Online Support for Amperage Creeping and Technology Brick Implementation

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Abstract

Over the last few years, successive cost cutting plans have reduced the in-house technical resources available to smelters. Meanwhile, ambitious projects such as progressively reducing the anode-cathode distance (ACD) so as to lower specific energy consumption have tended to reduce the robustness of the electrolysis process. To meet this kind of challenge and to guarantee a smooth and reliable improvement in performance, Rio Tinto Aluminium has developed a whole suite of benchmark tools some of which provide technical support from a location distant from the smelter concerned. This article will present the different phases of a project for progressively improving performance and describe some of those benchmark tools, including operating window, low ACD operation assessment and development plan, transition plan for moving from the present situation to the new one, go-no go process and RADAR™ remote support.

Keywords: Aluminum electrolysis cells, cell performance, progressive improvement, remote support.

1. Introduction

Most aluminum smelters are looking for ways to progressively improve the electrolysis process so as to increase their profitability. Moreover, considering the evolution of energy cost, such improvements must not increase specific energy consumption (SEC) but even reduce it to maximize the benefits. Rio Tinto Aluminium (RTA) has a solid track record in this field. For example, AP18 cells developed in the 1980’s to operate at 180 kA are now running at more than 250 kA, as illustrated in Figure 1. To make this kind of change possible, technology solutions have been developed and are now available over the whole range of AP Technology™ cells either to increase productivity or to reduce specific energy consumption or a mix of both depending on the business case for the plant in question. To convert those technology solutions into value creation, a very rigorous process has to be followed using dedicated tools, some of which are presented in this paper. This process is even more essential to successful progressive improvement considering the cutbacks in technical staff over the last few years.

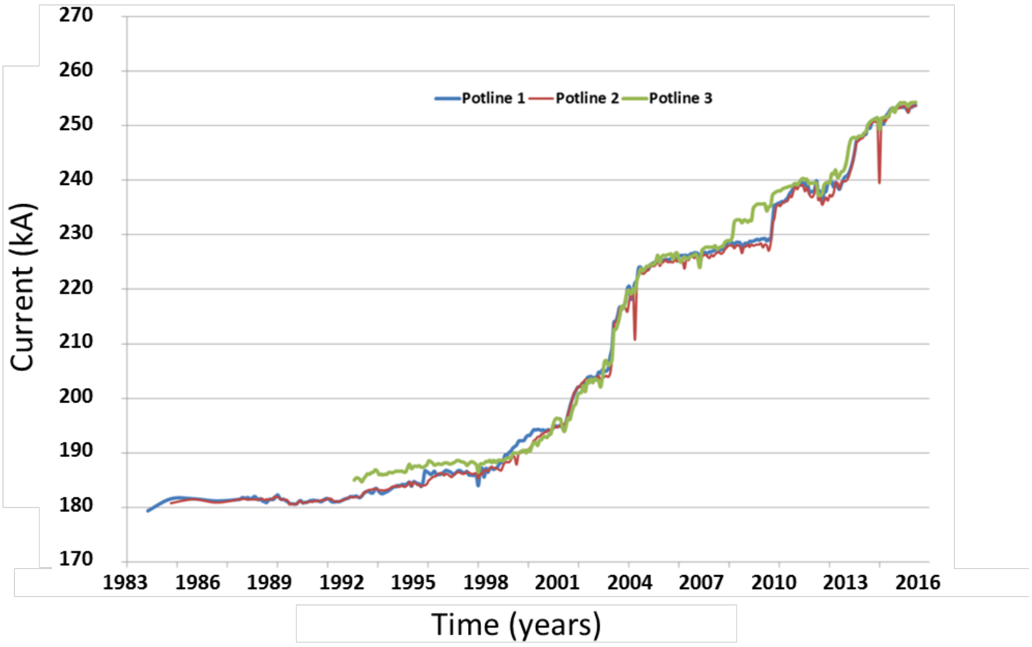

Figure 1. AP2X current increase in one RTA plant.

2. Cell Development Cycle

The cell development cycle is used to ensure that the proposed design will be optimal considering the technical and economic constraints of the plant. As Figure 2 shows, the cell development cycle consists of seven different stages; these will be described in detail in the following sections. Sometimes the prototype building and measurement stages can be skipped, as will be explained below.

