Artificial Intelligence for Gibbsite Crystallization Control at CBA

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Abstract

Industry 4.0 is a new era in the context of major industrial revolutions. It encompasses the main technological innovations in the fields of automation, control and information technology, simulation, big data and Internet of Things applied to manufacturing processes. Several changes are taking place in the industrial processes, having impacts in all market sectors. The impacts of Industry 4.0 on productivity, cost reduction, employee safety, control and optimization over the production process, among others, boost company's competitiveness by improving machine efficiency, reducing maintenance costs, reducing energy and raw material consumption, as well as improving product quality.

In this context, one of CBA's focuses is the development of artificial intelligence models. The aim is the reduction in process variability and the improvement on the produced alumina granulometry. An AI model was created to predict the hydrate precipitation process behavior. The paper presents the implementation of the AI model on the CBA precipitation process, the utilization of this tool in the daily routine of process engineering and the main results on process control and alumina quality.

Keywords: Artificial Intelligence, Industry 4.0, Gibbsite Crystallization, Hydrate Precipitation.

1. Introduction

Gibbsite crystallization is a process widely studied in universities and research centers around the world, reflected in the great number of patents since Bayer process beginnings. Today, it exists in more than a hundred refineries with different production capacities that vary from 0.1 to 6.4 million tonne per year. The residence time of the crystallization process ranges from 30-100 hours, where high yields are required to justify economic viability. To produce standard quality alumina with high plant yields is a challenge to every refinery, according to Stamatiou et al[1]. In this context, process modelling with computational resources are important tools for process control.

1.1 Gibbsite Crystallization in the CBA's Alumina Refinery

Pregnant liquor (PGL) from the Heat Interchange Departments (HIDs - stage responsible for cooling the red side liquor) flows to the agglomeration tanks where fine aluminum hydroxide seed is added. After this stage, the liquor and agglomerated solids flow to the growth stage, controlled to target temperature by cooling systems, called ISCs (Interchange Stage Cooling) composed of flash tanks, barometric columns and cooling towers. The growth tanks also receive coarse seed from the classification system. The resulting suspension is pumped to the last growth tanks in the chain, without seed addition and later to the hydrocyclone classification system.

The first hydrocyclone clusters separate the final product from the seed which, in turn, are separated between fine and coarse seed by new hydrocyclone batteries. Both product and seed are filtered to recover liquor, while the product is then sent to calciners, the fine seed to the agglomeration tanks and the coarse seed to the growth tanks. The precipitation and classification system at CBA are illustrated in figure 1.

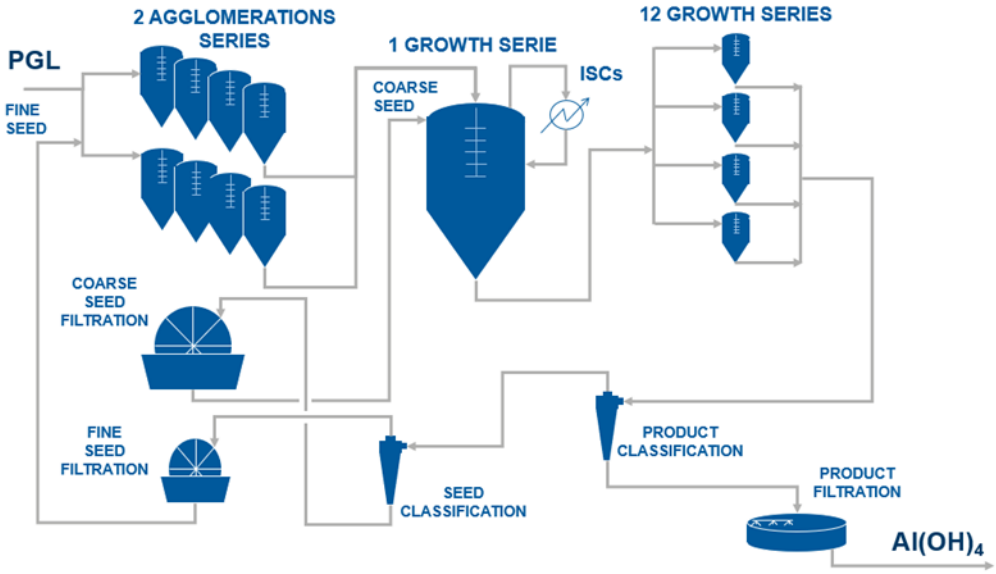

Figure 1. Flowsheet of the CBA precipitation process.

