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ALUMINUM REDUCTION TECHNOLOGY

Potline Operation I – Smelter Operations

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LOW POWER OPERATION AT ALUMINIUM DUNKERQUE SMELTER

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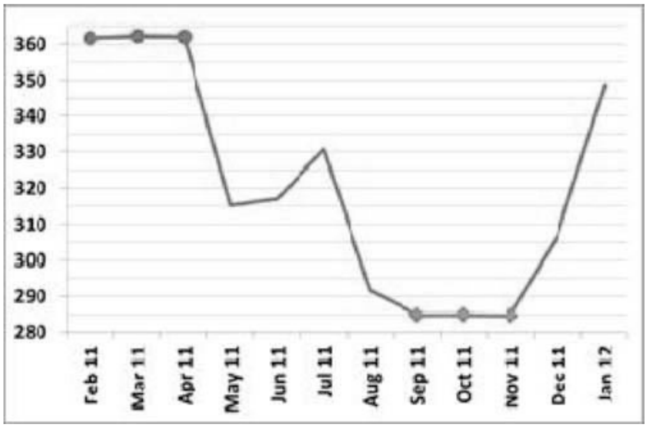
Abstract

The Aluminium Dunkerque smelter came on stream in 1991 with AP30 technology at 295 kA and since then the technology has been regularly improved to operate around 360 kA nowadays. In mid-2011two successive severe technical incidents took place in the Substation and limited the maximum Substation capacity to 285 kA for several months. To cope with this 20% amperage reduction and limit the risk of smelter stoppage, a major action plan was launched not only in the potrooms but also in the smelter as a whole. After adjustments on both operation and process sides, Aluminium Dunkerque has been able to continue operating the potline for 8 successive months at reduced amperage with satisfactory operating condition and technical results. This demonstrates the robustness and capability of the technology to operate at reduced power and paves the way for flexible power operation at AP Technology™ smelters.

Introduction

The Aluminium Dunkerque smelter, located on the shores of the North Sea in northwestern France, came on stream in late 1991 as the first AP30 AP Technology™ smelter (1). At this early stage of the smelter's life, the 264 AP30 pots were operated at around 295 kA, a value consistent with the original cathode design and a conventional Anode Cathode Distance (ACD) management. Due to a progressive change to fully graphitized cathode blocks and continuous improvement practices to reduce ACD, the operating set point was progressively increased to 320 kA, which was achieved in 1999, [1]. From early 2002, the AP35 lining design, [2], was implemented for pot turnover. In summer 2002, implementation of both the patented Forced Convection Network and the final AP35 anode format were completed. After twenty years of operation, the Aluminium Dunkerque potline was operating at 362 kA at the beginning of 2011 thanks to the AP35 lining upgrade and new settings [3].

A first Substation incident occurred in January 2011 and normal amperage was recovered after a few days at lower amperage. Two more serious incidents occurred at the beginning of May 2011 and beginning of August 2011 leading to limited amperage due to Substation group failures. Between May and August 2011, amperage was partially recovered after taking a number of measures at the Substation but after the August incident, the amperage was limited to 285 kA for more than three months during the second half of the year (see Graph 1).



Graph 1 - Potline amperage in kA (monthly values)

The limited amperage, 285 kA, was lower than the potline start-up period amperage of 295 kA. The plant and the AP Technology™ organization did not have any experience of such low amperage in this technology and the ability to operate at this amperage for such a long period was called into question. A coordination working group drawing on personnel from the plant technical team and the AP Technology™ expert team, took charge of modeling procedures and operations.

To be able to operate the pots at such a low amperage, new settings were implemented in two mains ways:

- heat loss decrease,
- resistance increase.

Heat Loss Decrease

To decrease heat losses, following settings were implemented

- decrease in gas exhaust flow rate while still keeping the potline emission within permit,,
- Forced Convection Network stoppage [2],
- increase in anode cover,
- decrease in metal level,
- external insulation of pot shells,
- limitation of basement ventilation on the potroom most exposed to the wind.

All these measures took time to be implemented and stabilized.

