Bauxite Mill Charge Control Based on Vibration Signal and Computer Vision

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Abstract

Grinding is one of the crucial processes in alumina production, and its stability and quality directly influence the extraction of the useful component (alumina) from bauxite ore. In order to ensure stable grinding conditions, it is necessary to maintain the optimum slurry filling rate, solid phase content in the slurry, and the number and size of grinding media in the mill. Stabilisation of the ore grinding conditions enables to improve the fractional composition of the ore in the product from the area, increase the area capacity, reduce specific energy consumption, and optimise the overhaul period of the mill lining. Since the raw materials may vary in particle size distribution, composition and other parameters affecting grinding, it is not possible to control the mill filling level sufficiently accurate with the slurry directly by using ore and liquor feed flow meters only. One of the ways to indirectly assess the degree of mill filling is to analyse the vibrations that occur when grinding media and material fall inside the mill. This method analyses the spectrum of the signal from vibration sensors and builds a mathematical relation between the resulting value and the level of mill filling. RUSAL Engineering and Technology Centre (RUSAL ETC) has developed a system that includes models for classifying mill feed ore by fractional composition, feed ore throughput, and identifying non-ore materials using computer vision methods. The paper presents the results of the application of the bauxite mill charge control system on one bauxite-lime grinding unit of RUSAL Krasnoturyinsk and its impact on the process performance indicators. The mill charge control system based on vibration signal and computer vision can be applied at almost every alumina refinery both in the ore grinding area and in coal mills; moreover, the system can be applied at beneficiation plants where various wet and dry grinding systems are used.

Keywords: Ball mill, Grinding, Vibration analysis, Computer vision, Advanced process control.

1. Introduction

Drum mills are extensively used for fine grinding of materials in various industries. In terms of structure, they consist of a hollow cylindrical or cylindrical-conical drum closed by end covers. Trunnions carried by bearings are attached to said covers. Rotation of the drum ensures grinding of the material due to the colliding, crushing and abrading impact of the grinding media, which allows achieving fine grinding [1].

The grinding is of key importance in alumina production, where it is necessary to obtain finely dispersed raw materials such as bauxite or nepheline for further processing into alumina by the

Bayer or sintering process. The fineness of the grind directly affects the efficiency of chemical reactions, namely the degree of aluminium extraction from the ore in digestion.

The grinding can be dry or wet. Dry grinding is effective for fine grinding of large grains; while wet grinding is used to obtain finely dispersed and ultrafine disperse fractions [2].

At RUSAL Krasnoturyinsk, wet grinding is used for fine grinding of the bauxite-lime mixture mixed with the evaporated spent liquor. The mixture is ground in two stages in single-chamber ball mills with slurry classification in hydrocyclones (HC). High-quality mechanical grinding of the ore and dosing of alkali to the slurry provide for efficient extraction of alumina in digestion. Figure 1 shows the process flow diagram of grinding the bauxite-lime mixture at RUSAL Krasnoturyinsk.

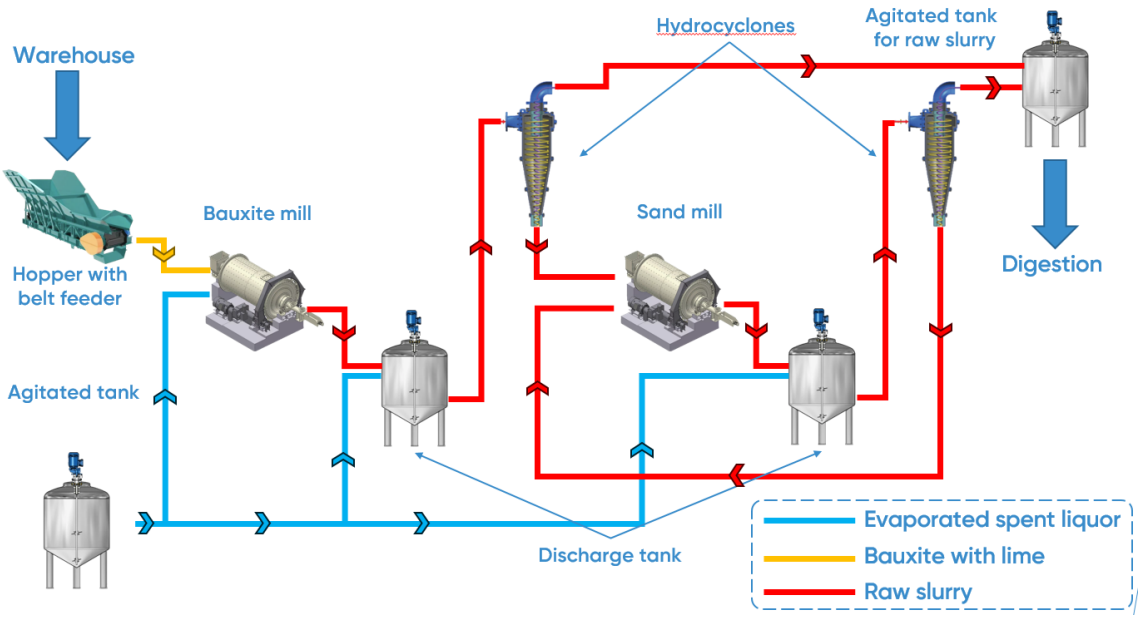

Figure 1. Process flow diagram of grinding the bauxite-lime mixture at RUSAL Krasnoturyinsk.

Presently, at RUSAL Krasnoturyinsk the level of the mills filling in the wet grinding area is determined by listening the sound of the balls hitting the mill lining. There is no weight measuring equipment on the mill feeder; therefore, the bauxite feed mass flow rate is calculated using a formula that depends on the speed of the belt feeder, the bulk density of the bauxite and the cross-sectional area of the bauxite layer on the belt feeder. The bulk density and the cross-sectional area of the bauxite layer on the belt feeder are entered into the calculation formula as constants. There are no systems for in-process quality control of the ore supplied to the area from crushing (size of the supplied ore, presence of non-metallic inclusions); there is no system for detecting ore congestion in bunkers and clogging of the mill chute when bauxite stops flowing into the mill. All these factors do not allow for effective control of the ore grinding process in the wet grinding area [3].

Currently, vibroacoustic sensors area available in the market for measuring the level and amplitude of the spectrum of signals from the mill during its operation, for example, Bruel & Kjaer (Denmark), ViKont (Russia), GlobalTest (Russia), Ronds (China), but they cannot be used without a mathematical model to show the correlations between the vibration energy of mills and the quality of ore grinding.

These properties of the system allowed achieving the following performance indicators of the mills in the wet grinding area at RUSAL Krasnoturyinsk:

- The fineness of the raw slurry grinding was maintained within the regulatory values, increasing the share of the minus 0.056 mm fraction in the overflow of the HC of the 1st and 2nd classification stages by 1.1 % and 6.6 %, respectively, and decreasing the share of the + 0.16 mm fraction at the 2nd stage of the HC by 2.4 % as compared with the period of operation in the manual mill charge control mode.
- The standard deviation of the α_k of blow-off slurry from the target value (1.63 units) was reduced by 14 %.
- The increase in alumina extraction by 0.2 % was confirmed due to the stabilization of modes and the reduction of process disruptions in the grinding of bauxite-lime charge in wet grinding. This leads to a reduction in the specific consumption of bauxite and alkalis in alumina production.

The mill charge control system has been implemented at four mills and is recommended for testing and implementation at other RUSAL's refineries.

6. References

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