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COKE BLENDING AND FINES CIRCUIT TARGETING AT THE ALCOA DESCHAMBAULT SMELTER

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Abstract

The continued increase of the demand for Aluminium metal combined with the fluctuations in the quality of aluminium grade coke makes it more challenging for the anode manufacturing plants to deliver steady quality anodes. The low sulfur coke material is becoming less available on the market and the price is steadily increasing. Environment regulations are aiming at reducing sulfur emissions, while the coke suppliers are offering higher sulfur material. The use of low sulfur material as feed stock increases anode CO_2 reactivity and therefore making the product less attractive for the downstream process. An attempt was made to use only the high sulfur material in the fines fraction, in order to optimize CO_2 reactivity while respecting sulfur emissions limit and coke supplier agreements. This paper presents the detailed results of this test, which later became a process flowsheet modification.

Introduction

The idea of using a dedicated coke to manufacture the fine fraction of an anode has been discussed for a few years now. In this particular case, the Deschambault smelter used the technique to improve the anode's CO2 Reactivity. The timing was perfect since the potline operations were observing a lot of dusting in the pots.

The results presented include lab bench scale tests testwork and plant test results. This study required a lot of effort from plant personnel and the plant trial in the smelter got stretched over many months. In this study we used actual pots to benchmark the performance of the new formulated anodes against the normal ones. The benchmarking results will also be discussed.

Finally, this new approach has allowed the Deschambault smelter to target a dedicated coke to manufacture the fine coke fraction of the anodes. The final process diagram enables future coke trials at the plant.

The problem – solution approach

The dusting cycle is characterized by anodes with a poor resistance to reactivity and hot pots operating at a lower current efficiency. Unstable pots can also lead to dusting in the pots and maintain the conditions that encourage the dust formation.

Anode plants need to produce anodes that perform better in the pots, thus reducing the tendency to generate dust in the pots. In order to do so, one approach is to dedicate the least reactive coke to the fines fraction.

Figure 1: Initial Process Diagram

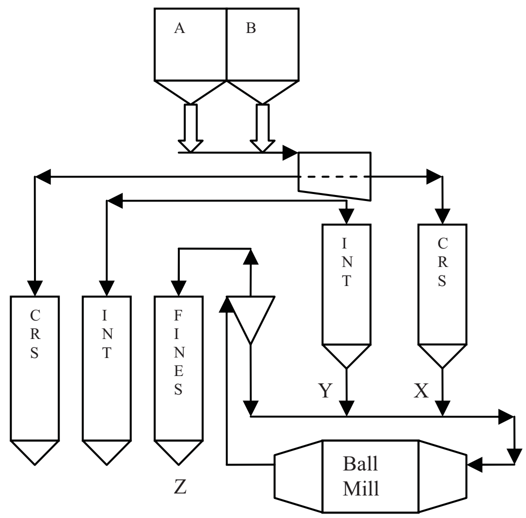
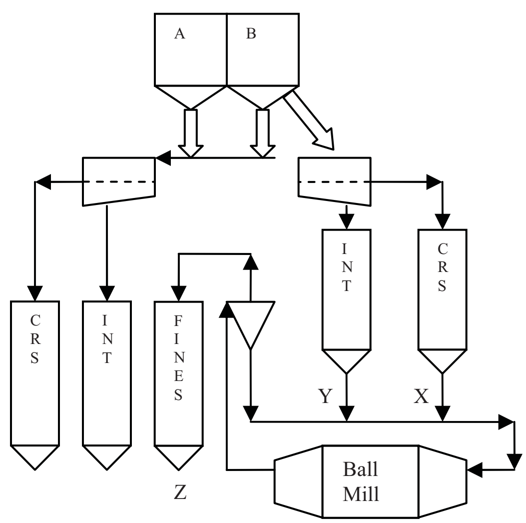


Figure 2: Modified Process Diagram



X : Coarse fraction
Y: Intermediate fraction
Z : Fines fraction

At the Deschambault smelter like many other recently built plants, the coke fractions used to make the anodes are characterized as coarse, intermediate and fines.

In the first step coke is received in the two main silos (figure 1 and 2: A,B) for storage, these silos will keep enough inventory for over a month's consumption. In figure 1, it is indicated that the material is fed to the plant by a single conveyor from which the material is sieved and redirected to the appropriate size fraction. The two size fractions at this point are coarse and intermediate. A portion of each stream is directed to two other separate silos to feed the ball mill and manufacture the fines fraction to complete the anode recipe.

In figure 2, a dedicated stream is organized to feed the ball mill and the fines fractions stream. This improvement is the main topic of this paper.

