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PRIMARY ALUMINIUM PRODUCTION: IS AUTOMATION THE KEY TO NEW SUCCESS?

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ABSTRACT

Managing and maintaining an Aluminium Smelter at its optimum is a challenging job. Only a mistake, like inferior joint on the anode, bad anode, sleepy operator or bad pot tending process can disrupt a pot. Once done, it may take months for a pot to recover from such a disruption and get back to its most productive stage again. Nowadays a modern smelter has more pots running at higher amperage. The operational team needs to use these pots and manage their performance in order to reach an excellent operational result. In this paper we will discuss the need for equipment that gives a constant predictable performance as well as real time feedback on this performance of people and equipment to the management. We see this is the way forward to change industry operational know how from a reactive behavior into a knowledge based pro-active behavior. In this paper, a helping hand to the aluminium industry is offered form an unusual perspective.

INTRODUCTION

Operating a smelter is a management challenge. Especially in a modern smelter with low manpower with approximately 320 cells each making around 2 tons of aluminium every 24 hours. Managing this smelter is a fussy control task with highly sophisticated pot controllers on one hand and human operators on the other hand. Or as stated by the Light Metals Research Center "Aluminium smelting energy efficiency is heavily dependent on the quality of cell control, which in turn is greatly influenced by the decisions that are made by human controllers. As a consequence, improving the decision-making of smelter operations represents a significant opportunity for reducing process variation and specific energy consumption." [1]

Although this statement of the LMRC is very true it does not give right to another challenge the management of a smelter will face. Although the cell control system is highly advanced and most likely of a well-tested modern nature. The material handling system that takes care of these 320 cells is of a less advanced nature and will leave many of the operational problems to the operational and maintenance manager to solve.

In multiple discussions with several clients it is surprising to notice that the clients do have little or no reports or control systems installed that give them real time data with regards to:

- Resource planning of critical equipment (this usually results in ordering a surplus of this equipment in time just to keep things going)
- Real time discrete material handling data on key processes as anode changing, bath levelling and metal tapping. (Most of the time the plan is available but actual data will follow in months)
- Real time Feedback on process data and accuracy. (anode setting heights, tapping of bath or metal is not real time monitored)
- Operational Availability and Preventive Maintenance. (knowledge on this aspect is hardly available and suppliers and users do not have a working method of getting the best out of the capital invested)

As a result the human aspect of running a smelter is hard to control and process variations that will influence the efficiency and therefore energy consumption of individual cells will become part of every days fact of life. But is there a way to avoid reacting on cell controllers that relate to decisions made by humans that operate these cells?

USE OF BIG DATA IN THE ALUMINIUM INDUSTRY

Aluminium Industry by nature is a labor intensive industry that took steps to reduce the number of operators required for making a ton of Aluminium. As a result in the early sixties the point feeder was developed: a mechanical device that was able to feed small quantities of alumina at a constant rate to a cell. However it did took until 1974 before the first computer controlled cell was introduced and a demand feed control algorithm was developed based on line amperage and cell voltage information by Kaiser Aluminium [2].

Since then controlling an aluminium cell became more and more a job of managing data and optimizing current efficiency, feed rates and additives together with lowering cell voltage and increasing amperage up to the point that we have been able to produce aluminium at ever lower kWh per ton.

However the human influence on this performance was left alone until the resent research of Mark Taylor and the introduction of a comprehensive control environment. This environment aims to collect all data in order to offer one control system that "integrate energy, composition, alumina feed and operational control systems with smelter improvement plans, in order to minimize energy consumption and smelter emissions, while maximizing productivity, and a clean working environment over time. This is achieved through continuously reducing and removing variation in the process by scientific problem solving approaches"[3].

This advanced controller can be seen as a step in industry to offer a holistic view on the performance of a smelter. However looking at the information map of this data communication device (figure 1) it also shows that it requires a great deal of human interaction in order to improve the cell performance.

