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ELECTRODE TECHNOLOGY FOR ALUMINUM PRODUCTION

Anode Quality and Performance

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AN APPROACH TO HELP CONTROL AIR PERMEABILITY OF PRE-BAKED ANODES

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Keywords: air permeability, density, pitch level, fines.

Abstract

Air permeability is one of the most important properties that impact the performance of pre-baked anodes in aluminum smelters. In this paper, the main factors that affect air permeability are identified, as well as the key process control points that could improve air permeability. A practical and effective approach to decrease air permeability and improve anode quality was developed.

Introduction

In the last few years smelters all over the world are increasing anode current density to increase their capacity and reduce their cost. Anodes being supplied to meet these higher current density applications require improved specifications of electrical resistivity (ER), air permeability (AP), oxidation resistance (ARR, ARD, CRR, CRD), and thermal shock resistance (TSR). By analyzing the performance of many different anodes, it is easily seen that those with poorer oxidation resistance and higher AP can significantly decrease a smelter's current efficiency by increasing the dusting in the pot, increasing the pot operating temperature and power consumption, and decreasing anode life.

From the R&D Carbon net carbon consumption (NCC) equation air permeability is seen to be one of the more important factors which influence anode consumption in the Potrooms.

NCC = C + 334/CE + 1.2(BT - 960) - 1.7CRR + **9.3AP** + 8TC - 1.5ARR
where:
NCC = Net carbon consumption, Kg/t;
C = Cell factor;
CE = Current efficiency, %;
BT = Bath temperature, °C;
CRR = CO_2 reactivity residue, %;
AP = Air permeability, nPm
TC = Thermal conductivity, W/m°K
ARR = Air reactivity residue, %

This paper addresses methods that Sunstone has found to improve air permeability.

Factors Affecting Air Permeability

Green petroleum coke (GPC) raw materials:
GPC is the primary raw material for anodes. Variations in GPC quality can directly affect anodes' AP. AP is especially sensitive to the volatiles level of GPC. If the GPC contains less volatiles, the resulting calcined petroleum coke (CPC) usually has higher density due to lower porosity in the individual particles.

Also the grain size of GPC plays an important role. Smaller size particles tend to burn more easily during calcining, making it more difficult to control calciner temperatures. Poorer control and higher calciner temperatures tend to decrease the bulk density of the CPC, resulting in higher air permeabilities of the baked anodes.

Therefore it is quite important to have a supplier of GPC which controls GPC volatile content and sizing adequately. Sunstone's main supplier is Sinopec and their GPC quality is more stable than others in China.

Baked Anode Density (BAD)
Looking at Sunstone's anode core analyses, there is an obvious correlation between AP and BAD. See Figure 1 below.

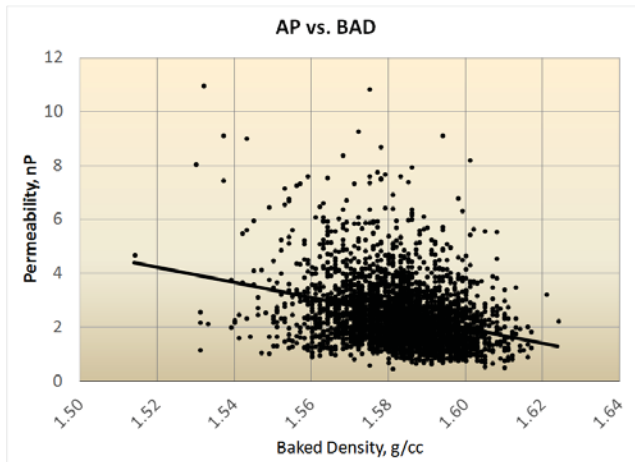

Figure 1. Air Permeability vs. Baked Density.

The following conclusions can be drawn:
1. Anodes with higher density usually have lower AP.
2. We can observe a breaking points around 1.58-1.59 where the rise in density correlate with diminution of the variability.
3. Anodes with density below 1.58 g/cc show more variability in AP.

