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MEASURES TO PREVENT BAKED ANODE DENSITY DROP WHEN USING HIGH POROSITY COKES

[1]Vinicius Piffer; [2]Chin Woo; [1]Fabiana Nicéas; [1]Rafael Bacelar; [1]Jeronimo Araujo; [1]Leonardo Paulino
[1] Consorcio de Aluminio do Maranhao (Alumar), BR 135, Km 18, São Luis, Brazil, Zip code 65065-604
[2] Alcoa Inc, 1200 Riverview Tower, 900 S Gay St. Knoxville, TN 37902, USA

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Abstract

In the last years, coke quality has been deteriorating throughout the world. One of the most affected properties is the coke porosity, commonly measured by the Vibrated Bulk Density (VBD). It is well known that the drop in VBD has a direct impact in the Baked Anode properties, especially Baked Apparent Density (BAD). This paper describes some measures taken at Alumar Smelter that enabled the BAD to be kept constant when using low VBD cokes.

A complete analysis of the system was carried out and several aspects were considered as potential for improving density. The most significant being the changes made in the fines fraction and optimization of mixing and forming. Whenever applicable, anode properties were compared before and after the changes, in order to estimate each action impact.

Introduction

With a production capacity of 440,000 MT / yr, Alumar is one of the major smelters in Latin America. From the start-up until 2005, the Electrodes Department, responsible for the anodes manufacturing, had always used coke from a single supplier. However, as the coke market grew tighter, it became extremely difficult and expensive to continue with the single supplier strategy: Very few had the capacity to fully supply Alumar coke demand. Therefore, in 2005 the Blending Facility project was implemented and Alumar started using two coke suppliers simultaneously [1].

Typically anode paste plants use coke in three different granulometry levels, in order to achieve the best particle packing and therefore the highest density. The blending facility in use at Alumar enables the different cokes to be blended after the granulometric classification, which allows process engineering to choose coke ratios in each granulometry level. This way, the strong aspects of individual cokes can be used to maximize the quality of the blended material.

Historically, Alumar Paste Plant has always used the coke vibrated bulk density (VBD) as a main process parameter to calculate the optimal pitch content that should be added to the formulation. It is used as an indirect measurement of the coke porosity. Different methods can be used to measure the coke VBD, the most common being ASTM D4292 and ASTM D7454. Some papers [2] [3] have been published comparing the methods and analyzing the repeatability of the tests. Alumar has always used D4292, analyzing samples before and after the coke has passed through the Hammer Mill.

In order to evaluate the fineness of fines, Blaine analysis is used. At Alumar, the Ball Mill product is mixed with coke dust from the exhaust system and is considered the fines fraction. It is important to know how fine the material is, since this fraction constitutes more than 80% of the total aggregate surface area and largely dictates the optimum pitch requirement.

Alumar Paste Plant uses batch scales, pre-heaters and mixers. There are 5 batch scales that are used simultaneously for production, one for each raw material (coarse coke, intermediate coke, coke fines, butts and pitch). The coke fractions and butts are weighed and sent to the same bin, from where it is transported to an electrical batch pre-heater. Eight pre-heaters and eight mixers are used to meet the paste tonnage required for the anodes production. Figure 1 shows a simplified design of Alumar equipment and material flow.

