BAKED ANODE QUALITY IMPROVEMENT THROUGH OPTIMIZATION OF GREEN ANODE PROCESSING

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Abstract

At Lanzhou smelter, there are more than 11 mainly delayed coke suppliers. The range of calcined coke real density was between 1.99 and 2.06kg/cm^3, the resistivity was 480- 570μΩ.m, and the operating cost of rotary kiln was high due to the short life of tuyere nozzles and chamber lining. The apparent density of green anode was low and the deviation was ±0.05kg/cm^3 because of variation in the recipe and process parameters. There was very much dust in the cells and the net carbon consumption was about 450kg/t.Al. By blending delayed coke, adjusting calcining process parameters and optimizing the recipe and process parameters of green anode manufacturing, the quality of calcined coke improved. The tuyere nozzles and chamber lining were not distinctly destroyed in the past 8 months, the quantity of dust in the cells has decreased, and the net carbon consumption has reduced to nearly 420 kg/t.Al. This paper describes the work done on the optimization of green anode processing and the results achieved in the past one year.

Introduction

Lanzhou branch of Chalco is a 300 kt/year aluminium smelter located at Lanzhou city. The potline is based on SY350 smelter technology, operating on 394 kA now and uses prebaked anodes. Calcined coke is produced on-site by a rotary kiln calciner. The green anodes are formed using a Solios vibrocompactor, and baked in an open ringfurnace.

The prebaked anode manufacturing is a continuous, stable process [1]. The quality of the baked anodes depends on green anode quality and baking parameters [2]. At present, the baking furnace condition of Lanzhou smelter is good. The key parameters, including final baking temperature, soaking temperature and heating curve are effectively maintained during the green anode baking. Therefore, baking parameters are not taken as variable factors that could impact the baked anode quality for the present study.

A stable, higher apparent density and homogeneous structure of the green anode are crucial points to improve the baked anode quality. The primary factors that influence quality are: calcined coke quality, green anode recipe (fine dust index and content as well as pitch content) and green anode process parameters [3]. Therefore, our attempts to improve the baked anode quality were focused on the optimization of the above factors.

Optimization of delayed coke blending

Delayed coke is received from 11 suppliers mainly by train. Figure 1 shows the contributions of the delayed coke suppliers in details. Figure 2 shows the volatile and sulfur content for the different suppliers. It may be observed from Figure 2, that the volatile and sulfur content of delayed coke is different from supplier to supplier, even the same supplier quality has been found to vary over time. Without delayed coke blending, it was impossible to guarantee a stable volatile and sulfur content in the rotary kiln. This directly impacted on the calcining process control, calcined coke quality and sulfur emissions.

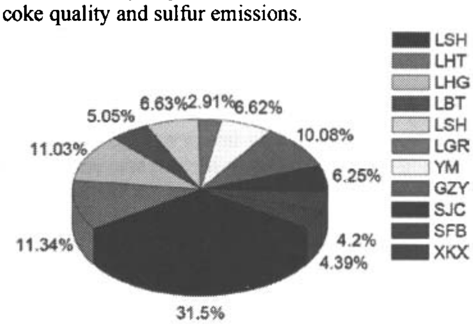


Fig 1: Delayed Coke Suppliers for Lanzhou Smelter

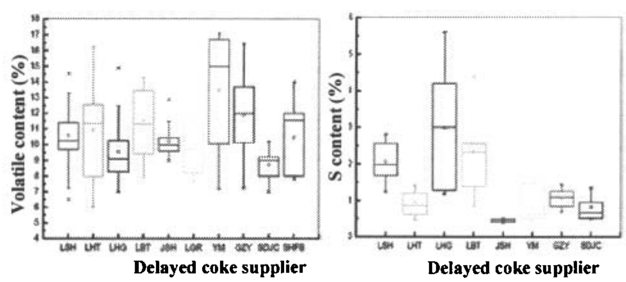


Fig 2: Volatile and Sulfur content for different delayed coke suppliers

Due to the fact, that calcined coke is produced by a rotary kiln in Lanzhou smelter, delayed coke blending rules are set by the volatile content. The target was to control the energy input to produce homogenous calcined coke quality with no extra fuel consumption.

