Light Metals 2013 *Edited by: Barry Sadler*
TMS (The Minerals, Metals & Materials Society), 2013

"MAXIMIZING CREEPING VALUE THROUGH RIGOROUS METHODOLOGY"

Bénédicte Champel[1], Nicolas Monnet[1]
[1]Rio Tinto Alcan – Smelter Technology, Centr'Alp, BP7, 38341 Voreppe Cedex, France

Keywords: "Creeping, methodology, modelling"

Abstract

Creeping of an existing smelter is often considered cost-effective compared to the development of a greenfield smelter. It indeed permits an increase in metal production and/or a reduction in operating costs with lower investment compared to a greenfield case.
In order to minimize issues during the execution phase, a rigorous and thorough preparation is required, including the identification of the creeping impacts on all smelter units, and the proposal of possible solutions to mitigate them.
Rio Tinto Alcan Technology group has developed an integrated approach to identify the impacts of creeping, starting at the smelter level and then extending to the different units. Such a method is now available as an AP Technology™ solution.
This paper describes the general approach used, and the main tools developed with this aim.

Introduction

Due to the ever growing global competition, all producers of primary aluminium have to face stronger cost pressure. In this context, increasing the production of a smelter and/or reducing its power consumption often represents an opportunity to cut the production cost of the metal.

The main levers used to increase the metal production of a smelter are:
- Current increase in the potline (Refs 1 to 7),
- Expansion of the potline with additional pots (Refs 2&8).

Creeping projects often have to integrate additional constraints, such as the need to adapt to a constrained environmental or energy context (Ref 2).

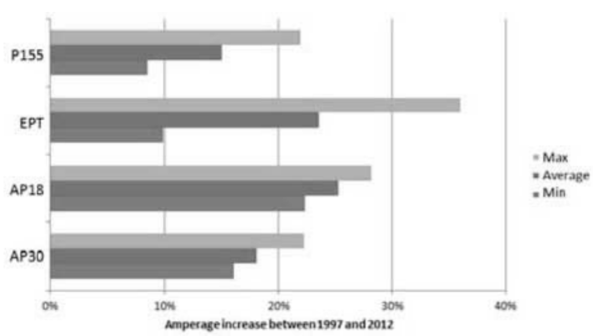

Figure 1 : Amperage increase in Rio Tinto Alcan smelters between 1997 and 2012 (P155 : Alcoa technology, EPT : Alusuisse technology, AP18 / AP30 : AP Technology ™)

Due to the continuous development of AP Technology™[1] pots, all smelters using these technologies have experienced creeping in the past years. Nevertheless, as can be seen in Figure 1, increase of current has been general within Rio Tinto Alcan in the past 15 years, whatever the pot technology.

Importance of preparation for creepings

In order to minimize issues during the execution, and ensure capture of all the gains produced by creeping, a thorough and rigorous preparation is needed at all stages of the project.
An insufficient preparation can induce a lower than expected investment return due to:
- Environment, health or safety issues,
- Partial achievement of the targeted performances,
- Delays in implementation of the required changes,
- Higher costs than estimated.

The preparation phase of a smelter project can be subdivided into several steps, each one with a specific purpose. Typical project development steps are:
- Order of magnitude (OoM): build a business case for the project and define project options,
- Pre-feasibility: narrow the number of project options to one and refine the estimate from the OoM,
- Feasibility: confirm and optimize the recommended option from the previous stage.

Over more than 30 years in greenfield, brownfield and creeping projects, Rio Tinto Alcan Technology has developed the ability to support its clients throughout the entire process of their projects.

This article focuses on the application of the integrated approach developed by Rio Tinto Alcan Technology for the specific case of the OoM study[2].

This approach is used for all Rio Tinto Alcan smelters projects, and has been put into practice for external customers as well.