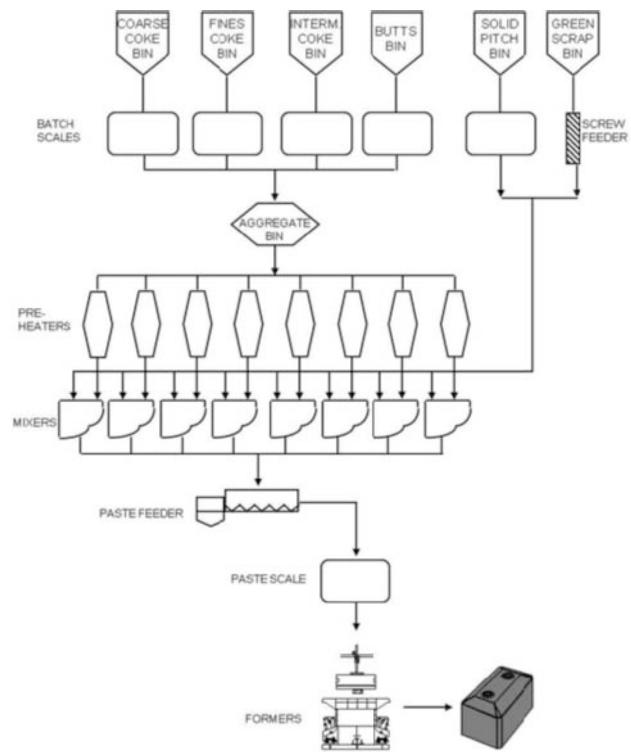

Figure 1. Alumar production process design and equipments

The mixers used at Alumar are sigma blade batch mixers. This type of mixer requires a longer time for mixing to achieve the same quality as in continuous / intensive mixers. Two other factors make the mixing quality yet more difficult: the use of solid pitch and the absence of a mixer/cooler downstream. The solid pitch will consume some extra minutes to melt and reach the viscosity needed to wet the coke surface. The mixer/cooler would enable the mixing temperature to be increased, which would certainly help to reduce mixing time and achieve a better mixing quality. After the mixers, the material is conveyed to the formers, where it is compacted and obtains the shape and dimensions required by the pot design. Alumar uses two vibro-formers with air bellows in the cover weight.

Optimize Use of Blending Facility

The first measure used at Alumar to react to low VBD cokes was the optimization of the Blending Facility. As a rule, cokes with higher VBD are used in the coarser fractions and cokes with lower reactivity are used in the fines fraction. However, the drop in VBD of suppliers previously considered as "high VBD" led to the need of rules to decide if a supplier should be used for coarse or fines fraction.

The idea of the rules is to assure that the best combined quality of the cokes is used to produce the anodes.

- Compare VBD of cokes and verify if the difference is significant
- If not significantly different, compare cokes for granulometry and reactivity (concentration of Na, Ca, S)
- Use coke with coarser granulometry and higher reactivity.

React to VBD Drops with Fines

In order to reduce the impact of low VBD cokes on Anode density, it is necessary to fill the pores of the coke particles. The common approach is to react to the lower VBD by increasing pitch content, which will melt and fill the pores during the paste mixing. This approach will certainly help to keep the Green Apparent Density (GAD) under control. However, during the anode baking process the pitch volatiles start leaving the anode, creating gaps. If more pitch is added, more gaps are expected, resulting in a poor Baked Apparent Density (BAD).

A different approach is to fill the coke pores with pitch dowsed with small amount of very fine coke particles. These particles will help fill the open pores in the big particles, reducing the amount of pitch required by the anode and, unlike pure pitch; fewer gaps will be left in the anode after baking. According to this strategy, if the VBD of the coarse particles is reduced, the amount of very fine particles must be increased. This can be done in two different ways:

- Increase fines content in the formulation
- Increase fineness of the fines fraction

<u>Increase fines content in the formulation</u>

Increasing the fines content in the formulation will certainly increase the amount of very fine particles, but it will also increase the portion of the fines fraction that is not small enough to fill the coke pores. This will increase significantly the surface area and will require more pitch to wet the entire dry particles surface. This option is much better than simply increasing pitch content, but is only recommended if the plant is at the limit of Ball Mill production.

<u>Increase the fineness of fines fraction</u>

Increasing the fineness of fines fraction will increase the amount of very fine particles while reducing the portion of the fines fraction that is not small enough to fill the coke pores. This will increase the surface area only slightly and will not require additional pitch to wet dry particles surface. This option is recommended if the plant has additional capacity in the Ball Mill. It is strongly advised to review all coke fines production circuit and make sure there is no more room to increase grinding before using the first option.

Mixing and Forming Optimization

Aiming to achieve the best density and minimum variability, trials were carried out to optimize the mixing and forming of the Green Anodes. As mentioned in the introduction, Alumar uses batch pre-heaters and mixers. Preliminary trials were focused on optimizing the paste quality without compromising production. In batch mixers, the batch weight and mixing time combination determines the production rate. The trials enabled changes in the batch weight and mixing time, optimizing performance. Although not shown in this paper, the data showed that optimal performance was achieved with an 8% reduction in the batch weight from the previously selected level.