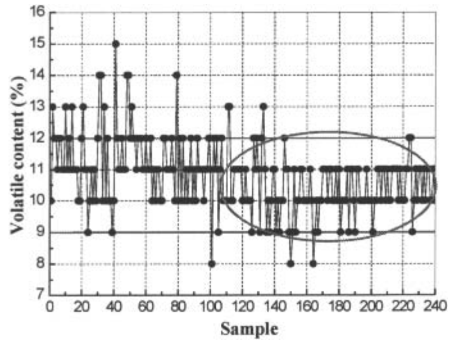


Fig 3: Volatile Content of Kiln Feed

Figure 3 shows the volatile content variation curve before and after blending. The delayed coke volatile content for rotary kiln feed gradually stabilized to a range between 10% and 11 % after blending.

Optimization of calcining process

Although the effective volatile content control was improved for the calciner operation, the control of the process parameters was also a key factor in improving the calcined coke quality as well as the kiln tuyere nozzles and chamber lining lifetime. Before process parameters were optimized, the range of calcined coke real density was between 1.99 and 2.06kg/cm^3, the resistivity was 480 to 570μΩ.m, rotary kiln tuyere nozzles lifetime was only 4 months, and the chamber lining lifetime was only 3 months. As a result, low and unstable calcined coke quality seriously impacted on the dry aggregate, liquid pitch content and green anode apparent density stability and caused some key equipment breakdowns. The low tuyere nozzles and chamber lining lifetimes not only directly increased the operating cost, but also the relative long repair cycle influenced the normal operating regime for the whole carbon plant.

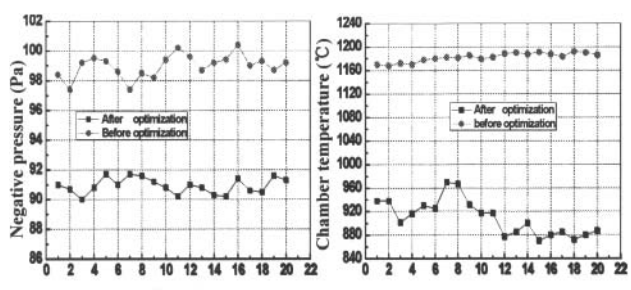


Fig 4: Comparison of Negative Pressure and Temperature Control After/before Optimization

The unstable negative pressure and temperature control were responsible for poor calcined coke quality in Lanzhou smelter. Figure 4 shows the negative pressure and temperature control before and after optimization. Volatiles were sucked into the chamber by higher negative pressure and firing in the chamber. This resulted in very high fume temperature and reduced the chamber lining lifetime. Also, not enough volatile combustion to keep the higher final temperature impacted on the coke quality in the rotary kiln [4]. Imperfect volatile combustion due to unreasonable secondary and tertiary air feed reflected on the lengthwise distribution of final section and kiln end temperature fluctuation. It resulted in lower product quality and shortened tuyere nozzle lifetime. Therefore, decreased negative pressure of the calcining system and control of secondary and tertiary air feed were the most important optimizing measures to guarantee stable calcined coke quality and normal lining and tuyere nozzles lifetime.

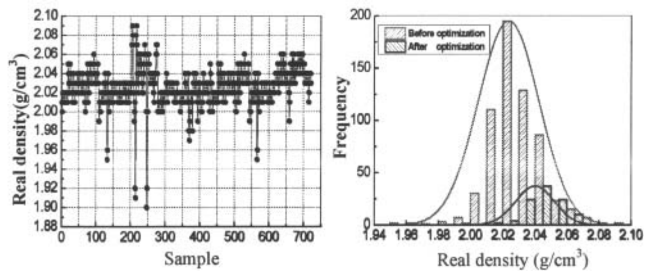


Fig 5: Increased Calcined Coke Real Density with Parameter Optimization

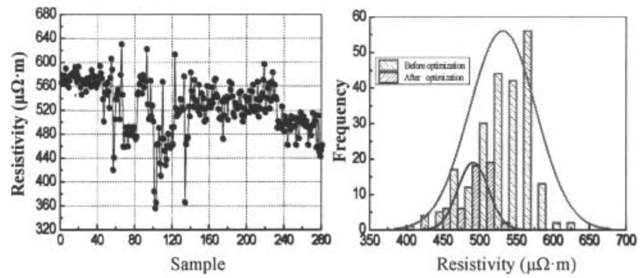


Fig 6: Decreased Calcined Coke Resistivity with Parameter Optimization

Figure 5 and 6 show the results of coke real density and resistivity before and after calcining parameters optimization. It may be observed that after process parameters optimization, the real density of calcined coke was evidently improved, the distribution range was mainly 2.04-2.06g/cm^3.The resistivity was distinctly reduced, the distribution range was mainly 480-510μΩ·m. These values and distribution range were better than before. In addition, the tuyere nozzles and chamber lining were not distinctly destroyed in the past 8 months and no extra fuel consumption was required. These optimum measures not only enhanced the calcined coke quality, but also reduced the operating cost.

