Optimization of Sodium Oxalate Removal within the Bayer Process

Marc Thomas
Chemical/Process Engineer
Jamalco, Halse Hall, Clarendon, Jamaica W.I
Corresponding author: marc.thomas@jamalco.com

Abstract

Oxalate removal is a critical process within the Bayer Liquor Circuit which minimizes the propensity of co-precipitation of sodium oxalate with aluminum hydrate in the Precipitation area by lowering the sodium oxalate concentration within the liquor circuit. Minimization of this co-precipitation is a quality critical element in ensuring proper alumina particle sizing. As the quality of bauxite feedstocks declines with respects to available alumina there is the need to process increased tonnage to sustain refinery nameplate operation. This has increased the oxalate input into the refineries and necessitated investigations into low-cost oxalate removal capacity expansion approaches. An investigation was done to identify and model the nature and magnitude of the relationships that exist between oxalate yield and process parameters of seed charge, temperature, holding time and solubility in elevated TA solutions, all deemed as critical parameters in precipitation theory. Process optimization models were then applied to an oxalate removal unit operation within an operating alumina refinery immediately following a period of curtailment. These adjustments resulted in an up to 30 % increase in attained yields with no significant change in initial oxalate concentration. To sustain throughput capacities at observed elevated yields, high permeability filter media were tested and compared to previous media, across the operating cycle of the filters. This paper outlines the methodology used during the investigation, the outcomes, observations as well as future steps to be taken.

Keywords: Sodium oxalate, Filtration, Oxalate precipitation, Process optimization.

1. Introduction

Oxalate removal is a critical process within the Bayer liquor Circuit, as it minimizes the propensity of co-precipitation of sodium oxalate with aluminum hydrate in the Precipitation area by lowering the sodium oxalate concentration within the liquor circuit [1]. With the quality of ores in existing bauxite reserves expected to decline, the Clarendon Alumina Works (CAW) refinery is faced with the challenge of sustaining production targets with reduced available alumina in bauxite. Stoichiometrically, it is understood that as the available alumina in bauxite declines, the required bauxite (bauxite factor) to achieve production target will increase. As this bauxite contains impurities, their loading also increases [2]. In the case of sodium oxalate, it was found, within the context of CAW that 2 % change in available alumina resulted in a net increase of > 0.5 tonne/day of sodium oxalate delivered to the process based on plant data for the past 5 years.

Plant data also indicated that there is more than 37 % change in the sodium oxalate content of "wash water" between wet and dry seasons. Further, a general increase has been observed in oxalate within lake water over the past 9 years despite general declines in the oxalate in bauxite as shown in Figures 1 and 2 below. The variation in concentrations between wet and dry seasons suggests that if there are increased intense dry periods, potentially influenced by climate change this trend will continue. This represents an increase of sodium oxalate to process of 4 tonnes per day on average during dry period due to impacts of increased evaporation in the residue storage areas.

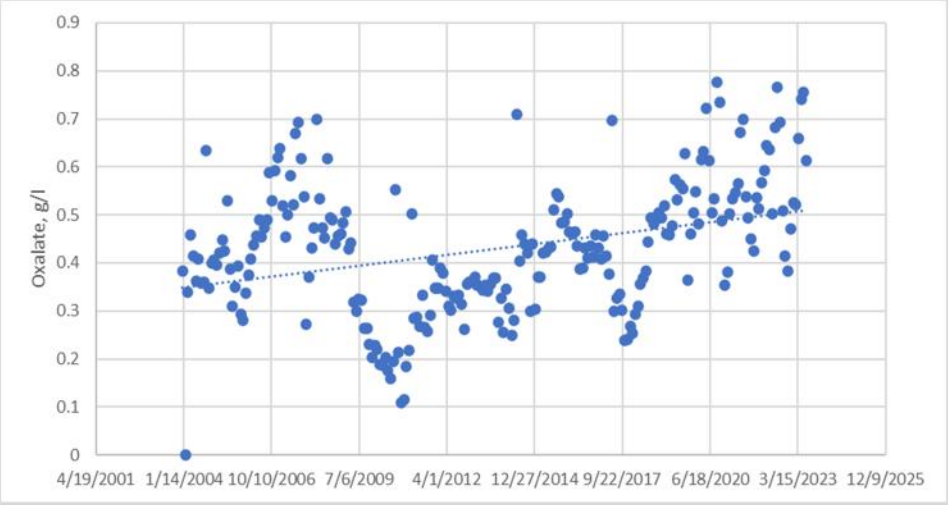

Figure 1. Oxalate in wash water to decanters.