Another idea implemented was to increase the mixing time of the dry aggregate before adding the pitch. The longer time leads to better homogenized dry aggregate, reducing the chance of forming pitch balls.

Experimental

The effectiveness of the measures to counteract the VBD drop was evaluated on the daily samples and routine analysis of anode properties. Specific production periods of 5 consecutive days were chosen based on the parameters being studied. Four different production periods were studied:

A. Production with high VBD coke, used as the baseline;
B. Production with low VBD coke, keeping fines fraction constant and reacting on the pitch content;
C. Production with low VBD coke, increasing fines content in the anode and reacting on the pitch content;
D. Production with low VBD coke, increasing fineness of fines and keeping fines and pitch content constant.

Low VBD coke was measured to be 0.040 lower than the high VBD coke using the measurement methods discussed earlier. Baseline Blaine is in the range of 4800 – 5200, and increased fineness has a Blaine of 5200 – 5600.

Around 40 anodes were sampled in each condition. These anodes were then analyzed according to R&D Carbon methodology [4] for the following properties:

- Baked Apparent Density (BAD) – Anode cylindrical samples are taken from the baked anodes and then measured and weighed. BAD is calculated with this data.

- Air Permeability (AP) – Equipment manufactured by R&D Carbon Ltd.
- Electrical Resistivity (ER) – Equipment manufactured by R&D Carbon Ltd.
- CO_2 Reactivity (CRR) – Equipment manufactured by R&D Carbon Ltd.
- Air Reactivity (ARR) – Equipment manufactured by R&D Carbon Ltd.

Results

The results of the baked anode core analysis were summarized in notched box plots to facilitate the interpretation and comparison between the production settings. The notches in the box plots represent the confidence interval for the median with a 5% confidence level. As confirmed by other statistical tests, when the notch interval between two charts is coincident, no statistical difference between the medians can be observed. The charts are presented in the Figures 2-7 below.

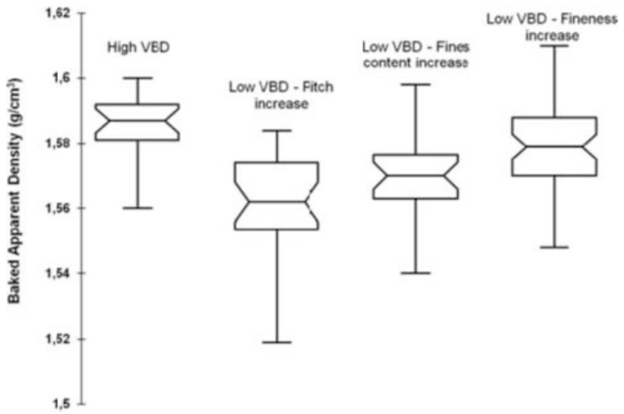

Figure 2. BAD results

Note: GAD Results for all four groups did not show significant difference.

