Issues of spent carbon potlining processing

Aleksandr Suss[1], Natalia Kuznetzova[2], Aleksandr Damaskin[3], Irina Paromova[4], Andrey Panov[5]
1. Director Technology Department
2. Senior Researcher
3. Senior Researcher
4. Chief Researcher
5. Director R&D Alumina
RUSAL Engineering & Technology Center, St. Petersburg, Russia
Corresponding author: Aleksandr.Damaskin@rusal.com

Abstract

While producing one ton of primary aluminum metal, 25 ± 15 kg of spent potlining (SPL) is generated with high content of carbon, fluorine compounds, including fluorite and cryolite, alumina, various cyanides, aluminium nitride and carbide, etc. Those wastes are specified as high hazard class and their disposal without prior neutralization is prohibited in some countries. Spent potlining can be processed into recycled cryolite and carbon material providing certain process improvement for fabrication of Portland cement and possessing high calorific value. The paper specifies individual steps of the process and potential of its implementation in units of cryolite regeneration from carbon dust. It was demonstrated that under new economic conditions it is possible to reduce operation costs for SPL processing and provide the required quality of recycled cryolite.

Keywords: Spent carbon potlining; cyanides; recycled cryolite; carbon-bearing material.

1. Introduction

With world annual production of more than 53 million tons of primary aluminum, more than 1 Mt of spent potlining (SPL) is generated, i.e., about 25 kg of toxic waste per ton of Al [1]. SPL was originally classified as industrial waste or mining waste that did not prevent its recovery or disposal. In the early 1980's Aluminum Association (AA) classified SPL as hazardous waste, based on the fact that SPL contains simple and complex cyanides, nitrides, carbides, soluble fluorides, and that after its interaction with water the medium becomes alkaline,. In 1988, US Environmental Protection Agency classified SPL as hazardous waste of class KO 88. In Canada, it was classified as special waste. Some difficulties appeared in connection with disposal or use of non-neutralized lining in cement and steel industry. Introduction of new regulations has led to the fact that SPL must be neutralized prior to delivery to a third party [2]. Right now, governmental regulations and high environmental payments for waste disposal are the main force for neutralization and processing of SPL.

In the former Soviet Union, thanks to a government program, the problem of SPL processing into secondary cryolite and carbon-containing fuel in the 1980's and 1990's was solved at the state level. Unfortunately, due to the collapse of economic ties, railroad rates increase, reduction in demand for secondary cryolite and a number of problems in processing technology, this program was halted.

Right now, concentration of the largest aluminum smelters in the Siberian region of Russia, substantial increase in the cost of fluorite concentrate and cryolite produced from it, the increase of environmental payments for SPL disposal and other reasons transformed secondary cryolite and other fluorides production into economically attractive process.

2. Processing options for spent potlining

In the USSR the following methods were already developed in 1960's and industrially implemented in 1970's to 1980's:

- Hydro-chemical method of spent potlining processing into secondary cryolite [2, 3, 4, 5],
- Thermal method using SPL in steel industry as flux addition [6, 7, 8].

Rio Tinto Alcan developed SPL digestion method comprising autoclave processing of all fluorine content into insoluble fluorite, cyanide destruction at a temperature of 180 °C and subsequent disposal [9].

Majority of proposed processes are based on hydro-chemical method consisting of conventional chain of process steps: crushing and milling, alkaline digestion followed by precipitation of the main component, thickening, filtration and drying. Figure 1 represents such generic flow diagram of SPL processing into secondary cryolite [10].

