Challenges of Anode Spikes in Aluminium Bahrain (ALBA)

Mohd Abdulhadi[1], Bhoopesh Jain[2], Nabeel Ebrahim Mohd Al Jallabi[3], K.S.R. Raghavendra[4] and Dr. Abdulla Habib[5]
1. Engineer, Carbon Process Control
2. Superintendent Carbon Process Control
3. Sr. Manager Process Control & Development
4. Technical Advisor, COO
5. Chief Operation Officer
Aluminium Bahrain, Manama, Kingdom of Bahrain
Corresponding author: bhoopesh.jain@alba.com.bh

Abstract

Aluminium Bahrain (ALBA) has been improving productivity through increasing potline current and improving current efficiency. The potline current creep has been achieved gradually by multiple changes in the cell components, lining design, cathode design, anode size, and by improvements of the process control and pot operation practices. In addition, operating at reduced anode-cathode distance (ACD) brings up the opportunity to convert the saving in voltage into current increase and to maintain cells in thermal balance. Nevertheless, operating at reduced ACD becomes one of the main challenges to sustain cells productivity and life in modern smelters. The reduced ACD creates anode problems and causes spikes. In order to sustain increased potline current, there are several anode quality parameters that must be kept stable or improved. This paper describes the challenges encountered in anode spike issues in potlines 4 to 6 in Alba over the last three years. It outlines the anode properties with respect to anode spikes issues and the work done to improve anode quality standard through improvements in anode baking furnaces and rodding plant. These improvements in anode properties have significantly reduced spike trends in potlines to acceptable level. The work done and the link between anode properties, along with changes introduced in potlines to resolve spike issues are discussed in this paper.

Keywords: Anode spikes, Anode baking furnace, Baking level, CO_2 reactivity residue.

1. Introduction

Aluminium Bahrain (ALBA), the world's largest single-site aluminium smelter outside China with aluminium production of more than 1.548 million tonnes in 2020 is known for its technological strength and innovative strategies. ALBA always striving to maximize productivity and reduce resource consumption such as carbon and energy in order to continuously reduce impact on environment, improve safety and overall business.

With meticulous approach, ALBA progressively has been achieving its potline current increase plan successfully. Potlines 4 & 5 use AP30 prebake technology. These potlines are presently operating close to 400 kA which is more than 20 % higher than the original potline current [1]. Potline 6 which uses EGA DX+ Ultra technology was commissioned in 2019 with original design current of 460 kA [2]. Presently this potline is operating close to 480 kA which is an increase of more than 4 % from the original design in just two years.

One of most critical elements to operate successfully at higher amperage is anode performance. To avoid overheated cells, most of the efforts have been made to keep the cell internal heat under control. This means lowering the bath resistance, i.e., reducing the ACD. When lowering ACD, the current efficiency may decrease and the pot becomes more sensitive to disturbances. Figure 1 shows the trends of ACD with pot line current increase.

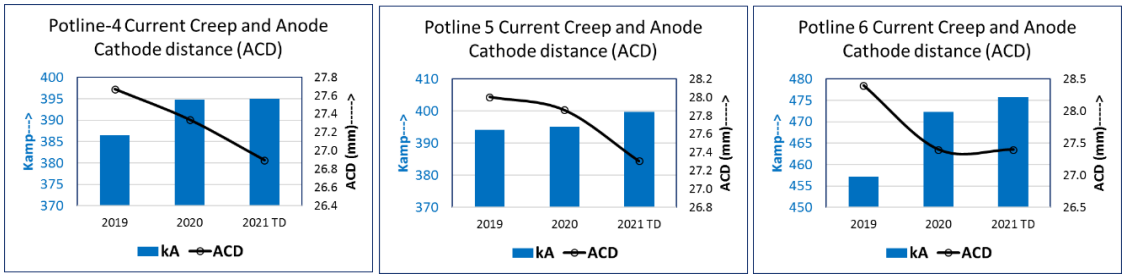

Figure 1. Potline current increase (creep) and ACD.

