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STUDY OF INFLUENCES ON THE ALUMINA/CAUSTIC (A/C) RATIO AND DISCHARGE DIGESTION (DBO) CAUSTIC OF THROUGH DESIGN OF EXPERIMENTS (DOE) STATISTIC TOOL

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Abstract

On the digestion stage of the Bayer process occurs the extraction of alumina contained in to bauxite. The Caustic/Alumina ratio determines the extraction efficiency and stability the digested slurry, as the caustic of discharge digestion determines the digestion delta caustic. Through laboratory experiments at Hydro–Alunorte refinery and the DOE, the influences of the input variables of digestion were evaluated and calculated a statistic model to predict the DBO caustic and A/C ratio. The experiments occurred as the same process conditions of the temperature and pressure by changing the following parameters: weight of bauxite, caustic and temperature digestion, time reaction, CaO and moisture in bauxite, the permutation of these variables totaled 128 reactions. The studies of influences results affirm that the digestion caustic and weight of bauxite are variables of major influence on the A/C ratio and DBO caustic. The statistic model allowed for better monitoring of these variables

Introduction

The Bayer process is responsible for the production of alumina, which is the main material for production aluminum metal. The digestion stage of the process, is responsible for the dissolution of alumina contained in bauxite, this dissolution occurs by adding caustic soda and under certain conditions of temperature and pressure and continued agitation. The alumina/caustic ratio and discharge digestion caustic, are important controls parameters on digestion, where from these is possible determinate the extraction efficiency, stability of the slurry and the digestion delta caustic. The control of alumina/caustic ratio and digestion discharge caustic has high variability because the dynamic process of digestion and the high oscillations of the variables that have a direct impact on your results.

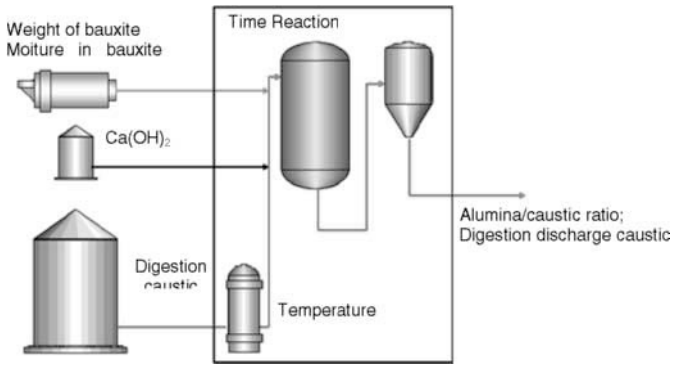

Figure 1 – Digestion process.

The objective of this paper is to conduct a statistical study of influences in order to measure quantitatively the impact of each input variable in alumina/caustic ratio and discharge digestion caustic through the DOE statistical tool, which can be defined as a technique for planning experiments that allows us to define what data, in what amounts and in what conditions must be sampled during a given experiment, basically seeking the largest possible statistical accuracy in response.

Materials and Methods

Initially the input variables of the process were elected, which were: weight of bauxite, caustic and temperature digestion, time reaction, CaO and moisture and their levels of variation.

Table 1 – Variables and theirs variation level.

Factors	Variation Level	
	+	-
Temperature (°C)	150	120
Time Reaction (min)	90	30
Weight of Bauxite (g)	6	3
Digestion caustic (gpl)	315	250
Weight of Cao (g)	0,00936	0,0117
Moisture in bauxite (%)	15	7

With the definition of the input variables was performed a factorial design of experiments, where the permutation of these 6 variables totaled 128 experiments (considering duplicate). The experiments occurred on the HYDRO ALURNORTE laboratory in digesters vessel under the same conditions of temperature and process pressure.

(a) (b)

Figure 2 – (a) Digester block. (b) digesters vessel

After experiments a statistical model was create for predict the alumina/caustic ratio and digestion discharge caustics values, based on teoric model (picture 3).

$$y_{ijklmn} = \mu + \alpha_i + \beta_j + \tau_k + \lambda_l + \phi_m + \psi_n + (\alpha\beta\tau\lambda\phi\psi)_{ijklmn} + \varepsilon_{ijklmn}$$

α_i = Temperature efect

β_j = Time reaction efect

τ_k = Weight of bauxite efect

λ_l = Digestion caustic efect

ϕ_m = Weight of CaO efect

ψ_n = Moisture in bauxite efect

Figure 3 – Estastical teoric model.