Optimization of green anode process

The stable, higher apparent density and homogeneous structure of the green anode were crucial points to improve the baked anode property. The fine dust (ball mill product) index was one of the key factors to decide on pitch content and green anode apparent density. The weigh scale system and other equipment also impacted normal operation. Before fine dust index optimization, the -200 mesh content of fine dust was nearly 98% in Lanzhou smelter green plant. Although the fine dust content was controlled by 20 to 22 % of weight in the green anode recipe, it still caused the following trouble:

-Too much pitch addition.
- Scale continual alarm.

- Higher green anode standard deviation.

Decreasing the dynamic classifier motor rotary speed and keeping a rational ball rate to get coarse fine dust were the primary improvement measures. The result is shown in Figure 7. It may be observed that the -200mesh content of fine dust was reduced from 98% to 82%.

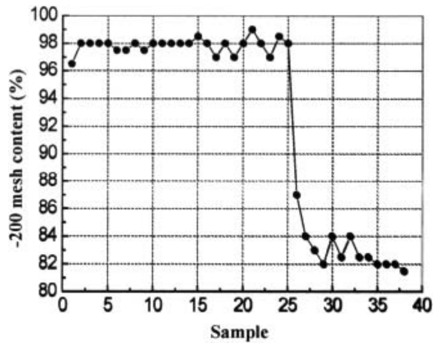


Fig 7: -200 Mesh% in Fine Dust with Ball Mill System Parameters Adjustment

Following the adjusted fine dust content and dry aggregate composition, the change of pitch addition and fine dust scale alarm frequency are shown in the graphs below:

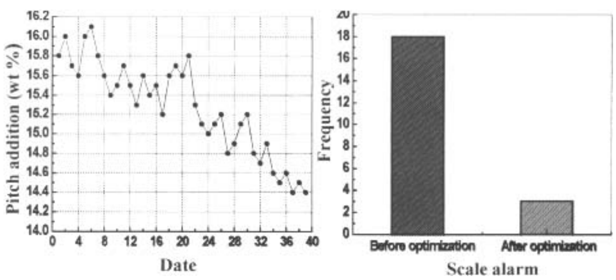


Fig 8: Pitch Content and Scale alarm Frequency Reduced with Modification of the Fine Dust Composition

It may be observed from Figure 8 that the pitch addition was gradually reduced and the fine dust scale alarm frequency decreased.
Paste kneading temperature was another crucial process parameter to enhance green anode quality. The change of paste temperature is shown in the graph below:

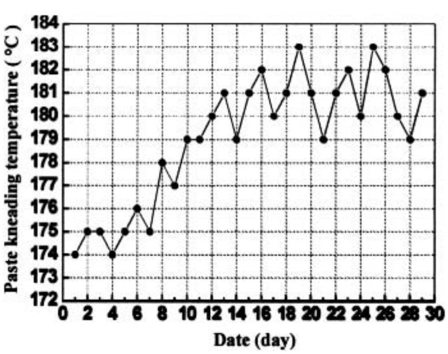


Fig 9: Paste Kneading Temperature Increased with Process Optimized

The green anode apparent densities are shown in Figure 10 after above process parameters optimization. It may be observed that with optimum -200 mesh contents in fine dust, pitch content and paste kneading temperature, a higher and stable green anode apparent density of 1.61-1.63 g/cm^3 was achieved.

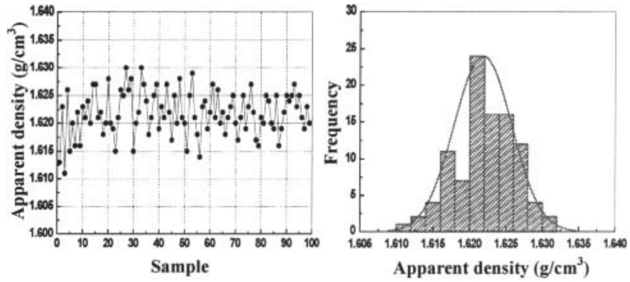


Fig 10: Apparent Density was higher and more stable with Optimum Process Parameters

Results

These modifications resulted in the following major changes:

- Butts quality improved.
- Anode cycle increased.
- Net carbon consumption decreased

Lanzhou smelter adopted the SY350 aluminium reduction technology. Pot rooms gradually increased the line current to increase the metal production. Figure 11 shows the results of potline current intensity from Jan 2009 to Aug 2010. It may be observed, that the potline current was gradually increased from 371 kA to 394 kA over the past one and a half years and a 6% anode current density increase was achieved.