Coke supply

Having two main silos allows the blending of two different coke sources to make an optimised mix. The purpose of the mix can lead to an improvement in many properties; in this particular case the objective was to significantly improve CO_2 reactivity.

The blending started with two different coke sources, one being higher in sulphur, while the second one is lower in sulphur (see Table 1). The higher sulphur coke has an obviously better CO_2 reactivity residue but produces high air reactivity. On the other hand the low sulphur coke produces poor CO_2 reactivity but excellent air reactivity. The mixture of the two coke sources make a good blend which presents properties that allow for a good anode performance in the pots while respecting environment regulations for SO_2 emissions.

Table 1: Coke specs

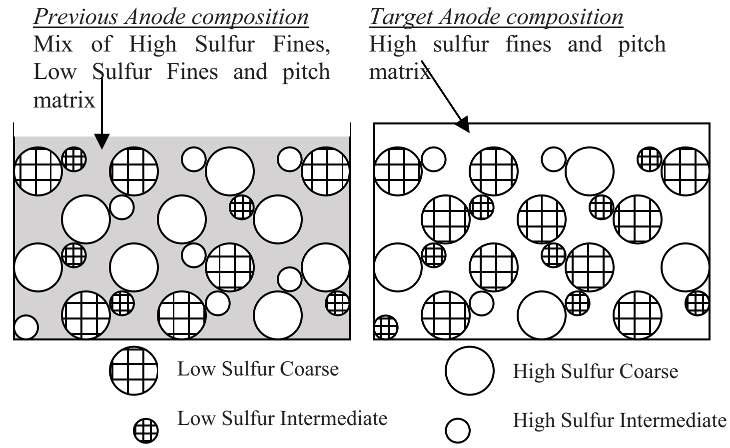
	SULPHUR	CO2 REACTIVITY	AIR REACTIVITY
High sulphur coke	3.3 % S	CRR +	ARR-
Low Sulphur Coke	1.8%	CRR -	ARR+

Looking at it closer

When the anode is immerged in a bath of cryolite at 970°C the portion of the anode that is the most susceptible to CO_2 reactivity is the binder matrix which is composed of the fines and pitch. The most efficient way to improve anode performance in this case, is to eliminate the highly reactive coke from the binder matrix.

In the figure below (figure 3), the aim of the target composition is to fill the matrix with the fines fraction having the least reactive material. The higher sulphur coke being less reactive, this material is dedicated for that stream. The coarse and intermediate fractions are still being made with a mix of the lower sulphur coke and high sulphur coke.

Figure 3: Representation of an anode matrix



Experimental Approach

To test this concept a benchmarking exercise was organized in the potline. A test group (12%) was defined and its performance was measured on a weekly basis for 3 months. A batch of "special" anodes were manufactured every week to feed the test group and the "special" anodes were tagged to trace them along the process and to measure the efficiency of the placing system.

While laboratory analyses were done on the weekly samples from the "special" anodes production run, the usual quality control process was still taking place.

Results and Discussion

-Laboratory results:

There is a significant improvement with the special anodes formula. The most obvious result is about the CO_2 reactivity, as shown in figure 4 below, the net improvement is above 3% CRR. This clear improvement is confirmed with the dust portion from the CO_2 reactivity test which went from 2.9% to 0.8% as shown in Figure 5. Also, the standard deviation of the results is significantly improved.

Figure 4: Comparison of CO_2 Reactivity Residue

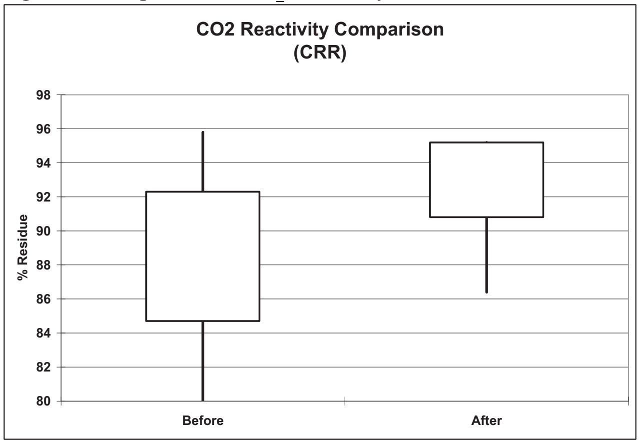
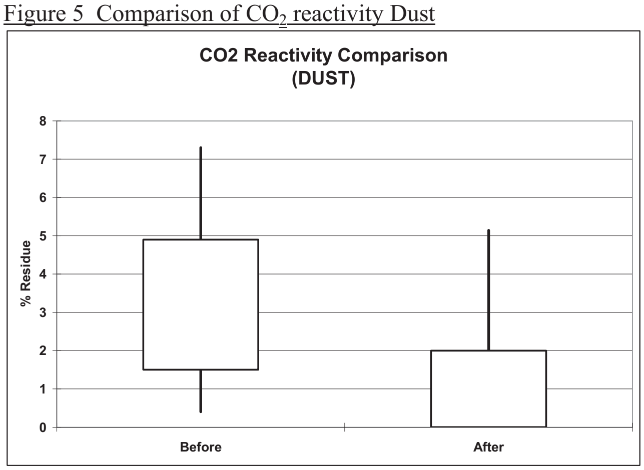


