Enhancing Solid-Liquid Separation in Alumina Refineries: A Comparative Study of Gravity Decanters and Diastar Filters

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Abstract

This research paper explores the challenges associated with the use of gravity decanters in alumina refineries. These decanters, employed for solid-liquid separation during the Bayer process, are found to have certain limitations. As a solution to these drawbacks, the authors suggest the application of Diastar filters. These innovative pressure filters are specifically designed to deal with high-solid concentration slurries at increased temperatures and pressures.
To substantiate this proposal, the efficiency of Diastar filters is compared with gravity decanters. This comparison is drawn through a bench-scale study using a blow-off slurry and SysCAD simulation modelling. The first findings reveal that Diastar filters exceed the performance of gravity decanters when it comes to solids separation, registering a specific feed capacity of nearly 0.9 $m^3/m^2 \cdot h$. In addition to superior solids separation, Diastar filters also show decreased liquor loss. This decrease leads to an increased filter cake solids concentration, thereby enhancing the overall efficiency of the solid-liquid separation process. Moreover, compared to gravity decanters, Diastar filters require less space, making them a more space-efficient choice.

The research paper also delves into the economic and environmental implications of replacing gravity decanters with Diastar filters in alumina refineries. The study suggests that Diastar filters could potentially offer significant economic benefits and positive environmental impact. However, the authors also underline the need for careful consideration of the filterability of residue specific to each bauxite and digestion conditions. They highlight that these factors can considerably affect the filtration characteristics of the residue. Conclusively, Diastar filters appear as a promising alternative for blow off solid-liquid separation in the alumina industry, given their enhanced performance, economic advantages, and environmental benefits. Nevertheless, the need for individual evaluation of residue filterability in relation to specific bauxite and digestion conditions is necessary.

Keywords: Alumina refineries, Bayer process, Diastar filters, Gravity decanters, Solid-Liquid separation.

1. Introduction

Since the development of the Bayer Process in 1888 [1] lots of process optimization have been made in refineries to adjust it for the ore characteristics and mainly to improve the process efficiency. In the earlier alumina refineries, the solid-liquid separation from digestion blow-off slurry (DBO) was performed by plate and frame filter presses [2]. The change from blow-off filtration to the current flocculant aided gravity decantation came about because of developments in thickening technologies (synthetic flocculants and thickeners design) and the necessity to reduce the high costs in labour, maintenance and depreciation associated with those filtration technologies [3]. Besides the benefits that came with these modern decanters, the process of densifying the solids in the underflow from 50 g/L (~4 % solids) to 500 g/L (~35 % solids) usually takes more than four hours, reaching in some cases up to 12 h. As a result, some part of the

dissolved alumina phase tends to auto-precipitates in the digestion blow off slurry, implying a drop of the alumina concentration (measured as A/C – alumina to caustic ratio, expressed as g/l of Al_2O_3 and Na_2CO_3, respectively) in the decanter. A common A/C ratio drop of 0.20 points (e.g., from 0.755 to 0.735) in the settler overflow is estimated to represent an alumina loss of approximately 3 % in terms of the bauxite feeding the Bayer process. Other inconveniences of decanters are related to its footprint, and high scaling rates [3,4].

Moving towards a substantial improvement in the digestion alumina recovery, it is paramount to reduce the auto-precipitation losses (APR) and maximize the liquor productivity. This is evidenced when considering the perspective that bauxite reserves tend to degrade over time (reducing the available alumina content and increasing the related mud factor) as more efficient processes are mandatory for the industry (reducing the generation of residues and the specific consumption of inputs such as steam and caustic soda). In this context, the present work proposes replacing current decanters by Diastar filters for the blow-off solid-liquid separation.

Diastar is a fully automatic pressure vertical leaf filter, that can operate under elevated temperatures and pressures. Currently it is widely used in alumina refineries (for liquor filtration) and other applications mainly for thickening and clarification of slurries [5].

