The LCL&L process: A sustainable Solution for the Treatment and Recycling of Spent Potlining.

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Abstract

Spent potlining (SPL) is a hazardous waste produced by aluminum smelters. SPL is generated from the internal lining of aluminum electrolysis cells, constituted of carbon and refractory bricks and replaced after five to eight years in service. It is classified as a hazardous waste because of its contamination with fluorides and cyanides and its reactivity with water, generating explosive gases. Nowadays, the aluminum industry has made some progress with the SPL issue by recognizing that landfilling is no longer acceptable by most local communities. In 2008, Rio Tinto Alcan inaugurated a new plant in Jonquière (Québec) for the treatment of 80 kt of SPL annually, based on the low-caustic leaching and liming process (LCL&L) developed at Arvida Research and Development Centre in the early 1990's. This paper describes LCL&L process, including valorization routes for its by-products and some technological challenges faced during the ramp-up of the plant to its nominal capacity.

Keywords: Spent potlining; LCL&L process; LCL&L by-product valorization.

1. Introduction

The aluminium smelting process takes place in a steel shell lined with refractory bricks and carbon cathodes. During the operation of the cells, molten fluoride salts and sodium penetrate into the carbon cathode lining and eventually into the alumina refractory lining or firebrick below. Pot failure occurs generally after five to eight years due to the thermo-mechanical stress generated within the pots, which allow attack of the iron collector bars and refractory lining by bath electrolyte or liquid aluminium. During pot shutdown, bath and liquid metal are siphoned off as much as possible. Once cooled, the remaining lining is then broken up and dug out of its steel shell. Iron and large aluminum pieces are sorted and recycled separately. The residual material is called spent potlining (SPL). Figure 1 shows the cross section of a pot. SPL is recognized as hazardous material because it contains significant concentrations of toxic and leachable constituents (cyanides and fluorides). Moreover, in contact with water, the reactive species of SPL, such as residual metallic Al, aluminium carbide and nitrides, have the potential of generating ammonia, hydrogen and methane. Hence, transportation, storage and final disposal of SPL are subject to strict environmental regulations.

Each ton of aluminium produced generates about 22 kg of SPL. Several factors can contribute to the variation in kg of SPL per ton of Al produced or to the variation in chemical composition of SPL. Electrolysis technology, pot operations, achieved lining life, and demolition/relining practices are the major factors. For example, the amount of bath and frozen aluminium that will remain inside the pot and thus in SPL depends on the dismantling procedures of the plant. The fluoride penetration inside the linings depends on the type of materials and the operation lifetime. For Rio Tinto (RT) in Québec, about 20 kt of SPL is generated per year.

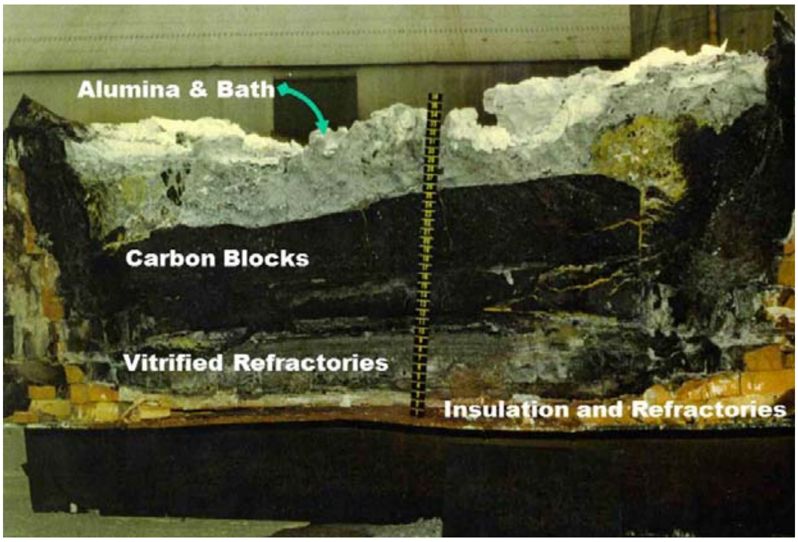

Figure 1. Cross section of an electrolysis pot.

Until mid 1980's, Rio Tinto (RT) operated in Jonquière (Québec, Canada) a plant treating SPL to produce cryolite. That plant was closed because of reduced cryolite consumption in smelters and, since then, RT has accumulated about 600 kt of SPL in safe dedicated storages. Today, less than 500 kt remain stored. Landfilling of SPL is not an option if the aluminium industry wants to claim an acceptable degree of sustainability. Several options to treat SPL exist and were reported in the literature [1, 2]. The biggest challenge for all these options for total recycling of SPL is coming from its heterogeneous composition and its high content in sodium and fluoride. Due to stricter environmental regulations in several places around the world, it becomes more difficult to send SPL without partial or total treatment directly to industries processing hazardous wastes (cement or steel industries).

In the early 1990s, RT developed at the Arvida Research and Development Centre (ARDC; Jonquière, QC) the hydrometallurgical process called LCL&L (Low Caustic Leaching and Liming), generating inert by-products with high potential for valorization [3,4]. In 2003, after a thorough evaluation of the various available alternatives, RT chose the LCL&L as the most sustainable solution for the treatment of its SPL. In 2008, RT built an 80-kilo tonnes per year (ktpy) SPL treatment plant in Jonquière (QC) based on this process [5]. This paper is an update of the experience acquired by RT since the plant's start-up [6], including ramp-up capacity, technology challenges that were overcome, and development of by-products valorization routes.

2. The LCL&L Process

2.1. Process description

The LCL&L process leaches fluorides and cyanides out of spent potlining (SPL) and generates inert by-products that can be valorized (Figure 2). The treatment is divided in two parts: one dry and one wet sectors. The dry sector includes unloading, handling and storage of SPL containers, SPL grinding (less than 300 microns) by an air swept autogenous mill with air classification and screening, and ground SPL storage. The wet sector consists first of leaching steps in series; the first leach is done with water to extract the water soluble fluorides and most of the cyanide compounds, followed by a low caustic leach to extract the remaining fluorides and cyanides. After filtration, hydrated lime may be added to the inert residues, also named carbonaceous by-product (CBP), to reduce if needed its content in leachable fluorides. Cyanide compounds (such as ferri-ferrocyanide complexes) contained in the leachate are destroyed in pressurized reactors the fluoride plant, making the LCL&L process a sustainable and economical option to efficiently treat SPL. This plant is an interesting option for other aluminium producers in Quebec and in North America for the disposal of SPL. The LCL&L process should also be foreseen as a commercially available technology solution for application in other regions of the world where a significant amount of SPL needs to be managed.

5. References

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