TOMAGO ALUMINIUM AP22 PROJECT

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Abstract

Late April 2002, Tomago Aluminium (TAC) announced the expansion of its production capacity by 70 000 tpy. This project is based on the AP22 Pechiney reduction cell technology, developed late 90's as re-engineered technology for the well known AP18 cell.
The project entered in its active phase early 2003 with the start up of a 20 pot trial section. Over and above the fine tuning of final operating set points, the purpose of this trial section is to pilot the anode and anode assembly transition phase, which, in such a large plant (3 potlines, 840 cells), requires mastering both logistics and transient cell operating targets. Progressive production increase will take place from 2004 and full production (530 000 tpy) is planned to be achieved in 2007 after lining turnover completion.
Project progress, technical performance of the trial section as well as technical options on the cell and its surrounding will be discussed.

1 –TAC history

Tomago Aluminium Company is a joint venture by Australian and overseas companies : Pechiney Pacific, Gove Aluminium Finance and VAW Australia. It is located in Newcastle 150 km north of Sydney on the east cost of Australia and produces currently 470 000 tonnes of aluminium per year.

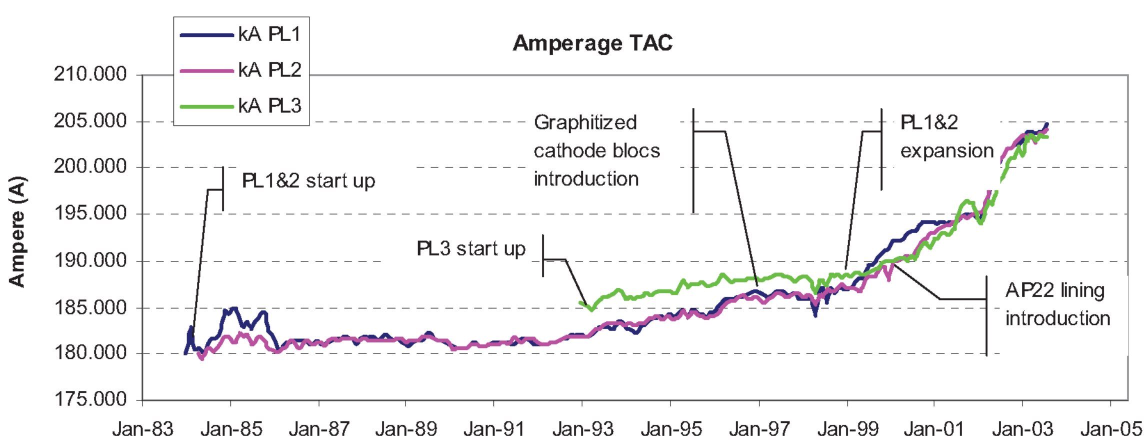
The Tomago plant was started in 1983 using AP18 technology. Two potlines with 240 pots each were built and operated at 181 kA for a production of 240 000 tonnes per year.

1.1 Production capacity increase

In 1993, a third AP18 potline with 280 pots was commissioned. After potline 3 start up, amperage on the three potlines was 182 kA for a production of 385 000 tonnes per year.

In 1998, the potlines 1 and 2 were extended with 20 pots at the end of each room. The production of Tomago was increased by 50 000 tonnes to 435 000 tonnes per year.

Figure 1 : Tomago amperage evolution



1.2 - Lining modification

Amperage increase has been possible with changes in the design of the lining and adjustment of the process parameters.

The first step took places in 1990 with the use of semi-graphitic cathode blocks in the lining to replace the anthracitic cathode blocks. After a first test of 60 pots as part of the initial commissioning of potline 3, graphitized cathode blocks were generalised and have replaced the semi-graphitic blocks since 1996. Resistance of the pots and metal heights have been adjusted to allow new pots with graphitized cathodes and old pots with anthracitic and semi-graphitic cathodes to operate at the same level of amperage.

The transition from anthracitic cathode blocks to graphitized blocks allowed reducing the energy consumption by reducing the voltage drop in the cathode blocks. Moreover the voltage drop increase with age of the pot has been dramatically reduced with use of graphitized blocks (see figure 2).
Within 17 years from 1983 to 2000, production was increased by 81%, reaching 435 000 tonnes/y.