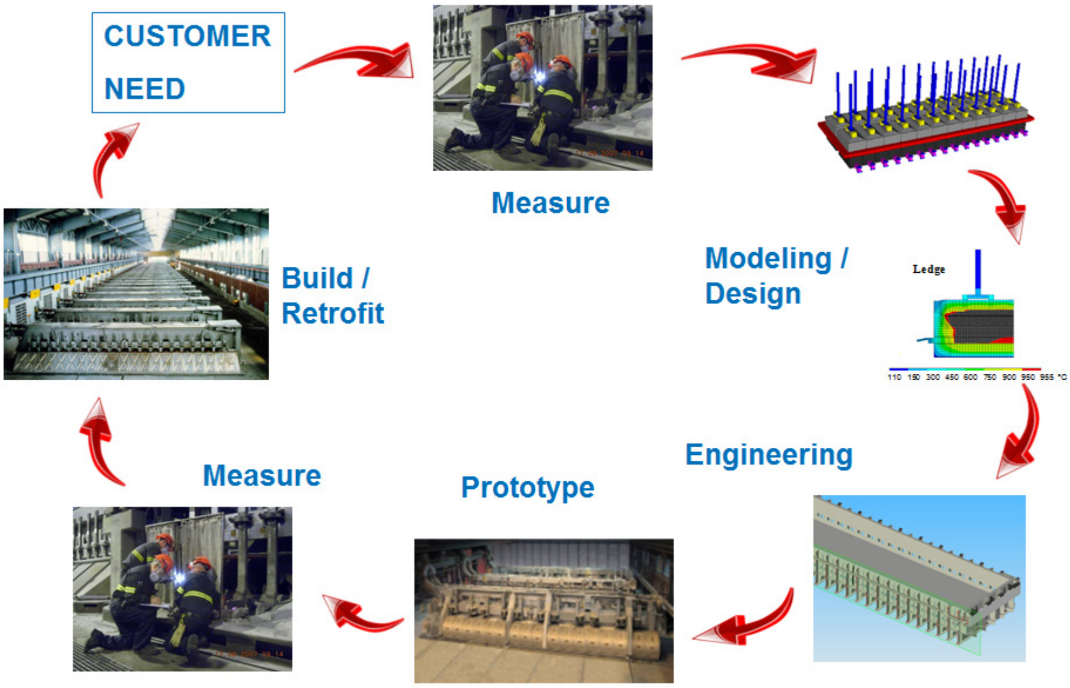

Figure 2. Cell development cycle.

2.1. The Customer's Needs

It all starts with the customer's needs. Each plant has its own improvement strategy, driven by its particular technical and economic constraints. RTA has developed a full portfolio of technological improvements, referred to as "technology bricks". Examples are a forced cooling network for the shell, a magnetic compensation loop, a low energy lining and optimum anode slots; and there are many more. A fast prototyping tool which includes economic aspects is used to select the set of technology bricks that will maximize the benefit to the plant.

2.2. Measurements

The next step is the vitally important job of assessing the existing performance by a thorough measurement campaign. The results are used to calibrate the numerical models described below. Reference [1] describes such a campaign, which includes for example measuring ledge thickness (Figure 3).

Figure 3. Ledge measurement in an AP60 cell.

2.3. Modeling and Basic Design

Rio Tinto Aluminium has developed state-of-the-art modeling tools to design high performance robust cells. These include:

- MHD stability assessment, which may lead to modifying the busbars or alternatively adding a compensation loop in order to increase the stability margin.
- Thermoelectric behavior. A major output of the thermoelectric model is the operating window which will help set the parameters during the increase in line current, as illustrated in Figure 4.
- Thermomechanical behavior, to ensure for example that the shell distortion is acceptable both in operation and in the initial charging with hot bath.
- Effect of liquid movement on ledge profile. This modeling tool is described in Reference [2]; it identifies the weak points of a design and is used to obtain an optimal ledge thickness distribution all around the cell.
- Alumina transportation and dissolution. This modeling tool, presented in Reference [3] calculates the concentration distribution of the dissolved alumina in the bath and is used to find those feeder positions and feeding rates that ensure an even concentration.

