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BAKED ANODE QUALITY IMPROVEMENT THROUGH OPTIMIZATION OF GREEN ANODE PLANT ULTRA FINE CONTENT IN BALL MILL PRODUCT AND PROCESS PARAMETERS

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Abstract

The two long term trends in the aluminum industry that will have the most effect on anode quality requirements are scarcity of good quality calcined coke for anode production and the current creep by pot lines. In ALBA the pot rooms have gradually increased the line current to increase aluminium metal production. Therefore there was need to improve baked anode quality and net carbon consumption so that the butts thickness at increased line current will be maintained. In ALBA, for a given set of raw materials, baked anode density in the range of 1.580-1.585 g/cm^3 was normal. With in-house research, baked anode density of 1.600-1.605 g/cm^3 was achieved by optimization of ultra fine content in Ball Mill Product, along with other process parameters of Green Anode Plant. The paper discusses the work done on the optimization of the Paste Plant's dry aggregate recipe & process parameters and results achieved over a period of one and half years.

Introduction

Alba is an 870,000 MT/year aluminium smelter operating in the Kingdom of Bahrain. Its line 4 and line 5 pots presently operate at 340 and 350 kA current respectively. The pot lines 4 and 5 are based on AP-30 smelter technology and use prebaked anodes. The green anodes plants utilizes conventional vibro-compactors, the anodes are baked in open type furnaces, are sealed with 6-stub yokes in rodding plants and delivered to pot rooms.

One of the main quality improvement objectives in the carbon plant is to produce baked anodes with higher density with current deterioration of raw material quality.

The baked anode density is influenced by:

- Nature of raw materials (coke, butts, and pitch)
- Dry aggregate composition of green anode
- Pitch content in green anode
- Process and Equipment Parameters

A set of trials were carried out to improve the baked anode density

1. Paste Mixer temperature.
2. Dry Aggregate Pre-heater temperature
3. Ball mill product fineness and content

Paste Mixer Temperature

Alba Paste Plant # 2 is using continuous Buss Mixer of design capacity 35 TPH. From long time mixer paste temperature was set at the level of 195 °C. In beginning of the year 2011, when baked anode density started decreasing due to deterioration in raw material quality, mixer paste temperature was increased from 195 °C to 200 °C (Fig-1). With increase in mixing temperature, a significant improvement in Baked Anode Density was observed (Fig-2).

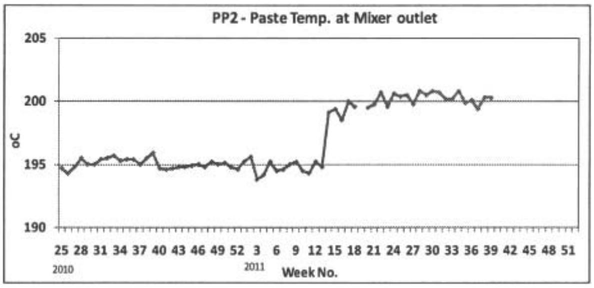

Fig-1: Paste Plant-2, paste mixer temperature increased from 195 °C to 200 °C

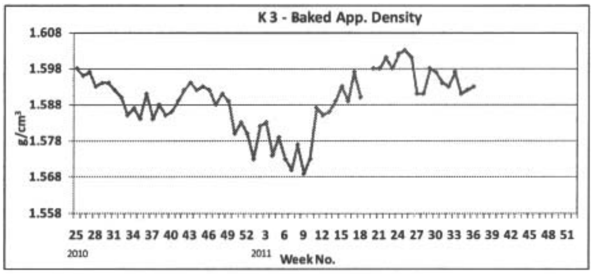

Fig-2: Paste Plant-2, Baked Apparent Density which deteriorated and reached to 1.568 gm/cc, started increasing with increase in mixing temperature

Dry Aggregate Pre-heater temperature

Alba Paste Plant # 2 utilizes pre-heater of 4-screw design with capacity of 30 TPH. From long time dry aggregate preheating temperature was set at the level of 210 °C. In beginning of the year 2011, when baked anode density started decreasing due to deterioration in raw material quality, dry aggregate preheating temperature was also increased from average 210 °C to 225 °C (Fig-3). A significant improvement in Baked Anode Density was observed in tandem with the second trial (Fig-1).

