Using SPC Method to Design an Aluminum Fluoride Addition Strategy for Aluminium Electrolysis

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Abstract

A 400 kA aluminum reduction potline suffers from extensive cathode damage due to defects in the refractories materials. The aluminum level was raised in order to reduce a further damage of the pots. However, it caused increased heat dissipation from the sidewall, which increased the energy consumption and formed long ledge toe that caused frequent cathode problems such as cracking. An optimization plan was carried out on six test pots over a year which included, among other measures, a new cryolite ratio (CR) and bath temperature control regime. These were necessary as reduction of CR and bath temperatures variations were a precondition for pot performance optimization. A new AlF_3 feeding strategy which is based on Statistical Process Control (SPC) method, was implemented on the test pots and compared to a group of reference pots. This strategy aimed to reduce the variations of AlF_3 feed leading to a reduction of variations in cryolite ratio (CR), and the bath temperature. After 4 months of operation, the variation of AlF_3 additions was reduced by 35 % and thereby reducing variation in CR by 37 % and bath temperature variations by 14 % compared to a group of reference pots. This control method ensured a more stable operation which allows optimization of metal level and voltage.

Keywords: Bath chemistry control; SPC method; aluminium fluoride feeding strategy.

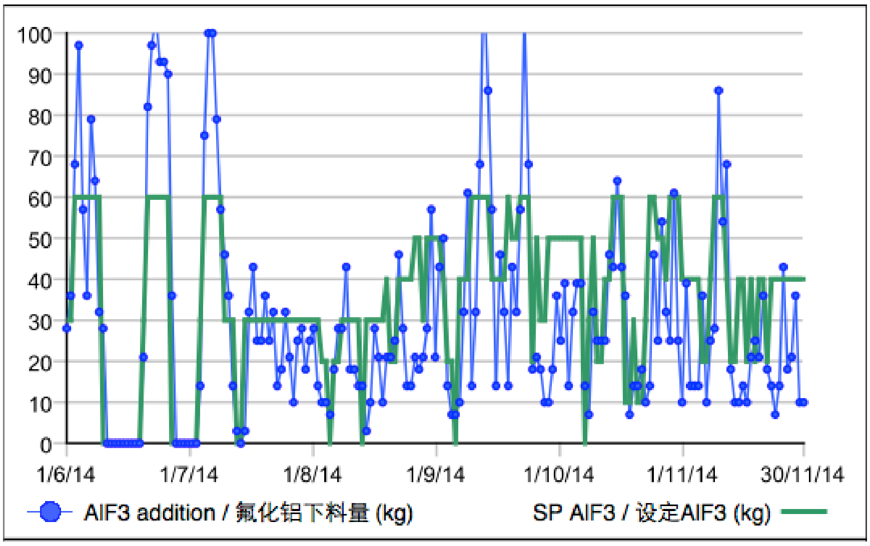
1. Introduction

A 400 kA series electrolytic cells potline suffers from extensive cathode damage due to defects in refractories materials. The cathode damage is mostly transverse cracks in the carbon block upper surface, which leads to high concentrations of Fe and Si in the molten aluminium metal. Most of the pots that were built during the initiation of the potline show signs of cathode damage, hence they all carry the risk of cathode damage. In order to reduce further damage of the pots, the metal level on all pots had been previously raised to 30 – 34 cm. This reduces the cathode temperature and reduced pot failure. However, operating at high metal level leads to many disadvantages: (1) higher energy consumption as more heat is dissipated out from the sidewall and extra voltage is needed to compensate for that heat loss and (2) reduced bath level due to the need to accommodate higher metal level in the cavity. This leads to a decrease of alumina dissolution in the bath and increase of sludge, resulting in an increase of cathode voltage drop (CVD).

A project was done, aimed to optimize the performance of six test pots by reducing metal level and voltage to optimum levels without reducing CE or causing further damage to the cathodes [1]. One of the preconditions for metal level and voltage optimization was stable pots operation. In this smelter, one of the main causes of pot instability is the automatic control system that controls the AlF_3 feeding, causing a wide variation in bath chemistry, CR and bath temperature. Hence a new strategy was required to address this issue. This paper focuses on the work and strategy done to stabilize AlF_3 feed in order to reduce the variations of CR and bath temperature.