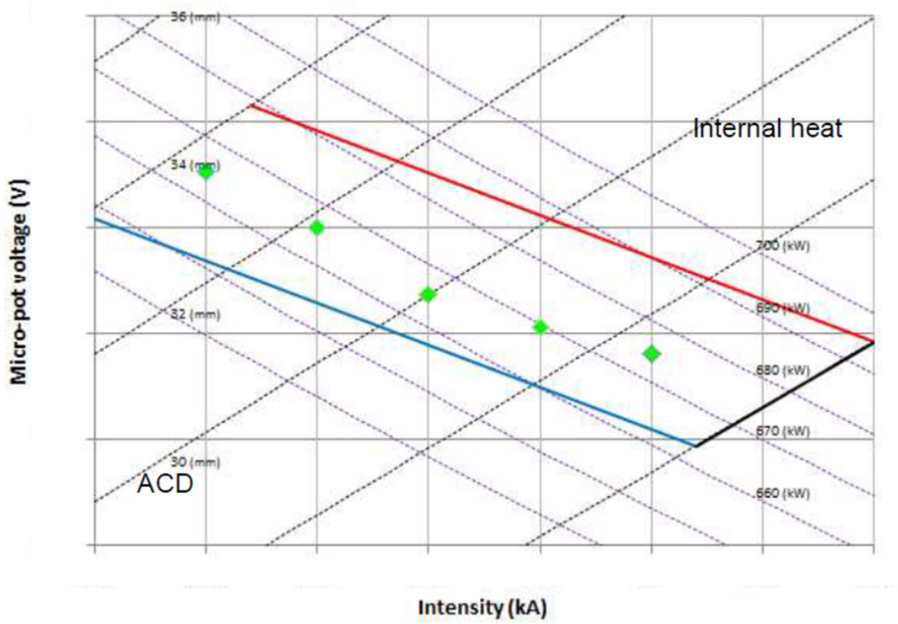

Figure 4. Operating window with set points.

2.4. Engineering

The basic design resulting from the modeling must now be translated into detailed drawings and specifications, and this is done in the engineering stage. It must be borne in mind that the basic changes decided in the modeling phase may affect many other departments of the smelter as shows Figure 5.

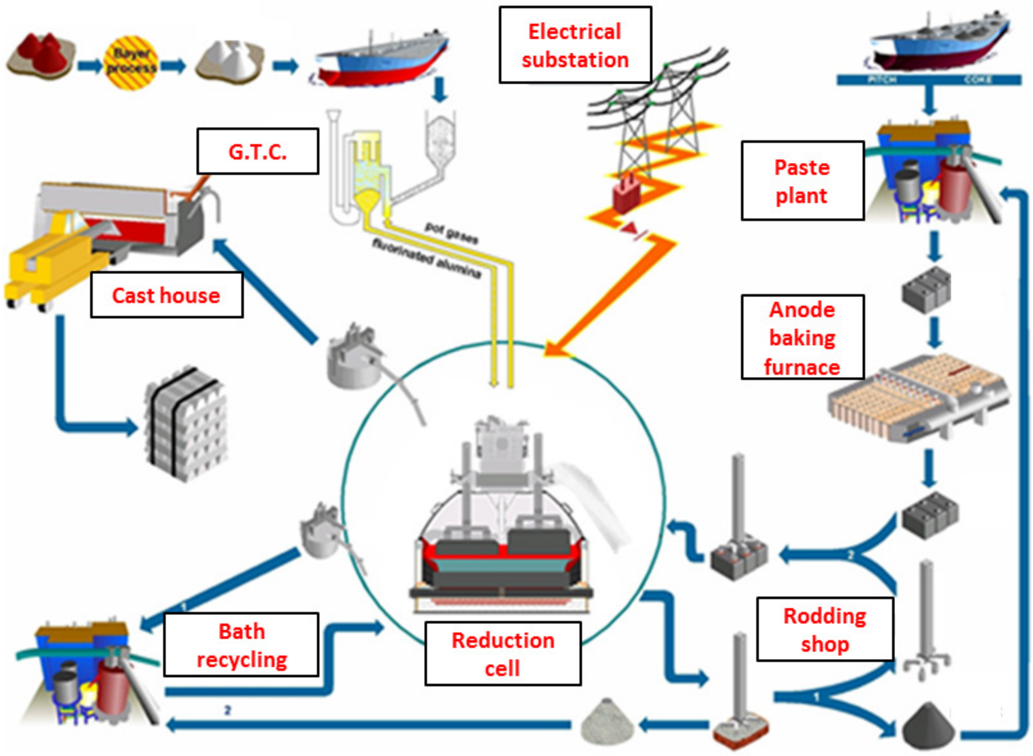

Figure 5. Assessing the effect of the changes on all departments.

2.5. Prototypes

Once the detailed design has been worked out, an exhaustive risk analysis is performed. If the solution includes limited and proven technology bricks, a project plan is issued and full implementation can start forthwith. If on the other hand the solution includes more risky technology bricks, a trial is organized of prototype cells. This may require a booster section fully representative of the future smelter configuration. For example, for the Alma smelter, magneto-hydrodynamic tools have been used to design a representative booster to test AP44 technology as illustrated in Figure 6 and presented in detail in [4]. Prototype cells were both tested at the normal line current of 400 kA and in the booster at their nominal current of 440 kA.