Figure 5 Comparison of CO_2 reactivity Dust



All other anode properties did not show significant changes and this can easily be explained since the total recipe remained in the same ratio for each coke. So the chemical results like: Ca, Fe, Na, S, V showed no significant change, while the pitch ratio was slightly reduced and baked density remained the same.

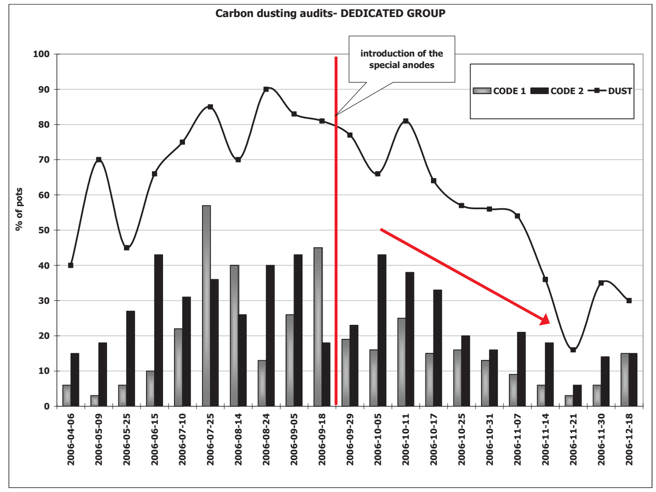
-Potline Benhmarking

The test group was chosen in the potline as being a section of pots having very intense dusting and unstable pots. A weekly audit was performed on all the pots in the potline, this way the test pots were monitored as closely as the benchmark group. The weekly audits involved observations at the tap hole and of the cover material. This operation is quite manpower intensive but allows a very good monitoring of the dusting evolution in the pots.

These observations were started early in 2006 to provide a good database and to have data to compare before and after the introduction of the "special" anodes.

The results of the audits are shown in figure 6. The investigation categorized dusting in three levels: code 0 being less than ½ inch of dust at the tap hole; code 1 is more than 1 inch of dust at the tap hole; code 2 being less than 1 inch and more than ½ inch of dust at the tap hole. Also, when observing the pot cover material, it is classified as being dusty or not. In figure 6, the pots with code 1 and 2 are reported as the dusty pots in percentage of pots in the potline.

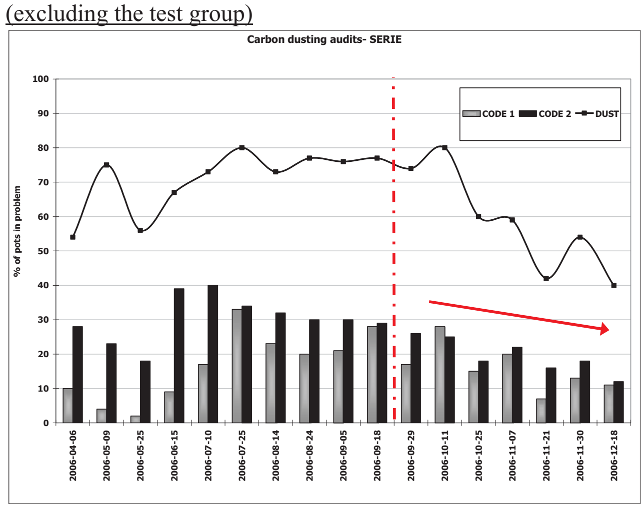
Figure 6: Evolution of carbon dusting in the group



After the introduction of the "special" anodes in the test pots, one can observe the significant reduction in the frequency of dusty pots going from more as much as 90% to less than 30%. Also, the code 1 pots went down from about 30% on a steady slope to less then 5% at the best time and back to 15% at the end of the test. The trend for code 2 pots also evolved from an average 40% to less then 20% and went as low as 5% to finish the test at 15%.

Overall, the test group was significantly impacted by the introduction of the "special" anodes which confirms the new "special" anodes are of a less reactive formula.