2 – TAC AP22 project

2.1 – Challenges for Tomago

After PL1 and PL2 expansion, Tomago, still seeking to increase its capacity and to lower its cost per tonnes kept on creeping up amperage and, in 2002, decided to launch the AP22 project to reach the amperage of 225 kA in 2007.
Tomago production will be further increased by 70 000 tonnes to 530 000 tonnes. This production increase will have to be managed in a plant originally designed with 2 potlines based on AP18technology running at 180 kA.

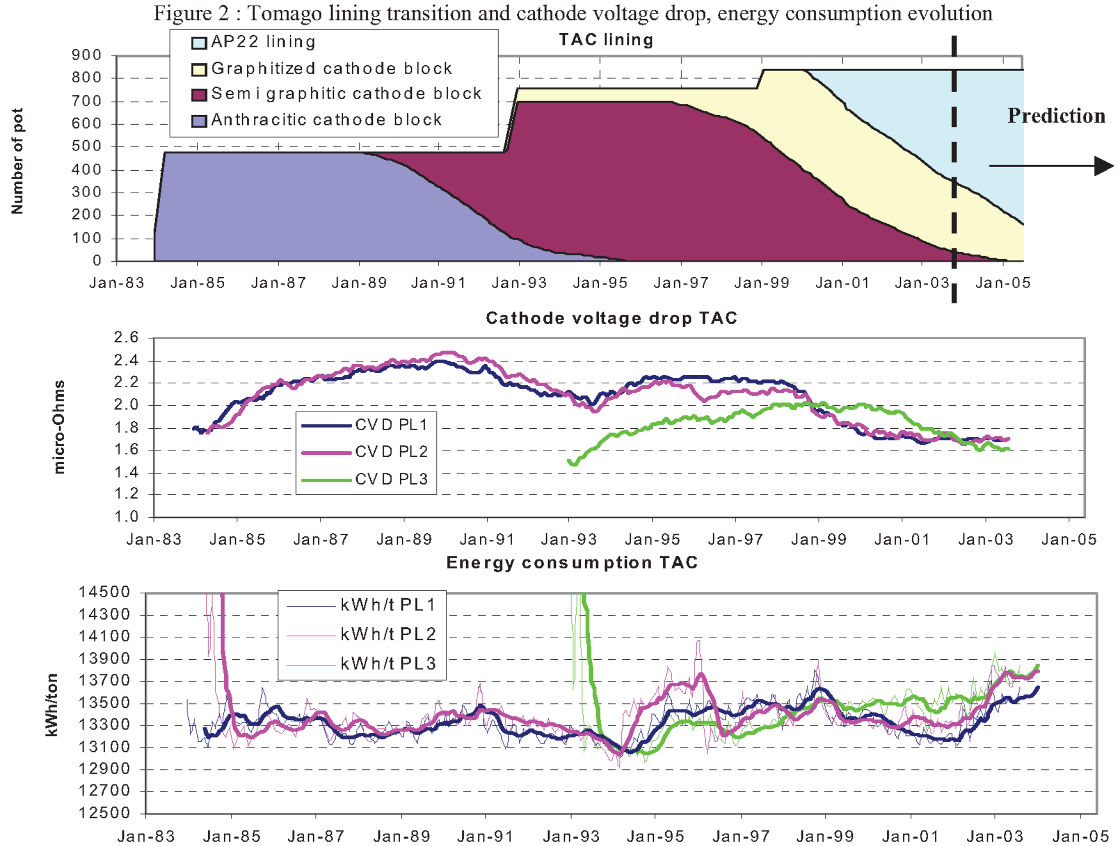
2.2 – In the potline and the casthouse

As part of the AP22 project technology (see paragraph 3 below) the AP22 linings have been adopted in 2000 and the changeover for all the pots will be completed in 2007. From now until this is achieved, 3 populations of pots (AP22 lining / AP18 graphitized cathode blocks / AP18 semi graphitic cathode blocks) will have to operate at the same level of amperage with different settings. With progressive introduction of the AP22 cell lining, amperage increase reaches 204 kA in late 2003, maximising the production without degrading the technical results of the 3 lining groups.

