it can be considered as an equivalent of 3.4 million tonnes of iron ore available in Europe. This would result in a 4 % decrease in iron ore imports and a 18 % increase in European iron ore production.

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