Results

Alumina/Caustic Ratio

The results obtained for the laboratory experiments, showed that for alumina/caustic ratio the factors that exercise majors influences are: weight of bauxite and caustic of digestion.

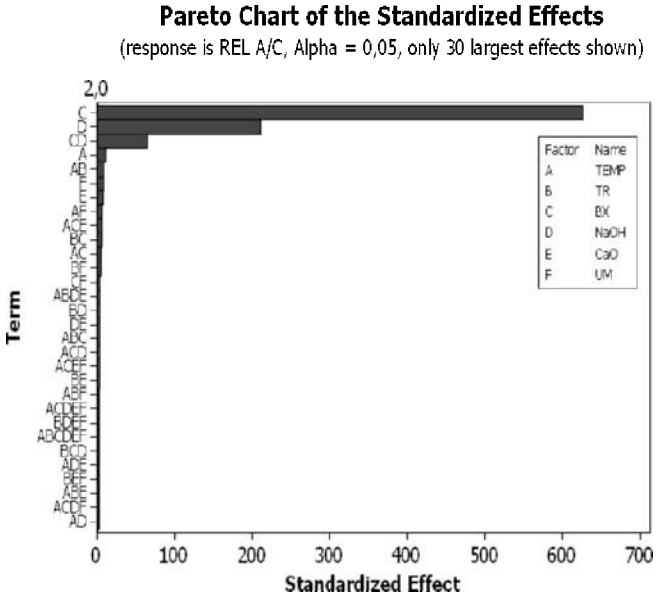

Figure 4 – Board of influences on the alumina/caustic ratio.

The results were accord with expected, the alumina/caustic ratio is high dependent of the weight of bauxite, and this can be explained through the mass balance. The digestion discharge caustic is the second variable of major influence on the alumina/caustic ratio, and this can be explained because the extraction reaction of alumina occurs by caustic liquor addition, which depending of your concentration can benefit or disadvantage. Other variables don't have high influences, but called attention to the large number of interactions between variables exerting influences, because it blocks all together, now have a significant. The Figure 5, show the influences of each variable on the alumina/caustic ratio.

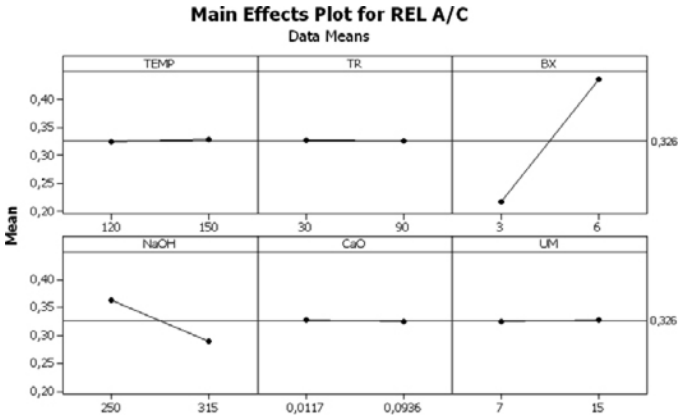

Figure 5 – Influences of each variable on the alumina/caustic ratio

The conclusions obtained through influences studies allowed the create of statistical model can predict the alumina/caustic ratio values, the model take into consideration the weight of each variable singly and combined. The statistical model can be showed on the Figure 6.

y = 0,32628+0,00201A-0,00033B+0,10974C-0,03698D-0,00122E+0,00143F+0,00146AB+0,00079AC
+0,00038AD-0,00115AF+0,00097BC+0,00069BD+0,00057BE-0,00078BF-0,01135CD+0,00075CF
+0,00068DE+0,00064ABC+0,00040ABE+0,00052ABF-0,00061ACD-0,00106ACE+0,00044ADE
+0,00048BCD-0,00036BCF+0,00038BD+0,00041BEF+0,00037ACF+0,00071ABDE-0,00040ACDF
+0,00061ACEF-0,00049BDEF+0,00050ACDEF-0,00048ABCDEF

A = Temperature, B = Reaction time; C = Weight of bauxite
D = Digestion Caustic, E = Weight of CaO; F = Moisture in bauxite

Figure 6 – Statistical model create for predict alumina/caustic ratio values.