Added to this gradual transition made at the relining rate, a step change transition will be undertaken in 2004 with the introduction of the large anodes / large pins and the use of the Forced Convection Network (FCN). This short transition will happen over a few months and will correspond to an amperage increase of 14 kA.
Work organisation is currently being studied to manage the changes required by the amperage increase. The main change to deal with will be the increased metal quantity to tap with the current capacity of the tapping ladles.

An extra ingot chain has been installed in the casthouse to manage the increase production of metal.

Figure 2 : Tomago lining transition and cathode voltage drop, energy consumption evolution



2.3 – In the carbon plant

Changing the anode format from AP18 to AP22 has a massive effect on the carbon facilities, requiring major investment and modifications from the paste plant to the rodding shop.
Up until the start of the AP22 project carbon facilities at TAC consisted of:

- Green anode production : two paste plants started in 1983 and 1992, producing 30 tph and 25 tph.
- Baked anode production: two bake ovens started in 1983 and 1992 with 4 fires 74 sections and 2 fires 34 sections respectively.
- Anode storage and handling : 2 automated stacking cranes with corresponding baked and green storage and handling.
- Rodded anode production : started 1983, upgraded 1993 average 350 stems per 12 hour shift.

- Green anode production

To make the larger green anode the two existing vibrocompactors needed to be replaced with new units, allowing the manufacture of three anode formats, the existing AP18 format, the intermediate AP22 format and the final AP22 anode. PP2 has been changed over in September 2003 and PP1 will be changed early 2004.

- Baked anode production

The larger anode dimensions requires the anodes to be loaded differently into the existing baking furnaces. Currently the AP18 anodes are loaded horizontally in packets of three in 4 layers in BO1 and BO2. The larger anodes will be loaded in two vertical packets of four anodes and a single packet of two horizontal anodes. This results in a loss of two anodes per pit in baking capacity. To make up the shortfall extra baking capacity has been installed with baking furnace 3 starting the dry out at the beginning of September 2003 and producing the first baked anode in mid October.

- Anode storage and handling

Due to the larger anode format and the need to handle both horizontal and vertical anodes extensive modifications to the storage and handling system were required.

- Rodding shop

The modifications required for the rod shop involved setting up the machinery to allow the rodding and processing of both the AP22 anode formats detailed in the 20 pot trial and the existing assemblies. Machines were progressively modified to allow the weekly batch rodding of anodes for the 20 pots trial while maintaining production for the remaining 820 pots for the smelter.

2.4 – GTC performance

The aim is for total fluoride emission level to remain constant with amperage increase. Consequently Gas Treatment Center (GTC) performance will have to be increased to operate with hotter exhaust pot gases and more alumina going through the system. Tests are being conducted currently to confirm the best solution to implement.

3 – AP22 technology

AP 22 technology was developed in the second half of the 90's by Aluminium Pechiney in order to provide a low cost retrofitting technology for AP 18 smelters.
After a design phase including extensive usage of computer simulation models in order to evaluate a large range of technical options, several versions of the new cell were industrially tested from 1997 to 1999 in the "F" line of the Saint Jean de Maurienne smelter. Results of this industrial test has been reported previously [1]
Further progress, linked to AP 50 [2] and AP 35 [3,4] technology developments, enabled Pechiney to consider a cell designed to operate in the range of 225kA whilst still complying with the constraint of not requiring temporary stoppage of the potline, or of the cells, other than for the relining.

The major changes implemented during the conversion from the AP18 to the AP22 technology are :

- Cell lining
- Pot shell design and ventilation
- The anodic equipment

3.1 - Cell lining

The lining design is a powerful way to increase the amperage in a pot, either by increasing the heat dissipation through the side and the bottom, or by decreasing the cathode resistance.
Compared to the standard AP 18 lining, the AP22 design gives a significant extra-amperage by using:

- Graphitized cathode blocks, with low electrical resistivity and high thermal conductivity,
- An advanced design of the side lining to increase the heat transfer and to insure the stability of the ledge protection

3.2 - Pot shell design and ventilation

Additional amperage is also possible due to improved side pot shell ventilation, increasing the heat flow evacuated to match the side lining design.
The patented [5,6] Forced Convection Network (FCN) technology that is implemented to cool the pot shell with a network of nozzles blowing air, ensures this increased heat flow. Furthermore, these improvements ensure a reduced thermal load on the pot shell, and thus better mechanical behaviour and less maintenance.
This network around the pot is installed while the pot is in operation.
Pots shell modifications are also implemented in order to provide perfect thermal contact between the side lining and cradle wall, with the use of stiffeners. This modification is made during the relining of the pot.