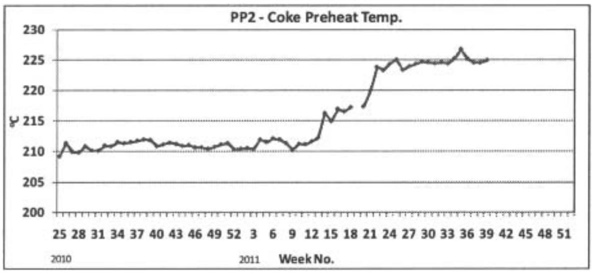

Fig-3: Coke pre-heater temperature increased gradually from 210°C to 225°C

Ball mill product (fineness and content)

The binder in dry aggregate is pitch content plus the dust in dry aggregate. The fines is categorized into two, first being size below 75 micron and the ultrafine fraction (below 32 micron) of the fines. In the trial the fines content (in recipe) was actually reduced from 23 % to 21 % but at the same time ultrafine in ball mill product was increased from 62 % to 71 % in order to achieve same ultra fine content in dry aggregate (14.5 to 15.5%) , see Figs. 5-9

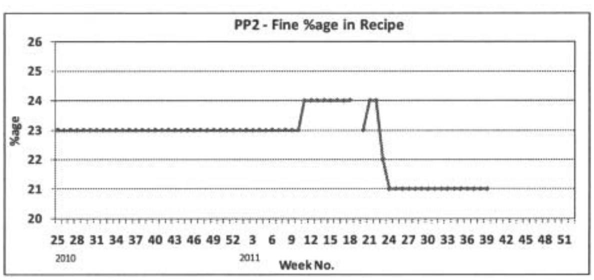

Fig 5: Fines content (BMP) in dry aggregate recipe reduced from 23% to 21%

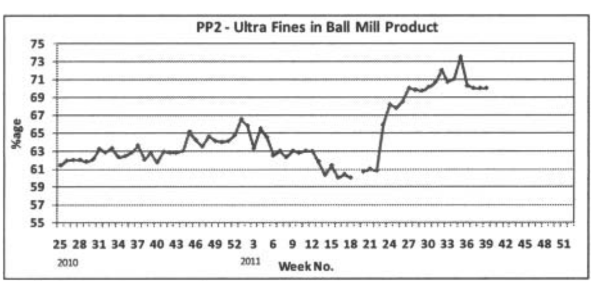

Fig 6: Ultra Fine (-32 micron) in ball mill product increased from 62% to 71%

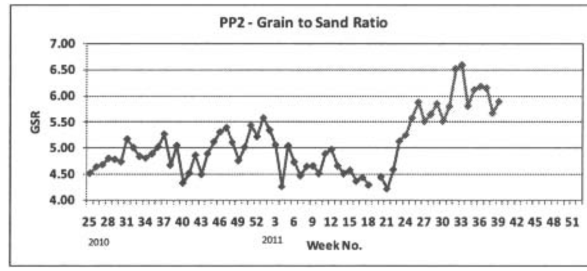

Fig 7: Reduction in Fines% in dry aggregate recipe resulted in increase in Grain to Sand Ratio (GSR)

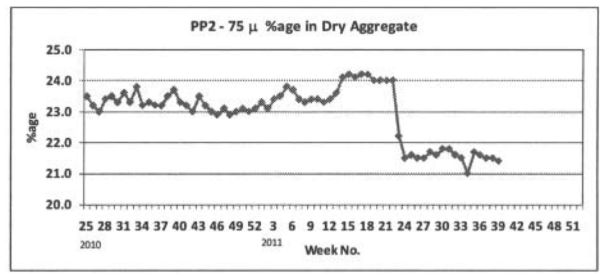

Fig 8: -75 micron in dry aggregate reduced from 23-24% level to 21-21.5% level

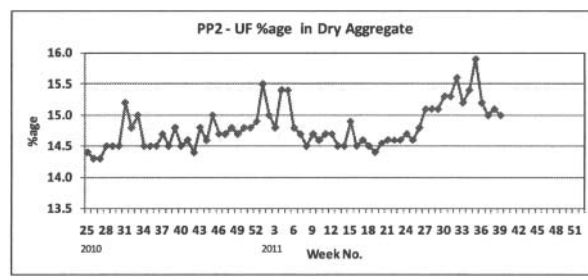

Fig 9: Ultra fine in dry aggregate was maintained in the range of 14.5-15.5%

The changes in dry aggregate recipe (Figs. 5-9) resulted in significant improvement in anode quality as indicated by baked anodes core samples analysis:

- Baked anodes density improved from 1.57 g/cm^3 to 1.605 g/cm^3 (Fig-10).
- Anodes electrical resistivity reduced significantly from 5600 μΩcm to 5300 μΩcm (Fig-11)
- Air permeability which increased to 0.6 nPm due to degradation of coke quality improved back to normal range of 0.4-0.5 nPm (Fig-12).