Methodology

The duration of the OoM study lies between one and three months, that include:
- A preparation phase and preliminary analysis.
- An on-site mission (typically two weeks), during which experts from Rio Tinto Alcan Technology, working in close collaboration with the smelter team, conduct a

[1] **AP Technology™** is a trademark of Aluminium Pechiney, used under license by Rio Tinto Alcan Inc
[2] The same methodology is proposed during the following steps of the project, going into more details

review of the existing operation and performance of the different shops, their potential and bottlenecks.

- The analysis of the collected information and the production of the deliverables.

The approach can be subdivided into 4 main steps (Figure 2).

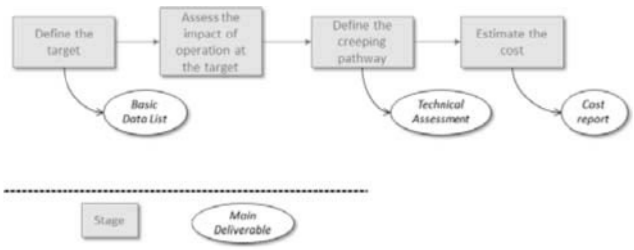

Figure 2 : Methodology Process map

Step 1 : Define the target

The first step aims at defining as precisely as possible the initial state and the target to be attained.

The definition of the initial state requires collecting all relevant information and data concerning existing operations, performances and organization of the smelter for its various shops (performance reviews, monthly reports, shifts organization…).

In order to define the target, customers' expectations and needs concerning the evolution of the smelter performance have to be analyzed in light of:

- potential constraints to be taken into account,
- state of the art technologies used in smelters,
- available technical solutions for the pot technology as well as for the individual capability of the different shops of the smelter,
- ongoing research and development and industrialization programs (if required and if the development program fits with the expected implementation of the creeping project),
- organizational benchmarks.

At the OoM stage, several combinations of technical solutions can potentially meet customers' expectations while integrating identified constraints. Further definition and optimization of the options will be carried out in the following stages of the process in order to select the most profitable one.

An open and constructive discussion between all stakeholders in the smelter and the technology experts is necessary in order to develop a common understanding of the needs and the levers that can be used. This shared vision is reflected in the Basic Data List.

Basic Data List

Rio Tinto Alcan Technology has developed a specific tool in order to structure this first step. The Basic Data List can be seen as the backbone of a creeping project. This document lists the basic data concerning the whole smelter for a set of milestones (at least present situation and target), on a template structured over all shops and departments (see Table 1).

The advantages of such a tool are multiple:

- It allows a consistent picture over the whole smelter of the targeted situation to be obtained: data impacting several shops (such as ladle size or anode change cycle) are defined in a common document.
- By listing main equipment characteristics, organization of operations and performances of the different shops, it helps identifying the main changes induced by the creeping project[3],
- It allows a common view of the project to be obtained by all stakeholders,
- It permits to compare different scenarios on a single document,
- It is a reference document to be agreed with the client and the technology that defines the case(s) that will be studied in the next steps of the analysis.

Table 1 : Example of breakdown for the Basic Data List

General & local Data	
Substation	
Reduction	
	Buildings
	Pots
	Pot Tending Equipment
	Reduction Services
Gas Collection and Treatment	
Carbon	
	Green Anodes
	Anode Baking
	Anode Assembly Recycling
Casthouse	
General Services	
Utilities	
Raw Materials	
Off-site Facilities (port,..)	

Material Balance

The Material Balance presents the annual flows of products circulating between the various units of the plant, set up on a pattern embodying the entire smelter to ensure the consistency.
This document gives a clear and accurate image of the real flows of products linked to the process, and entering or leaving each shop of the smelter. It forms the basic specification for the determination of annual flow rates and equipment sizing.

Step 2 : Assess the impact of operation at the target

The second step consists in assessing the modifications required in each facility of the smelter in order to support the operation at the target.