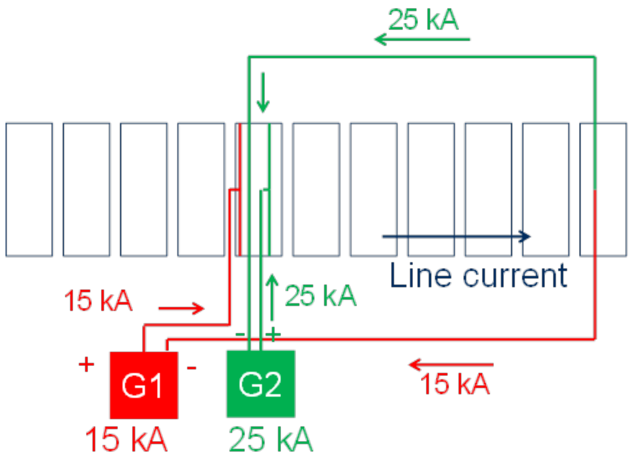

Figure 6. Alma booster configuration to test AP44 technology.

2.6. Measurements

Once the pots of the booster section are optimally tuned, a fresh measurement campaign is carried out to assess the performance of the new design. Many of the current technology bricks have been validated in this way at Rio Tinto Aluminium's LRF facility in Saint Jean de Maurienne. Furthermore, combining some of the most advanced low energy technology bricks led to the APXe technology with its benchmark pot SEC below 11.8 MWh/t as illustrated in Figure 7 and presented in Reference [4].

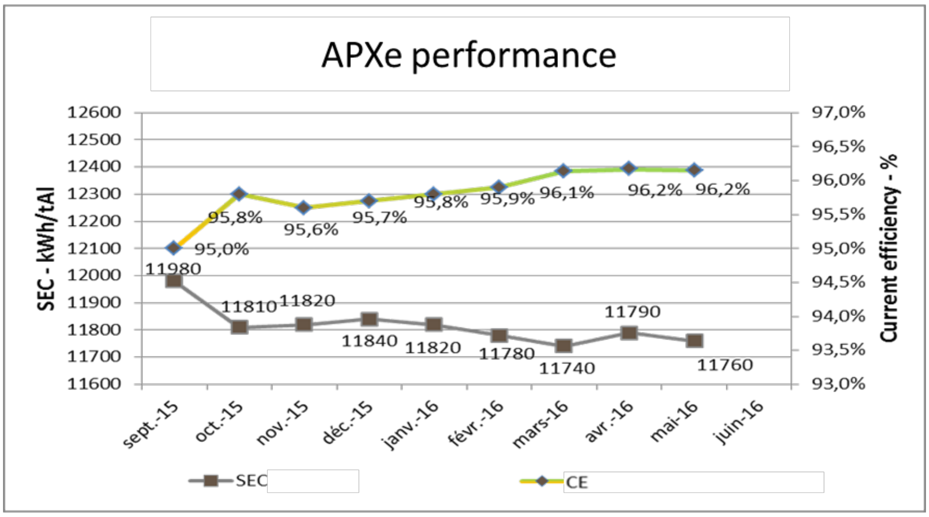

Figure 7. APXe technology performance at 505 kA.

2.7. Validated Technology

At Rio Tinto Aluminium, a rigorous cell design cycle is in place. It matches customer constraints and the most advanced technology bricks to make sure the best solution is delivered. During the process, technology risks are assessed and if required, tests are performed to verify the performance of the proposed solution, as illustrated in Figure 8. Then, the technology transfer can start. To make sure it delivers its full value, RTA provides complete know how, part of it being presented in the following section.