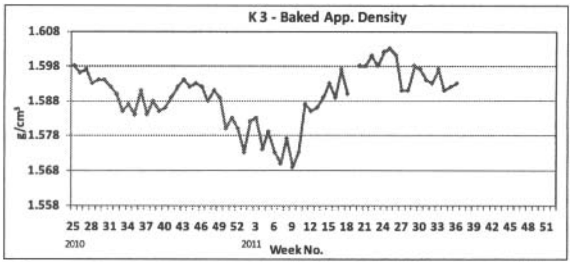

Fig 10: Baked anode density improved further and peaked at 1.605 with optimization of ultra fine in ball mill product

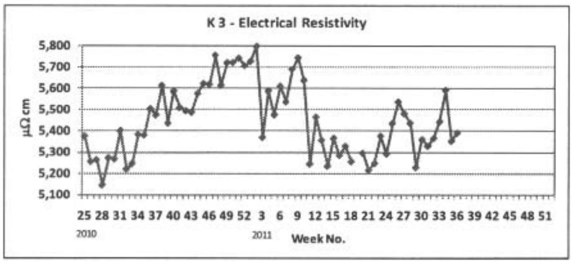

Fig 11: Optimization of ball mill product fineness resulted in significant reduction in anodes electrical resistivity

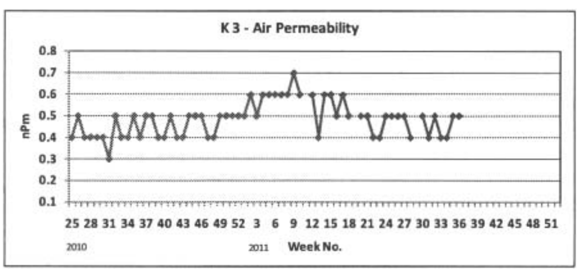

Fig 12: Optimization of ball mill product fineness resulted in significant improvement in Air Permeability

Discussions

Degradation in coke quality and increasing pot room quest for higher amperage imposed challenge for Alba carbon plants to maintain/improve baked density. With experience and literature survey Alba took initiative to optimize process parameters further to improved Baked Anode Density. Dry aggregate preheating temperature which was already on higher side compared to many other carbon plants increased further from 210 °C to 225 °C and mixing temperature raised from 195 °C to 200 °C.

Change in dry aggregate preheating temperature and paste mixing temperature improved anodes baked density but still it was lower than 1.600 gm/cc. Then one more initiative was taken to optimize fineness of fines (Ball Mill Product).

Ball Mill Product (Dust): Ball mill product is 95-100% below 75 micron measured by normal sieve analysis. Fineness of fines is measured through well known Pechiney method of Ultra Fine (<32 microns) using Alpine machines. Ultra fine in dry aggregate is defined as:

$$UFDA = BMP \times UF$$

UFDA - Ultra Fine in Dry aggregate (%)
BMP - Ball Mill Product (%)
UF - Ultra Fine in Ball Mill Product (%)

Baked apparent density improved by increasing coke temperature and mixing temperature but showed a peak when Ultra fines in ball mill product was increased from 62% to 71%

Using finer fines in anode formulation can improve anode quality significantly. An evaluation of the capacity of the dust production system and optimization of pitch content may be required to achieve the same. The ball mill throughput and product fineness can be approximated by below equation [1].

Ball Mill Throughput x Dust Fineness = Constant

Impact on pitch content: Carbon dust contributes more than 90% of the total aggregate surface area and largely dictates optimum pitch requirement. The grain size above 32 micron represents only about 10% of the total specific external surface area of the dry aggregate to be coated with pitch [2]. Pitch content reduced from 13.3% to 13.1% (Fig-13)

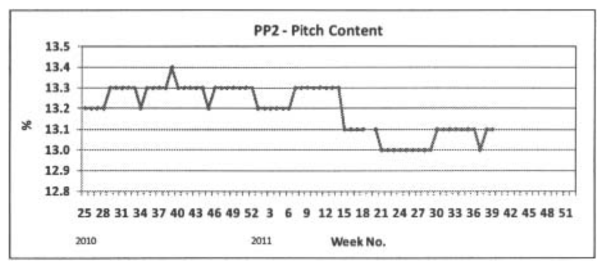

Fig 13: Pitch content in recipe reduced from 13.3% to 13.1%

Conclusions

Significant improvement in Baked Anode Density was achieved by optimizing dry aggregate preheating temperature, paste mixing temperature and finally by optimizing fineness of ball mill product. Other baked anode properties like electrical resistivity and air permeability of anodes also improved and pitch requirement for green anodes production reduced by nearly 1.5%.

Finally, increasing fineness of fines is an important modification to allow smelters to increase line amperage and minimize impact of deterioration in calcined coke quality

References

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