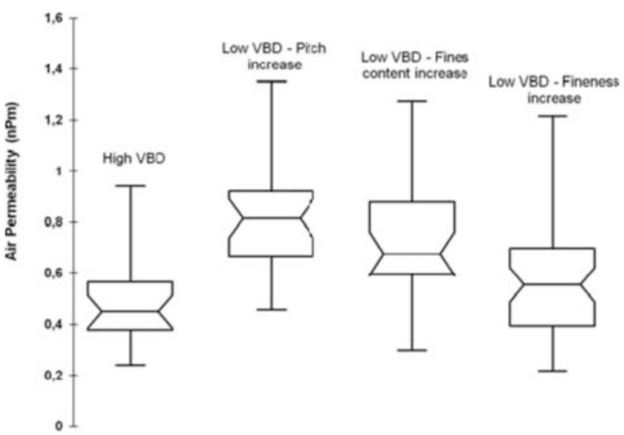

Figure 3. Air Permeability Results

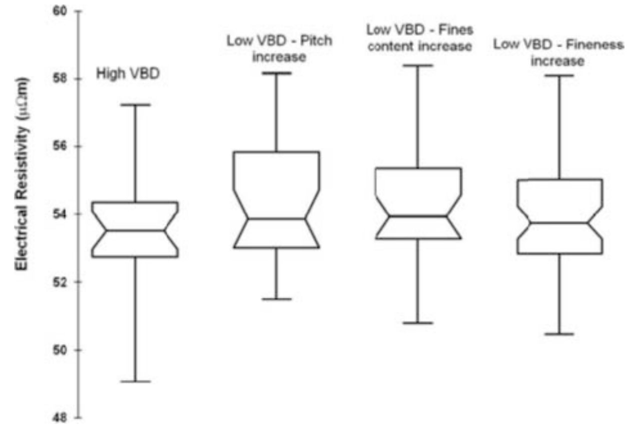

Figure 4. ER Results

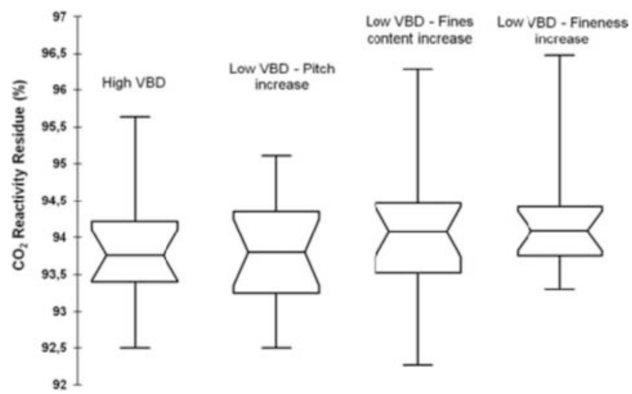

Figure 5. CO_2 Reactivity Residue Results

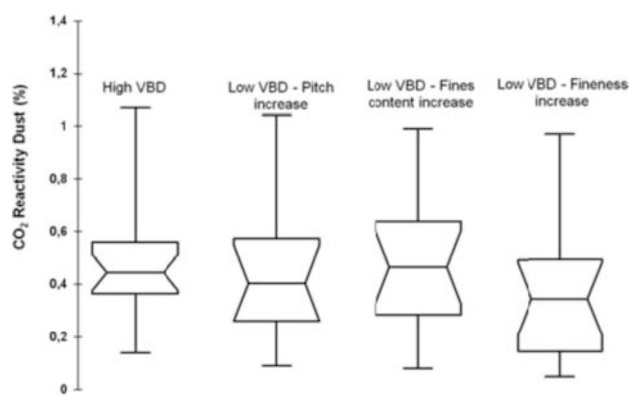

Figure 6. CO_2 Reactivity Dust Results

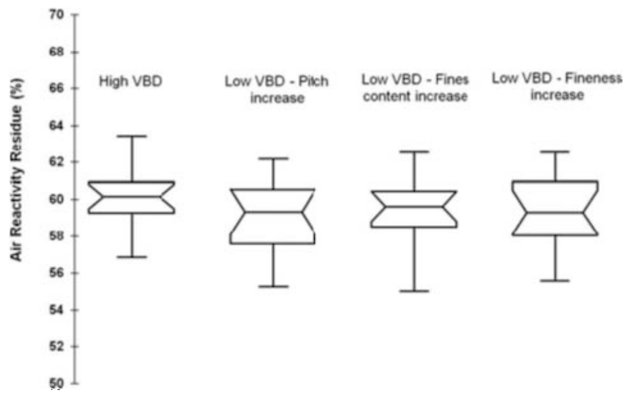

Figure 7. Air Reactivity Results

Conclusions

The results show a significant improvement in the anode density when reacting to VBD drop by making changes in the coke fines fraction. Air Permeability results confirmed the improvement in density. The other properties did not show significant changes, as expected, since these properties are affected mainly by other factors, such as baking temperature and metal impurities in the anode.

The increase in the fineness of the coke fines showed to be the best option, but it requires extra ball mill capacity, which may not be available at some plants.

In the current scenario of coke VBD deterioration, the optimizations in mixers, formers and other equipments should be continuously pursued to make the anode production process more robust.

References

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