Therefore, increasing BAD may be one way to both reduce the magnitude and the variability of AP.

Fines Content
For aluminum industry anodes the primary role of the fines is to increase anode density by filling in the voids and gaps between the larger particles. The fines contain about 90% of the total aggregate surface area, and all fines surfaces have to be coated by pitch. These pitch-coated fines then fill the voids between the larger aggregate particles and form the binder bridges between these particles. Therefore it is quite easy to see why both sizing and amount of fines to a large extent determines the optimum pitch requirement.

The sizing of the fines fraction is best characterized by measuring its Blaine number, a value related to the surface area of the particles. Blaine values for the Sunstone fines fraction are shown below in Figure 2. As shown into figure 2 variability in the size of the fines show improvement

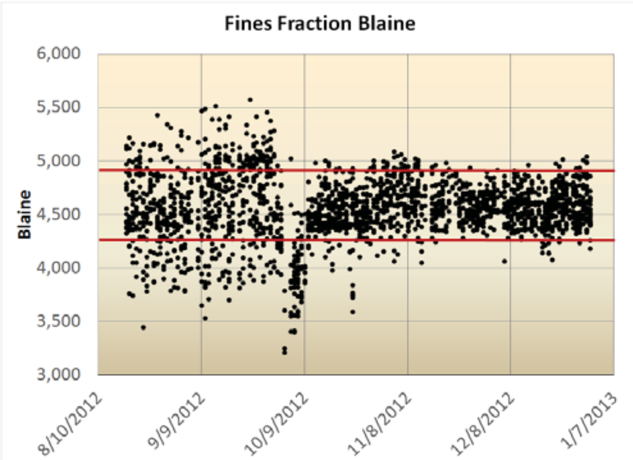

Figure 2. Fines Fraction Blaine Number.

By comparing the Blaine data from the less stable period (8/18/2012 to 10/2/2012) to the data from the more stable period (11/15/2012 to 12/31/2012) the improvement is even more apparent. See the histogram in Figure 3 below.

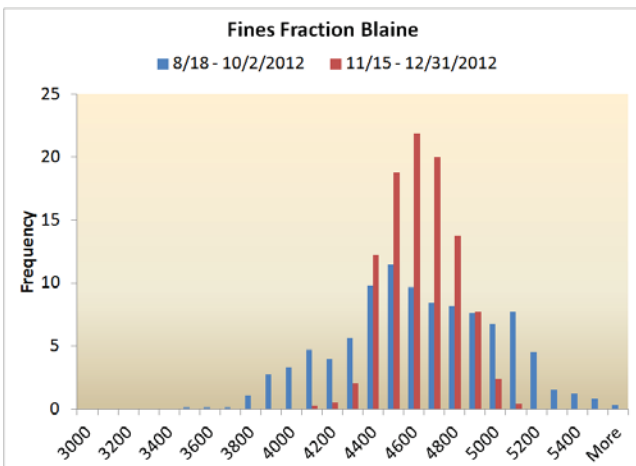

Figure 3. Fines Fraction Blaine Histogram.

The population distribution of the Blaine values has become much narrower. The range of values has been reduced from about 1700 to 700. With this more consistent fines fraction, properties of the baked anodes should also improve.

See Figure 4 for the change and improvement in the air permeability, comparing these same time periods. Just as in Figure 3, the distribution of AP values has also become much narrower. AP values become lower and more consistent as the sizing of the fines fraction becomes more consistent.