Resistance Increase

A modeling procedure was carried out by the Rio Tinto Alcan LRF Research Center, in Saint-Jean-de-Maurienne France, to adjust power in the pot and determine the required unsqueezing on

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(1) AP Technology™ is a trademark of Aluminium Pechiney, used under license by Rio Tinto Alcan Inc

the pots. Based on the modeling results, new setting for ACD and metal level were proposed taking into account the actual decrease in heat losses. The results, shown in Figure 1, indicate a normal isotherm distribution shape after stabilization. The side heat flow rate enables a proper ledge profile to be maintained.

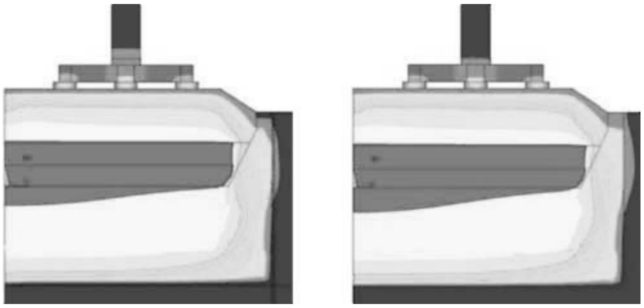


Figure 1 - Modeling of isotherms at rated amperage on the left and at lower amperage on the right (half cross-section of the pot)

The anode change procedure was modified for higher additional resistance to counterbalance the cooling effect of the new anode assembly, especially at lower amperage.

Other Adjustments

Slotted anodes were replaced by anode without a slot in order to increase bubble overvoltage and power in the bath.

Decreasing the anode length was considered but, due to the time needed to modify the handling of smaller anodes, this solution was not implemented.

Anode cycle duration was increased but not as much as possible because bath height was increased to take into account the ACD increase and to prepare for the possible need for more pot unsqueezing as explained below. Operating in such a manner allowed the iron content to be kept within the usual range.

Aluminium fluoride excess was decreased and bath temperature increased to limit risk of having excessively cold pots.

Due to unsqueezing, total pot voltage was increased and five pots had to be stopped due to the Substation voltage limit.

Preheating conditions were changed to enable the proper pot temperature to be reached before pot start-up with lower amperage.

Transition Period

Before the three-month period stabilized at 285 kA, the potline went through a transition period with intermediate and variable amperage.

When amperage had to be decreased at the beginning of May 2011, two main problems had to be addressed:

- bath quantity increased with unsqueezing for all the pots,
- and cooling on some pots led to bath tapping with metal.

To limit the negative impact of cooling and the resulting ledge formation, a special team of process technicians made daily pot-to-pot inspections to adjust resistance and extra shift operators were hired to maintain tapping hole quality.

When the Substation incident occurred, bath additions had to be prepared by adjusting the anode cover mix (decrease in alumina content), using crushed bath additions in some pots and liquid bath transfer to balance the pot-to-pot situation. As Aluminium Dunkerque has only one potline and as there are no other smelters in the vicinity, it was not possible to make liquid bath additions. A small number of pots were chosen as donor pots, by increasing bath target, to allow emergency liquid additions in the event of a sudden lack of bath in some pots. Solid bath had to be procured to address the situation.

Due to pot cooling and bath tapped with metal and then on metal ladle surface, the sodium content in the Casthouse metal was temporarily a problem and it was not possible to produce certain casting products during the transition period.

Despite the action plan in place, there was an increase in the quantity of bath tapped with metal, in ladle fouling and in tapping tube clogging with the result that extra cleaning was required. Specific equipment operated by a contractor under normal EHS rules and extra manpower were put in place.

Once the Substation group had been repaired, amperage recovery took more than a month. This duration was needed to allow bath tapping and cooling when the ACD was squeezed, thermal adjustments made and metal level increased.

A large amount of liquid bath had to be tapped to allow the decrease in resistance. The logistics for such an operation depends on manpower and available equipment. Critical points had to be overcome regarding the metal ladle and tube cleaning as well as cooling and storage of solid tapped bath.

Stabilized Period With Risk Of New Incident

Due to the risk of a new incident occurring on the Substation groups left operating at the highest possible amperage, some settings were needed to prepare for the worst situation concerning amperage.

The thermal target was chosen on the hot side with lower bath acidity and higher bath temperature than really needed by the lower amperage.