The expertise and models owned by Rio Tinto Alcan Technology over the different facilities and equipment of a smelter, permit

3 In the case of amperage increase, the main driver of creeping often arises from modifications performed on the pots: new lining (Refs 1, 3, 4, 5, 6), change of anode format (Refs 1, 5, 6), improved process settings (Ref 9)... The side-effects on the other shops of the smelter of the changes carried out in the reduction area have to be carefully identified in order to ensure the capability of the full smelter to support the creeping.

identification of the potential bottlenecks to reach the identified target for all shops.
After bottlenecks have been identified, required modifications and possible contingencies to reach the target can be proposed.
The Basic Data List is an essential input to this analysis, as it gives for all shops a view of the major changes to be expected with the creeping.

Modeling
Modeling tools covering all sectors can be run to better quantify the capability of the different shops to support the expected modifications.
They can also predict the impact of different contingencies and then allow discrimination between different options to select the most efficient.

Among the available modeling tools within Rio Tinto Alcan Technology group, the most commonly used for creeping studies are (see Figure 3):

- Paste plant model (equipment sizing, working modes),
- Anode baking furnace model (dimensioning of furnace tending equipment),
- Anode handling and storage model (dimensioning of equipment, working rules),
- Rodding shop model (dimensioning of machines, trolleys, buffers, storage areas…),
- Pot modeling (thermoelectrical and magneto-hydro-dynamic balances…)
- Reduction area models (dimensioning of pot tending equipment, work organization),
- Metal flow (dimensioning of vehicles, ladles, furnaces, casting units, metal treatment units…),
- Casthouse (dimensioning of equipment),
- Ventilation models (reduction, anode baking furnace, anode pallet storage, covered roads,…)
- Traffic on site (identification of dangerous zones, improvement proposals, safety recommendations).

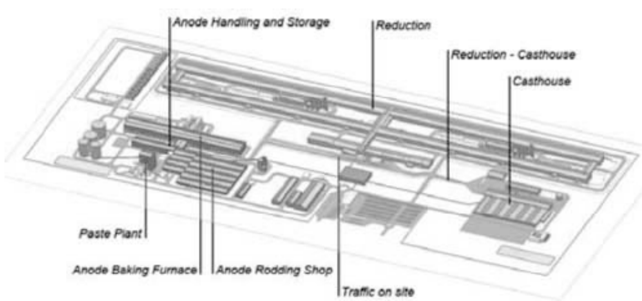

Figure 3 : Areas covered by modeling activities

Risk assessment
At this stage a preliminary risk identification is conducted in order to list critical project risks. Mitigation options can be proposed. The list established at this stage is dynamic. It must be completed and discussed with the client teams prior to a formal risk assessment exercise. This risk register will be updated and detailed during the next stages of the project preparation until the elaboration of the risk management plan.

<u>Step 3 : Define the creeping pathway</u>
The objective of the third step is to establish how the target will be attained.

All types of constraints linked to the path are integrated into a consistent roadmap for the creeping project (Figure 4).

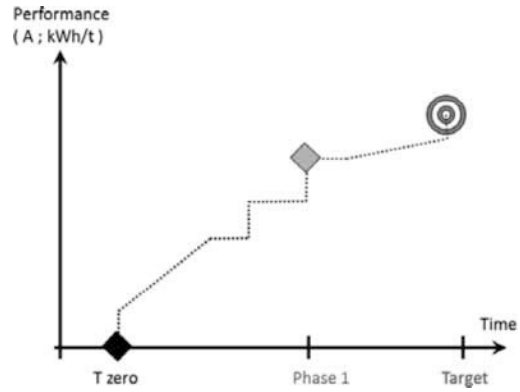

Figure 4 : Building of a creeping pathway

Some constraints can be external, such as availability of energy, local regulations, logistics etc.
The time required for performing the modifications identified for the different shops and equipment is also taken into account: duration needed to get internal approvals, purchase, install and put into operation the required material or equipment.
The planned dates of availability of the technical solutions required to reach the target are considered as well. When some levers are not fully validated, the schedule of validation and industrialization is integrated in the analysis.
The robustness and operability of transitory phases during the creeping are checked in order to ensure a proper operation of the whole smelter throughout the creeping.
Finally, the sequencing of the implementation of the different levers is carefully planned, so that no bottleneck remains when implementing a new technical solution.

