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FINER FINES IN ANODE FORMULATION

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Abstract

To facilitate continuous improvement and permit amperage increases in the potroom, efforts have been focused on anode formulation at Alumar.

The impact of finer fines on baked anode properties was considered and trials to measure this impact were developed.

Green mill operation and process parameters were adjusted to produce finer fines as measured by Blaine Number – the R&D Carbon method used to infer the "fineness" of carbon dust.

Analyses were conducted on green and baked anode properties. Green and baked apparent density and air permeability improved with high statistical correlation. Electrical resistivity and flexural strength required increased pitch content to demonstrate improvement. No crack rate increase was observed and the bake loss was very low. Finer fines are also a potential control for baked anode properties as calcined petcoke VBD declines.

Introduction

In order to provide an amperage increase at Alumar and continuously improve the anode production process, anode properties that could be impacted by the aggregate formulation were identified.

In November-2003, an increase in the Blaine Number of the fines – as determined by the R&D Carbon method - was suggested as a possible change, among others.

Blaine number has been increased from 3000 to 4000 in the last 8 years. For this trial, an increment of 400 points was implemented. The goal of this paper is to demonstrate the positive results in the baked anode properties resulting from this change.

Development

Method to Measure Carbon Dust – Blaine Number

Coke dust consists of material less than 250 μm and includes the ball mill product along with the filter dust taken from various sections of the anode plant (Figure 2). This faction contributes more than 90% of the total aggregate surface area and largely dictates the optimum pitch requirement. In an anode plant, fluctuations in coke dust granulometry cannot be adjusted for by continually changing the binder content and will lead to incorrectly pitched anodes and inconsistent performance.

Typically, dust quality control in an anode plant is carried out by sieve analysis which measures particle size distribution. This is generally insufficient when assessing the suitability of a dust in the binder matrix as the pitch requirement is related to surface area which does not necessarily correlate with a given size distribution. Fischer (1980) outlines how the Blaine air permeability apparatus can be adapted to more carefully measure and compare coke dust granulometries. The calculated value of the specific surface is referred to as the Blaine Number, a dimensionless index. The Blaine Number is intended to take into account the physical differences between the non-porous, ball-like particles used as calibration standards and the porous, irregularly-shaped coke particles being measured. This approach gives a useful relative scale for comparison of different coke dust granulometries and is not intended to be an absolute measure of specific surface.

In the RDC-Blaine apparatus, the sample bed is under constant pressure and the quantity of powder is constant. The measurement is not a function of the apparent and real density. This avoids discrepancies due to coarse or very fine dusts and the consequent variance in the packing tendency of the powder bed.

The equipment used at Alumar for dust measurement is shown in Figure 1.

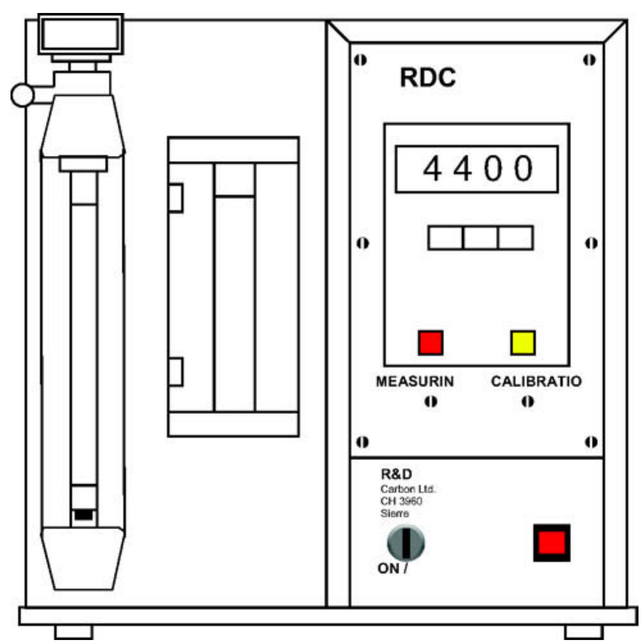


Figure 1 – Blaine Test from R&D Carbon

Design of Experiment (DOE)

A detailed plan was developed to increase the Blaine Number by 400 points, from 4000 to 4400.

In the green mill, adjustments were made to the ball mill and air classifier (Figure 2). The ball mill was retrofitted to support incremental ball volume by increasing the power input. The existing air classifier operation was modified without the need for mechanical changes.

