Feasibility Study to Remove Impurities from CBA's Liquor as an Alternative to Increase Precipitation Yield

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Abstract

CBA's alumina refinery aims to increase its precipitation yield to reduce its specific consumptions, mainly live steam, thus reducing its CO_2 emissions. Precipitation yield is directly related to the impurities level present in Bayer liquor. CBA has developed a feasibility study to evaluate different technologies to remove organic and inorganic impurities from liquor as an alternative to increase precipitation yield. This paper details the studies and tradeoff analyses of different technologies available to promote the removal of impurities present in CBA's liquor. Laboratory tests were carried out with the selected technologies to evaluate the impurities removal efficiency and yield gains.

Keywords: Bayer liquor, Impurities removal, Precipitation yield.

1. Project Description and Opportunities

One of the projected challenges up to 2050 for alumina industries operating with the Bayer process is to reduce energy consumption [3,5]. Improving energy recovery, reduce scaling in heat exchanger and increase precipitation yield are some enablers to achieve this goal.

The precipitation yield in the Bayer process is directly related to the precipitation kinetics, ionic solutes thermodynamics, process conditions variations, design of equipment and impurities level in the liquor. One of the ways to directly improve the precipitation yield is through the removal of impurities in the liquor resulting in a purer liquor. With a purer liquor, there is a reduction in the encrustation rate on heat exchangers and reduction of energy consumption, also contributing to reduce CO_2 emission.

CBA runs its refinery with 3 different sources of bauxite (Barro Alto, Miraí and Poços), which has a relative high input of impurities to the liquor. These impurities can be classified basically in three categories: sodium oxalate, sodium carbonate and organics in general.

The refinery's energy consumption is of 10 units and the precipitation yield is of 100 units. The level impurities control is through soda purge in the bauxite residue.

2. The Potential Solutions

Innumerable methods of control and removal of impurities from Bayer liquor are known, totalizing more than 60 patents of this subject [2]. Each one of these methods has its operating characteristics, efficiency, and specific controls. An important factor to be considered is, in addition to removing these impurities, is to carry out the correct destruction treatment and/or storage of impurities removed from liquor due, for example, sodium oxalate is toxic, and its destruction or disposal must follow strict safety and environmental controls. A potential benefit of sodium oxalate destruction or disposal is the possible recuperation of sodium hydroxide that was lost in the process during sodium oxalate's generation [6].

An evaluation study of the technologies of liquor's impurities removal was performed according to the Table 1. It was considered the most used or with the most potential for application, generated benefits, and challenges to be overcome.

Table 1. Evaluation of the main technologies of impurities removal.

Technology	Principles	Pros	Cons
Dawsonite Process	CO_2 bubbling in the aluminate, that reacts to generate the compound as Dawsonita ($NaAlCO_3(OH)_2$). Filtered and sent to calcinate.	Efficient process on impurities removal	Loss of caustic and alumina. CO_2 emission on calcination.
Wet oxidation	CO_2 injection in digestion tubes to oxidate TOC under 270 °C temperature.	Relatively low capex	Decomposition of organics generates CO_2, CH_4 and H_2. Operational risk (explosion). Generation of Na_2CO_3 in the digesters (yield impact).
Liquor Burning	Mix of spent liquor with bauxite. Solid undergoes grinding and calcination. TOC is degraded and the sodium generates carbonate, which is leached with spent liquor. Liquor returns to the process and the residue is sent to the mud circuit.	Effective process on organic carbon's removal.	High investment cost. Complex operation. Odor generation. CO_2 emission.
Plasma treatment	Liquor is subjected to plasma (4 000 °C), the organics are degraded and the solution returns to the process	Does not generate carbonate nor scaling, reduces foam and changes liquor's color (improves hydrate's whiteness)	Technology in lab-scale. Generation of gases (CO_2). High investment.
Liquor's ozonation	Bubble the liquor with air + 3 % ozone to generate sodium oxalate, which is removed by centrifuge for adequate destination. The liquor returns to the process.	Reduces foam generation and clarifies the liquor.	Carbonate generation, which can redyce the yield. Generation of toxic waste (challenge for adequate destination + costs). Operational difficulty.
Coagulant additives (precipitation)	Polymer addition to generate a complex with humates, which precipitates and can be incorporated in the waste or are removed by filtration.	Low investment. Does not generate carbonate.	Relatively low efficiency. Limited to organic impurities.

6. Conclusion

This study evaluated the pros and the cons of the main technologies applied to the removal of liquor's impurities according to its characteristics. In established criteria, there was a classification of 3 that were evaluated in lab-scale.

All the technologies evaluated showed a level of impurities removal in the liquor and by consequence an increase in precipitation's yield. The results showed an increase of up to 12.3 % in precipitation yield for the technology Salting Out Evaporation.

It was possible to carry out the treatment of the waste generated in SOE's process through causticization process, and the efficiency results were 98 % for the carbonate and 92 % for the oxalate. Soda recovery is significant, and it was not considered in this study as gain.

Using increase precipitation yield obtained in the test, it was calculated the reduction of liquor flow in alumina refinery and vapor equivalent saved to heat this flow. The reduction in the refinery's energy consumption can reach 17.4 %.

Through the viability study, the technology that shows the best benefit for CBA is Salting Out Evaporation.

7. References

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