3.3 - Anodic equipment

An increase in anode surface area lowers the electrical resistance in the bath, thus allowing an increase in amperage to maintain the thermal balance of the pot.
The limitations of the enlarged anode surface area are linked to the decrease in the volume of liquid bath that affects the alumina dissolution and the increase in the pumping effect of bath (liquid level altitude evolution for a given altitude change of the anode beam).
Further amperage increase is accomplished by increasing the anode pin dimensions, which increases the rate of thermal dissipation through the top of the pot.

4 – Technical performance of the trial pots

4.1 – Description of the AP22 trial

The industrial AP22 trial was implemented on 20 adjacent pots in the A-Line of the Tomago smelter, with a 30 kA booster. Operating such trial pots gave us the opportunity to :

- test the retrofitting process on a significant number of pots
- test the equipment with AP22 technology (procedures / rules for use, start up equipment)
- collect data to assess the impact of the AP22 project on the whole plant process (bath & metal logistics, environment)
- monitor the work ambient environment.
- adapt the process regulation to the system used in Tomago

The tested modifications are:
- implementation and use of the Forced Convection Network
- large anodes introduction
- large pins introduction

Those pots are operated in an equivalent manner as the rest of the potline, without any additional human resources, other than technical staff to monitor the performance and collect data.

4.2 – Trial planning

The trial was divided into three periods :
- phase 1 : use of FCN with large anodes / standard pins
- phase 2 : return to AP18 configuration
- phase 3 : use of FCN with large anodes / large pins

The objective was to test the performance and the behaviour of the pots with two transition scenario at different amperage increase rates.

4.3 - Process results

The parameters for AP22 thermal regulation and alumina feeding process control have been adapted to optimise the AP22 performance and to take into account the greater consumption of alumina and the decrease in bath volume. Those changes have been made on the standard pot regulation in place at Tomago.
The pots are operating in the standard TAC working organisation.
The measurement cycle (bath temperature / metal & bath samples / metal & bath heights) has not been modified.
The operations on the pots are made at the same frequency as on the standard pots and with the same operating procedure.
A double tapping operation had to be organised regularly given the extra production and the limited capacity of the ladles.

Equipment was strengthened to handle the extra weight of the AP22 anodes and crust grab devices have been modified to open wider.

4.4 – Environment results

Emission
Fluoride emissions have been continuously monitored above the trial section. No significant change, when expressed per ton of aluminium, was observed so far with amperage increase. These emission measurements are confirmed by the pot fluoride specific evolution (F emitted by the pot, in kgF/tAl) which remains at the same level as for the AP 18.

Exhaust gas
A special focus has been made on the exhaust gases from the AP22 pots in order to evaluate their temperature increase and anticipate the impact on the Gas Treatment Center capacity. Temperature and flow are monitored continuously on exhaust gas manifold.
A total increase of 5°C has been observed on the exhaust gas during the second stage (+14 kA) and 3°C during the first stage (+ 10 kA). Impact of this temperature increase on the GTC is currently under evaluation.

Ambient work environment
Personal and static monitoring has been conducted to see the effect of AP22 pots on ambient work environment.

- Noise

The results highlight that the AP22 technology with use of FCN has not produced any significant increase in the noise levels around the pots.

- Ambient temperature

The results show an increase of 3°C on the ambient temperatures around the pots.

- Fluoride and dust

The results of the testing indicate that AP22 technology has not produced any appreciable increase in the fluoride levels as well as in the dust concentration around the pots, which have the potential of impacting potline crews.