Increased amperage and low ACD have a tendency to increase the frequency of anode spikes [3]. Furthermore, with increasing amperage the probability of increasing carbon dust increases especially when cells operate outside their operating window. Carbon dust increases electrical resistivity of the bath [4] which further decreases ACD, lowers current efficiency and increases bath temperature. Differences of just 2-3 mm in ACD will have a great impact on the frequency of spikes in the cells when the ACD is close to the operational limit. Therefore, any attempt to reduce the overall cell voltage through squeezing of ACD results in a significant increase in risk of anode spike formation [3]. Other smelters have experienced anode spike crises and have analysed possible causes [5-6].

From the potline perspective, anode quality has a direct impact on current efficiency, pot operation, and carbon dust and anode spike generation. Anode quality dictates how aggressively the pot operating parameters can be pushed. Improving anode quality has been a key challenge during current increase and ACD reduction strategy.

This paper discusses the ALBA's anode improvement initiatives, results and the impact on spike formation.

2. Anode Performance in ALBA Potlines

ALBA has four carbon plants with total gross bake anode capacity of 897 kt/y. These four carbon plants meet the anode requirement of the six potlines. Carbon plants use calcined petroleum coke manufactured in captive calciner located at the marine terminal, 16 km from the main smelter anode plant. Green anodes are made using vibro-compactors, baked in open-top horizontal ring furnaces.

ALBA has five anode baking furnaces (ABFs). These furnaces bake four different sizes of anodes to cater the potlines. ABFs are equipped with latest Innovatherm firing control system. Over the years, anode sizes have been increasing to support potline current increase. The baking, process and the ABF condition are crucial for maintaining good baking quality with increased anode size. Anode performance in potline largely depends on baked anode quality and its consistency. Final anode baking temperature, or anode baking level monitored with the parameter Lc (crystal length) in ALBA, is one of the key anode quality parameters, which must be maintained within the target range. Underbaked anodes can cause carbon dust and spikes which lead significant deviations in potline operation. The baking level is being continuously improved through optimization of the baking curve and improvement of the furnace condition. Another important parameter is the anode reactivity; increasing the anode reactivity increases carbon dust generation which leads to anodes spikes formation.

Alba has had a few periods of anode spike problems in Potlines 4, 5 and 6 for the last three years. The causes, impacts and corrective actions vary from one potline to another as it will be illustrated in this paper.

It was realized that the anode quality needs to match the potline current increase in all potlines. Alba improved anode quality through data analysis and optimization carried out systematically. Baking level is one of the many key parameters which were improved in phases without negatively impacting the other related anode quality parameters such as desulphurization, air permeability and pitch burning efficiency. Carboxy and air reactivity have been reduced significantly through optimizing anode baking and controlling butt cleaning efficiency. Alba implemented many innovative solutions to improve butt cleaning efficiency of butt shot blast machine.

All of the initiatives resulted into overall anode quality improvement and in the reduction of net carbon and gross carbon consumption.

5. References

1. Mohsen Ahmed Shukralla et al., The roadmap of AP-ALBA to 400 kA, *Proceedings of the 39th International ICSOBA Conference*, 22-24 November 2021, *Travaux* 50, Paper AL01.
2. Michel Reverdy, Abdalla Alzarooni et al., Abdalla Habib et al., The successful implementation of EGA DX+ Ultra Technology at ALBA, *Proceedings of 38th International ICSOBA Conference*, 16-18 November 2020, *Travaux* 49, 539-549.
3. Bernd Rolofs, Experience and cause of anode spikes, *Proc. 6th Aust. Al Smelting Workshop* 1998, 205-210.
4. Louis Bugnion, Jean-Claude Fischer, Effect of carbon dust on the electrical resistivity of cryolite bath, Light Metals 2016, 587-591.
5. Halldor Gudmundsson, Anode dusting from potroom perspective at Nordural and correlation with anode properties, *Light Metals* 2011, 471-476.
6. M.M. Ali and A.M. Omran, Anode spike formation in prebaked aluminum reduction cells, *Al-Azhar Engineering twelfth international conference*, December 25-27,2012, *Al-Azhar University Engineering Journal, JAUES*, Vol. 7, No. 4, Dec. 2012, 29-41.