# Modeling of Aluminum Tapping Operational Management to Enhance Smelter Productivity

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**Abstract**



A good planning and control of the operations involved in a smelter is crucial for achieving a high-level of performance and productivity for the plant. Given the large number of processes involved in a smelter, as well as their complexity and interrelationships, it is far from trivial to evaluate the actual operational impacts of changes to the cell amperage, work organization and schedules, equipment capacities and replacement, the layout, etc. In the present work, a simulation model based on the discrete event method is developed to analyze the operations management related to the tapping of aluminum from the electrolysis cells. The inputs to the model are the plant layout, the work schedule, the travel and process times, the availability and the capacity of the equipment such as crucibles, cranes, etc., and the list of required cells to be tapped, based on the cast house requirements. The model was validated with plant data. Results of the simulation include the details of all operations performed within a 24 hour period and the time at which they were completed. The simulation also provides information such as the idle times of equipment and workers, and the operational incapacity to respect the planning, if applicable. The simulation model proposed can therefore be viewed as a powerful tool to test different scenarios and guide towards profitable short-term and long-term planning decisions.

**Keywords:** Planning and control of operations; aluminum electrolysis cell tapping; discrete event simulation; amperage creep.

## 1. Introduction

Primary production of aluminum is a highly competitive sector. One of the main issues for this industry is to constantly increase its production. Smelters have been relying for over a century on the Hall-Héroult process to transform alumina into aluminum according to the well-known overall reaction in Equation (1):

$$2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2 \quad (1)$$

This reaction takes place in the electrolysis cells and requires an important electric current. In order to increase their production, smelters need to creep the current.

However, changing the production rate from the electrolysis cells affects all related operations. For example, carbon anodes are consumed faster and therefore, need to be replaced more frequently. Similarly, operations such as aluminum tapping, beam lifting, and addition of bath and $AlF_3$ may be needed at a different frequency. As these tasks involve several workers and pieces of equipment with different requirements and constraints, the modification to the planning and control of operations can become difficult to evaluate. Therefore, before implementing amperage creeping in a smelter, it becomes interesting to study its impacts on all the operations.

In fact, whenever smelters modify their technologies, face significant changes from their suppliers or deal with variable demands, they typically need to adapt the planning and control of their operations. There is thus a need to develop and exploit systematic simulation tools to better support operational management.

Among the first published analytical models for planning and management of technical and economic changes in the aluminum industry was that of Nicholls *et al.* [1] which was implemented in a Portland smelter. Later, Tuck [2] proposed an optimization approach of the aluminum tapping. He applied the cell batching problem to the New Zealand Aluminium Smelter (NZAS) at Tiwai Point. Ryan [3] and Piehl [4] mentioned that this problem could be solved more easily by a set partitioning problem (SPP) approach. Voorhis *et al.* developed a software based on the Branch-and-Bound method to generate the optimal casting planning in smelter's cast house [5]. However, they concluded that without a simulation program, it was impossible to make a decision while considering all applicable constraints. Finally, again for optimizing production, Duman *et al.* developed a multiobjective ant colony optimization metaheuristics in order to schedule the continuous production of aluminum [6].

This body of work on mathematical modeling of operations management adapted to primary aluminum production has paved the way to the development and exploitation of systematic tools for operational management. However, as mentioned by Harton, up to now, *"these models have not been able to model the complex real world constraints. The only way to truly do this is through an aluminium smelter simulation. [7]"*

Harton simulated metal flows in a smelter [7]. He claimed that improving the management of metal fluxes provides an opportunity to increase revenues without altering the main production process. The objective in his approach was to use more efficiently the available resources in order to produce the most profitable metal grade for the smelter. His simulations showed how the decisions affect the overall efficiency of the system and their impacts in the smelter.

Given the advent of the lean manufacturing concept, Meijer explained that the development of simulation models adapted for operations management in smelters should be given more attention, because it represents an important solution to reducing costs: "Combining discrete modeling with the advanced models of cell simulation open up a new area of research in which the material flow can be optimized, towards the need of the individual cell. Since anode changing and metal tapping are important parameters that influence the stability of a cell, such an attempt can create a more efficient use of assets and higher productivity of the smelter" [8].

Recently, Eick *et al.* [9] used a dynamic logistic simulation model to aid the planning of potroom activities, traffic flows, and logistic equipment needed for a smelter expansion project. They used the software POSES++, a modeling and simulation environment for discrete event systems with applications in the fields of logistics, communication systems, hardware design, and algorithms validation.  He concluded that the simulation is a visual tool that can predict the reality with reasonable accuracy.

## 6. References


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