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Using a Multivariate Statistical in the Identification of Alumina Loss in Red Mud

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Abstract

The red mud is a residue obtained from the Bayer process for the alumina production and alumina control (gibbsite) present in this important residue, being the limit loss designed is for values below 3.5%. This study used multivariate statistical (Principal Component) to identify the changes of the flow of the plant during the period 2005/2012 that influenced the increase of loss of gibbsite in the red mud residue. This study was conducted in the seven production lines of Hydro-Alunorte, in Pará, Brazil, designed to produce 6.1 million tons of alumina per year. The results confirmed that when the flow of the plant is reduced, there is an increase in the time of contact with the Bayer liquor in decanters and washers, increasing the loss of gibbsite in the red mud. Considering that reducing the flow is a condition inherent to the operation system of a plant, the study recommends adjustments in the routines to reduce operational losses.

Introduction

Bauxite contains aluminium hydroxides in large percentage and is therefore largely used for the production of alumina through the Bayer chemical process, which is based on the reaction with sodium hydroxide under heat and pressure. The overall refining of bauxite to alumina through the Bayer process implies the production of a large quantity of residue is characterized by very high alkalinity called “red mud”. The production of 1 t of alumina generally results in the creation of 1–1.5 t of red mud.

More than 99% of the bauxite residue is thickened in the decanting stage it is very important control logic and operation. The decanter underflow is pumping for washers chain, whose goal is to recovery soda content on mud minimize costs and increase process yeld throgh gibbsite loss decrease on the mud.

Materials and Methods

Process digestion and mud filtration

The digestion step has the purpose of dissolving the alumina contained in bauxite in caustic solution to form sodium aluminate. The area of decantation and washing sludge is intended to separate the sodium aluminate present in the mud by washing counter-current and providing the filtration area with flow and solids within the process specifications.

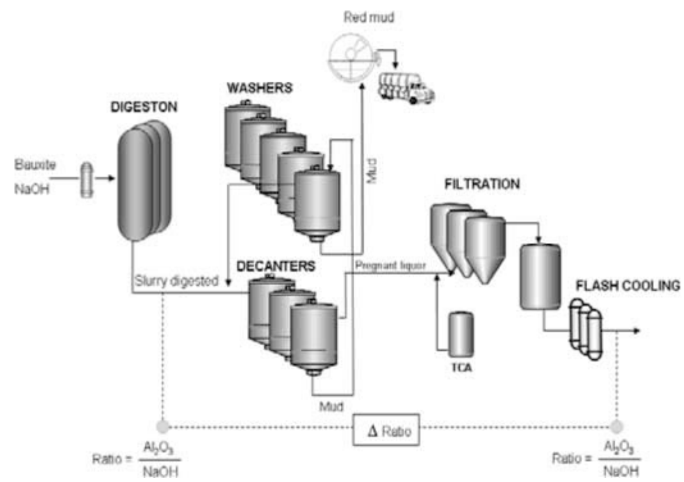

Figure 1. Case Summary

Principal Components Analysis (PCA)

- Explains the structure of variance and covariance of a vector consisting of random variables by constructing linear combinations of original variables called principal components. The goal of principal components analysis is to explain the maximum amount of variance with the fewest number of principal components. Principal components analysis is used in the industries that use large data sets, is commonly used as one step in a series of analyses. You can use principal components analysis to reduce the number of variables and avoid multicollinearity, or when you have too many predictors relative to the number of observations. Figure 2 shows the principle of PCA.

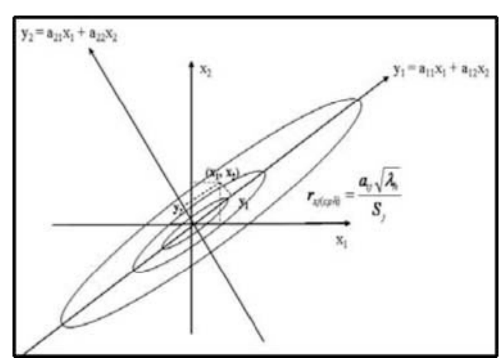

Figure 2. Principle of PCA.

- Whereas the main chemical reaction occurs in digestion, a study of variance and covariance of process inputs (caustic concentration, concentration of alumina, flow and temperature) and the effect on delta ratio. Figure 3 shows the inputs for digestion.

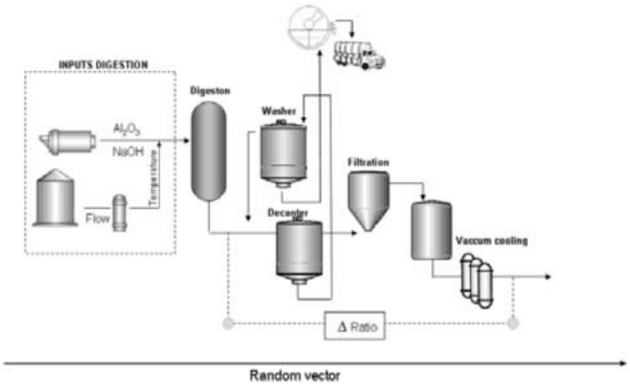

Figure 3. Inputs digestion

Results and Discussion

- The principal component factor 1 is the most important because it explains 63.8% of the variability of the process. In this component, 35.42% of the variability was influenced by the alumina content, 36.34% of the variability was due to the influence of caustic concentration, 27.20% was influenced by the flow of the plant and only 1.02% by temperature. It was expected that the alumina content and caustic strong influence exerted by the characteristic of the process. As the influence of temperature was very small, the study was conducted correlating the plant’s flow with the delta ratio. Figure 4 shows the projections of the variables and factors in Figure 5 shows the contribution of each variable in the factors.

