Treatment and Valorisation of Solid Wastes from Smelters with the Low-Caustic Leaching and Liming Process

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Abstract

Spent pot lining (SPL) is a hazardous waste generated from the internal lining of aluminum electrolysis pots consisting of carbon and refractory bricks. This residue is classified as a dangerous waste mainly because of its contamination by fluorides and cyanides, and its reactivity with water, generating explosive gases. In 2008, Rio Tinto inaugurated a new plant in Jonquière, Québec, for the treatment of spent pot lining. This plant is based on the "Low-Caustic Leaching and Liming" process (LCL&L) developed at the Rio Tinto Arvida Research and Development Centre (ARDC). This hydrometallurgical treatment detoxifies SPL and produces inert by-products, which are then used as raw materials in different industries such as the cement industry.

In the last decades, Rio Tinto operations in Québec accumulated about 20 kt of alumina contaminated with electrolytic bath and other impurities. Due to its higher content in impurities (Si, Fe and P) and constraints in product quality, re-use of this alumina in aluminum electrolysis is limited and other solutions are sought. Insertion of this material at the SPL treatment plant was studied by ARDC. It was demonstrated that the hazardous properties of the contaminated alumina (mainly leachable fluoride) can be removed by the LCL&L process and that the content in alumina of the inert by-product can thus be improved. This alumina beneficiation in the by-product of the SPL treatment helps for its valorization in cement plant.

This paper describes the LCL&L process characteristics, including valorization routes for its by-products, and the proof of concept and pilot test done for the insertion of contaminated alumina.

Keywords: Spent pot lining, LCL&L process, Waste valorisation.

1. Introduction

In 2020, approximately 1.45 Mt of Spent Pot Lining (SPL), also known as Spent Cell Lining (SCL) or "Brasques Usées" in French, were generated from the production of primary aluminium according to the International Aluminium Institute [1]. It is the most significant solid waste stream from the aluminium electrolysis process and the second one from the aluminium industry after bauxite residue (approximately 160 Mt of dry residue in 2019). The amount of SPL generated to produce one tonne of aluminium will vary from one technology to another, the most recent technology being the most sustainable one (about 20 kg SPL/t Al).

SPL is the solid cathodic waste product generated during the production of primary aluminium. The lining of the pot is typically made of two layers, an insulating refractory lining and an interior carbon lining. During the life of the cell, the carbon cathode material is continuously impregnated by the chemical components of the bath and the components coming from the electrolysis reaction. One of the main causes for electrolysis cell end of life is when liquid aluminium and bath pass through the cathode and reach the steel bars or the pot shell. At the end of its life, the

electrolysis pot must be shut down and rebuilt. After removing as much bath and metal as possible and separating the cathode bars from the rest, materials left over are the SPL. SPL includes both a carbonaceous fraction (first cut) and a refractory fraction (second cut) as well as entrained cell electrolyte, alumina crust, metallic aluminium particles and the mineral phases created by fluoride and sodium attack of the refractories. Some smelters keep the first (1^{st}) and second (2^{nd}) cut SPL separate, others do not, and the SPL is removed as one 'cut'.

SPL is recognized as hazardous material. The disposal and/or processing of SPL is complicated by the presence of reactive metals and toxic substances such as cyanides, nitrides, carbides and fluorides salts. In contact with water, SPL emits hydrogen, methane and ammonia. The historical solution to dispose of SPL was landfilling close to smelters. Even if this solution does not correspond today to environmental and regulatory considerations in most countries, it is estimated that more than 50 % of SPL generated annually is stockpiled or landfilled. Other options for managing SPL include treatment and use in other industries, either as a direct feedstock material or fuel, for example in cement or steel production. The classification of SPL as a hazardous waste also makes it subject specific to The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Thus, the transport of SPL across borders is highly regulated in most jurisdictions.