Digestion discharge caustic

For digestion discharge caustic, the results concluded that the factor that has major influences are: digestion caustic and weight of bauxite, according with showed on Figure 7.

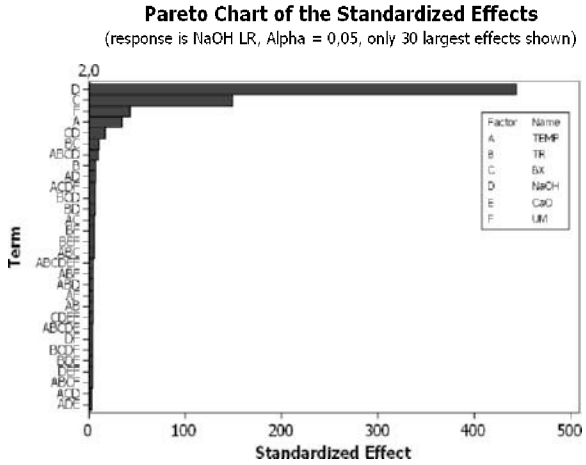

Figure 7 – Board of influences on the digestion discharge caustic.

According with expected, the major influence variable on the digestion discharge caustic are the digestion caustic, which as for alumina/caustic ratio can be explained through the mass balance. The weight of bauxite has the second major influence variable, because the alumina dissolution need consume caustic. Singly the moisture in bauxite showed significant influence, because the water consume caustic. As the same occurs on the alumina/caustic ratio, the large number of interactions between variables exerting influences, because it blocks all together, now have a significant. The Figure 8, show the influences of each variable on the digestion discharge caustic.

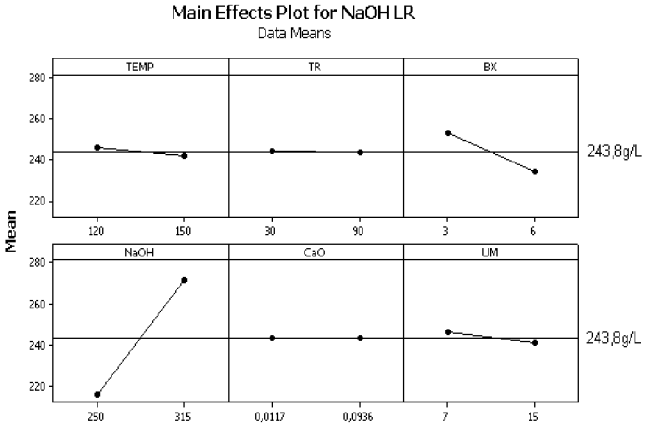

Figure 8 – Influences of each variable on the digestion discharge caustic.

The conclusions obtained through influences studies allowed the create of statistical model can predict the digestion discharge caustic values, The statistical model can be showed on the Figure 9.

y = 243,787-2,157A-0,459B-9,441C+28,084D+0,016E-2,685F-0,255AB+0,337AC-0,448AD-0,177AE+0,262AF-0,565BC-0,362BD+0,320BF-1,041CD-0,223DF-0,302ABC-0,265ABD-0,274ABF-0,188ACD+0,179ADE-0,371BCD+0,196BDE+0,163BCF-0,316BEF+0,154CDE-0,140CEF-0,193DEF

A = Temperature, B = Reaction time; C = Weight of bauxite
D = Digestion Caustic, E = Weight of CaO; F = Moisture in bauxite

Figure 9 – Statistical model create for predict digestion discharge caustic values.

Conclusions

For alumina/caustic ratio the majors' influences variables were weight of bauxite and digestion caustic. This model was measured with projects data's and the difference between the project value and the calculated value was 0,004. The model is being tested in plant.

As the same for digestion discharge caustic the marjor's influences variables were weight of bauxite and digestion caustic, and was measured with projects data's and the difference between the project value and the calculated value was 4 gpl and is under rating on plant.