Diastar's deadtime can be brought down to around 30 seconds, making it possible to operate with filtration time as low as 3 minutes. The backwash system is designed to dislodge cakes as thin as a few millimetres. Both these features, together with the possibility to isolate each filter element in case of solids breakthrough, allow Diastar filter to handle slurries with high solids concentration and high specific cake resistance.

Dislodged filtration cake settles in a cone as dense mud. Thanks to continuous mud level measurement, mud can be extracted from the filter with solids concentration as high as two thirds of the saturated cake solids concentration.

The opportunity to significantly reduce the retention time for the solid-liquid separation and, consequently, maximize digestion alumina recovery by reducing the auto-precipitation was investigated. This work represents a pre-feasibility evaluation of this application.

2. Experimental

A preliminary bench-scale laboratory study was carried out to assess the filtration performance of blow-off slurries. Subsequently, SysCAD modelling and steady-state simulation of scenarios with the replacement of the decanter by Diastar Filters were performed to demonstrate the benefits.

2.1 Filtration tests

The tests were performed in Hydro's Bauxite and Alumina (B&A) R&D laboratory, which is equipped with an autoclave apparatus for digestion of about 5 L slurry and a pressure filter designed and fabricated by Gaudfrin (Figure 1). This system allows to perform filtration tests of digestion blow-off slurry (DBO) from autoclave and from plant at temperature pressure up to 150 °C and 16 bara, respectively. More details on this system can be found in LaMacchia et al. [6].

Digestion tests were carried out using Mineração Paragominas bauxite (Miltonia 3) and plant spent liquor at temperature of 145 °C, residence time of 60 minutes, to achieve a final A/C ratio of 0.750. Filtration runs were performed at different ΔP and temperature, using blow-off slurry from autoclave and plant. Pressure was increased during some of the tests to check compressibility

Among the scenarios, *C* seems to be less interesting, as the number of necessary filters doubles due to a lower filtration rate (~0.4$m^3/m^2/h$, less filter availability due to the need to empty and fill it with water for pre-wash), with an increment in savings of only 0.09 MUSD/year. Compared to gravity decanters, Diastar filters require less space, making them a more space-efficient choice. For a brownfield project, however, scenarios *A* and *B* must be better evaluated concerning the associated cost of retrofitting, demolishing, and available footprint. Environmental aspects related to the significant reduction of caustic in residue may also be considered, mainly in the context of its disposal and the ambition to implement/increase its utilization.

Despite the benefits demonstrated, it is worth noting that that the filterability of blow-off may significantly change from different bauxite slurries and digestion conditions, so this opportunity must be evaluated for each individual case.

5. Conclusion

This works presents a preliminary evaluation of digestion blow-off solid-liquid separation by filtration with the main benefit of reducing the auto-precipitation losses in clarification circuit. The opportunity of using the Diastar filters for this purpose is highlighted, considering its potential to perform higher thickening of solids in short filtration cycles (about 10 min). A total gain of 0.020 in A/C ratio is estimated in comparison with decanters. Savings due to reduction of bauxite and soda consumptions were also calculated, together representing a benefit of about 5.7 MUSD/year for a typical plant of 1.0 Mtpa. The cost for this implementation was estimated to be approximately 11 MUSD, whit a payback time of 3 years.

Worth noting that other potential benefits may be further evaluated and accounted, such as the reduction of flocculant and TCA consumption, reduction of bauxite residue alkalinity and with potential to lever its utilization, reduction of plant net-dilution (when necessary for evaporation control – obviously it competes with the soda recovery benefit, but may enable more flexibility for plant volume control), and even the by-passing of the security filtration if demonstrated a reduction of solids concentration in green liquor below 5 mg/L. A pilot plant test is recommended to confirm these benefits as well as the challenges for the DBO filtration in Diastar filters. This test is planned for the next phase of the project in Hydro Alunorte.

6. References

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