AMI Artificial Intelligence Developments for Stainless Steel Production in Aperam Genk

Matthias Schops[1], Bastien Soete[1]
Thierry Koeger[2], Guillermo Fernandez[2], Saul Gonzalez[2]

[1]Aperam Genk
Swinnenwijerweg 5, 3600 Genk, Belgium
E-mail: matthias.schops@aperam.com

[2]AMI Automation
Diaz Ordaz 402, NL, México, 64650
E-mail: thierry.koeger@amiautomation.com

ABSTRACT

The complexity of the stainless-steel production process requires precise control of the electrical and chemical energy input to avoid material or energy losses and deviation from the required bath chemistry. Facing this challenge, an agreement was reached between Aperam Genk and AMI in 2022 to install the SmartFurnace™ EAF optimization system including the DigitARC™ PX3 Electrode Regulator and SmartARC™ for electrical energy optimization, together with the Oxygen Module for chemical energy optimization.

Aperam in Belgium is a fully integrated steelmaker dedicated to the production for high quality stainless-steel grades for the global market. The AC Electric Arc Furnace with 130 tons capacity and 80/96 MVA transformer has also significant chemical energy available for assisting the scrap melting.

The AMI system integrates a wide range of technologies including real-time data analytics, dynamic control based on machine learning algorithms, and predictive control capabilities. Using the available data from the Aperam Genk process, an Artificial Intelligence algorithm takes real time decisions for the control of the electric power input, and the flow of gas and oxygen given the operation goals and requirements of every heat. After the finalization of this project in November 2022, a next stage in this collaboration is the Slag Module development, optimizing the slag practices using the same technological platform.

Details of the installed system are presented in this paper, as well as the reported results.

INTRODUCTION

The 130 ton & 80/96 MVA AC furnace has a diameter of 7200mm with a designed capacity of 700,000 tons per year. For the control of the chemical energy input, it has Three wall Virtual Lance Burners, and their production is focused on Austenitic + Duplex grades.

The implementation of the SmartFurnace system by Aperam Genk was a continuation of the collaboration with the Aperam group which started with the implementation of the AMI technology in Aperam Châtelet, also in Belgium.

CONTROL SYSTEM

The dynamic control of the SmartFurnace concept effectively manages the input of chemical and electrical energy in their Electric Arc Furnace. Its main goal is to adapt and improve the production process based on specific requirements and limitations. With this in mind the DigitARC PX3 Electrode Regulator, the SmartARC Electrical optimization module, and the specialized Chemical Energy Module for their stainless-steel process was implemented. The SmartKnB graphic programming platform, a new proprietary software developed by AMI, played a crucial role in integrating the SmartFurnace system into their existing network infrastructure to acquire the required data. This software offers flexibility in modifying and enhancing the program's functionality, contributing to the development and improvement of dynamic melting profiles for scrap melting.

The architecture of the AMI system, as depicted in Figure 1, showcases a comprehensive arrangement comprising two key hardware components. The first element is the Electrode Regulator cabinet, which communicates with the SmartFurnace server housing the essential optimization modules. After being integrated into the Aperam network, these devices facilitate efficient information exchange with the existing infrastructure, including PLCs and databases allowing the needed data flow.

