Cathode Life and Failure in a High Amperage CWPB Potline

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Abstract

With increasing number of high amperage center-worked prebake (CWPB) pots in the primary aluminum industry, the cathode life of the CWPB pot-lines will affect the economic and ecological performance more seriously. In this case, how to prolong the pot life for the large CWPB pot-lines is becoming one of our first priorities and urgent work.

Based on the basic effects of the CWPB pot cathode lining engineering, cathode materials and quality on the cathode life, the paper presents a detailed cathode failure investigation and analysis example of one 500-kA pot-line in a Chinese domestic smelter. The cathode failure causes and mitigation methods are discussed at the end.

Keywords: Potline, Potlining engineering, cathode, raw material quality, pot life.

1. Introduction

In recent years, with increasing number of larger capacity CWPB pots has been being deployed in primary aluminium industry, cathode life plays an increasingly important role in affecting smelter economic and ecological performance. Therefore, prolonging the pot life for larger CWPB pot-lines is becoming the first priority for smelters. Factors affecting pot life are multiple — engineering, material, lining, prebaked startup and operation, all of which are interconnected.

Decades of industrial practices have proved that the normal pot life could be 10 years, according to the calculation for cathode annual erosion rate (including electric and chemical erosion and mechanical wear). However, the fact is that most of larger pots could not run for 3000 days, and some were even shut down within 2000 days. The reasons why pot life is usually shorter than it should be lie in 5 aspects: engineering, raw material quality, lining, pot startup and operation. According to statistics and analysis, these influence factors account for unequal proportion: engineering – 20 %, material – 10 %, lining – 20 %, pot startup – 25 % and operation – 25 %. With improved pot control and anode effect frequency (AEF) decrease, the factors of engineering and operation have decreased while the factor of materials increased. But it cannot be ignored that all these factors are not separate but interconnected [1, 2].

Based on the basic effects of the CWPB pot cathode lining engineering, cathode material and quality on the cathode life, the paper presents a detailed cathode failure investigation and analysis example of one 500-kA pot-line in a Chinese domestic smelter. The cathode failure causes and mitigation methods are discussed at the end.

2. Lining Engineering of Larger Pots

Lining engineering of larger pots consists of thermal equilibrium and mechanical stress engineering. The key principle of lining thermal equilibrium is that the bath solidification isotherm should be located within the refractory brick structure that is beneath cathode blocks, and 800 ~ 900 °C isotherm should be located in the impermeable structure above thermal

insulation bricks so that thermal insulation does not deteriorate when compounds like bath penetrate into it, and problems caused by thermal insulation breakdown are avoided.

Fig. 1 presents the simulation of lining isotherm distribution for one kind of larger pots:

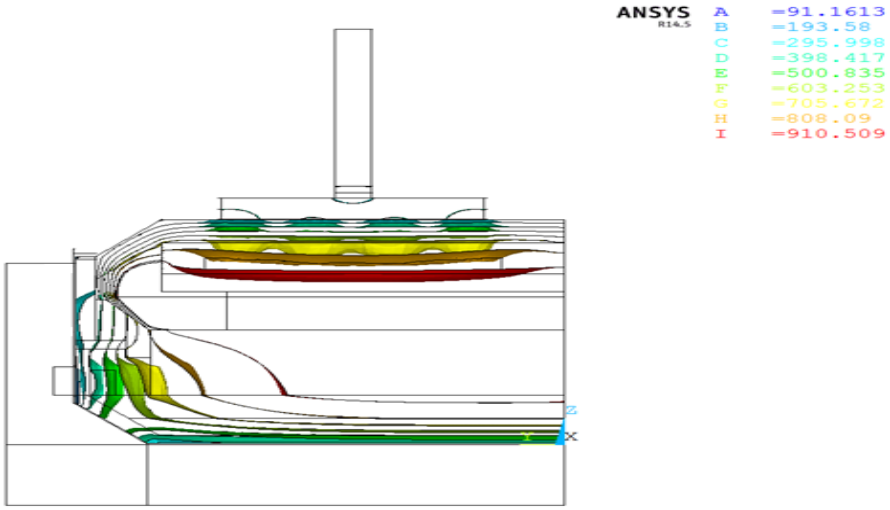

Fig. 1. Simulation of lining isotherm distribution for one kind of larger pots.

The principle of lining mechanical stress engineering is to make lining always under an appropriate compressive stress, avoiding the expansion of materials (including ramming paste-carbon block surface and pot shell-side carbon block surface), which could crush carbon blocks. Lining stress engineering mainly consists of potshell strength engineering and stress compensation engineering.

Stress of lining is mainly caused by expansion due to high temperature and sodium infiltration. Different materials will lead to different expansion performances. So to speak, lining stress engineering is closely related to thermal equilibrium engineering and lining materials applied.
Cracks formed and propagated at cathode carbon blocks is one of the mian patterns of pot lining failure. Generally speaking, cathode carbon blocks with lower degree of graphite will face higher possibilty of cracking, and vice versa. If compressive stress is too large, horizontal and vertical cracks are easily formed in the lining; while if compressive stress is too small, only verticle cracks are easily formed.

Horizontal cracks will significantly increase the electric resistance of carbon blocks, and carbon blocks with horizontal cracks will carry much less current. If most carbon blocks of one pot generated horizontal cracks, the cathode voltage drop (CVD) would increase dramatically, of which the impact is even bigger than sludge. Therefore, cathode current distribution and CVD indicate whether horizontal cracks are formed: if CVD of one pot is much higher than any other pots while sludge is basically the same, it can be concluded that most cathodes blocks of this pot have generated horizontal cracks [3].

3. Quality Standard for Chinese Cathode Carbon Block

Cathode carbon block is made of electrically calcined anthracite, metallurgical coke, graphite and so on, bonded with coal tar pitch. At present, commonly-seen cathodes in Chinese market are graphitic with different namounts < 100 % of graphite, 100% graphitic and graphitized cathode.

is usually heated unevenly during baking phase, volatile matter releasing rate is different and the pitch is also coked unevenLy. All of these factors will cause specific electric resistance discrepency among one batch of cathodes, and discrepency at different parts of one cathode [7].

As Table 1 shows, at present, the standard for Chines domestic cathode carbon blocks is relatively weak and the technical parameters standard also need to be revised. Some physical and chemical parameters are higher or uneven, and some need to be added. Specially there is no warranty given for tracing, re-inspecting and refunding of so many batches of cathodes in this project. These were the main reasons for the shortened pot life in this case of a Chinese domestic 500-kA potline.

6. Conclusions

Larger capacity pot production and ecological operating costs are closely related to pot life. The larger the pot capacity is, the bigger impact on the pot life. In recent years, although Chinese domestic aluminum reduction technology has been improved from design to operation and has stepped into international advanced level with modern constructed green-field smelters adopting 400 to 600 kA large or super large pot lines, but the pot life factor has not improved much. Especially, the quality of pot cathode carbon lining (cathode carbon block + ramming paste) and the small number of graphitized cathodes used do not meet expectation. Experts in primary aluminium industry should pay attention to this condition, so as to propel Chinese aluminium industry forward to a high-qualified, eco-friendly and sustainable future.

7. Reference

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