Superior Sensitivity of Blaine Method Compared to Sieving Analysis of Ultrafines

Nikolaos Katsavos[1], Triantafyllos Karasoulos[2], Antonis Kyriazis[3], Markus W. Meier[4] and Francesco Carlos Baccalà[5]
1. Paste Plant Chief Foreman
2. Carbon Plant Process Engineer
3. Carbon Plant Manager
Aluminium of Greece, Mytilineos, Agios Nikolaos, Greece
4. Vice President Technical Services,
5. Research and Project Engineer
R&D Carbon, Sierre, Switzerland
Corresponding author: francesco.baccala@rd-carbon.com

Abstract

One of the most critical components of the aluminium reduction technology is the carbon anode. For the manufacturing of prebaked anodes several process steps have to be optimally combined to obtain high quality anodes including an optimal recipe. In the carbon paste plant the petroleum coke and the butts are sieved, crushed, weighed, and preheated. The required fines fraction is produced by milling the petroleum coke. Experience shows that the consistency of the fines fineness is crucial to ensure good carbon anode quality. The Blaine value corresponds to the external specific surface area characterizing the fines fineness. It is indirectly determined by measuring the air permeability of the fines powder bed. This paper describes the Blaine method as a rapid, reliable and accurate test as a key process parameter in the carbon paste plant. In fact, the data of Aluminum of Greece show that the Blaine method has a sensitivity being 3 times superior as compared to the sieving analysis of the ultrafines < 32 µm.

Keywords: Paste plant, carbon anodes, fines fineness, Blaine value, ultrafines, process control

1. Introduction

The production of aluminium is carried out in electrochemical cells. The Hall-Héroult process consists of the electrolysis of alumina (Al_2O_3) dissolved in a bath of molten cryolite (mostly Na_3AlF_6) at approximately 960 °C, high amperage, and low voltage [1]. The current is passed through immersed carbon anodes and flows to a layer of molten aluminium formed at the carbon cathode surface. Steel bars imbedded in the cathode blocks carry the electricity to the next cell.

The electrochemical reaction of the aluminium production is the following:

$$2Al_2O_3 + 3C = 4Al + 3CO_2 \quad (1)$$

The carbon anodes used in the aluminium industry are consumed during the electrolysis as shown in Equation (1). The primary raw materials of an anode are calcined petroleum coke (CPC) as the dry aggregate and coal tar pitch (CTP) as binder. Anode recycled material, i.e. anode butts, remaining after the electrolysis together with green and baked scraps are also added in the recipe. Typically, prebaked anodes are made of approximately 60 % CPC, 15 % CTP and 25 % recycled material. The anode manufacturing process flow starts with the paste production. First, the dry aggregate is prepared, preheated and mixed with pitch. The paste is then compacted, and green anodes are formed by vibrocompacting or pressing. Finally the anodes are baked and rodded embedding the steel stubs into the anode [2].

Thus, the dry aggregate is composed of different fractions of CPC and butts previously sieved and crushed according to a defined recipe line, optimized for the highest possible apparent density. The butts particles compose the coarse fraction while the medium and fine fractions usually consist of CPC particles [3]. The fineness of the fines and its percentage in the dry aggregate are known to be decisive for the pitch demand of the paste.

2. Aluminium of Greece Reduction and Anode Plant Facilities

The smelter of Aluminium of Greece (AoG) was constructed with technology from Pechiney and started up in 1966 with an initial Al production capacity of 72,000 tons per annum (tpa). Today, three potlines are in operation with a total production capacity of 184,000 tpa. The green anode plant was constructed in 1966 also based on technology from Pechiney. The targets of the production and dosage of fines in the dry aggregate were adapted towards less but finer fines in the recipe, aiming to minimize the risks of anode block thermal shock cracking.

A detailed testing of the anode properties has shown that the variabilities of key-properties were below the benchmark, including the specific electrical resistance and flexural strength. The green anode blocks weight range was above 3 %.

