LIBS – An Emerging Technique of Real-Time Elemental Analysis for Process Control in Alumina Production

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Abstract

Currently the aluminium industry faces many challenges as it must deliver premium quality products for a competitive price while minimizing CO_2 emissions at the same time. Addressing these challenges is not possible without knowing the composition of raw and intermediate materials in the production process, ideally in real-time or near real-time. Traditionally prompt-gamma neutron activation analysis (PGNAA), X-ray fluorescence (XRF) and X-Ray diffraction (XRD) techniques have been used to get insight into mineral, chemical and elemental composition. The drawback with these techniques are harmful gamma, neutron, X-Ray radiation, high operational expenses, a need for frequent recalibration and limited analytical capabilities. This has lead to the emergence of the modern LIBS (Laser Induced Breakdown Spectroscopy) technology. Modern LIBS analyzers are completely safe, cost-effective, easy to maintain, and capable of analyzing both light and heavy elements. These instruments run 24/7/365 without additional recalibration and generate elemental composition data in real-time without any sample preparation directly on the conveyor belt or slurry pipes. With real-time data, it's possible to reject low-grade ore, blend different grades of bauxites, make real-time dosages of lime and sodium hydroxide, as well as to provide quality control of the final product. To ensure stable and accurate measurements in real-time, we use different chemometrics and machine learning optimization approaches. Traditional calibration methods provide rather poor results for real plant operation, where many other factors influence the results (i.e. variation in grain size and shape, density, moisture, material height on the conveyor belt and etc.). A range of comprehensive spectra filtration, normalization and advanced machine learning techniques were studied and implemented into our specialized software which provided good correlation with laboratory analysis data.

Keywords: LIBS, Online analysis, Bauxite, Alumina, Machine learning.

1. Introduction

Modern society is becoming more and more conscious of environmental protection and responsible companies strive to reduce waste streams, CO_2 emissions and energy consumption. Many of the efforts to *greenify* the production process require considerable investments and are hampered by the market demand for the supply premium quality products at a competitive price. Addressing these challenges is challenging without knowing the composition of raw and intermediate materials in the production process in real-time.

The chemical composition and mineralogy of bauxite ore vary from different mines or even different parts of the mine, open casts and storage. The presence of impurities such as silica, iron oxide and titanium in the bauxite ore, which is the main raw material used in the aluminium industry, not only influences its subsequent processing but also can increase production costs and compromise the quality of the final product, besides causing environmental pollution.

With real-time data, it is possible not only to reject low-grade ore, properly blend different grades of bauxites, but also to make real-time dosage of sodium hydroxide and lime and control the quality of the final product.

Growth in the global alumina supply and the tendency to extract lower grades of bauxite in the future will only increase the demand for reliable tools for real-time analysis that will provide the data required to control and remove impurities, make prompt corrections in the process without the need to wait several hours for lab results.

It is possible to solve these problems by sorting the raw materials by grades, including the rejection of the material unsuitable for a specific application, and by well-grounded adjustment of the processing parameters based on real-time information on the chemical composition of the material streams. This adjustment can be applied at all the production stages – from minerals survey, extraction, beneficiation and up to preparation of mixes with the pre-set composition and prompt automatic adjustment of the technological parameters.

In most cases, information on the chemical composition of materials on conveyers after extraction, crushing and blending that is required for the process control, averaging of stockpiles, batching of mixture components, becomes available to process operators only after several hours or the next day or after sampling. For large-tonnage production, such information delays significantly influence the impact of process control approaches. Besides, the precision of the information received is not always high enough, due to the complex procedures required to ensure the representativeness of the samples and their preparation for laboratory analysis.

2. Application of Online Analyzers for Alumina Production

The lack of uniform quality bauxite is an ongoing challenge for many alumina refineries. Bauxite ore consists of different minerals with silica, iron oxide and titanium as the major impurities. The proportion of the minerals varies depending on the bauxite source and sometimes within the same source.