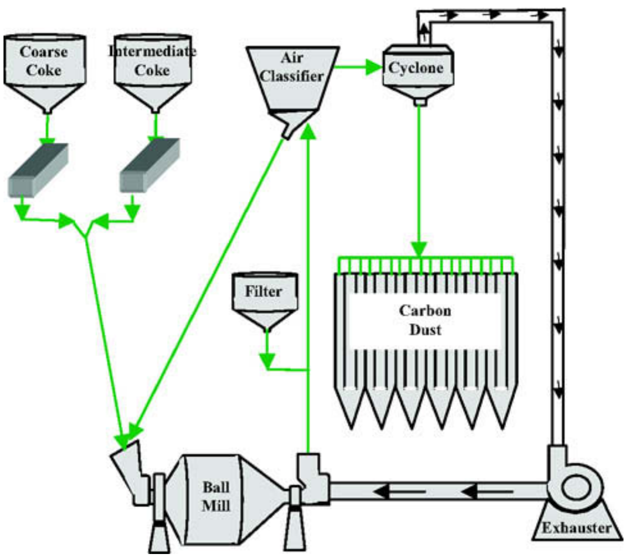


Figure 2 – Carbon dust generation system

Anodes were produced based on the following procedures to minimize any forming and baking variation:

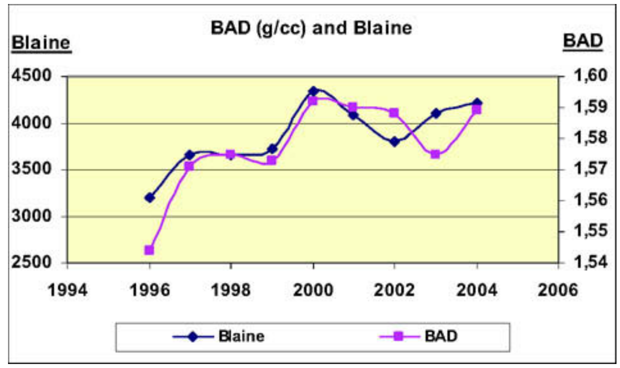
- Pitch content: 14.3%; 14.7%; 15.0%; 15.3% and 15.6%;
- Mix temperature, mix time, vibration time and all others parameters were fixed at green mill;
- All green anodes marked for tracking;
- All anodes loaded at furnace 1, at least 4 sections far from the crossover and in central pits;
- All baked anodes sampled and weighed.

Results

BAD – Baked Anode Density – has significantly improved at Alumar since Blaine Number carbon dust control began. Initially, the Blaine Number was 3000. Graphic 1 shows the BAD evolution in the last 8 years. Significant improvement occurred in 1996/1997 when the BAD increased from 1.544 g/cc to 1.571 g/cc. Of course, the increase in Blaine Number was not the only process change. Another important, incremental improvement in 1996 was a change in the imbalance angle of the forming machine (KHD).

Some anodes in 2000 were produced at 4400 Blaine, butt some operational limitations forced a decrease in Blaine to 4000.

Changes in petcoke properties (VBD and sulphur content) in 2002 and 2003 impaired BAD; the Blaine Number was 4000 through this period.



Graphic 1 – BAD and Blaine in the last 8 years

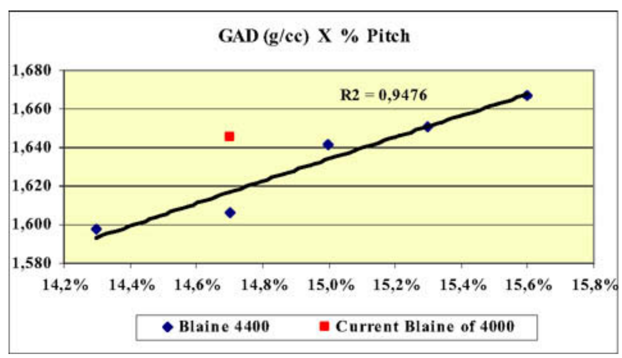
Process Parameters

No variation in the coke and pitch properties was observed during the test.

Blaine averaged - as planned - 4400 with a standard deviation of 112.

Green Mill

The improvement in the green anode density (GAD) during the trial is shown in the Graphic 2.



Graphic 2 – GAD versus % Pitch

The effect of higher Blaine is evident while changing from 4000 to 4400 at a pitch content of 14.7%. GAD decreased from 1.645 g/cc to 1.606 g/cc. Specific area of the carbon dust increased and resulted in anodes underpitched.

GAD was improved with 15.6% pitch, 0.9% more than the original formulation. According to R&D Carbon, each 1000 points increase in Blaine requires an additional 1% of pitch. Higher pitch content in the anodes can result in anode gluing in the baking furnace as well as difficulty with the packing material.

Baking Furnace

Flue temperature, soaking time, gas pressure and all others parameters in the baking furnace were remained the same of normal production.

Green anodes were loaded in the central pits and 11 sections far from the crossover (eliminating any unknown effects of this part of baking furnace).

Baked Anode Properties Results

The baked physical properties analyzed were: BAD, air permeability, electrical resistivity and flexural strength (Graphics 3, 4, 5, 6 and 7). Chemical properties results were not considered here once is not the focus.

The trends do not show the inflection point indicating overpitching, the point where additional pitch has no more positive impact in the baked anode properties. All graphics also show one point (red/square point in graphics) representing the original process condition of 4000 Blaine, allowing comparison at both levels.

Comparison of the baked anode properties at 4000 and 4400 Blaine yields the following observations:

– BAD showed a significant improvement of 0.012 g/cc (from 1.573 g/cc to 1.585 g/cc) in spite of underpitching at 14.7% and 4400 Blaine.

– Baked loss decreased significantly without compromising baked properties.

– Electrical resistivity had a considered deterioration due to low BAD.