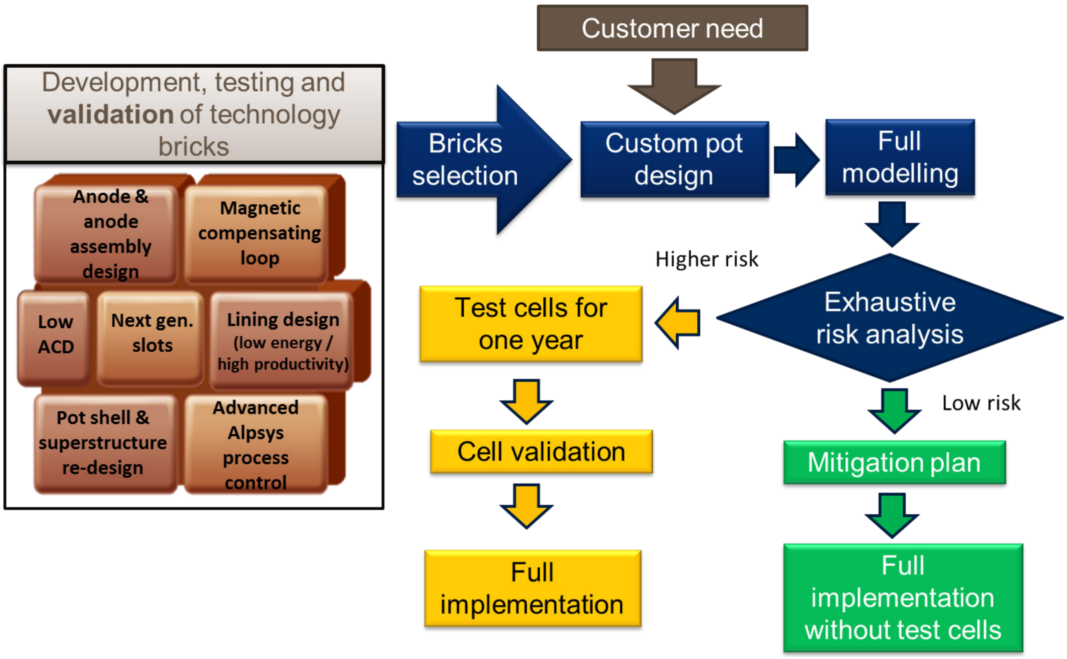

Figure 8. Technology brick approach.

3. Technology Transfer

Rio Tinto Aluminium has a solid track record in technology transfer, whose success lies first in the quality of the documentation. For example, 1000 to 1200 documents are provided for a greenfield smelter. These cover everything from general layout to detailed engineering documents for pot shell, lining, superstructure and busbars as well as other subordinate elements. The second guarantee of project success is the technical support that is provided with local assistance by experts in the various fields: engineering, construction, training and start-up. Technical assistance is also of the utmost importance even after start-up. The best practices illustrated in Figure 9 are also put in place for brownfield project of progressive improvement. This section will present some of the tools used before, during and after installation to ensure a smooth transition.

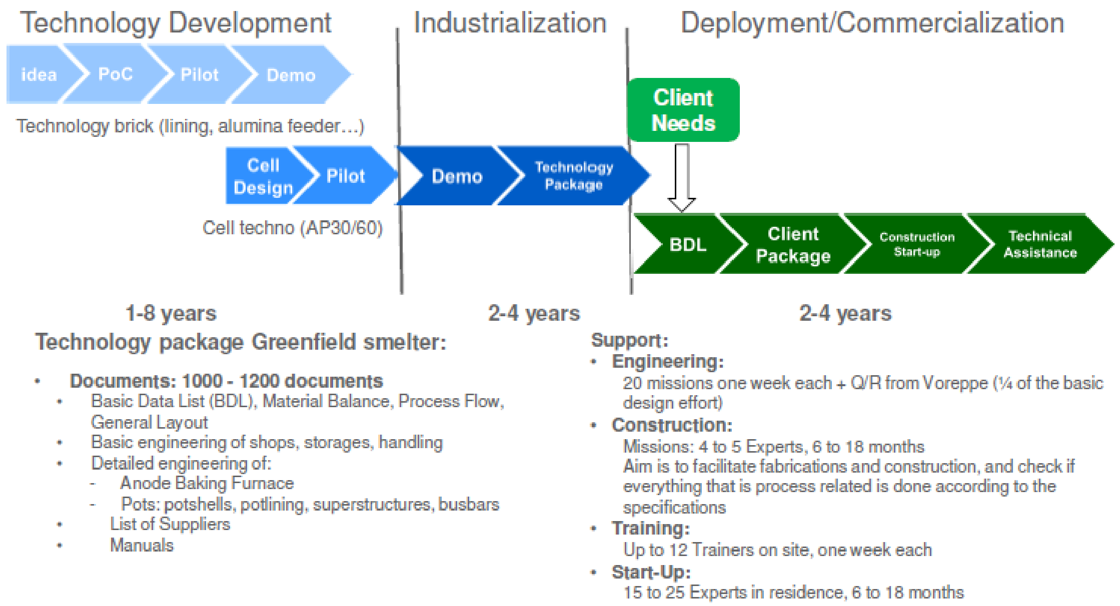

Figure 9. Key elements in technology transfer.