Bath target was increased to prepare for the possible need for additional pot unsqueezing.

Anode Effect Treatment Efficiency Issue

Considering unsqueezing and higher bath height, an increase in impossible automatic treatments and overvoltage of anode effects had to be addressed. Automatic anode effect treatment is managed by alumina overfeeding and anode beam squelching. The treatment procedure had to be changed for a deeper squelching but due to higher ACD and greater bath height, gas exhaust from under the anode assemblies was more difficult.

Generally speaking, the efficiency of anode effect treatment was recovered but overvoltage remained higher than during the reference period.

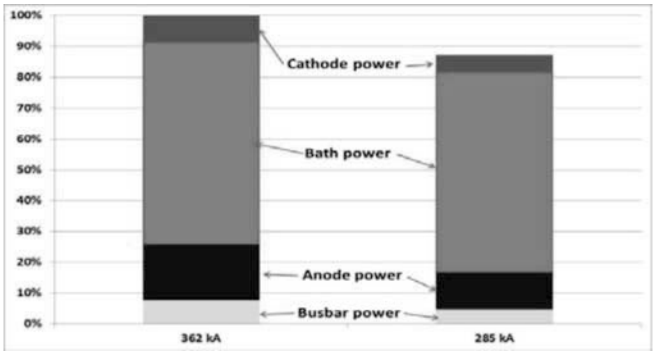
Technical Results

Results For Pots With The Most Common Type Of Lining

This section considers the results obtained for pots aged more than 60 days having the most common type of lining. These represent two-thirds of the pots during the operating period at 285 kA.

Three months of operation at 285 kA, from September to November 2011, are compared with three months of operation at 362 kA, from February to April 2011.

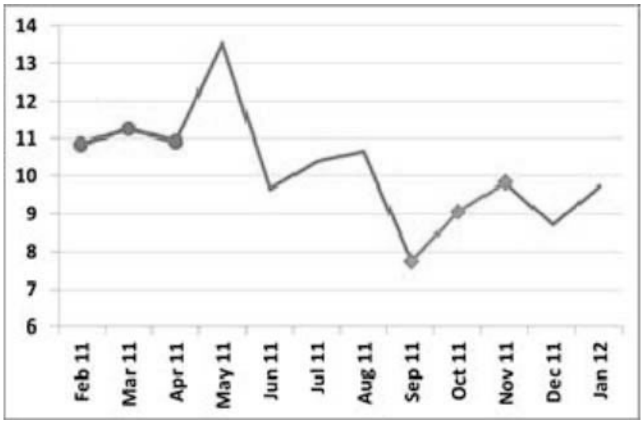
Ohmic Power In The Pot. In term of ohmic power, Graph 2 below shows situation during the two stabilized periods. Bath power was maintained relatively constant and other power values were decreased with a relatively constant resistance and lower amperage.



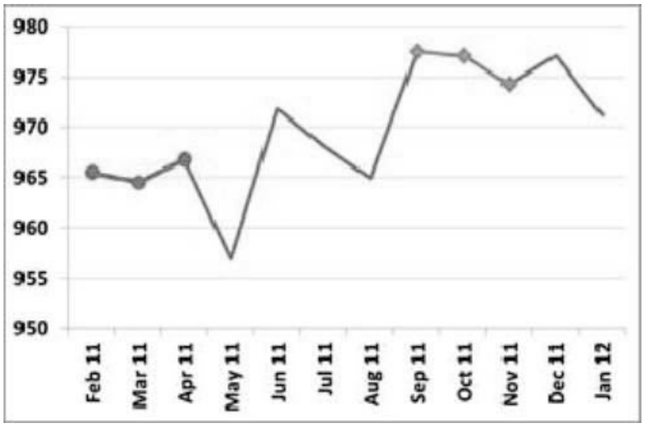
Graph 2 – Average ohmic power distribution during the quarter at 362 kA and the quarter at 285 kA

In the graphs below, the period at 362 kA is shown as a line with circle markers and the period at 285 kA as a line with lozenge markers.

Thermal Adjustments. New adjustments led to a decrease in aluminium fluoride excess by 2.2 % and an increase in bath temperature by 10.9 °C due to a "hotter setting" in case of new incident, as mentioned above.

