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ALUMINIUM SMELTER LOGISTICS – CAN THESE BRING REAL COST SAVINGS?

Maarten Meijer
[1]TMS (The Minerals, Metals & Materials Society); 184 Thorn Hill Rd.; Warrendale, PA 15086, USA
Hencon B.V., de Stenenmaat 15, 7071 ED Ulft, the Netherlands

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ABSTRACT

Discrete logistics studies has proven to be a low cost tool to evaluate and implement technologies and lower the risk of investments into large scale infrastructural projects. So far this tools have not been used much with similar complexity as in other industries in order to evaluate design issues, feasibility questions and bankability. This paper describes how simulation tools do have an impact on capex and opex. What effect simulation has on optimizing interaction between smelter units and processes for additional cost savings. Finally how the use of simulation tools help to achieve "lean thinking" in new smelters or upgrades while at the same time lowering the risk of such innovations.

INTRODUCTION

Traditional, discrete simulation tools like Simio[i], Arena[ii] and Automod[iii] are used to evaluate the feasibility of discrete material flows at airports, terminals, food and beverage industry, car manufacturing facilities, metal production, oil and gas, etc. In aluminum industry several studies have been done in a limited amount of time to support investment decisions on casthouse expansions, gantries cranes, warehouse optimization, plant traffic safety, etc. Although this studies have been helpful to take educated decisions on Greenfield and brownfield projects, this knowledge did not lead to frequent use of this tools as a decision making support in other projects.

Now with a new challenge to the Aluminium Industry where most smelters have cost reduction programs running of $100 to $200 per ton produced, discrete simulation can help to optimize Aluminium Manufacturing and turn it into a lean process.

LEAN MANUFACTURING

Electrolyze cells have always been studied and optimized within the industry. There is also a long tradition in this technology to use fluid dynamic calculations and test pots in order to come to a reliable and stable cell design that has been tested for many years. Typical examples of such long running research programs are: Development of the AP39: The new Flagship of AP technology[iv] and DX Pot technology powers green field expansion[v]. However from a discrete point of view this development programs still have room for further optimization of the material flow and a discrete approach towards anode handling and metal tapping.

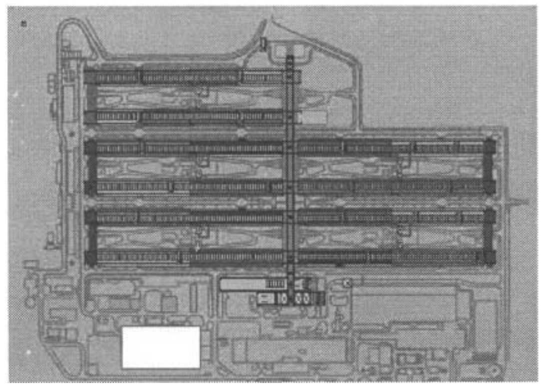

Figure 1: typical lay out and schedule for a potline

The room for optimization get more clear if we study the shift pattern and material flows of a modern smelter. Most smelters organize their potlines in several sections. Each section is treated in more or less the same pattern. Anode setting periods and tapping periods follow each other up, per section in a more or less regular pattern. Per section a PTM or GP crane is dedicated to the pots to assist the operators in completing the task in time.

This operating regime is adapted by most smelters as the ideal and most reliable way to handle the pots in time with a reliable operator performance and relative stable line. However when amperage increased and smelters become larger, this regime start to become a critical aspect of running a smelter. For instance where the original design concentrated on one or two PTM's that could handle the pots in sequence. Nowadays the smelter is handled by a minimum of two PTM's and 1 GP to catch up with the production rate of the pot. Keeping the operating regime in sequence requires gantry cranes and after a shift is concluded the cranes are set up in the right sequence to be ready for the next shift. As a consequence fly times (the time that a crane is moving without a load) is increased and vehicle performance has decreased. On both the cranes and the vehicles OEE indexes of 60% are not unusual. Finally if we compare manufacturing results with the principals of lean manufacturing we see many cases in which waste is produced, a view examples of such waste are:

- Anode's and Ladle's arriving to early at the crane or stacked in a row in the potroom to solve just in time problems between the transport cycle and handling cycle of the crane.
- Uneven distributed anode change patterns or metal delivery patterns during the shift.
- Not optimized metal flows to the cast house, resulting in a overflow or underflow of metal to the casthouse
- Empty rides between the section and the different stations of vehicles.
- Early or late anode changes to keep cells in the desired shift pattern per section.

All this items indicate there is room for improvement with regards to a lean distribution of materials into the potline. However they also indicate that the material handling system is not optimized to the knowledge collected in running stable pots at high current density. Due to the physical nature of cranes, human beings and introduction of sections handled by a dedicated team. There are two disturbing factors that are not controlled by the cell, but determined by the shift pattern. This factors are: anode setting and metal tapping.

Today's pot control systems collect enough information to plan this activities more smart and according to the demand of the pot and casthouse. However the operating regime and lack of knowledge on discrete logistics applied to our industry stop us from changing our typical section based approach.