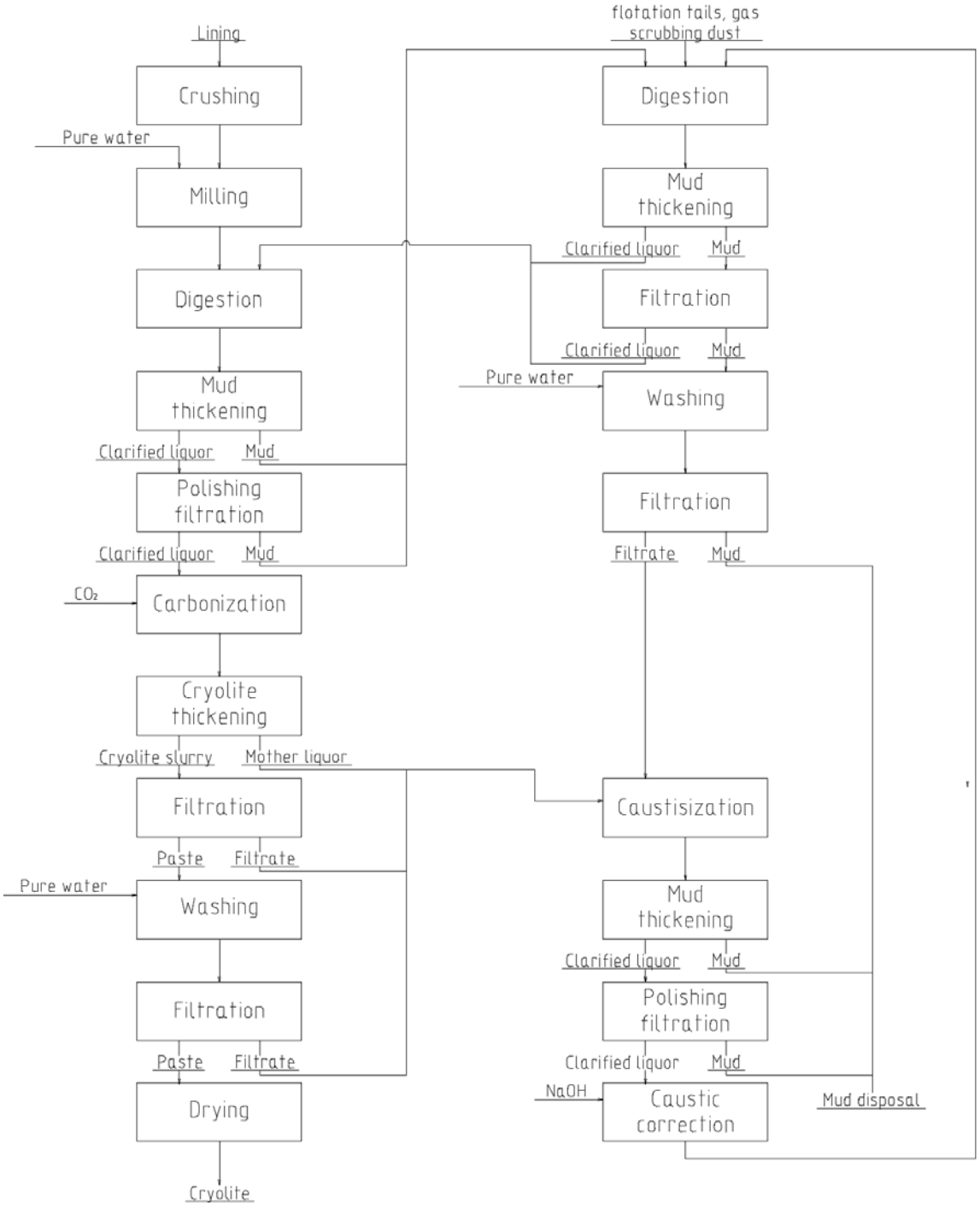

Figure 1. Flow diagram of SPL processing into cryolite [10].

The specifics of the produced carbon material are high ash content and relatively high fluorine content (2 - 3 mass %). Therefore ash has a low melting point (≈ 850 °C), which requires adjustment of the combustion mode for the use of carbon material as process fuel. Due to the insignificant amount of carbon material (≈ 10 000 tons per year) it is advisable to use it as flux addition in cement production, allowing to reduce by 30 – 50 °C clinker formation regime and amount NO_x emissions.

4. Conclusions

- X-Ray phase analysis demonstrated that in all cases cryolite was produced. Traces of chiolite ($5NaF \times 3AlF_3$) are not detected. In 2 samples insignificant amount (≈ 2 - 3 %) of polymorphous nordstrandite (γ-$Al(OH)_3$) is determined;
- Cryolite samples differ in SiO_2 content by ≈ 4.5 times, from 0.11 to 0.53 mass %, but even with the highest silica content were significantly below the limit value of GOST (Russian Standard);
- Calculation of cryolite ratio by chemical analysis demonstrated variation from 1.94 to 2.2.
- Grain size measurement of the produced secondary cryolite demonstrated that an average particle size varies from 15 to 20 micrometers.

5. Acknowledgements

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6. References

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