3.1. Preparation

The plant that is to receive the new technology has its own specific needs. Some of them will be design ones and will be identified during the initial measurement campaign of the cell development cycle as described in Section 2.2. Some of the specific needs and constraints will relate more to operations. It is important to have an operational assessment of the capability of the plant to handle a progressive improvement project, in particular since most of the recent projects include technology bricks which require attention to good operating practices, as for example does a move to lower ACD operation. For this specific case, Rio Tinto Aluminium has developed a tool called Low ACD Best Practice on a Page (BPoaP), which reviews the operational data of the plant to assess its ability of running at low ACD. This includes forty-six items on eleven different themes. For each item, the current situation is assessed and an action plan issued to improve the score. At the end of the process, the plant ends up with a score card of its actual performance and a score card of its potential if all the identified changes to operating practice are made. Figure 10 presents the Low ACD BPoaP template and the eleven different themes, beginning with anode setting.

NAME OF THE PLANT	
Results	
Current result	
Potential result	

Explanation	
0%	Non existing item
25%	Non functioning existing item
50%	Existing item, partly operational
75%	Existing and operational item
100%	Existing and totally operational item

Colour code	
Blue	95%
Green	80%
Yellow	50%
Red	< 50%

Anode setting	Anode cover
Magnetic compensation	Amperage modulation
Bath level management	Raw materials
Operation delays	Control logic
Exception pot management	Anode effects
ACD and measurement management	

Figure 10. Low ACD BPoaP template and the 11 evaluated themes.

3.2. Transition

The transition phase needs a current increase curve. The shape of this curve usually depends on the relining rate and the start-up of new equipment such as an MHD compensation loop. Figure 11 is an example of such a curve. In case of coexistence of several cell designs, different operating windows are provided to adjust the settings specific to each design. Regular measurements have to be performed to make sure all designs are under control. Start-up rules are also adjusted depending on the amperage and the design.

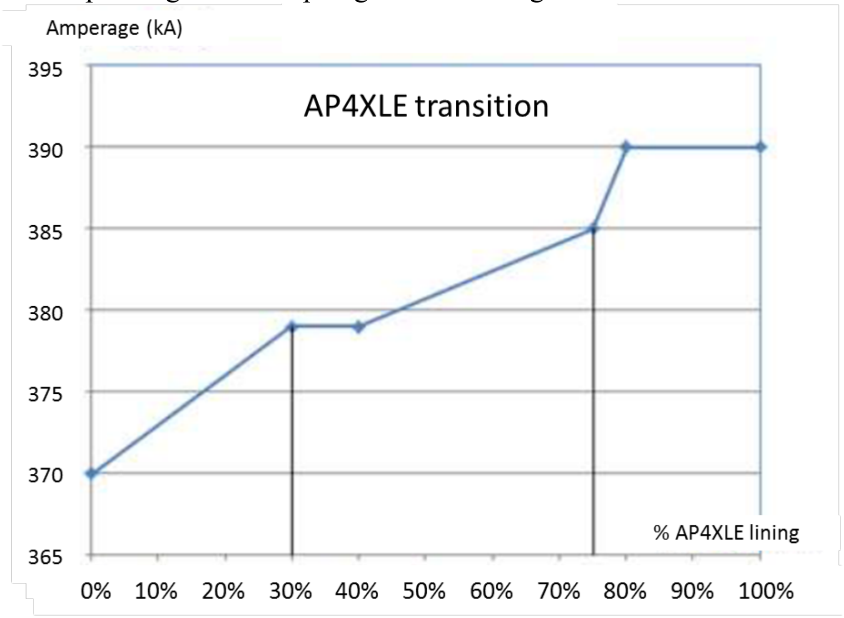

Figure 11. Current increase curve based on relining rate and compensation loop start-up.

The go-no go process has to be in place to make sure everything is under control before further increasing the line current. Figure 12 is a typical example of the go-no go tool. In this particular case, the current was not increased from 392 to 394 kA because of concerns about anode change and anode cover compliance.

AMPERAGE INCREASE GO / NO GO CRITERIA		
Current amperage: 392.0 kA	**GO**	**NO GO**
Desired amperage: 394.0 kA	**GO**	**NO GO**
Production	**GO**	**NO GO**
Thermal balance	**GO**	**NO GO**
Instability	**GO**	**NO GO**
Power	**GO**	**NO GO**
Bath height management	**GO**	**NO GO**
Process measurements	**GO**	**NO GO**
Sick pots / pots failures	**GO**	**NO GO**
Operations	**GO**	**NO GO**
All operations done on schedule		
Anode Change compliance last two weeks		
Anode Covering audits last two weeks		
Anodes	**GO**	**NO GO**

Figure 12. Example of Go-no go tool.

Using adequately the different tools eases the transition and makes the line current increase smoother. It should be noted that part of the analysis can be made remotely, of which more in the next section.

