Strategy for sustaining anode quality amidst deteriorating coke quality

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Abstract

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The gradual deterioration in anode grade coke quality over the past two decades and its impact on anode quality has been well documented [1, 5] by coke suppliers and anode producers alike. EGA Jebel Ali (also known as Dubai Aluminium PJSC or DUBAL) also experienced the challenge of decline in vibrated bulk density (VBD) and increased impurity levels in coke. To minimize the impact of these variables on anode quality, DUBAL devised a strategy to blend different coke types; and adapt its anode manufacturing process, which yielded an increase in baked anode density of more than 0.015 g/cm^3 without compromising other key anode properties. As a part of its long-term business strategy to secure its own raw material, DUBAL entered into a joint venture with Chinese coke producer Sinoway Carbon Energy Holdings (Sinoway) in Shandong. This paper describes DUBAL's strategy for the blending of shaft and rotary calcined coke at DUBAL, process adaptations at Carbon Plant and the joint work done with Sinoway to optimize the calcining process, thereby improving key coke properties such as - VBD, coke reactivity and particle sizing - which resulted in improved anode quality and performance.

Keywords: Shaft calcined coke; vibrated bulk density; coke blending; baked anode density; Blaine Index.

1. Introduction

Consistent high quality anodes are a basic requirement of any high performance smelter. Anode quality is influenced by several key factors, including raw materials properties and the anode formulation process. Calcined petroleum coke (CPC) is a key raw material used in the production of anodes for the aluminium industry, representing approximately 65 % of the anode weight. The quality of CPC has gradually declined over the past two decades. Presently, deterioration in raw material properties (CPC and coal tar pitch) is considered to be one of the most significant challenges in the anode manufacturing industry, as it adversely affects anode quality and performance.

DUBAL has traditionally sourced CPC from US Gulf Coast producers. As the demand for CPC grew in the late 1990s and CPC production in the Middle East and Asia became prevalent, economics and logistics favoured the procurement of CPC from these sources. For economic reasons and security of operations, DUBAL sourced CPC from multiple suppliers. Exposure to CPC from a multitude of geographic locations provided valuable insight into its unique characteristics.

It was observed that the general increase in the quantity of heavy sour crudes processed by the petroleum industry in the past decade resulted in an increase in metallic impurities and a decrease in VBD, both of which were detrimental for anode performance and aluminium purity.

Since DUBAL used CPC from individual suppliers on a campaign basis (prior to blending until 2008), the properties of the anodes that were produced with these cokes became more

pronounced due to variations in coke quality from different suppliers (Figure 2). This made optimising anode usage in the reduction cells more challenging. In particular, step-changes in baked anode density and reactivity were observed. DUBAL's aging Paste Plants were operating beyond their design capacity; so the issue of increasing the density of anodes while using lower VBD coke for production, could not be addressed by process adjustments alone.
This paper explains DUBAL's journey to sustain and further improve the anode quality in spite of the deteriorating coke quality. Figure 1 outlines the long-term strategy applied by DUBAL in various stages to overcome the market challenges for coke quality and prepare for future challenges.

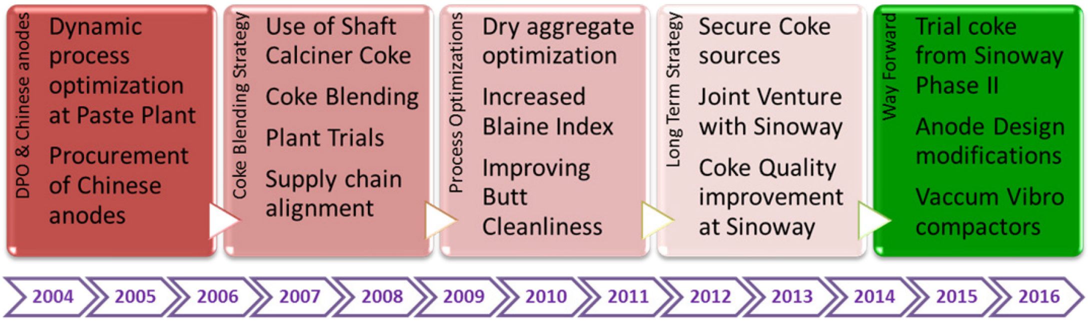

Figure 1. DUBAL Strategy to address deteriorating coke quality.