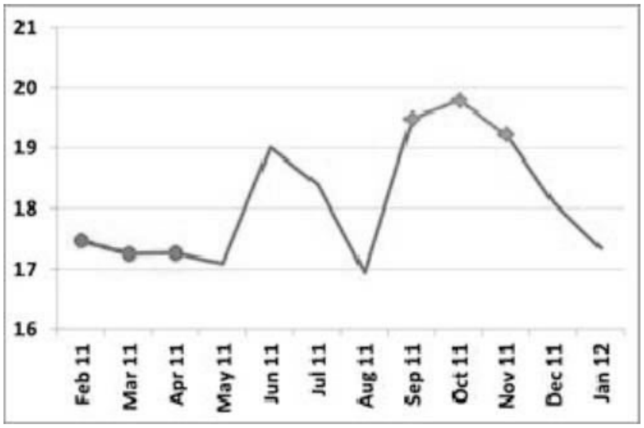


Graph 3 - Aluminium fluoride excess in % (monthly values)

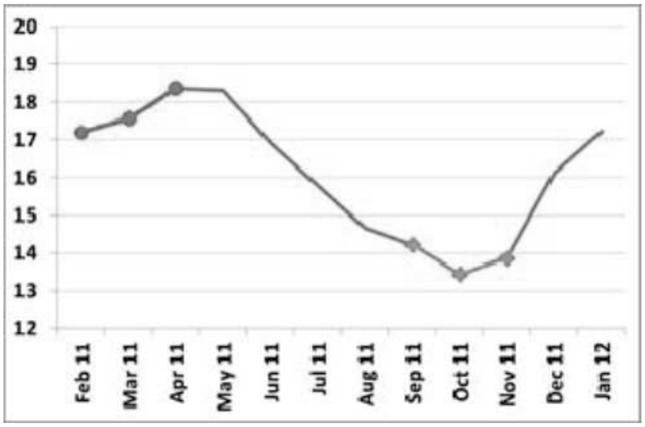


Graph 4 - Bath temperature in °C (monthly values)

Liquid Adjustments. Bath height increased by 2.2 cm and metal level decreased by 3.9 cm. Bath height was difficult to stabilize during the transition period and the target was changed to follow amperage fluctuations. Metal level was high in April due to an operational backlog prior to the Substation incident.



Graph 5 - Bath height in cm (monthly values)



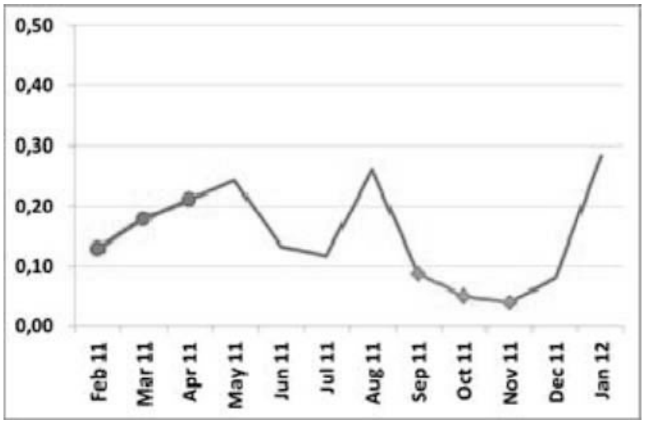
Graph 6 – Metal level in cm (monthly values)

Other Results. **Iron content** in the metal produced was constant despite higher bath height, but carbon under pin was higher than usual because no attempt was made to increase the anode cycle duration to the maximum.

Cathode resistance stayed constant on average showing that the cathode surface cleanliness was maintained despite temporary ledge formation on some pots but the action plan implemented with specific process control was efficient and the recovery after these problems was rapid.

Anode incident frequency decreased drastically, 4.5 times lower frequency during the quarter at lower amperage compared to the reference quarter.

Anode effect frequency was divided by more than three, the percentage of impossible anode effect treatment was increased by 50 % and overvoltage by anode effect was multiplied by more than six so total overvoltage increased by 70 %.



