Carbon Dust Metrics for Cell and Plant Process Audits

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Abstract

Anode dusting is named as one of the main influences on unwanted anode consumption and therefore non-productive CO_2 emissions. While improvements in anode quality have reduced carbon dusting from anodes, the dusting problem still occurs in plants from time to time and is difficult to deal with. This paper shows possible metrics and diagnostic tools to monitor for early onset of a developing dusting crisis. It also uses the feedback from a survey conducted in the aluminium smelting world and shows practical approaches for dealing with carbon dust. Practical examples gathered at plant visits for the interpretation of certain data sets are given.

Keywords: Carbon dust, Cell performance, Process audits, Anode dusting.

1. Introduction

Carbon dust is a concern for all reduction managers, as it is one of those influences that can spiral out of control, if not contained correctly. Dusting leads to a vicious cycle with spiking, increasing specific energy consumption (EC) and losses in current efficiency (CE), as discussed in the literature [1-4].

The carbon inputs in the process and possible sources for carbon dust have been discussed [5]:

- Cathodes: mechanical erosion or chemical reactions with aluminium forming Al-carbides cycling through the cell;
- Resistor coke: used during start-up, expected to flush during bath up and then skimmed out, amount depends on the kind of bed (full bed, anode shadow or spots [6], [7]);
- Anodes: reaction with air and CO_2 leads to the formation of dusting, cracking anodes lead to free carbon particles;
- Anode cover material: crushed particles from broken anodes or collected carbon dust on top of anodes, sometimes recycled carbon dust skimmings;
- Secondary alumina: collected carbon particles from the offgas of the cell, if airborne.

Table 1 shows the accumulated carbon input for a 180-kA cell (retro-fitted Reynolds P19 in Hamburg). As anodes are the biggest input regarding volume, the focus during plant and cell audits in this project focused mainly on them.

Table 1. Carbon inputs in a 180 kA cell over a 6-year lifetime.

Input material	Mass (t)	%
Resistor graphite	0.2	0.011
Ramming paste	7	0.390
Cathodes	14	0.780
Anodes gross (net 1310)	1760	98.050
C from ACM (0.5 % C)	1.5	0.084
C from secondary alumina (0.2 % C)	12.3	0.685
Sum	1795	100

Some of the basic concepts for dust formation have been discussed previously by the author [5]. To understand the scope and impact of carbon dust on the industry, an industry survey was conducted; and then, systematic carbon dust audits for individual cells and potlines were conducted.

2. Findings from the Industry Survey

Part of the study was a questionnaire with 10 questions sent out to professionals in the aluminium smelting industry. 20 replies were analyzed; however, some of the questionnaires were filled out only partially. This leads to a more qualitative rather than a quantitative picture on the common understanding of carbon dusting. The questions were related to three main parts: what is understood as dust and a dusty cell, what are the results of carbon dust, and how to prevent and reduce the impact. The questionnaires were filled out 30 % by carbon specialists, 70 % by electrolysis specialists.

The common description of a dusty cell was a cell with operational problems and a visual black mixture on the bath surface. Additional characteristics were an increased bath temperature (+30 °C deviation from target) and an abnormally increased superheat (20-30 °C).

Root causes for the problems were separated into three fields: anodes and their quality, work quality in the operations for anode change and anode covering, and general cell operations. For anodes, the quality of the product was named: oxy- and carboxy-reactivity test residue and dust, air permeability and impurities from raw materials, mainly V, Na, and Ni. In operations, the quality of anode setting, with correct height and cavity cleaning, was mentioned as well as the quality of anode covering and the continuous anode redressing in order to maintain a protective barrier between air and anode. For the general cell operations, the following were mentioned: spikes/mushrooms and cracking of anodes can lead to carbon detachment from the anodes; a high bath temperature due to improper voltage targets or wrong bath chemistry increases the risk of preferential oxidation of the carbon binder matrix, anode-to-cathode distance (ACD) squeezing can lead to local temperature increases for anodes and anodes acting as cathodes.

The impact of dust is perceived uniformly and described. Cells with dust have an increased temperature, and anodic incidents like spikes and cracking of anodes occur. The cells' current efficiency is reduced, the specific energy consumption increased. Both a decrease in metal production or an increase in power requirement were mentioned as the root cause for the increase in specific energy consumption. Two participants mentioned a higher bath resistance, and therefore, a squeezed ACD. Setpoints in the process control system, assuming a bath resistivity with no dust, stayed the same and the anode beam is moved downwards.

Mentioned side effects in dusty cells are anode effects with low maximum voltages of approximately 12 to 18 V. Monitoring of the maximum voltages of anode effects was used as an indication for dusty cells and increased focus on these cells. The dust is expected to prevent alumina dissolution in the electrolyte.

Every participant counteracts dusting with manual or crane/vehicle-based skimming of carbon dust. The skimming positions were anode hole during anode change, specific actions on corner anodes for reduction of carbon dust or on tap hole. Other individual measures on cells are decreasing feeding, so that the possibility of sludging is reduced, increased offset for new anodes, and the change of voltage targets (increase or decrease). While most increase the voltage target in order to reduce the risk of squeezing of the ACD, two participants decrease the voltage, as the resistivity of bath decreases at higher temperatures.

Performance indicators used for monitoring must be adapted to a given plant, as plants can differ structurally from each other, leading to other baseline values. The comparison of absolute values can lead to wrong assumptions in the process and operations quality evaluation.

The future work will involve the investigation of the carbon content in anode cover material over the anode cycle and the influence of carbon dust on anode current distributions and anode cathode distances. These experiments should help identify further process parameters, which can be monitored.

6. References

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