AL19 - A Novel, Zero-Waste Technology for Spent Pot Lining Recycling

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Abstract

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Each tonne of aluminium produced in aluminium smelters generates approximately 20 kg of hazardous waste, known as spent pot lining (SPL)`which is a mix of the carbon lining and the refractory lining. The waste contains high levels of leachable cyanides and fluorides, as well as components that form combustible gases (mainly CH_4). The current practice of the waste management of hazardous SPL is still often landfilling or incineration, which costs aluminium producers on average 200 €/tonne of SPL waste (240 million € annually on a global level).

A novel zero waste process has been developed and optimized in the frame of the SPL-CYCLE project (http://splcycle.zag.si/) for wastes originated from two aluminum smelters. The new process consists of five main separation and purification stages which are dilution, filtration, crystallization and flotation, resulting in the production of four products: a) fluoride salts for aluminium production, b) graphitized carbon for aluminium production, c) aluminosilicates for refractory industry, and d) manufactured aggregate for construction (supplementary cementitious materials, lightweight aggregates, geotechnical fill, bricks, concrete).

The current research paper presents major aspects of SPL and SPL-CYCLE process, including characterization results from raw materials (1st and 2nd cut) and the products, description of the process' flowsheet and the pilot plant, and presentation of thermodynamic data.

Keywords: Aluminum spent pot-lining (SPL), carbon cathode lining, aluminum reduction cell, industrial waste valorization, waste detoxification.

1. Introduction

Spent potline constitutes the bottom part of Hall-Héroult electrolytic cells that are used in aluminum production. It constitutes the spent carbon cathode (1st cut) and high temperature resistant bricks (2nd cut). During cell operation, the lining is subject to reducing conditions and fails after 5–9 years depending on the operating conditions, materials quality and construction technique. All the parts are toxic due to the impregnation with molten electrolyte during the operating period, containing leachable fluoride salts and cyanides. The best available technologies for non-ferrous metals describe many options to treat SPL: use SPL in cement production, as a carbonaceous substance in ironworks, as a secondary raw material (glass wool, salt slag) and as a substitute fuel [1].

A novel zero waste process has been developed and optimized in the frame of the SPL-CYCLE project (http://splcycle.zag.si/) for SPL 1st and 2nd cut recycling. The new process consists of five main separation and purification stages which are extraction and detoxification for fluoride salts and cyanide removal, filtration for solid-liquid separation, crystallization of fluoride salts, and flotation, resulting in the production of four products: a) fluoride salts for aluminium production, b) graphitized carbon for aluminium production, c) aluminosilicates for refractory industry, and d) manufactured aggregate for construction (geotechnical filler, bricks, concrete) [2].

The SPL-CYCLE project is exploring the potential customers for technology and recycled products markets (graphite, fluoride salts, alumosilicates) and is preparing the techno-economic study and tailored-made business strategies for addressing various industrial needs in order to bring the sustainable supply of critical resources close to the local industry. Through the SPL-CYCLE project, the foreground for the smooth market penetration is in preparation to avoid common bottlenecks in the successful commercialization. The SPL-CYCLE technology is utilizing zero waste principle by closing material loops as all products could be recycled or reused in other industries.

2. SPL-Cycle Process Flowsheet

The SPL-CYCLE technology is a hydrometallurgical detoxification process at ambient temperature and pressure that transforms the SPL into a non-hazardous material suitable for recycling. The technology is self-sustained, and thereby ideally adapted to the needs of small-scale Al smelters looking for a local, on-site solution. Further to detoxification, the method succeeds in the production of 2 high purity products that can be considered as carbon and aluminosilicate-source material on various industrial branches.

In the frame of the SPL-CYCLE project, a pilot plant was built in 2019 with a capacity to treat at least 5 kg SPL/h (40 kg/day). For a full-scale Al smelter, it is assumed that 200-250 kg/h SPL treatment is needed, depending on the Al-smelter capacity. The tests on the pilot plant are set to get sufficient information for the preparation of the scale-up configuration in the intended industrial applications. The process is applied separately for the 1st and 2nd cut and takes place in the following steps presented in Figure 1.

6. Conclusion

The current research paper presents a new method for SPL Recycling that has been developed and optimized in the frame of the "SPL-cycle" research project (http://splcycle.zag.si/). The SPL-cycle technology is utilizing zero waste principle by closing material loops as all products could be recycled or reused in other industries. The major processing steps constitute extraction and detoxification (for cyanides and salts removal), filtration for solid-liquid separation, crystallization of fluoride salts, and flotation, resulting in the production of four marketable products: a) fluoride salts for aluminium production, b) graphitized carbon for aluminium production, c) aluminosilicates for refractory industry, and d) manufactured aggregate and alumosilicates for construction (geotechnical fill, bricks, concrete). Within the project, a pilot plant capable to treat 5 kg SPL/h has been constructed and operated, thus allowing studying of crucial processing stages and optimizing its overall performance under realistic conditions.

7. Acknowledgement

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8. References

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