Therefore, a complete technical assessment of the entire chain of the anode production from the raw materials storage to the rodding shop was performed to identify the root causes of the above mentioned anode deficiencies. In this paper, the status quo of the fines preparation and of the pitching in the green paste is addressed. Eventually the potential adaptations of the grain fractions preparation and of the ball mill circuit are considered aiming to squeeze the variability of the green anode production.

2.1 Green Anode Production and Variability

With a throughput of 17 t/h and a scrap rate of 4 %, the green anode plant at AoG has a nominal capacity to produce 101,000 tpa of green anodes. Several studies have shown that recipe parameters and in particular the granulometry influence different aspects of the anode quality [4].

The Figure 1 shows, in blue, the evolution of the daily mean green anode density (GAD) from October 2022 to March 2023. It also illustrates the evolution of the pitch content over the same period. The pitch content varied from 13.2 % up to 14.1 %. The GAD oscillates from 1.67 kg/dm^3 down to 1.62 kg/dm^3. The benchmark of GAD range is about 3 times lower and this with no noticeable drift to guarantee a constant anode block weight and height.

The excessive variations in GAD observed in Figure 1 are induced by several factors such as the raw materials properties. Certainly, the absence of blending facilities leads to GAD variations so that about half of the observed variability can be attributed to the different CPCs. The other half is related to the dry aggregate preparation and especially the fines characteristics, i.e. by the fines percentage in the recipe and its fineness, as well as to the pitch content in the green anodes. These variations in the GAD induce variations on the baked anode density disturbing the pot operations.

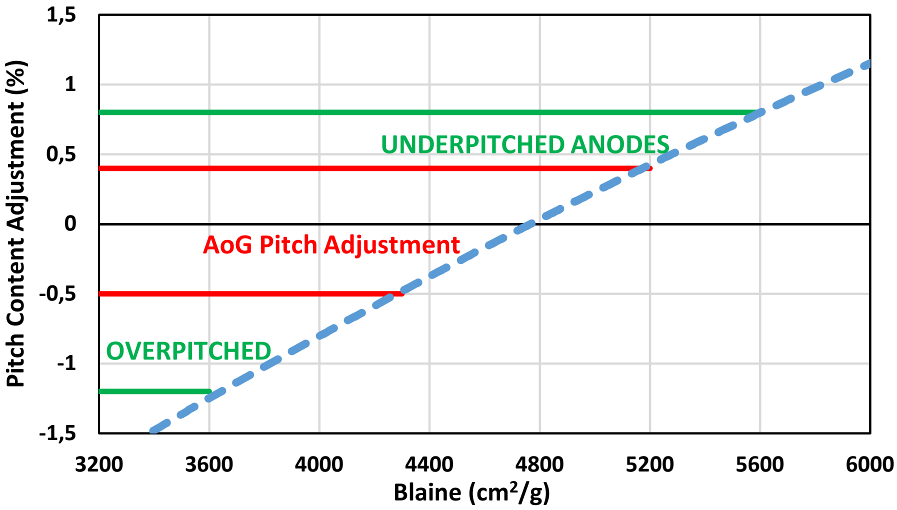

Figure 9. Variation of the *fines* fineness at AoG leads to under- and overpitched anodes.

5. Conclusion and Perspectives

The recipe parameters, particularly the *fines* fineness and *fines* content have a significant impact on the anode characteristics such as the baked anode density or the pitching level, both being highly interactive. Indeed, the higher the *fines* fineness and *fines* content, the higher is the pitch requirement. This is due to the larger external surface area available for binder coating. Therefore, it is crucial to monitor the *fines* fineness for an optimal process control at the paste plant, to ensure constant and high anode quality. The Blaine method is a sensitive, reliable and fast test enabling to follow the ball mill operation and the consistency of the *fines* fineness.

The entire dry aggregate preparation is under review at AoG to precisely identify the opportunities for improving the anode performance in the potlines. The implementation of the Blaine apparatus will improve monitoring the achieved progress towards consistent fineness of *fines* because of the superior sensitivity as compared to the ultrafines air jet sieving method.

6. References

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