Data Science Applied to Anode Baking Furnace Environmental Footprint Reduction

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Abstract

Gas consumption and related CO_2 emissions become a critical challenge for all aluminium smelters, particularly in Europe. Aluminium Dunkerque, Boston Consulting Group, and Fives Solios have jointly embarked on a project to reduce gas consumption in the anode baking furnace by employing data-driven techniques. Beyond the objective of reducing gas consumption, this project was an opportunity to exploit production data to improve an industrial process. An approach that has been successful in other industries, but which is a premiere for the anode baking furnace.

The project cleaned and consolidated historical data from various sources to derive interrelations across the entire furnace, across time, and across adjacent departments (e.g., Gas treatment center, Electrolysis). In close collaboration with process experts, predictive models were developed which link the actionable baking furnace process parameters with the key process outcomes of gas consumption and anode quality, under consideration of other causal factors such as refractory state. The models were developed and tested on historical data during the Proof-of-concept phase to evaluate and confirm the potential benefits. During the subsequent Minimum-viable-product phase, for which dedicated user interfaces are co-designed with the end users, the models are evaluated in an online fashion to demonstrate gains under operating conditions.

This paper presents the project methodology, the data analysis done and the first results on ABF gas consumption and CO_2 emission reduction.

Keywords: Data science, Anode baking furnace, Gas consumption.

1. Introduction

1.1 Aluminium Dunkerque Smelter

Aluminium Dunkerque (ADK) specializes in the manufacture of rolling slabs and foundry ingots in a wide variety of alloys for high value-added applications in the automotive, transport and packaging sectors. Built in 1991, it is one of the largest primary aluminium smelter in Europe with more than 300 kt Al/y. It operates 264 AP technology pots running at 390 kA and powered by low carbon nuclear power plant.

Aluminum is a strategic metal for the environmental transition, and ADK is one of the world leaders in the production of low-carbon aluminum. The company has reduced its emissions (scope 1 & 2) by 17 % since 2013 and emits four times less greenhouse gases than the global average for the sector. On the strength of these assets, ADK intends to play a major role in the European production of low-carbon aluminum for the benefit of the customers and communities. This is why, in line with the objectives of COP21, ADK is accelerating its energy and environmental transition with an ambitious low carbon trajectory in three phases.

By 2025, efforts to optimize operations and increase recycled aluminium use aim to cut emissions by 5 %. **The Anode Baking Furnace (ABF) project will help, as it uses 50 % of the site's gas**. By 2030, ADK targets a 30 % emission reduction with increased energy flexibility and carbon capture technology. By 2050, ADK aims to reduce emissions by over 70 % by deploying a new smelting line with inert, non-carbon-emitting anodes and further increasing recycling activities.

1.2 Why Data Driven Techniques Applied to ABF?

ADK, Boston Consulting Group, and Fives Solios jointly embarked on this project, each party having already experience and expertise in either smelter operation or data-driven techniques.

Over the years ADK has developed, at smelter level, data driven practices to support operation performance with the deployment of a plant-wide data historian and data visualization tools based, in particular but not only, on PI platform from AVEVA (Figure 1). On ABF side, it encompasses process parameters, measured KPIs, baked anode quality as well as all the refractory field survey data on a flue wall and headwall conditions. The use of the data science techniques like machine learning, parametric or Bayesian modelling was not new for ADK [1] and therefore, ADK wished to investigate these techniques again in order to further optimize the smelter operations, their use being a premiere for such application to ABF.