2. Original AlF_3 Control Strategy

The AlF_3 additions at this Chinese smelter are controlled by an automatic system based on a complex "online intelligent optimization" process [2] aimed to control superheat using (according to the manufacturer claims) a variety of process inputs such as: bath temperature, alumina concentration, noise, resistance and it does not require human intervention. However, this system operation leads to significant daily fluctuation in AlF_3 feed, resulting in severe fluctuations in bath chemistry, CR and bath temperature as can be seen in Figure 1. The fluctuations in actual AlF_3 feed over 6 months on a single pot caused by the automatic AlF_3 control strategies can be seen in the top graph in Figure 1, which resulted in fluctuations in CR and bath temperature (bottom graph), leading to unstable pot condition.



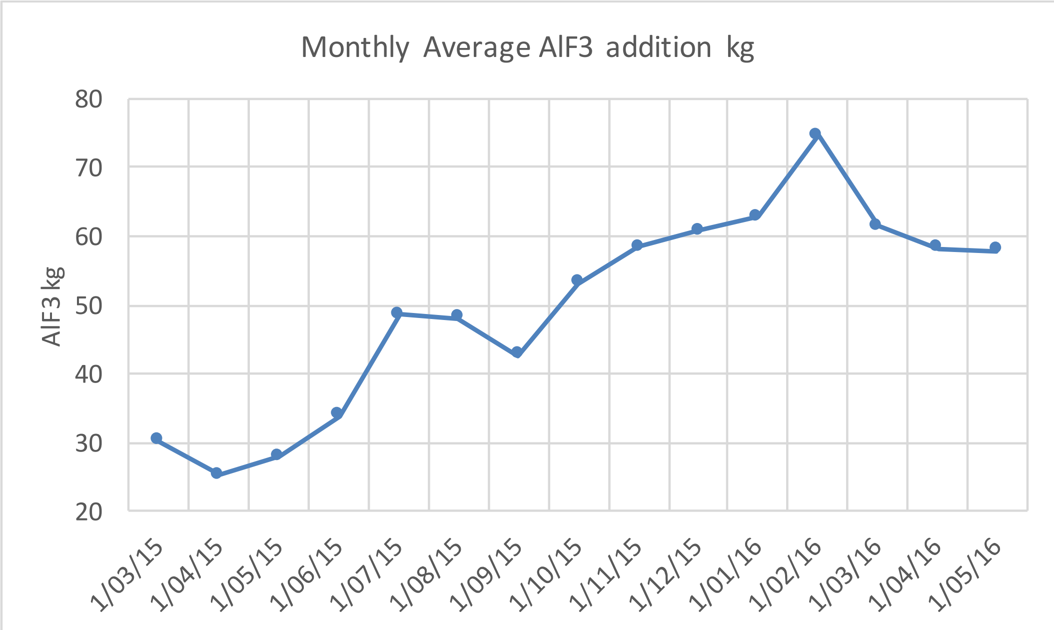


Figure 12 – Monthly average of actual AlF_3 additions over 14 months for test pots.

6. Conclusions

A new AlF_3 feeding strategy, which is based on long term feed target and correction using SPC of CR trends, was used as part of a project that aims to optimize damaged cathode pots metal level and energy consumption. This new fluoride feeding strategy aimed to minimize the variation of AlF_3 feed and hence reduce variations of CR and bath temperature trends.

The new strategy was implemented on 6 test pots and compared to a group of 6 reference pots over 4 months. During the test period, the test pots AlF_3 addition variation was reduced by 35 %, CR variation was reduced by 37 %, and bath temperature variation is reduced by 14 %. This strategy ensured stable operation of the pots, which was a precondition for metal level and energy consumption optimization without a reduction in current efficiency or causing further damage to the cathodes.

This AlF_3 feeding strategy had an additional benefit on top of the stable AlF_3 and CR control, which was the ability to identify the impact of external factors on pot performance. This led to the ability to study and better manage external factors affecting bath chemistry and material balance and opened the way to a process of continuous improvement.

7. Acknowledgements

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