Advanced process control application in VM-CBA bauxite digestion unit

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Abstract

Bauxite slurry and heated caustic liquor are fed into digestion reactors for alumina extraction. The main parameter of the reactor output, the A/C (alumina/caustic) ratio is adjusted manually through the bauxite flow, based on laboratory analyses that are made to calibrate the system every two hours. Since many variables interfere in the A/C ratio, such as bauxite and liquor composition and scaling process, the measurements have low reliability, making this control not effective. The current work presents an advanced process control application, based on Fuzzy Logic technology, in a bauxite digester in order to control the bauxite slurry. The software does not require phenomenological knowledge to control the A/C ratio and uses empirical rules to estimate it. By anticipating production variances, the process variability was reduced by 50 %, which saved 3.2 % of the steam used for caustic liquor heating.

Keywords: bauxite digestion, fuzzy logic, advanced process control.

1. Introduction

Companhia Brasileira de Alumínio (CBA), of Votorantim Group, is located in Alumínio, 74 km from São Paulo city, and it is the biggest integrated aluminium plant in the world. CBA started to operate in 1955 and it belongs to Votorantim Metais, leading Brazilian producer of primary aluminium, which is part of the Votorantim Group, one of the largest Brazilian conglomerates operating in the industrial market segment. The aluminium production capacity of the plant reached 0.415 Mt in 2013, by using a traditional low temperature Bayer Process.

The Bayer Process, developed by Karl Josef Bayer in 1888, is used for refining ore bauxite into smelting grade alumina (Al_2O_3) [1]. This process can be divided into two parts, popularly known as red side and white side. To briefly summarize, in the red side occurs the alumina trihydrate ($Al_2O_3.3H_2O$) dissolution in caustic solution and the residue separation of bauxite ore; in the white side occurs the alumina trihydrate precipitation and afterwards the removal of structural water in this hydrate (next step to Bayer Process called calcination), generating the compound known as alumina (Al_2O_3).

Digestion is one of the steps of Bayer Process and in CBA it consists of three series of autoclaves that receive the bauxite slurry and the heated caustic liquor. This equipment promotes the alumina trihydrate ($Al_2O_3.3H_2O$) dissolution of the ore, under high pressure and temperatures close to 418 K, according to Figure 1.

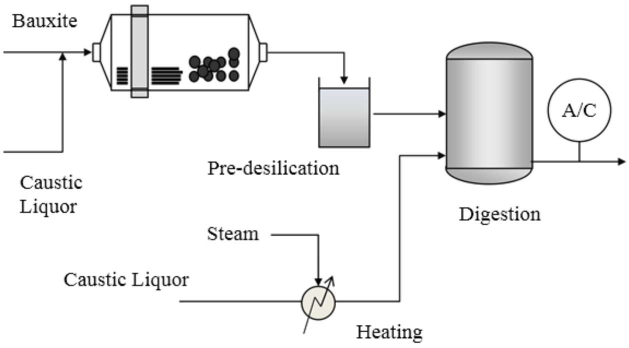

Figure 1. Process diagram of the digestion unit.

The chemical reaction is presented as follows (1):

$$Al_2O_3.3H_2O\ (s) + 2NaOH\ (aq) = 2NaAlO_2\ (aq) + 4H_2O\ (l) \quad (1)$$

The main parameter to be controlled in this process is the A/C ratio (alumina concentration/caustic concentration) in the liquor. Two phenomena happen when controlling the A/C as shown in Figure 2:

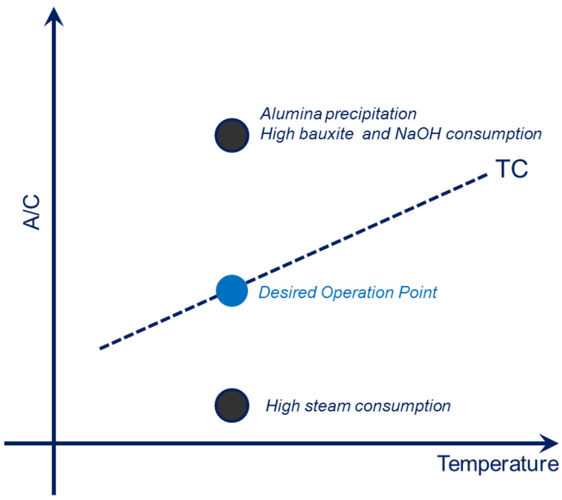

Figure 2. Equilibrium curve to A/C ratio as function of process variables in digestion.

The equilibrium curve shows the desired A/C ratio operation point from the liquor with a known caustic concentration and at a fixed temperature to digestion. Below this curve, it means a high caustic liquor consumption, which results in a higher steam consumption. On the other hand, above this curve, it means a high bauxite consumption, which implies in a higher caustic liquor consumption besides the risk of alumina precipitation in the next steps of the process, which impacts production and raises plant costs.

The A/C control was done manually adjusting the bauxite slurry flow by a control room operator, based on laboratory analysis, whose results are available two hours after the samples are collected. Even more, several process variables influence the Digestion, as slurry and liquor

The same data can be put into a distribution where the damped curve won't be an influence to compare the self-precipitation event. In Figure 11, it is possible to see that Leaf operated closer to the superior limit and within the ideal operation range.

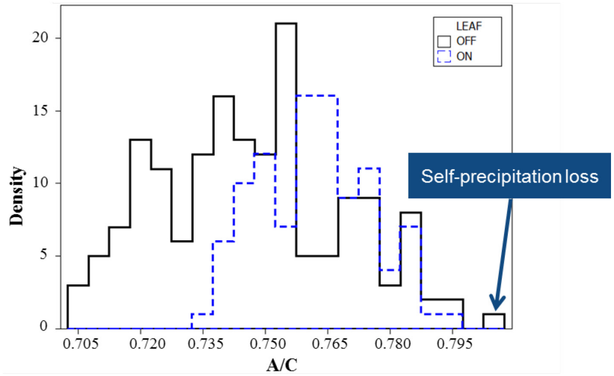

Figure 11. A/C ratio histogram with Leaf on and off.

Meanwhile, with manual operation, data points that indicated a self-precipitation event were collected. Figure 11 also shows that the points collected with Leaf off are more scattered, which is the reason they operated with a lower A/C.

The caustic liquor in circulation decreased with the 2 % increase on the digestion A/C ratio, which implied a reduction in steam consumption of 2 %. On Figure 11, it's clearly possible to observe the productivity gain by increasing and maintaining the A/C ratio stabilized.

The process capability increased from 1.95 to 3.26 after the Leaf implementation. By considering the reduction on steam consumption due to productivity elevation, the potential saving to the company is about U$ 0.4 Million per year, per digestion unit.

3. Conclusion

The operating costs have benefited by the process variability reduction in 38%. This made possible a 2 % reduction of the caustic liquor flow, which implies in steam generation savings and economical gains to the plant.

Another gain is the stabilization of the A/C ratio sent to the white side. It provides a better control for the precipitation, impacting on the precipitation yield and on the final product quality.

Leaf was able to stabilize the operation, achieving a higher A/C ratio always within target safety ranges through precise control of the bauxite slurry flow, replacing the manual one.

4. References

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