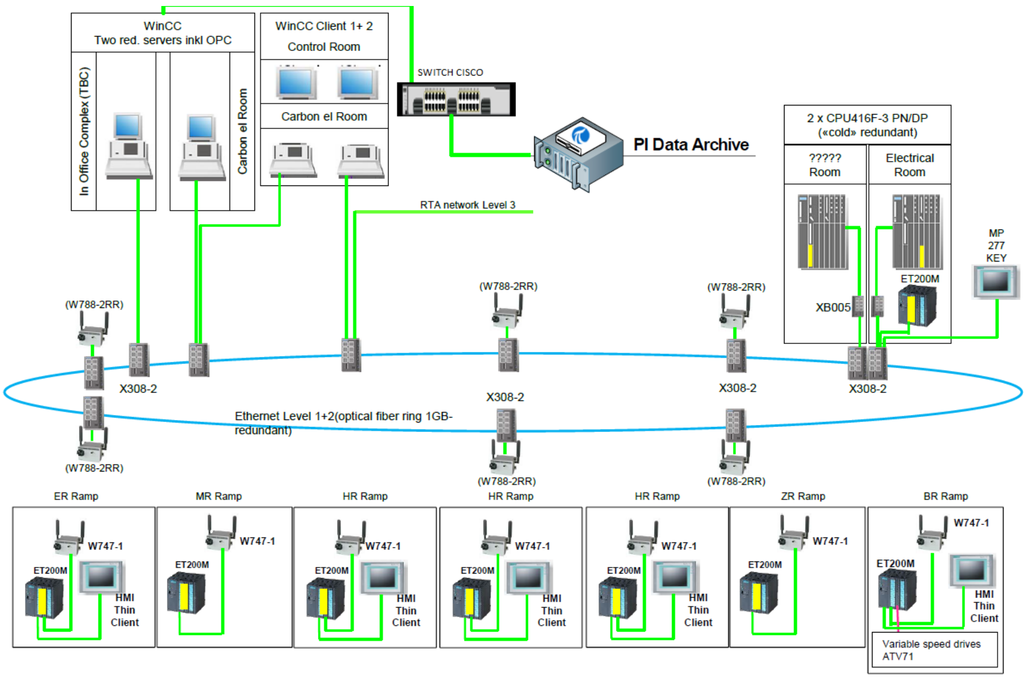

Figure 1. Data flow architecture at ADK.

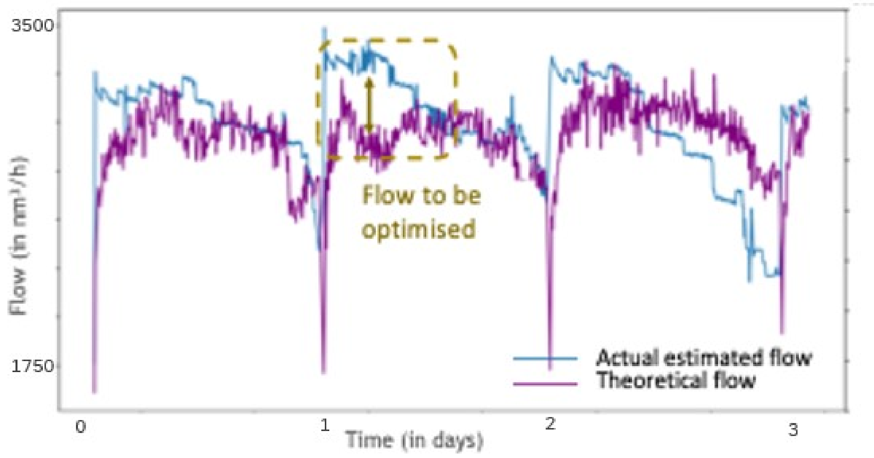

Figure 12. Exhaust flow model – Comparison between actual and theoretical air flow.

5. Conclusion

The use of data-driven techniques for real-time ABF control with such granularity of action is a first and a great challenge. The results obtained in the first two phases of this project look promising, with confirmation of over 5 % reduction in gas consumption while maintaining anode quality.

The combination of data science, OEM expertise and field operations, as well as the project methodology with frequent cross-checks with the operating team and validation of each step by management, are the key factors in the success of this project.

This proves that the use of granular operating data can be exploited with modern data science tools to enable detailed prediction of gas consumption and anode quality. Due to limitation of instrumentation in the preheating zone, we continue to rely on physical and theoretical modeling to characterize optimal flow rates in real time.

Although there are still improvements to be made in predicting the position of the degassing front, the results obtained so far are sufficient to deploy and test the new advanced control strategy and measure the reduction in gas consumption. This will be the next phase of the project.

The deployment of this future control strategy and the results of actual performance will be carried out progressively to build confidence and acceptance of the operation and will provide a decision-support tool on the operation side that will enable practices to be standardized.

Eventually, if pushed to the limit of granularity with actions potentially tailored for each pit and updated at each fire cycle, the existing conventional FCS will have to be upgraded.

6. References

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