DISCRETE LOGISTICS STUDY FOR POTROOMS

Light metals gives a limited number of papers that deal with using simulation tools to optimize the flow of discrete materials within a potroom. In 2009 Hydro published a study.[vi] In 2010 an outlook of our research program was given in another publication. [vii] Apart from that a number of experts within our industry are using discrete flow simulations to take educated investment decisions or improve the safety of a factory lay out. However making a potroom model is a complex task in which the detail of the model is very often limited due to the time constraints of the project at hand. Within our own research it took from 2007 till 2010 to upgrade the model to enough complexity to handle the material flows successfully and start using it as a base model to discuss and evaluate alternative manufacturing policies with our clients. At the moment the model is a good tool to investigate alternative scenario's for the use of vehicles in the manufacturing of Aluminium. Everybody that sees the model and use the model immediate understands its potential. However adaption's are still going on to add functions that help to evaluate lean manufacturing strategies for existing and future pot rooms.

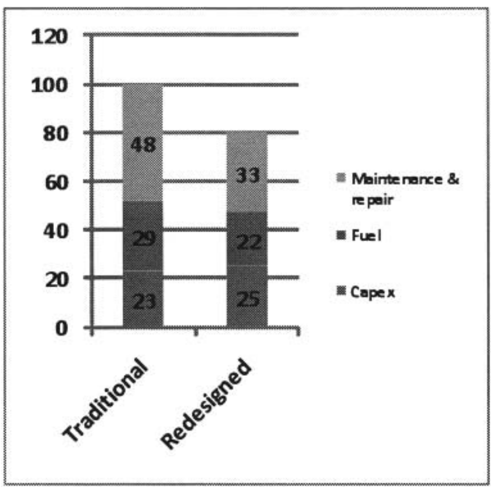

Figure 2: a typical result of cost saving by using the model

A typical result of the model is shown in figure 2, in this study we successfully reduced the fuel consumption and repair cost by introducing a new design in an existing smelter. The model convinced the operating staff with regards to the use and flexibility of this new design. Apart from that the model started a discussion on how this vehicle should be operated that resulted in additional functionality in order to utilize the vehicles more successfully than could have been done in their old shift pattern. The 20% reduction in OPEX, never would have been approved and achieved if the model was not build. The reason for this was that the model was the first platform in which different stake holders from, engineering, operation, maintenance and smelter management shared their ideas. The model was used as a "common language" tool, to evaluate consequences from their mutual decisions, based on their combined knowledge presented in the model.

This working method, convinced the investment team that a 20% reduction in cost was achievable, however more important once they agreed that this was the best option, it helped them to illustrate their complex task and results to top management in order to get the investment improved.

DISCRETE MODELLING CONSIDERATIONS

Like in any good model, the biggest dilemma stay's how to reflect the reality without modeling the reality in every detail. Therefore for every model we have to evaluate what level of detail is needed? Within our model we solved this issue by using a object orientated approach. This results in objects (for instance a cell) with a fixed set of variables that successfully simulate a cell. This allows us to reuse information and make objects as smart as they need to be. Next to that we simplify processes as much as possible. For instance if we study vehicle movements we do not include the crane as an object, but use the cell as an item that generate the demand. This allow us to only evaluate movements on the floor and not interfere them with a complex object like a crane.

VALIDATION

Validation of results will always be important. This is a part where the stakeholders of our customers play the most important role. If they do not recognize their own manufacturing process in the model, the model is not suitable to run new experiments and suggest alternative manufacturing processes. This is an important validation step within our process. Without this step the model cannot be used to evaluate future processes and decide they are valuable to invest in. As a manufacturer and supplier of transport systems we know how important it is to match system performance with design calculations. Unlike funded research validation, the results are confidential in most cases.

CONCLUSION

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 assist and higher productivity of the smelter.

With today's model it is possible to support an investment team during the feasibility and design phase of an investment in order to come to a best practice solution that is, validated and proven making use of the combined know how of all stakeholders in the project.

Discrete modeling is a tool that helps to justify or research new manufacturing methods up to a point that reaches further than gut feeling. This tool can help to find new manufacturing methods (outside pot technology research) that make fruitful use of the capacity of modern smelters with nameplate capacities between 150 thousand and 1 million tons of Aluminium produced a year.

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[i] http://www.simio.com/
[ii] http://www.arenasimulation.com/
[iii] http://www.automod.se/eng/home.html
[iv] Development of the AP39: The new Flagship of AP technology O.Martin, X.Berne, P.Bon, L.Fiot, D.Munoz, C.Ritter, R.Santerre, (Light Metals 2010, page 333-338)
[v] DX Pot Technology Powers Green Field Expansion. A. Zarouni, M. Zelicourt, M. Jallaf, K. Alaswad, A. Kumar, A. Reyami, V. Kumar, D. Bakshi, J. Blasques, and I. Baggash (Light Metals 2010, page 339-344)
[vi] Logistic simulation of discrete material flow and processes in aluminum smelters. Anton Winkelmann, Ingo Eick, Christian Droste, Martin Segatz,.(Light Metals 2009)
[vii] New Logistic Concepts for 400 and 500 KA Smelters. Maarten Meijer (Light metals 2010, page 345-348)