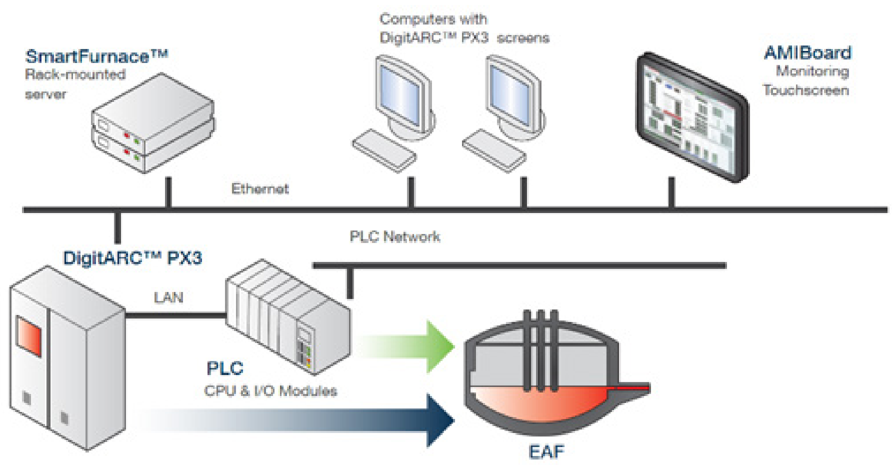

Figure 1. *AMI EAF Optimization Technology.*

1. DigitARC PX3 Electrode Regulator System

The electrode regulation system, implemented on both AC and DC furnaces, incorporates the cutting-edge DigitARC PX3 Electrode Regulator. This advanced system is engineered with a rapid closed-loop control mechanism and the execution of intricate algorithms, leveraging a dedicated CPU for swift data acquisition. A range of optimization tools and process monitoring features are integrated into the system such as arc stability calculation, noise filtering for the control signal output, and high-speed signal acquisition and logging.

To enable logging, diagnostics, and connectivity, an additional processing unit is employed. This dual setup facilitates prompt execution of the control program, ensuring zero delay in transmitting control commands to the proportional valves, providing dedicated input/output (I/O) capabilities for high-speed data logging, essential for both control operations and diagnostics, such as monitoring electrode arm pressure and position. A user-friendly graphic interface enhances user experience and simplifies system interaction.

The instrumentation employed in the Electrode Regulator system includes a Power Quality Meter which enables power distribution diagnostics and measurements of flicker and harmonics. Additionally, precise position sensors are installed to evaluate the behavior of electrode movements, enabling Electrode Tests. Changes observed in the test results over time can indicate variations in the hydraulic system's dynamics or mechanical issues, aiding in timely troubleshooting and maintenance.

2. SmartARC

The operation principle of the SmartFurnace system is the Dynamic Power Profile. In the case of SmartARC, this approach is used to control the electrical energy input in the furnace, ensuring optimal performance under varying steel grades and furnace conditions. The controlled variables include transformer and reactor taps, regulation mode, and current/voltage setpoints. The integration with the electrode regulator enables enhanced responsiveness and adaptability, resulting in more efficient process control. The SmartARC system at Aperam considers other process variables such as Heat MWH, Arc stability, Steel grades, and electrical signals.

Moreover, any available data in the PLC or database regarding raw material characteristics, equipment availability, or the overall process can be monitored to enhance the adaptability of the system. Specific control algorithms are developed to improve safety and efficiency, such as protections for Water Cooled Panels and refractory materials. This is achieved primarily by implementing better arc control to reduce radiation-related damage and continuously adjusting current setpoints.

3. Oxygen Module

The Oxygen module is designed to regulate the burners and oxygen lancing within the furnace. A dynamic program, tailored to the practices specific to the steel grades is implemented, taking into account various heat conditions, particularly the stability of the electric arc with the plans to add more criteria in the future. The Stability Factor, calculated by the DigitARC PX3 Electrode regulator, serves as a direct indicator of the efficiency of electrical energy input. As such, it can be utilized as feedback for a dynamic chemical energy profile. With this calculation, the SmartFurnace system determines the precise timing and flow rate for the burners, and subsequently for the oxygen lancing.

4. Slag Module

The Slag Submodule focuses on determining the recommended fluxes to be added to the furnace to achieve an optimal slag composition and improve the slag formation process. As part of this project a joint development between Aperam and AMI is being carried out using real-time calculations through the logic integrated into the SmartKnB programming platform, making it an open system for continuous improvement. A user-friendly HMI screen shown in Figure 2, is employed to visualize and select the set points, establishing communication between the SmartKnB and PLC.