– Air permeability and flexural strength were the same.

Results at 4400 Blaine:

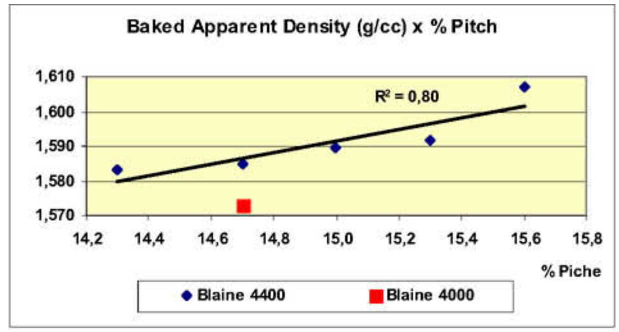
– BAD can be improved 0.019 g/cc, from 1.573 g/cc to 1.592 g/cc using 15.30% pitch (without overpitching)

– For all pitch levels, air permeability is better than current (0.600 nPm). Considering specifically 15.30% pitch, an improvement of 0.100 nPm is very agreeable considering the current level results.

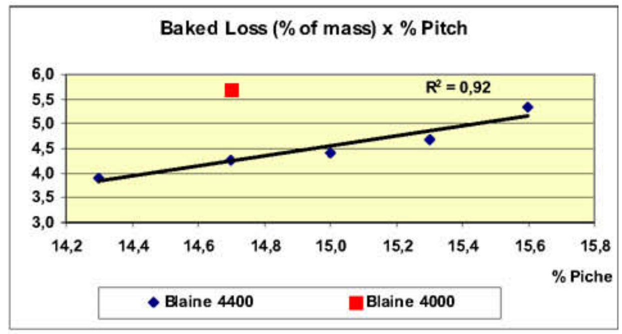
– Electrical resistivity remained the same due to low BAD.

– Flexural strength can be improved from current level of pitch of 14.70% on.

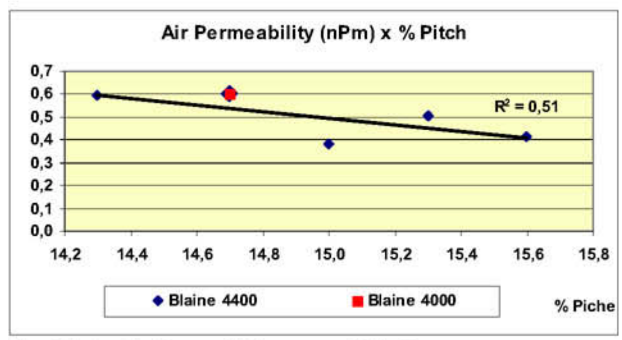
– Notable improvements in the bake loss for all pitch levels were observed - normally lower than 5% - resulting in more carbon available for electrolysis.



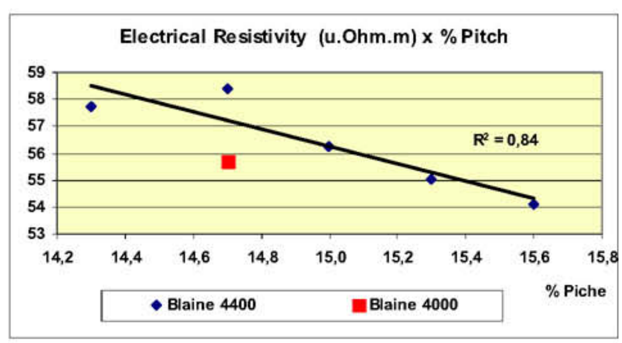
Graphic 3 – GAD versus % Pitch



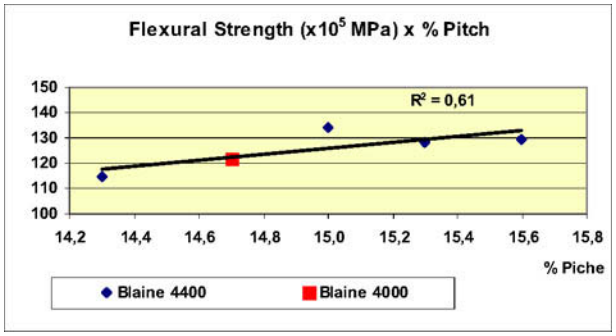
Graphic 4 – Baked Loss versus % Pitch



Graphic 5 – Air Permeability versus % Pitch



Graphic 6 – Electrical Resistivity versus % Pitch



Graphic 7 – Flexural Strength Resistivity versus % Pitch

Conclusion

It is important to emphasize that efficient and frequent control of carbon dust is required to avoid inconsistent anode quality as well as burning and thermoshock problems. A Blaine apparatus from R&D Carbon is recommended.

It has been shown that by using finer fines in anode formulation, baked anode properties can be significantly improved in terms of physical properties. An evaluation of the capacity of the dust generation system and optimization of the pitch content, in the context of both economics and physical properties, may be required.

Finally, finer fines can be an important process modification to:

– Allow amperage increase at smelters.

– Minimize the impact of calcined coke VBD (vibrated bulk density) deterioration.

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