There are a total of 75 tanks. Ten (10) of these tanks are agglomeration tanks divided into 2 parallels series. The agglomeration tanks feed a series of 7 growth tanks connected to ISCs and 12 parallels series of 58 growth tanks. The total operation volume varies between 55 000 and 65 000 m³. In these tanks, aluminum hydroxide is crystallized through the chemical reaction as follows:

$$Al\,(OH)_4^- + 2Na^+ \xrightarrow[Cooling\;+\;Seeds]{} Al\,(OH)_3 + 2\,NaOH$$

This is the main reaction responsible for plant yield, alumina strength and quality indicators. The reaction occurs through three mechanisms: nucleation, growth and agglomeration.

There are different kinetics for the three mechanisms. The aluminum hydroxide solubility in the liquor (dependent on the dissolved chemical species) and all the process parameters to be controlled including temperature and solid concentration profiles make the crystallization process very complex.

1.2 Artificial Intelligence (AI)

To model the chemical process is a challenge faced by every hydrometallurgical plant, and in the context of industry 4.0, new applications are emerging. The artificial intelligence models problems through nonparametric algorithms using a method known as machine learning. It

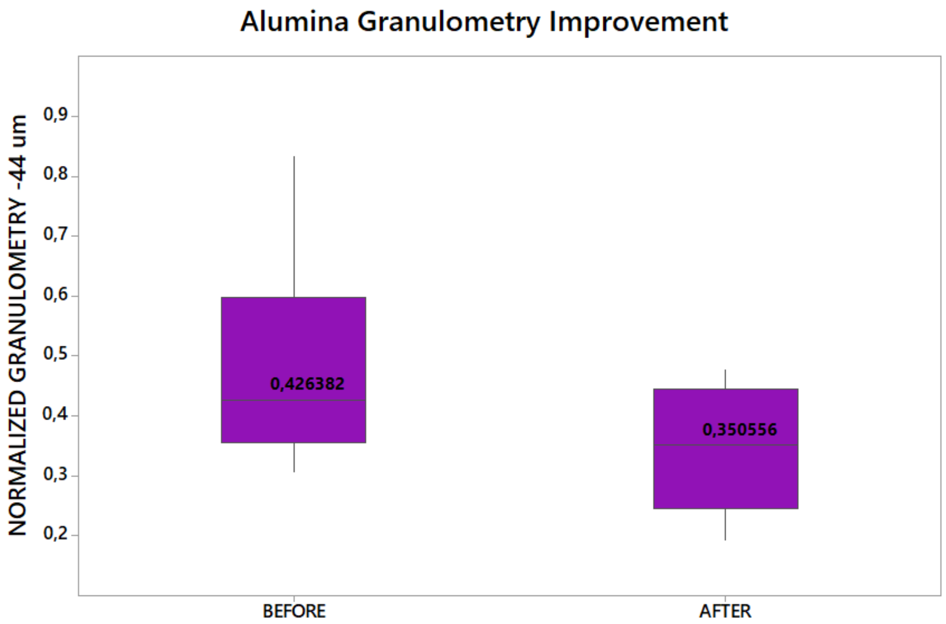

Figure 5. Boxplot of alumina normalized granulometry improvement with artificial intelligence application

Alumina attrition index showed an improvement of 12%, indicating a better efficiency in the agglomeration control in crystallization, while the alumina granulometry in the -44 µm sieve showed improvement of 30% and more than 10% in process variability, indicating a much better control of the entire crystallization process.

4. References

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