Optimization of the Control and Monitoring Strategies for Precipitation Yield and Particle Sizing using Predictive Modelling

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Abstract

The production of good quality alumina in the appropriate tonnage are two key aspects relevant for any alumina refinery. Meeting these targets are dependent on the stable operation of the precipitation circuit. The ability to maximize the precipitation yield while maintaining product sizing specifications is a key objective to improve the refinery's efficiency and cost targets. At Jamalco, the consistent production of product of the required particle size and tonnage has posed a challenge with the changes in the liquor chemistry resulting from a shift in the quality of raw materials, such as bauxite, to the process. Optimization of the various key process indicators within the precipitation circuit is an enabler to meet the refinery's customer obligations as well as its cost targets. This paper highlights the predictive tools developed using linear regression in Microsoft Excel to optimize the control and monitoring strategies used within the precipitation circuit at Jamalco. Furthermore, this paper provides a summary of the recommended model optimization steps that will be explored for future use.

Keywords: Precipitation yield, Particle size, Predictive modelling, Optimization.

1. Introduction

Jamalco, an alumina producer in Clarendon Jamaica, has a nameplate capacity of approximately 1.4 million metric tonnes per annum of sandy grade alumina utilizing the traditional Bayer process. One of the major challenges for the refinery is bridging the gap between increasing yield in the precipitation circuit and attaining the required product sizing. Literature dictates that the yield of gibbsite is largely determined by nucleation and growth of particles, while the production of coarse crystals for commercial purposes is determined by agglomeration [1]. However, the optimal conditions required for nucleation and growth typically aligned with maximizing precipitation yield do not always coincide with the optimum product size specifications or agglomeration conditions [1].

The optimization of the precipitation circuit is a key enabler in meeting the refinery's productivity and efficiency targets. The yield and strength of precipitated hydrate particles is dependent on several key process indicators such as liquor to precipitation alumina to caustic ratio, temperature profile across the circuit, seed ratio or charge, holding time, precipitation rate, and impurity levels of input seed and liquor [2].

With the changes in the bauxite feed quality to the refinery over the past 6 years, the refinery's ability to consistently meet its yield and sizing requirements has become increasingly difficult. As such, the countermeasure of crystal growth modifier, CGM, addition has become an integral part of the sizing management practice for the refinery. The coarsening effect of crystal growth modifiers on alumina trihydrate is the primary use of this product for refineries such as Jamalco, the intended purpose or result of the addition of CGM has been to improve precipitation productivity through increased seed charge and/or temperature reduction [3].

One of the major concerns for Jamalco in the refinery's sizing management program is the presence of dissolved oxalate in liquor, one of the strategies used is the addition of CGM to the circuit. The presence of the CGM results in pronounced changes in the sodium oxalate morphology by the formation of sodium oxalate clusters [3].

Linear Regression is a statistical tool used to model the relationship between two variables fitted to a linear equation, i.e., an equation in the form Y = a + bX, where Y is a dependent variable and X is an independent or explanatory variable. This is the basic concept utilized throughout this paper to predict the precipitation yield and sizing for optimization purposes. Prior to the development of the regression model, a critical step is the data cleaning process to remove outliers which can affect the model developed. Once the data clean-up process is complete, a correlation test is done using scatter plots, the CORREL function or Regression Data Analysis tool in excel to determine the correlation coefficient, which falls between -1 and 1 thus indicating an inverse and direct correlation. For multilinear regression, such as those that will be discussed, the regression data analysis tool and the CORREL function are preferred.

2. Precipitation Yield Prediction Tool and Impact

The regression data analysis tool was utilized to determine the correlation coefficients for several key process indicators such as seed specific surface area, number of precipitators in service as a measure of holding time, precipitation solids, circuit temperature amongst others with the liquor from precipitation alumina to caustic ratio. These correlation coefficients were then used to generate a singular linear equation for the prediction of the liquor from precipitation alumina to caustic ratio (LFP A/C). To facilitate optimization of this model, an error comparison was done between the LFP A/C measured by the laboratory and the predicted LFP A/C. The Solver add-in was then utilized to minimize the sum of errors while updating the model coefficients; to facilitate robustness of the model, over 300 data points were utilized for each key process indicator in this process.

To facilitate a link between the attainable agglomerated size and precipitation yield, the head tank +44 micron was incorporated in the model. The model generated was found to be in good tolerance to the actual LFP A/C ratio as shown in figure 2 and could therefore be used to predict the trend of the LFP A/C ratio in real time.

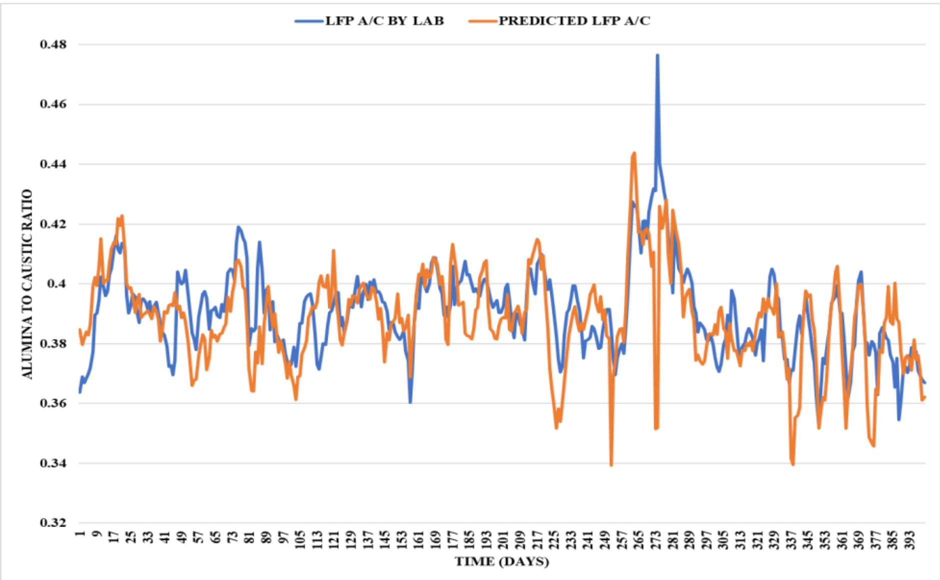

Figure 2. Comparison of the actual versus predicted LFP A/C ratio.

5. Conclusion

Linear regressions can be used to effectively develop tracking and prediction tools for the optimization of the precipitation yield and sizing for refineries in the absence of a simulation software. Due to its user interface, excel is a viable option for maintaining and generating supplemental models for refinery optimization. Baseline tools have been successfully created to support Jamalco's efficiency and quality management systems; the optimization of which will continue to be done periodically. With tools such as these, Jamalco will continue to be in alignment with its commitment to be "*The Best Alumina Producer*".

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6. References

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