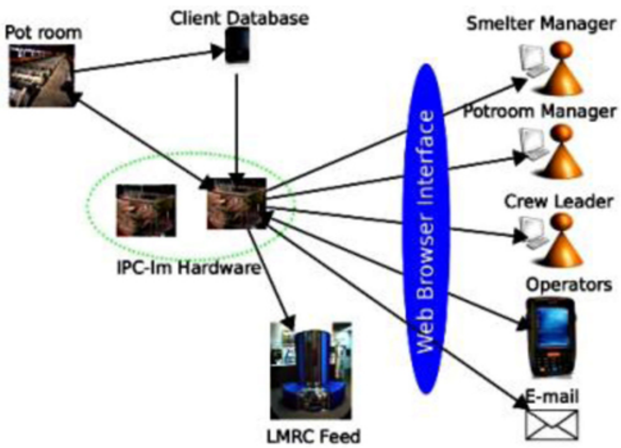

Figure 1: IPC-Im architecture

However looking at the IPC-Im architecture it does fulfill the necessary requirements to offer real time data that can be analyzed in order to respond much faster than before to “unwanted” cell behavior. If used correctly the information supplied by the operators might give an impulse to understanding better what is to be done to let a cell perform at a more constant and productive level of operation.

On the other hand its architecture also might give an answer to a presentation of Halvor Kvande who in 2012 during the Norcast Aluminium Conference [4] gave an overview of jobs that until today are carried out by operators. Despite attempts in industry to make these jobs easier to handle over time, it is still an operator that together with his tools controls anode setting and tending, metal tapping and liquid bath compensation.

OPERATOR DEPENDENT EQUIPMENT AND PERFORMANCES

Looking at recent developments in aluminum industry there is no direct need any more to further reduce manpower based on the cost of manpower during operation.. Even more, since 2008, the urge to lower investments has decreased attempts to further automate equipment, since this initially most likely will increase cost. However at the same time we increased requirements with regards to HSE and especially human safety that come at a cost. As a result, manual operated solutions can be ordered by companies like Hencon, Techmo, ECL, NKM Noell and others for cell tending purposes. Looking at the catalogues of these companies and the tools they introduced, it is safe to say that duties such as anode tending, metal tapping and liquid bath compensation are still dependent on the skill set of the individual operator. Reliability of the equipment and cost of maintenance are left to local crews that very often are challenged to keep their skills up to the level required for the job. It is therefore not strange that a typical example of the IPC-Im as shown in figure 2, indicate several human issues (a feeder that require maintenance and a relative low metal level) that could have been discovered earlier (or never would have happened) if not all cell tending actions were performed by humans in a stressful and harsh environment.

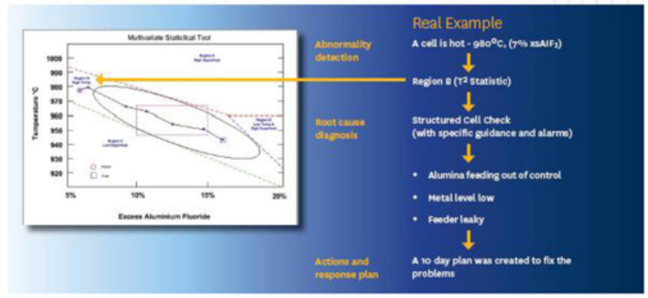

Figure 2: IPC-Im pamphlet example [5]

The need for lower investments volumes, the reduction of knowledge of end users (started in the mid-eighties already by Alcoa and RTA by reducing their engineering staff to the absolute minimum) and lack of consolidation in the supplying industry to the aluminium producers results in a flock of material handling solutions that leaves the effectiveness to the operator. It is therefore no surprise that cell tending operations (excluding alumina feeding done by a point feeder) is still the domain of the operator’s individual skills and the ability of the team leader to gradually raise the skills and awareness of his team towards excellence. Finally when it comes to a new project, the decision making is reduced to mainly a request for lower capital cost without real criteria about the ability to offer reliable process equipment that helps to reduce operational cost and increase process stability.

