Statistical Analysis of Aluminate Liquor Precipitation Process with Statistica: Classic and Modern Data Mining Methods

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Abstract

In the paper, a review of the application of modern and classic statistical methods for analysis of precipitation process of aluminate liquor is carried out. It is known that this process is highly inertial, characterized by significant variation and depends on many factors that affect the product quality. The review is using both classic and modern analysis methods of aluminate liquor decomposition on seed comprising neural networks and CART models (classification and regression trees), etc. Predictors in the studied models are: aluminate liquor flow, concentration of caustic soda, seed concentration, temperatures in a precipitator, etc. The target variables are content of aluminum hydroxide fractions - 5, - 20, - 45, +150 um after hydrocyclone. The paper compares the accuracy of models: classic regression, CART models, artificial neural networks. The viability of the methods for solving real production problems is demonstrated. The study was performed with Statistica 13 RU software.

Keywords: precipitation, aluminate liquor, statistical analysis, machine learning.

1. Introduction

One of the stages of alumina production is decomposition of a metastable aluminate liquor to produce aluminum hydroxide.

At Russian alumina refineries processing boehmite - diaspore raw materials, the process of crystallization is forcibly carried out at a high A/C ratio, reaching 1.65 - 1.71 units. Besides, the inability to significantly affect particle size distribution of crystals by controlled agglomeration leads to strong oscillatory fluctuations in PSD of the resulting product - the content of " - 45 μm" fraction can vary from 5 to 50 % within 3 - 4 months.

An example of the precipitation train used as the object of the study is presented in Figure 1. The flow of aluminate liquor and the seed flow are fed into the first tank of the precipitation train. As it passes through precipitators, the temperature of slurry is reduced resulting in crystallization of aluminum hydroxide. At the outlet of the last tank, crystals of aluminum hydroxide are classified in hydrocyclones. Spent liquor is separated from solid phase by filtration and removed. Coarse crystals after the hydrocyclone are removed from the process. The collected fine fraction is recycled to the first precipitator as a seed and reslurried with a flow of fresh undecomposed liquor.

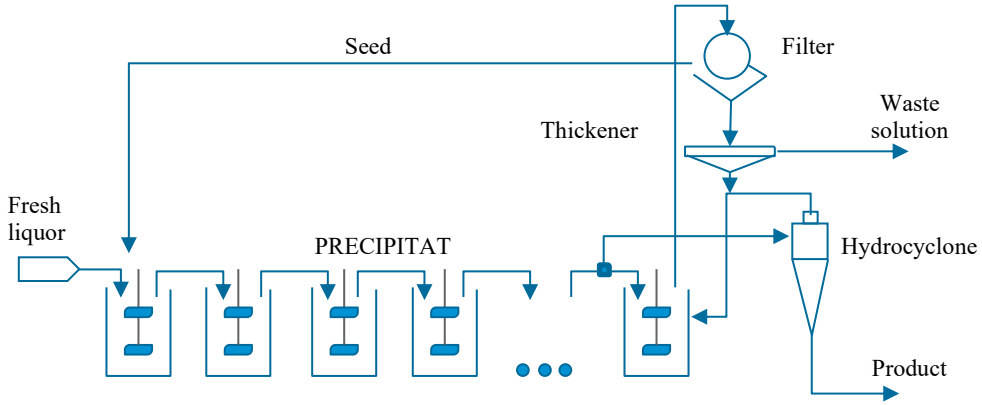

Figure 1. Flowsheet of precipitation process.

The process of precipitation is highly inertial, since the seed flow exceeds the flow of product by tens of times. However, at the same time, it is affected by numerous disturbing factors, such as: fluctuation in composition of aluminate liquor, ambient temperature, seed reactivity, etc. The process control can be implemented by changing aluminate liquor flow, seed concentration, temperature of the head and tail precipitators, profile of temperature variations by precipitators, pumping seed from other precipitation trains and sites.
So, along with the cyclic character of precipitation process, periods of instability is recorded with their amplitude of fluctuations (Figure 2).