4. Remote Support

4.1. Aluminum Operations Center (AOC)

A few years age, Rio Tinto Aluminium started its Aluminium Operations Center (AOC) in the Saguenay region of Canada. Now the AOC gives technical support to 8 smelters worldwide (3000 cells) without interruption 24 hours per day. Its objective is to optimize the output from the different existing technologies by sharing best practices, implementing synergies and standardizing operations. Figure 13 illustrates the AOC and indicates the smelters under supervision.

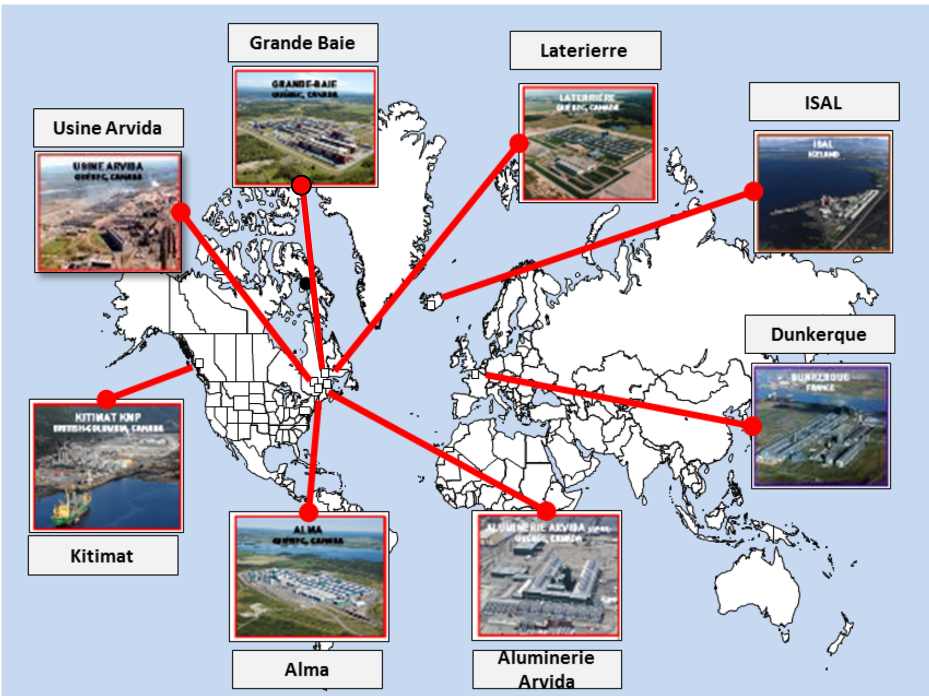

Figure 13. Aluminium Operations Center and smelters under supervision.

The Aluminum Operations Center is now fully operational and has demonstrated the feasibility of giving support remotely from the smelter location.

4.2. Remote Support for Progressive Improvement

Following the same line of thinking, RTA has developed remote support for progressive improvement projects with non-RTA partners. It is based on an Internet connection as shown in Figure 14. The supervision room can be anywhere. In the example of Figure 15, it is located in Voreppe, France.