PROVEN TECHNOLOGY GIVES ROOM FOR INNOVATION

The first question any client in the aluminium industry asks to its supplier is if it is proven technology. The answer to this question is rather simple: “Yes”. However when it comes to innovation and setting new standards the request for reference clients ask is very often answered with “Not yet.” This combination of Yes and Not Yet, most of the time results in the decision not to implement new material technology solutions that do use modern more powerful electronics. This is also why the research of the Light Metals institute that is using “big data” is so essential to understand. Unlike the development of the point feeder or the pot controllers, that more or less gave improved performance results by accident, we can clearly see that reducing human influence will give us the new breakthrough technology that improves efficiency of the cell based on the data collected by the LMI. At the moment, it is most likely that it is human behavior and our inability to successfully perform repetitive tasks reliably that now limit our ability to further improve power consumption and current efficiency of the individual cells.

It is this understanding that made Hencon start its research program in 2005 and publish about it in 2011 and 2012 in Light Metals, to make the industry aware of the potential benefits that will come from “controlled material handling systems”. The key objective of this research program is not to offer information on the performance of humans and their machines, but to gradually reduce the human influence on cell tending operations such as metal tapping, bath levelling, crust breaking, cavity cleaning and anode setting processes. As a second objective, the research focuses on controlled preventive maintenance according the pillars of a TPM [6] system. Aiming again to reduce human influences on the performance of machines due to bad operating habits or poorly executed maintenance programs.

The first result of this program was surprising. From a discrete simulation of potroom events, it was found that a modern crane equipment has difficulty to keep up with cell technology that easily can result in back log of essential cell tending jobs. It proved that as a result of normal disturbances such as: slower anode setting, anode effect quenching short interruptions and breakdowns the scheduled tasks of one crane increased from 20 hrs to over 24 hrs. In reality this means that the scheduled tasks of a day will take longer than a day to complete and a back log in tasks is created. A similar simulation experiment with the same disturbances and separation of the critical tasks showed that the tasks could be completed well in time and further continued to be completed even if disruptions became much more. However as a side effect, the performance of the potline seem to improved. The individual cells in the simulation showed a better reaction in the model with regards to their stability and use of resources. [6]

The next step was to investigate if controllers and sensors required for further automation would withstand a potline environment, with regards to ability to resist magnetic fields, dust, emissions and temperatures and G forces that are normal to our operations up to 600kA cells and layouts of modern potlines. This test has been conducted with the help of Hydro and Trimet and showed that most of the industrial available components if selected carefully will be reliable. Many failed but we ended up with a set of controllers and sensors that would withstand the high temperatures, air quality and magnetic influences of a potline.

Finally steps were made towards an overall control system that combined operational and maintenance information into one environment, collectingdata from mobile equipment and share this information at a set time interval with a database that is accessible to all stakeholders. This system is tested in smelters in Russia, India, Europe and the Middle East as a pilot. The results of this test shows that it is possible to collect and share real time data on performance of operators, maintenance personal and the equipment in order to generate management data.

It is therefore safe to conclude that there is enough technology available to lead the industry into a decade of less human influence on cell performance. However it is not commonly adapted by the industry (due to lack of references) and it will take dedication and courage of individuals to get on the market at all.

It is for this reason that the industry, when it comes to material handling solutions is stuck into labor intensive operations that lead to multiple errors in process control. Getting out of this (less attractive) operational mode is not easy, due to the lack of operational empowerment to introduce engineering and decision taking skills that result in (capital) investment decisions supported by the need to increase productivity or profit on the short run.

If the process knowledge is available within the material handling supplier's organisation, this might become the best source for this kind of innovations to happen. However the focus on lower capital spending does lead the industry away from this potential source of increased productivity at lower cost.

CONCLUSIONS

Historically, the combination of material handling solutions and computer skills did lead to breakthrough technology that improved cell performance. The more we learn about cell performance the more it looks that the best cell is a stable cell. Abnormalities that stop this stable behavior are very often caused by humans. Therefore human influence is a cost factor that goes beyond salary cost. There is a good reason to understand this link better. For instance, research from LRMC of New Zealand confirms that process optimization can be reached by combining human behavior with cell performance. Unfortunately when it comes to human tools, the focus in industry is more on reduction of capital investment than on the introduction of advanced tools that remove human influences. However research of Hencon shows that the technology required to introduce unmanned operations is available, but the lack of knowledge in the industry will make it hard to implement this new technology, even if it could be the next breakthrough the industry is waiting for. I hope the future will show that this last prediction on the willingness of industry to accept and implement automated processes will proved to be wrong.

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