1.1 LCL&L Process

All the SPL generated by Rio Tinto in Canada is treated and valorised by the SPL treatment plant in Saguenay, based on the LCL&L (Low Caustic Leaching and Liming) process. This hydrometallurgical treatment removes hazardous properties of SPL by leaching fluorides and cyanide compounds out of SPL and removing hydroreactivity of SPL, thus generating inert by-products that can be more easily valorised. This process has been developed by the Rio Tinto Arvida Research and Development Centre (ARDC), in Quebec, since the 90s. It was developed to process SPL from old storages and fresh SPL from operating smelters. It can also process SPL cuts individually or mixed SPL.
As shown in Figure 1, the main steps of the LCL&L process are:

- SPL crushing, grinding and sizing,
- Low caustic leaching,
- High-pressure cyanide destruction,
- Evaporation to separate fluoride from high caustic solution,
- Calcium fluoride precipitation by liming.

The LCL&L process has been industrialized in the SPL treatment plant in Quebec. This plant was started up in April 2008 and reached its full capacity in 2014. Due to the demonstration context of a new technology, a progressive ramp-up strategy was needed before reaching the nominal plant capacity (80 kt/a). Through ongoing R&D work on the LCL&L process, major improvements were made to the SPL treatment plant in 2018 to provide a more energy-efficient process and facilitate inert by-product valorisation. More details on these process changes can be found in [2].

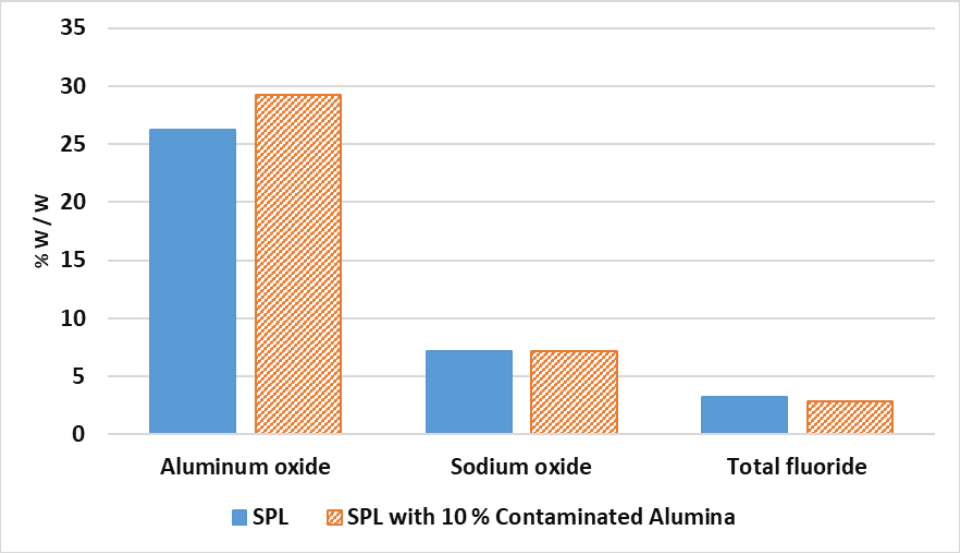

Figure 5. Average composition of the solid by-product achieved during pilot test with SPL only, and SPL mixed with 10 % contaminated alumina.

4. Conclusions and Next Steps

The LCL&L process was developed to treat fresh and stored spent pot lining (SPL), to remove hazardous properties of SPL and to transform it into valuable by-products. This work showed that it can also treat another separate waste and use its alumina content to increase the quality of the by-product used by cement plants. This represents another option of circular economy whenever aluminum smelters would struggle with the reinsertion in their process of alumina contaminated with bath.

In regard of the obtained results, the objectives of the pilot test were met. It was demonstrated that the co-dosing of contaminated alumina with SPL is a feasible option for the LCL&L process and can be operated at the SPL treatment plant. This represents an interesting opportunity to decontaminate alumina while increasing the alumina content of the final product from SPL treatment, which is advantageous for its valorization as raw material for cement plants.

As future steps, Rio Tinto is looking to perform a scale-up of the solution. This scale up would allow to evaluate mid-term impact of contaminated alumina addition with SPL, like sulfate and chloride content as well as alumina caustic ratio trend in the leachate. At the same time, diverse types of SPL would be tested and contaminated alumina variability would be more knowledgeable.

5. References

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