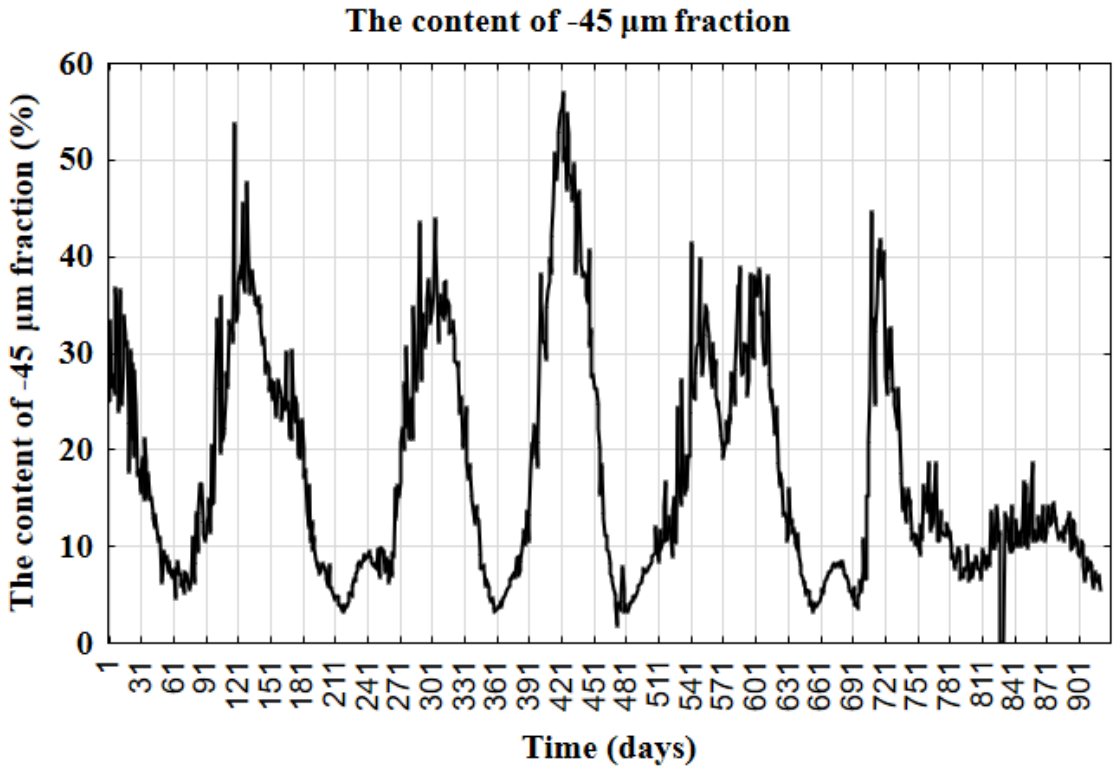

Figure 2. The content of -45 µm aluminum hydroxide fraction in the last precipitator.

To develop measures that allow to stabilize size distribution, it is necessary to have an idea of its change in the future. Today at Russian alumina refineries a forecast of this kind is carried out

4. Conclusion

The study examined both linear and non-linear dependency models:

- Multiple linear regression,
- Tree CART,
- Artificial neural networks.

An analysis of the factory data of precipitation stage showed that non-linear Data Mining methods allow building models with high accuracy to predict the target characteristic - the content of - 45 μm aluminum hydroxide fraction.

Thus, these methods can be considered promising for solving the problem of control and stability of size distribution of aluminum hydroxide product: using the obtained forecast model, having solved the optimization problem, it is necessary to calculate preliminary the volume of hydrate output per day and the values of other controlled factors of the process to obtain the desired response.

Data Mining methods have also proven to be good in solving the problems of various industries, both non-production and production. We give examples of such problems from ferrous metallurgy:

- Prediction of mechanical properties and optimization of chemical composition of metal,
- Identification of causes and prevention of defects of various origin,
- Statistical product quality management.

5. References

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