Creeping involving a lining modification
A particular situation occurs when the creeping project requires modifying the pots' linings. In that case, the creeping pathway has to be carefully drawn up to ensure that pots having two types of linings can be run at a balanced operating point throughout the transition from the existing lining to the new one.

The first check to be performed is the compatibility of the present and the targeted pot designs: the operating windows[4] of the two linings need to have common operating amperages (Figure 5). If the targeted operating point is too far from the present situation, this might be impossible, and the use of an intermediate lining might be necessary to accommodate the transition.

[4] The operating window is an essential tool used by Rio Tinto Alcan Technology to define an acceptable zone for pot operation within prescribed design limitations (see Refs 4&9 for more details)

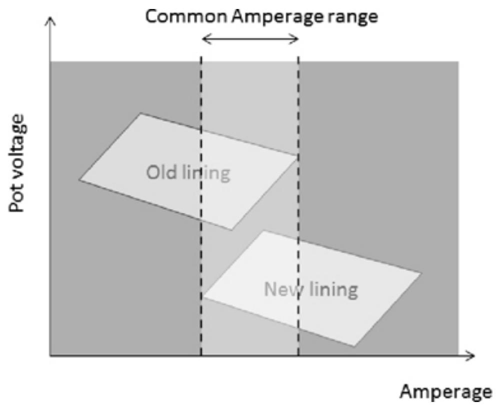

Figure 5 : Compatibility of linings on the basis of their operating windows

If the two linings are compatible, the next step consists of analyzing the pot replacement pattern of the smelter.
In recent smelters, the pot relining distribution is peaked, while in older ones, the peak has been flattened at each relining: the relining activity can, therefore, be considered roughly continuous (Figure 6).
The ramp-up duration will reflect the relining pattern of the smelter:

- In the case of a recent smelter, the creeping has to be planned in accordance with the relining peak in order to profit from high pot replacement rate and ramp up current rapidly.
- In older smelters, the creeping duration will be longer as the transition from one lining to the other one will take five to six years. In some cases, shortening pot lives can be considered as an option to speed up amperage increase.

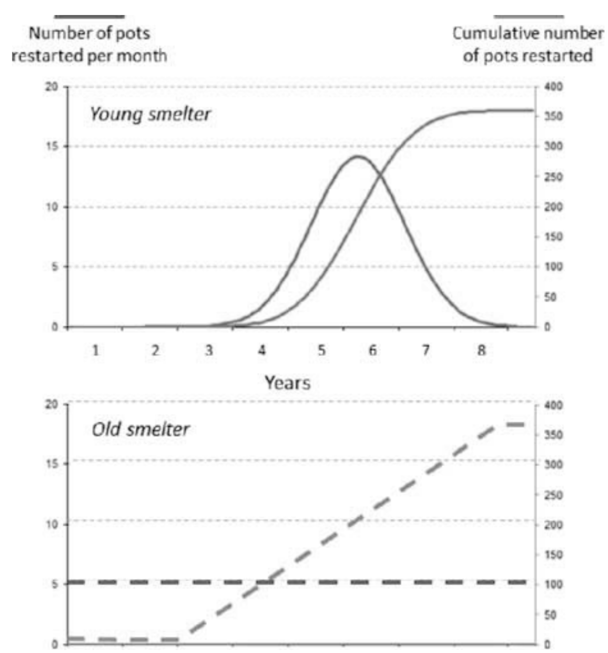

Figure 6 : Comparison of relining patterns in a recent smelter (top) and in an old smelter (bottom)

Comparison of scenarios
At the OoM stage, several paths to reach the target can be built (Figure 7).