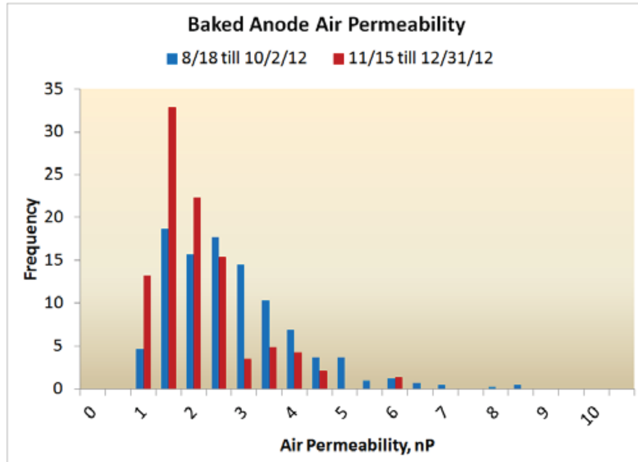

Figure 4. Air Permeability Histogram.

In order to get the aggregate to maximum dry bulk density the amount of fines fraction used has to be enough to fill the voids between coke particles and also enough to fill the pores of the larger coke particles. However, neither the fines nor the pitch must be in excess. Excess fines means that the aggregate has a larger surface area that have to be coated by pitch. More pitch means more baking loss, higher porosity, and increased air permeability. So during anode paste production, the pitch % should not be in excess. An "ideal" paste will have the surfaces of all particles totally covered by pitch, but there should be no more pitch added after the surfaces are coated. Therefore, a suitable pitch level based on the fine/specific surface area should be a way to judge proper pitch content and therefore improve the anodes air permeability. See Figure 5 below.

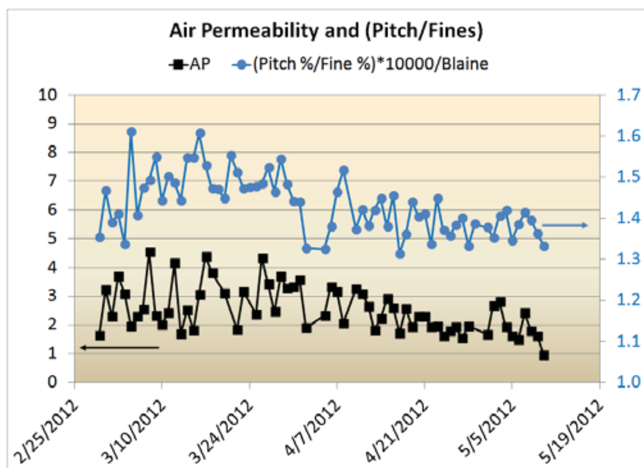

Figure 5. Air Permeability Compared to Pitch/Fines.

In this figure the (Pitch%/Fines%)*(10^4/Blaine) ratio is calculated and plotted for about a 3 month period. This ratio changes as the Pitch/Fines ratio changes and/or as the Blaine changes. A lower Pitch/Fines ratio or a higher Blaine or both will cause the ratio to decrease. Figure 5 is a chronological plot that shows how the air permeability changes as this ratio changes.

As the pitch % goes down and the sizing of the fines fraction is better controlled, the ratio decreases, as it should. At the same time air permeability also decreases.

Practice

There are several things that we can do to control the Blaine index of fines used in the production.

- Dust materials from dust collector are fed to the ball mill system through a star valve feeder. As the dust material is extremely fine, it flows like water. If the star valve feeder is not working properly, dust material will not be controlled correctly. So, the first step we did is to replace the original feeder with a precise feeder.
- Operation method of ball mill was changed. Blaine index was not considered as important as it should be before. Now the ball mill operation is connected with fines Blaine index.
- Maintain a certain volume of fines and dust in the silo to avoid segregation problems.

Conclusions

In order to reduce baked anode air permeability:

- Ensure that the volatile content and fines content of each green coke being used to produce anodes are as low as possible.
- Produce a stable fines fraction with low Blaine variability.
- Avoid over-pitching the anode paste
- Operate the Green Mill in a manner that minimizes any changes in fines fraction percentage or pitch percentage.
- Reduce any additional sources of variability in the Green Mill in order to minimize the fraction of low baked density anodes produced.