- Sulphur dioxide

The SO_2 concentration has not changed significantly with the introduction of AP22 technology operating at higher amperage.

Table I : trial process results

		Phase 1	Phase 2 / AP18	Phase 3 : AP22
amperage	kA	213.3	204.1	218
Current efficiency	%	95.3	94.8	95.1
pot voltage	Volts	4.33	4.30	4.35
power consumption	kWh/t	13530	13520	13650
pot resistance	Micro-Ohms	11.9	12.5	12
Instability	Nano-Ohms	118	133	113
bath temperature	C	957	960	959
excess AlF3	%	12.5	11.5	12.4
Cathode resistance (graphite pots)	Micro-ohms	1.60	1.65	1.65
Anode effect	Nb/pot/day	0.11	0.16	0.11
iron	ppm	990	1150	950

5 – Subject of interest

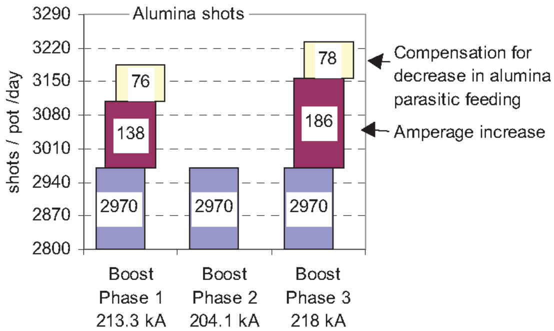
5.1 - Alumina regulation

The major challenge with larger anode is the alumina regulation. Two combined effects make this regulation more critical to control :
- less volume of bath, due to bigger anodes, to dissolve alumina

- higher alumina consumption rate with amperage increase.

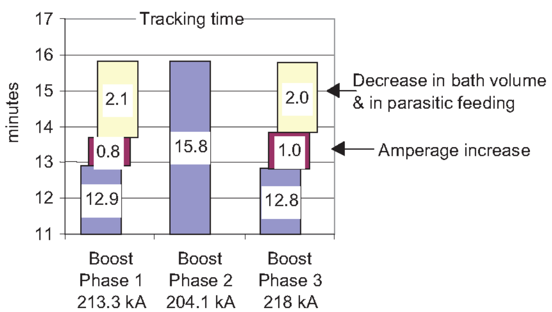
Optimisation of the feeding periods leads to a better performance in alumina feeding with good results in term of anode effect rate.

Figure 3 : alumina shots per day



We observed an increase in alumina feeding rate that was higher than expected due to the decrease of the parasitic feeding with larger anodes. This decrease in parasitic feeding and in bath volume gave some lower tracking duration.

Figure 4 : control tracking time

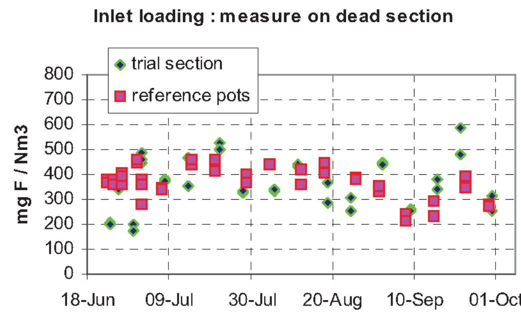


Tracking duration is 3 minutes shorter, which is more than expected: 1 minute is explained with amperage increase and the other 2 minutes are due to lower bath volume and the decrease in parasitic feeding.

5.2 – Fluoride evolution

Regular measures are made in the exhaust gases manifold to follow the loading of fluoride in the gases. Results show no significant increase in the trial section compare to reference sections.

Figure 5 : Fluoride loading in exhaust gases



We could not observe any increase in the evolution with the amperage increase. Thus the quantity of AlF_3 extracted with exhaust gases remains the same in term of quantity per pot per day.

Given the increased number of shots of fluorinated alumina, we had to adjust the AlF_3 regulation to deliver less shots of AlF_3.