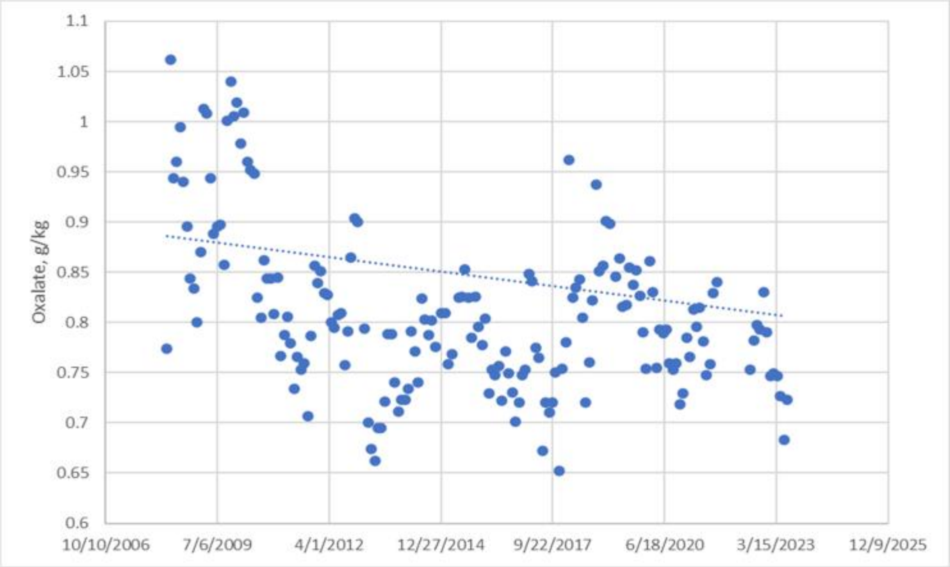

Figure 2. Oxalate in bauxite.

An increase in sodium oxalate removal capacity to manage inputs is dependent on two key factors: maximization of sodium oxalate precipitation yields and the maximization of supersaturated liquor flows. As both factors exist in an inversely proportional relationship, achieving optimal balance between both is essential. In line with general precipitation theory [1], a series of experiments was conducted to determine the relationship between oxalate yield and controllable process parameters: seed ratio, temperature, holding time and solubility in high total alkalinity (TA) solutions. Further, it was expected that an increase in sodium ion concentration would decrease the solubility of sodium oxalate. Stability studies done with synthetic liquor have indicated circa 0.8 g/L reduction in stability for every 40 g/L increase in TA [4]. Within the refinery context such could be achieved via addition of sodium hydroxide, sodium sulphate or via Bayer liquor evaporation. Solubility investigations were done to determine maximum total alkalinity for supersaturation and precipitation of sodium oxalate within plant liquor samples.

Kelly presses utilized at CAW are pressure vessels containing 10–12 spigots connected to metal frames. These metal frames are covered in semi-permeable filter cloth. In operation, the press body is filled with Bayer liquor (including precipitated oxalate crystals), with the process liquor