2. Deterioration in coke quality before coke blending at DUBAL (2000 to 2008)

DUBAL, like many western smelters, has sourced the majority of its CPC requirements from producers using rotary kiln technology. The gradual deterioration in aluminium grade green petroleum coke (GPC) made it extremely challenging for CPC producers to meet smelter specifications. As a result, the quality of coke used at DUBAL shifted towards lower vibrated bulk density (VBD) and higher impurity content – mainly vanadium (V), nickel (Ni) and sulphur (S) (Figure 2). From 2000 to 2008, V levels in calcined coke increased on average by 23 % (48 ppm) , while the concentrations of Ni and S increased by 33 % (38 ppm) and 14 % (0.3 % abs.) respectively. Coke VBD also dropped on an average by 0.02 g/cm^3 with minimum of 0.87 g/cm^3 from a few suppliers, due to the higher volatile matter content of processed green cokes.

The impact of increased chemical content of coke is well known to the anode manufacturing process experts. V is a known catalyst for the reaction of carbon with oxygen at elevated temperatures. As V and Ni levels increase, there is a rise in excess carbon consumption because of air burning of anodes, which can negatively affect cell stability. Likewise, calcium (Ca), silicon (Si), sodium (Na) and iron (Fe) are also undesirable impurities in coke. Calcium can have a significant negative effect on coke and anode CO_2 reactivity, and therefore needs to be controlled; while sulphur represents an environmental constraint to meet the permitted limits for SO_2 emissions, which is not an immediate threat for DUBAL.
Another important aspect is that DUBAL operates six different cell technologies, with the oldest technology being more than 30 years old. Modern electrolysis cells such as DX cells (DUBAL technology) with deep cavity designs are not as susceptible to anode air burn as the oldest cell design (D18). This is because the ability to cover anodes and maintain cover levels is significantly better in DX cells than older cell designs, where the anodes sit higher in the cell cavity. Thus, more reactive anodes are likely to cause variations in butt thickness for older DUBAL technologies. Higher variation in butt thickness increases the Fe contamination in the metal. Greater amounts of carbon dust from more reactive anodes also increases the percentage of "hot" pots, which ultimately increases the proportion of Fe and Si in the metal. Therefore, anode air reactivity is a concern for DUBAL anodes that are used in older cell designs.

5. Conclusion

DUBAL Carbon Plant has adapted well to the changing requirements of the smelter by ensuring that continuous improvements in anode quality were realised.
Synergistic blending of cokes at DUBAL has proven to be an effective strategy to address the deterioration in coke quality. Thorough understanding of the strengths and weaknesses of individual cokes and a well-aligned supply chain have been fundamental to successful coke blending.
As bulk densities of rotary kiln cokes continue to decrease, shaft calciners provide a viable source of high density coke that can be used to sustain anode density. DUBAL has applied an effective long-term strategy by securing more than 50 % of its coke requirements through a joint venture with Sinoway, with the added flexibility to customise the coke calcining process in order to meet DUBAL's process requirements. This approach was pivotal in addressing the high CO_2 reactivity, which seemed typical of Chinese cokes, through the proper selection of GPCs and subsequent process changes.

Sinoway is expected to increase its production capacity by 350 000 t/year in 2016 (Phase II); and would use its patented calcination technology to produce low sulphur CPC from high sulphur GPC at competitive cost and without any adverse impact on environment. A trial consignment of this coke will be tested at DUBAL to establish the process advantages.

To further improve anode performance and provide greater flexibility for processing cokes with varying VBD, DUBAL plans to install vacuum vibration systems in both paste plants. Cutting of length-wise slots, anode top profile modification and anode length increases will also be introduced shortly to further improve anode performance and generate energy savings.

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