Graph 7 – Anode effect frequency per pot and per day (monthly values)

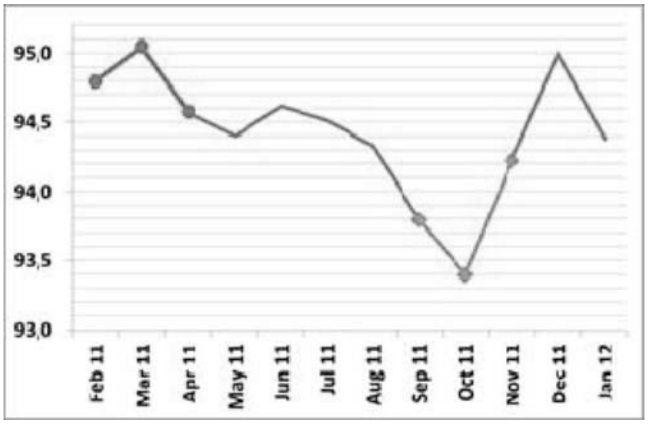
Potline Results

The potline results for three months of operation at 285 kA, from September to November 2011, are considered below compared with three months of operation at 362 kA, from February to April 2011.

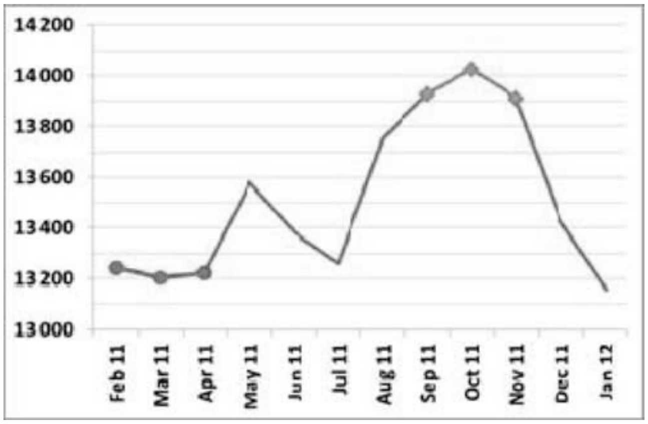
The main average monthly results during the period at 285 kA for the whole potline are

- 1,0 % decrease in current efficiency,
- 745 kWh/t increase in DC specific energy.

The positive impact of ACD increase and lower magnetic disturbance with lower amperage was not strong enough to compensate for the negative impact of the decrease in aluminium fluoride excess and the increase in bath temperature [4].



Graph 8 – Potline current efficiency in % (monthly values)



Graph 9 – Potline DC power consumption in kWh/t (monthly values)

The number of pots in operation decreased in average by 3.9 pots due to

- longer waiting period for restarting pots due to the need to be prepared for proper preheating
- and increase in voltage by 186 mV per pot leading to the total voltage limit of the potline being exceeded and the stoppage of five pots.

Except for the five pots stopped due to voltage limitation, no more pots than usual had to be stopped during operation at low amperage and the average age of stopped pots increased slightly showing the stability of the operation and correct thermal balance of the pots.

Fluoride specific emissions per ton of aluminium were maintained within the expected range after adjustments of gas exhaust flow rate which had to be increased back to a higher level than that set when amperage decreased.

Conclusion

Thanks to the period of operation at 285 kA it was possible to adjust the settings and to show that Aluminium Dunkerque pots could operate at an amperage reduced by more than 20%, corresponding to a 16% decrease in plant power.

By implementing a major action plan integrating process adjustments and controls managed by the technical team of the plant with the support of AP Technology™ expert team, it was found that the potline could be operated properly and the main conclusions that can be drawn from this experience are as follows:

- operation at 79 % of rated amperage with satisfactory operating conditions for the pots was possible and sustainable,
- EHS performance was maintained in accordance with company rules and compliance to local regulation,
- technical results were maintained at an acceptable level with only 1 % loss in current efficiency,
- very few pots (2 %) had to be stopped due to the Substation voltage limitation and no extra pots were stopped due to operation at low amperage.

After this experience, contingency plans were reviewed and the plant is now better prepared for another incident of this type.

The lessons learnt during this incident have demonstrated the robustness and capability of the technology to operate at lower energy and pave the way for flexible operation of AP Technology™ pots.

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