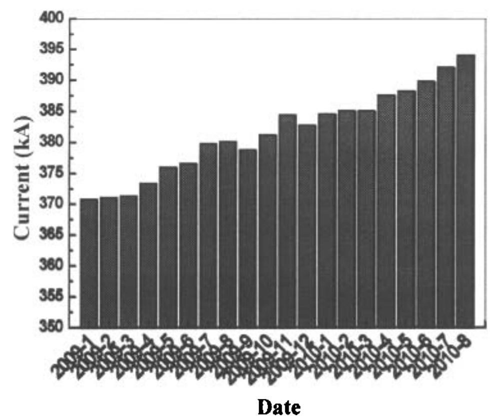
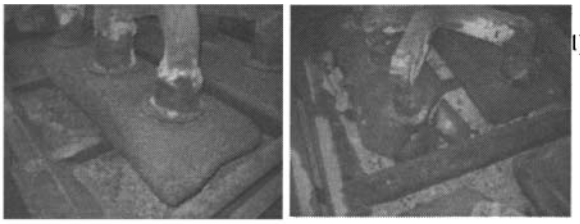


Fig 11: Results of Pot Current Intensity from Jan 2009 to Aug 2010 at Lanzhou Smelter

At the beginning of this project, butts quality was poor due to no high and stable green anodes quality supplied. Prebaked anodes were excessively consumed as a result of CO_2 and air reactivity. Therefore, much dust and soft butts occured in the cell. Much dust directly decreased the current efficiency and increased the operator work intensity. Recycled soft butts influenced the green anode quality, then butts became more soft and in the end, caused a vicious recycle of soft butts.



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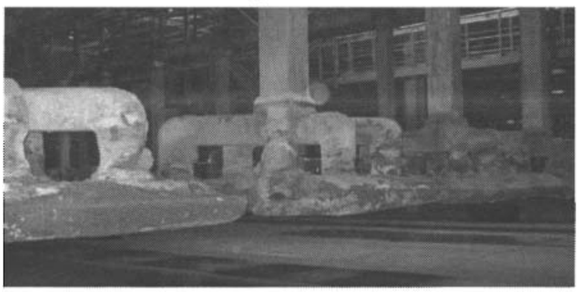

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Fig 12: Comparison of Butts Shape in Apr 2009 with Apr 2010

Figure 12 shows the butts shape variation before and after parameters optimization. It may be observed from Figure 12 that butts shape and depth had a more remarkable improvement in April 2010 compared to one year ago. In addition, the quantity of dust also gets less in the pot. The anode cycle variation is shown in Figure 13 form Aug 2009 to Aug 2010. It may be observed that the anode cycle was gradually increased. The maximum cycle was able to reach 32 days. All these results mean that butts quality had evidently been improved. According to primary calculation, the net carbon consumption was reduced from 450 kg/t.Al to 420 kg/t.Al.

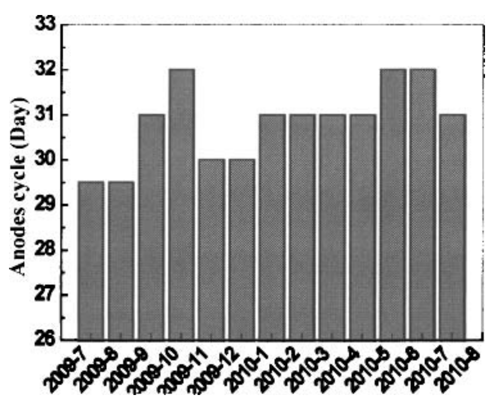

Fig 13 Anodes Cycle from Aug 2009 to Aug 2010 at Lanzhou Smelter

Conclusions

(1) Quality of calcined coke, the kiln rotary tuyere nozzles and chamber lining lifetime have increased to over 8 months.

(2) The apparent density of green anode could be controlled effectively and the stability increased.

(3) Butts quality improved and anode cycle was increased.

(4) Net anode consumption was reduced from 450 kg/t.Al to 420 kg/t.Al.

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