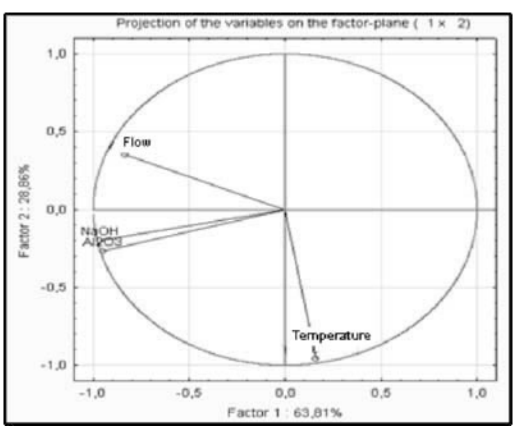

Figure 4. Projection of the variables on the factor

Variable	Variable contrib	
	Factor 1	Factor 2
Al2O3	0,354294	0,063057
NaOH	0,363451	0,034306
Flow	0,272025	0,107414
Temperature	0,010230	0,795223

Figure 5. Variables contribuition

- From the indication that the flow of the plant also affected significantly, this study was conducted variable correlated with the delta ratio for the period 2005 to 2012, , which showed an inverse correlation. With decreasing flow rate was increased delta ratio. The loss of alumina can be measured by increasing the gibbsite concentration in decanters. These conditions can be checked in Figures 6 and 7.

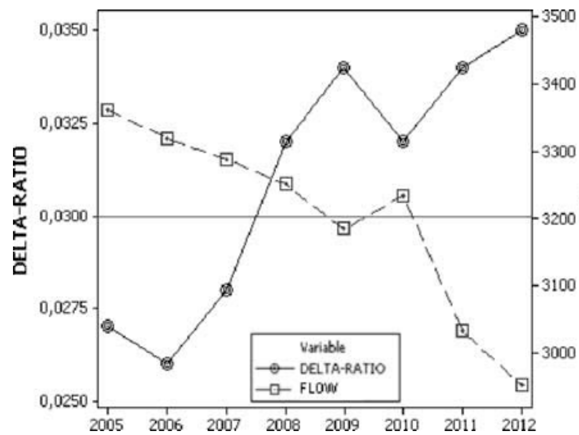

Figure 6. Delta ratio versus flow

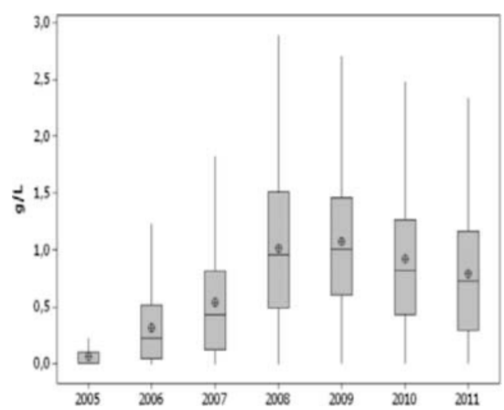

Figure 7. Gibbsite in decanters

- The constant flow reductions caused the increased variability of the delta ratio and consequently a decrease in productivity during the period 2008 to 2010, as shown in Figure 8.

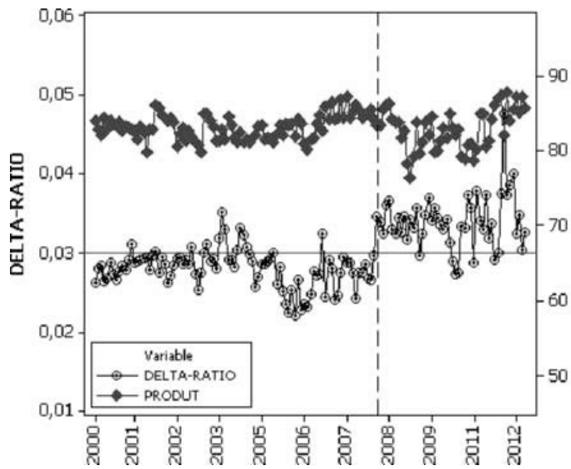

Figure 8. Delta ratio versus productivity

- The response surface plot (Figure 9) productivity associated with the delta ratio and flow, and shows that the region of maximum response (> 86kg / m³) can only be achieved with delta ratio below 0.03 and above flow 3200m ³ / h.

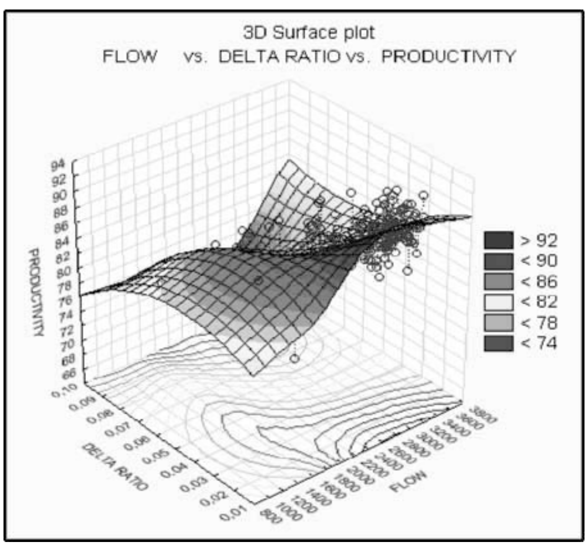

Figure 9. Surface plot productivity versus delta ratio versus flow

Conclusion

- The contanste flow reductions caused the increased residence time of the pregnant liquor in contact with the mud in decanters and washers, which must necessarily correspond to an increased loss of gibbsite and soon, the delta ratio.
- From this evidence, studies will be developed to minimize the effects of flow reductions, considering that it is something inherent in the system of operation of a plant.

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