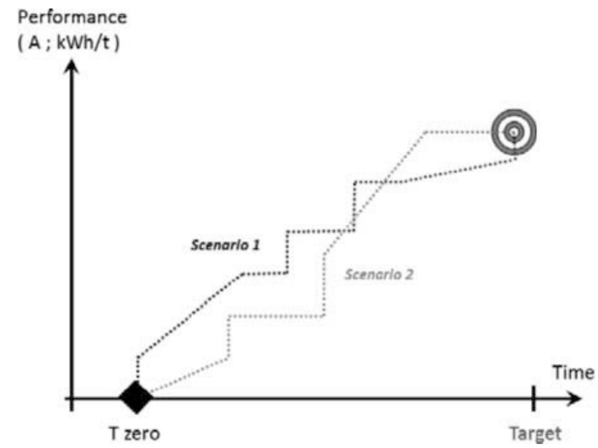

Figure 7 : Comparison of two creeping scenarios

The comparison of the different possible pathways, and the selection of the optimal one, will take into account:

- The cost assessment,
- An advanced financial analysis,
- The risks,
- The availability of the technical levers,
- The sustainability of the transitory phases involved.

Step 4 : Estimate the costs
The last step of the analysis consists in building a preliminary cost estimate for the creeping.

Drawn up at the early stage of a project with a precision linked to that of the technical assessment, it will be refined throughout the project in order to reflect the progress of the technical analysis.

Main inputs to this estimate are:

- The technical assessment on the project,
- Experience and lessons learned on similar (internal or external) projects,
- Budget proposals for some lots,
- Information received from procurement departments for some pieces of equipment or material.

The cost of a project is made of 3 main parts:

- Direct costs include construction costs, cost of materials and the cost of various equipment items and equipment assembly. This part can be broken down into the different facilities of the smelter.
- Indirect costs represent all the costs linked to the project execution, which cannot be allocated to a specific element (such as project management, temporary site installations…).
- Contingencies include all unpredicted costs. They are linked to the project maturity level regarding business ownership, scope, planning, engineering and cost estimate basis.

The interests of the cost estimate are multiple:

- It permits to identify the highest budgetary parts, that will have to be optimized during the project,
- It is a decision-making tool, permitting to discriminate between different options or scenarios (Figure 8),
- It permits to build a business case for the project.

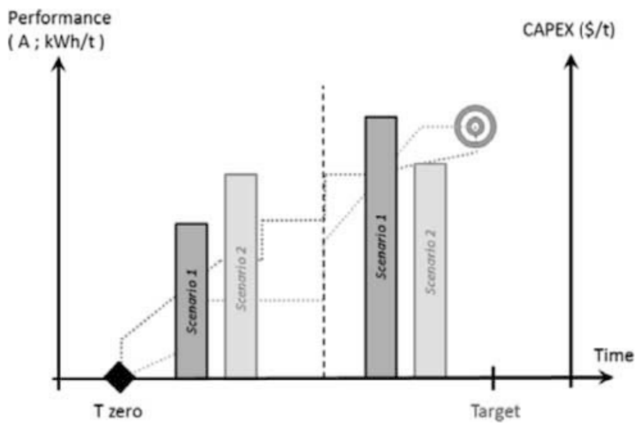

Figure 8 : Comparison of cost estimates for different creeping scenarios

Conclusion

To minimize the number of issues and prevent occurrences of roadblocks during the execution, and to capture all anticipated savings and benefits, a thorough and rigorous preparation is needed at all stages of a creeping project.
The end result for the client is a project that fits perfectly to its needs, and delivers the maximum value.

The knowledge of the different facilities and equipment of a smelter, the expertise acquired over more than 30 years on greenfield, brownfield and creeping projects, the application of a rigorous and proven methodology, and the strong technology transfer capacity, make Rio Tinto Alcan Technology the first choice partner to help smelters prepare their creeping projects.

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