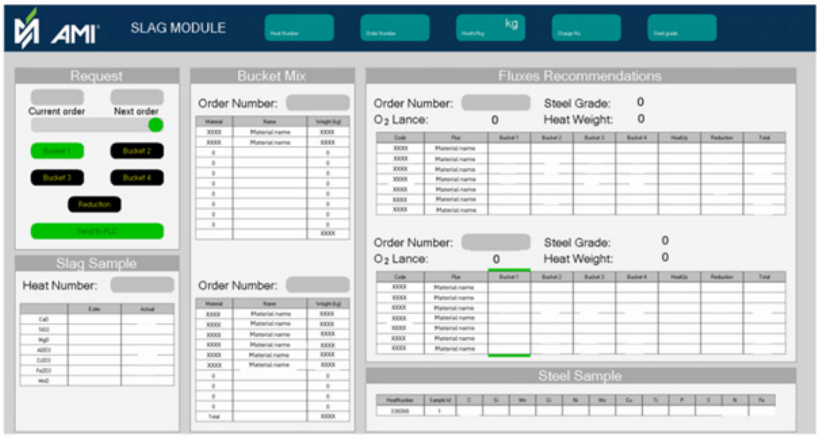

Figure 2. *Slag Module HMI screen.*

By utilizing comprehensive scrap chemistry information, a model capable of adjusting the quantity of fluxes and alloys is developed to attain the desired basicity-saturation and required steel composition, thereby optimizing material consumption. Figure 3 represents the algorithm approach. Main calculations are displayed in blocks, where the arrows directions indicate data input or output. A color code is used to specify model recommendations (green), feedback variables (yellow) and heat targets (red).

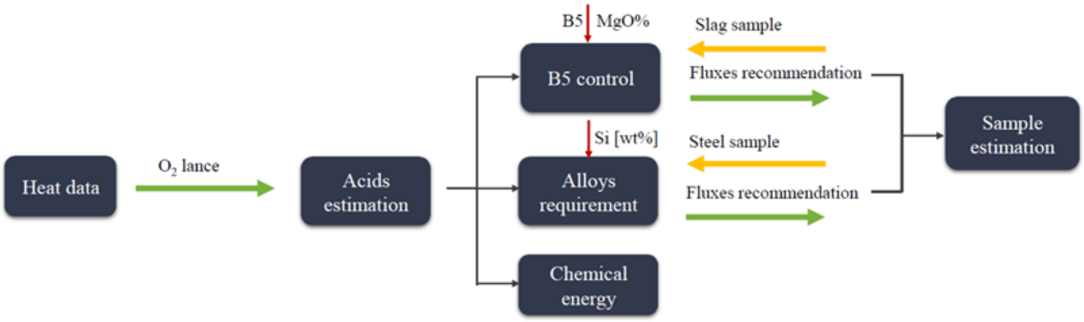

Figure 3. *Slag Module algorithm.*

PROJECT EXECUTION

The project was installed and commissioned in a period of 4 weeks with the involvement of engineers from Aperam and AMI. At a first stage, the DigitARC PX3 Electrode Regulator as well as the SmartFurnace Modules were installed, with the exclusion of the Slag Module for Stainless Steel.

A gradual implementation of the dynamic control started with an emulation of the original profiles and over time implementing the functionality of the SmartFurnace control step by step.

RESULTS

With the implementation of the system, after an operation of 6 Months, the following results were observed:

- 11% decrease in electrode consumption

No affectation in Power On Time was observed. While a decrease in Electrical Energy consumption was expected, the operating conditions of the furnace during the evaluation period did not allow an accurate estimation.

Initial slag module trials heats showed higher consistency in steel chemistry samples. An improvement is expected through the continuous usage of the module. This, additional to the enhancement of functionality by the inclusion of scrap density. By conducting an energy balance analysis of the furnace, in conjunction with price data, the furnace can be optimized in terms of the balance between electrical and chemical energy. Additionally, the tapping temperature can be predicted, allowing for an indication of when the heat is completed.

CONCLUSIONS

The utilization of an open and adaptable system for Electric Arc Furnace optimization brings numerous advantages by adapting the control parameters to specific conditions of the furnace at any given point.

As a second phase of the project, a collaborative framework between Aperam Genk and AMI has been established with services dedicated to continuous improvement.

One of the advantages of the AMI system lies in its open platform, facilitating a transparent understanding of the system's operations and providing access to essential tools for data verification. Additionally, the support provided by AMI experts has helped maintain the performance and offers the opportunity for continuous improvement.

The strong expertise and active involvement of Aperam team and the collaborative environment with the AMI specialists, ensured that the project not only met its objectives but also surpassed expectations.

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