Impurities contained in the bauxite are one of the major reasons for inefficiencies in the Bayer process. The caustic soda used in Bayer liquor is a critical raw material, having a significant influence on total operating costs in an alumina refinery. Its consumption largely depends on the composition of the bauxite that is used in the process and the chemistry of the desilication product as the result of digestion. The maximum concentration of silica in the final product is also strictly controlled due to its negative influence on the quality of the final product.

Online analyzers can provide a chemical composition and thus means for more accurate process control for process engineers in real-time (Figure 1).

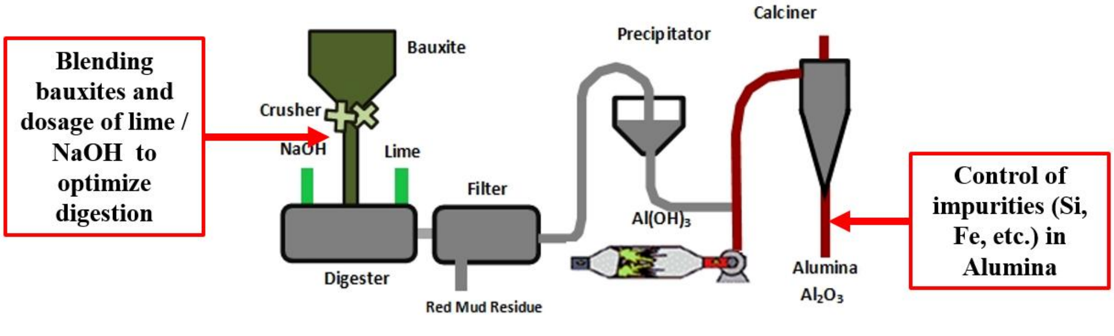

Figure 1. Possible points for online analysis.

commissioning period and vary depending on the material supply with different chemical and mineralogical compositions, variations in density, particle size distribution, moisture and temperature.

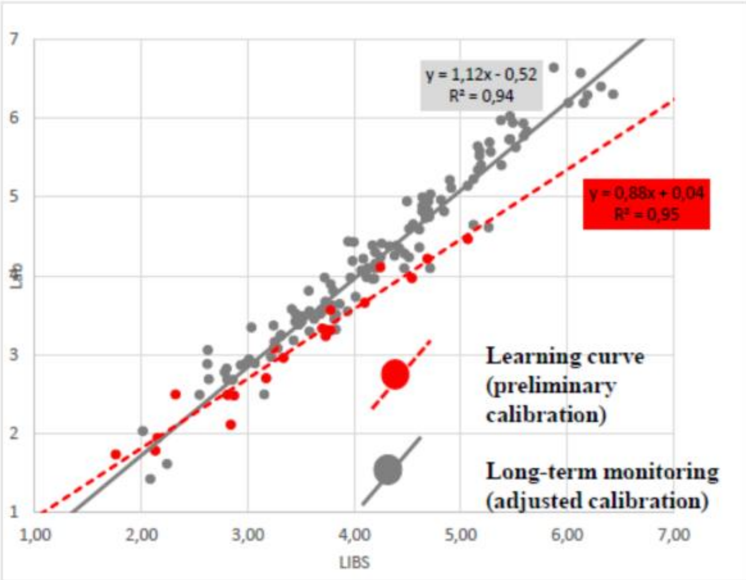

Figure 11. Long-term calibration.

Our experience shows that in order to get a stable algorithm that can work for a long period, the user of the system needs to carefully monitor the readings of the analyzer for several months after the commissioning and, if necessary, add new calibration samples to the calibration algorithm to take into account the factors described (Figure 11).

6. Conclusions

It has been demonstrated that LIBS analyzer technology is well suited for the online analysis of bauxite and alumina without any sample preparation for real time process control. Both major and minor elements and impurities – Al, Si, Fe, Mg, Ca can be identified and quantified with a high level of confidence. Safety, low cost maintenance and excellent analytical performance of LIBS analyzers make it advantageous against traditional techniques like PGNAA, XRF or XRD. Further installation of online analyzer for real time control of blending of bauxite ore, lime dosage or quality control of final product should follow.

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