Figure 7: Evolution of carbon dusting in the potline (excluding the test group)



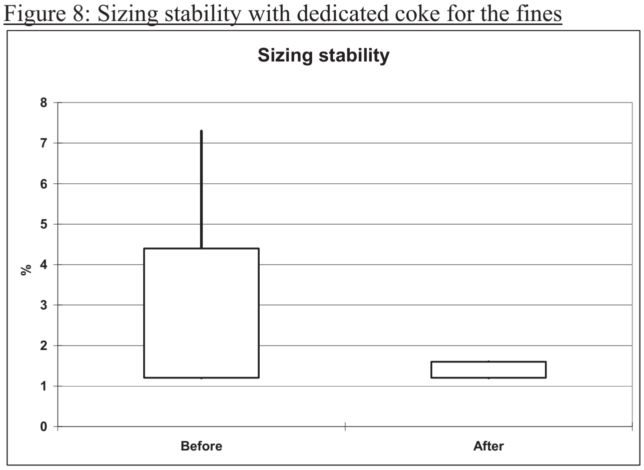
The results from the dust audits for the remainder of the potline (figure 7), show a more stable level of dusting in the pots and a reduction from approximately 75% to 45% at the end of the year. The code 1 pots evolved between 20% and 30% to complete the period of the test at 11%. The trend for code 2 continuously reduced on a very small slope from 30% to 20% and completed the test period at 12%.

These two graphs showed the significant impact the "special" anodes had on the test group compared to the rest of the potline. Obviously, the number of pots with dust presence was reduced significantly in the test group, even though the whole potline has experienced a reduction of the dusting issue, the pots in the test group went from being the worst pots to be the best pots.

-Process stability:

During the manufacturing of the fines fraction with a dedicated coke, it was observed that the overall sizing variations was significantly reduced. As shown in figure 8, the standard deviation of the sizing was compared and shows a very sudden reduction. The impact of this stability is confirmed with the slight reduction in pitch ratio which reduced by 0.3%.
One could explain this improvement in stability with the more stable hardness of the material feeding the ball mill since the two cokes used in the test showed a significant difference in hardness.

Figure 8: Sizing stability with dedicated coke for the fines



-Potential for a reduction in Sulphur mission :

In the present plant trial, the recipe used was stable and the ratio of the two coke sources used was unaffected as this was one premise of the test. With the present results, one could target to produce an anode of similar properties with a different ratio of coke. For instance, the high sulphur coke could be used to exclusively manufacture the fines fraction while the low sulphur coke to be used for the coarse and intermediate fractions. This would lead to a significant reduction of high sulphur coke consumption and the corresponding reduction in SO_2 emissions.

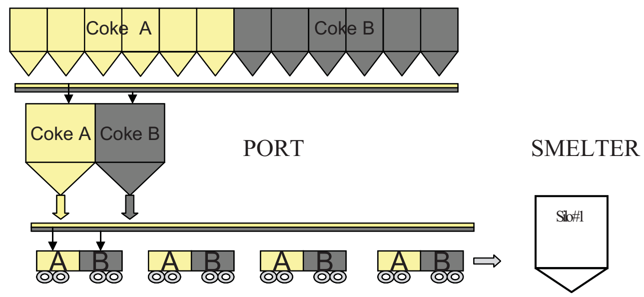
-Potential for other improvements

Coke targeting can lead to improvements in other fields than CO_2 reactivity. The same principles can be applied to improvements in density or air reactivity for instance. Once the systems are in place, it can be used to fulfill the need for improvement that coke targeting can deliver.
In some cases, the anode density might be the target issue. Using the lowest bulk density material to manufacture the fines to keep the highest bulk density for the coarse and intermediate fractions could lead to more dense anodes and thus reducing number of blocks produced to satisfy the needs of the customer.
Also, the same principle can be applied to manufacture anodes with better air reactivity. This would involve using the least reactive material in the fines fraction to avoid the presence of highly reactive material in the fines-pitch matrix.

Coke Blending

Following this project of coke circuit targeting an additional step was reached in the coke blending path. Since the plant can receive coke in two main silos, and that one of the two silos is dedicated to the coarse and intermediate, this silo is now fed with a blend of two cokes.
In order to do so, an additional step of blending was realized at the port facility when loading the railcars as shown in figure 9.

Figure 9: Coke Blending at the port facility



This coke blending diagram allows the introduction of 3 different coke sources in the plant at a controlled rate without increasing the process fluctuations while improving anode performance.

Conclusion

In this paper we have discussed the coke targeting principle. It was demonstrated to be a proven application that the higher sulphur coke dedicated to a specific stream can positively affect anode properties. Many other opportunities in anode properties improvements are possible using the coke stream targeting approach.
Also, coke blending allows for a more flexible recipe once coke circuit targeting is implemented.

Acknowledgements

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