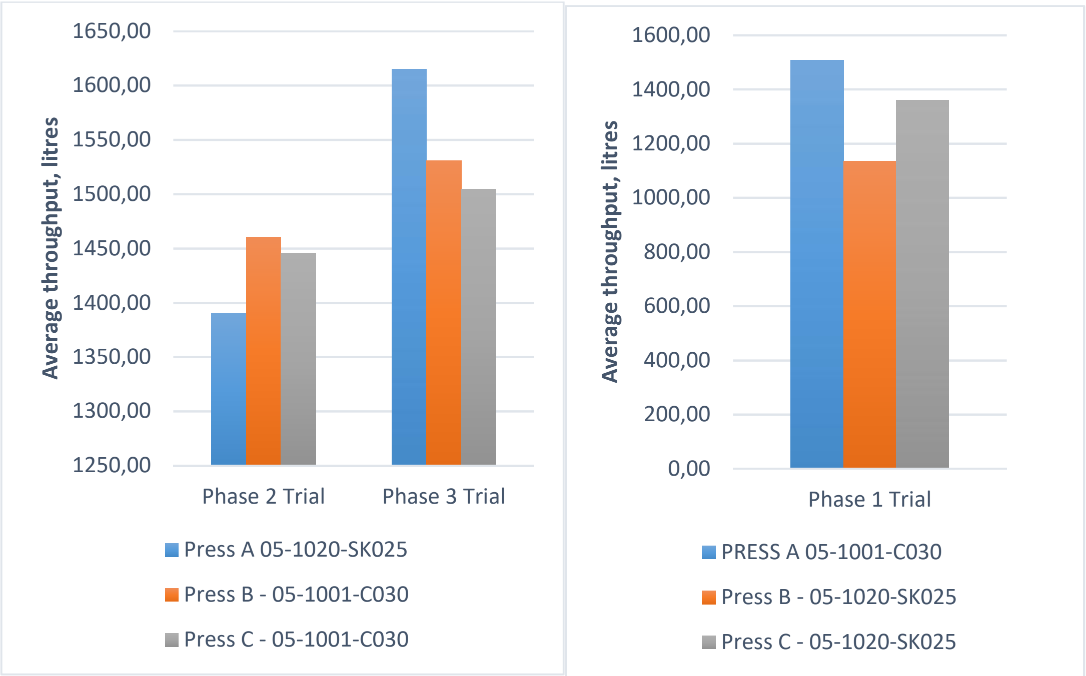

Figure 11. Average Press Flows Across Filter Media Lifecycle.

4. Conclusion

Attainable sodium oxalate removal capacity increase realized through yield and throughput optimization was found to be up to 25 %. This is the equivalent of operating 1.2 additional Kelly presses based on current throughputs, but without the capital required for such an addition. However, continued management and optimization of supporting systems for Bayer liquor conveyance, absolute filter frame availability, and minimization Kelly press cycle time and down times remain critical to sustain maximum process flows. Periodic assessment of oxalate solubility within Bayer liquor is crucial to fine-tuning of developed predictive models and the actual oxalate precipitation and removal process, especially where there continues to be noteworthy changes in bauxite or recovered lake water characteristics. Throughput gains obtained via use of higher permeability and strength fabric should be maximized through standardization of the fabric use across all Kelly presses. Consideration should also be given to revising maintenance cycles to accommodate extended runtimes achieved through use of the more durable trial fabric (05-1001-C030). Additional opportunity remains to explore and document the impacts and interactions of other organic species present with the refinery's Bayer liquor, both in terms of oxalate removal optimization but also general liquor stability.

5. Acknowledgement

The author wishes to express gratitude for the support provided by the teams of the laboratory. Technical services division and digestion department at CAW for the provided during the study.

6. References

1. Chester, R., et al. (2018). Management and Control of Sodium Oxalate Precipitation in the Bayer Process. Alumina 2018 (11th AQW).
2. Power, G.P., The impact and control of organic compounds in the extraction of alumina from bauxite, Extractive Metallurgy Conference, 337-334.
3. Regina Maher, Structural Determination, Identification and Removal of Bayer Liquor Organic Poisons, Masters Thesis, Macquarie University, Sydney, Australia, 2015.

4. Beckham, K., et al., Factors Affecting Oxalate Stability, AWA Research and Development, 29 December, 1997, KWW11959
5. Al-Sudani, J.A., et al, Estimation Liquid Permeability Using Air Permeability Laboratory Data, Iraqi Journal of Chemical and Petroleum Engineering, Vol. 15, No. 1, (2014), 43-50.
6. T.S. Li, J. McShane, D. Bedell, I. Livk, The influence of solid phase oxalate (spo) on gibbsite secondary nucleation in synthetic caustic-aluminate solution, 10th International Alumina Quality Workshop, Perth, Austrailia, 19 - 23 April 2015
7. SEFAR, Technical data sheet for filter media (woven), 05-1020-SK025, Fiches techniques\fiche techn.tis.ang.doc
8. SEFAR, Technical data sheet for filter media (woven), 05-1001-C030, Fiches techniques\fiche techn.tis.ang.doc