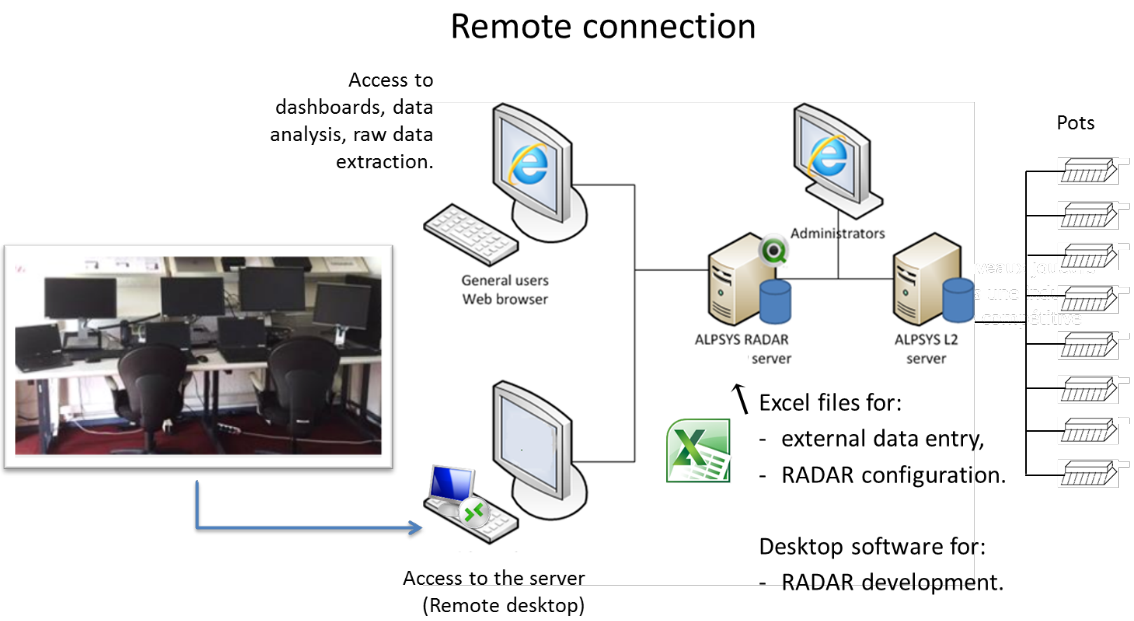

Figure 14. Network architecture to be put in place for remote support.

Figure 15. Remote support from experts based in Voreppe.

The existing RADAR™ tool has been updated recently to deliver the appropriate level of information to be able to make the relevant analysis and draw adequate conclusions to recommend the appropriate adjustments. Figure 16 shows a typical RADAR™ screenshot, giving an impression of the degree of detailed surveillance available to the support team even at a range of thousands of kilometers.

Figure 16. RADAR™ : one appropriate tool for remote support.

4.3. AP4XLE Technology Transfer Example

In 2016 the AP4XLE technology was transferred to one of our licensees using both onsite and remote support. Onsite support was focused chiefly on the operational side, making sure all the delivered procedures were correctly followed. Remote support was mainly for adjusting the process parameters to make sure start-up and ramp-up were progressing according to plan. For remote support, weekly meetings were held between the licensee's technical people and RTA's experts using the following standard agenda:

- Presentation of the evolution of relevant key performance indicators (instability, temperature, voltage, feeding).
- Presentation of the different analyses performed and discussion of the results leading to consensus on what is to be done.
- New concerns from the plant (RTA's analysis of these and corresponding recommendations to be presented at the next meeting)
- Action plan follow-up.

All analyses were performed remotely at the LRF facility in Saint Jean de Maurienne, using Alpsys™ and RADAR™ tools on the licensee's database. During the meetings, it was also possible to share real-time information using these tools to focus on the situation of any individual pot.

After a few months of remote support, agreement was reached on adjusting several process parameters, leading to the benchmark performance of the AP4XLE cells in term of cell voltage and cell stability which is illustrated in figure 17. The adjustments which had the greatest effect were metal height, target resistance and AlF_3 management.

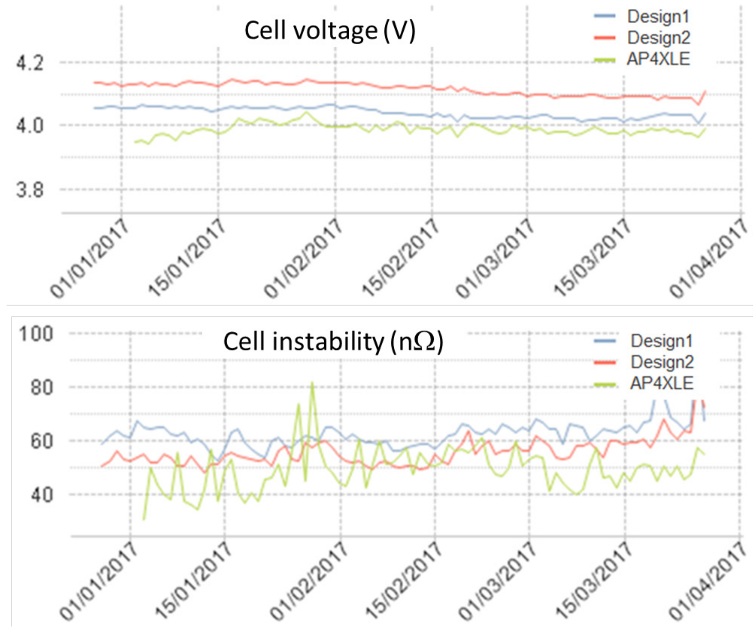

Figure 17. Performance of the new AP4XLE design under remote technical support.

5. Conclusion

Rio Tinto Aluminium has a solid track record of progressive improvement in smelter performance. This has led to the development of numerous tools, which ensure both optimal cell design and optimal transition. Optimal design is obtained by selecting the appropriate technology bricks in the AP Technology ™ portfolio in accordance with plant technical and economic constraints. The optimal transition is obtained by close technical support from the inception of the project through to smooth regular operation. Part of this support can be supplied remotely thanks to new technology including RADAR™ supervision.

6. References

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