5.3 – Pots instability

♦ Transition period

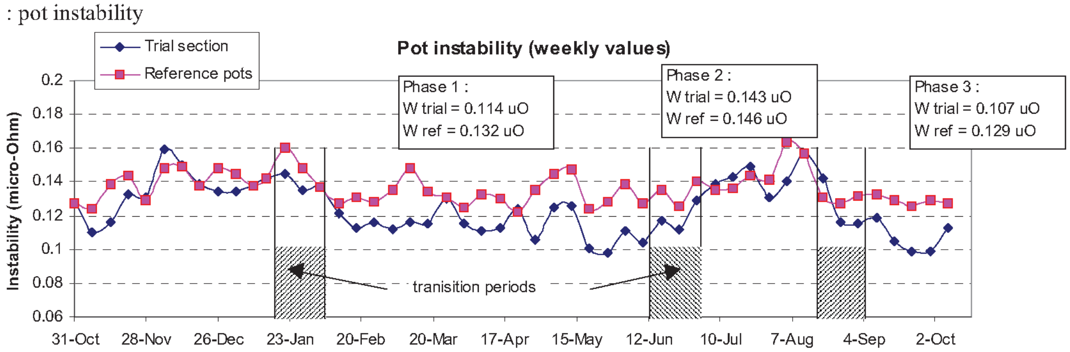
During the transition period, large anodes replace the standard AP18 anodes as per the anode change cycle. Amperage increase and resistance adjustments were made with proportion of big anodes increasing in the pots.

No increase was observed in pot instability during the transition periods with the introduction of different anodes.

♦ Stabilized periods

Instability level of the trial section in phase 1 and 3 is 15 nano-ohm less that the reference section which is expected given the larger anode surface area.

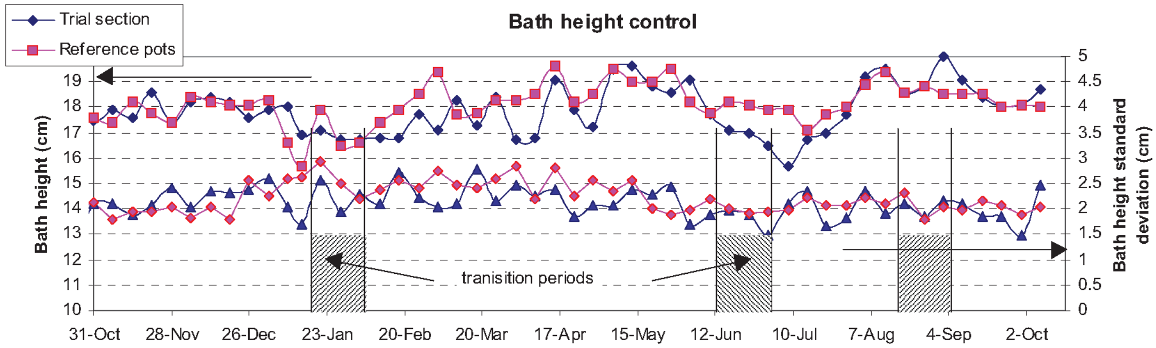
Figure 6 : pot instability



5.4 - Bath height control

With decrease in liquid bath volume and the increase of the pumping effect, bath height control is much more critical on AP22 pots than on AP18 pots.

Figure 7 : bath height and standard deviation evolution



Adjustments have been made on the bath tapping table to take into account the decreased volume of bath, and on the thermal regulation of the pot to minimize the movements of beam.
With those adjustments done, the bath height standard deviation is at the same level as the reference pots at around 2 cm.

6 - Conclusion

Since 2000, AP22 cell linings have been introduced in the potlines at the relining rate. The conversion in linings will be completed by 2007. Modifications are being implemented in the carbon plant to be able to produce AP22 anodes early 2004.

An industrial trial has been conducted in a boosted section of 20 pots involving AP22 anodes implementation and the use of the Forced Cooling Network. The trial has been divided in two phases with two anode configurations tested.

Tomago gained considerable knowledge with the qualification of the operating parameters of the pots during and after the transition. The AP22 pots confirmed their good performance in Tomago work organisation : amperage at the expected level and current efficiency results at least equivalent to results achieved in the reference section.

The AP22 project progresses according to the planning so far to be ready to add 14 kA in 2004 with the AP22 anodes implementation and to reach 225 kA in 2007 after AP22 lining conversion completion.

References

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