EAF Optimization with AMI SmartFurnace System in KWT Steel

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SYNOPSIS

With a 120 ton EAF, designed originally to run mainly with HBI and DRI, KWT Steel in Kuwait installed the AMI SmartFurnace system in order to add flexibility to an operation requiring significant variability in the charged scrap weight, and at the same time increase the production output.

With the AMI TransformerCare service, an exhaustive study revealed potential risks in the EAF transformer before the installation using a dedicated remote monitoring system. Potential risks were identified and the collected data was used to implement an optimization strategy. Taking into consideration the transformer situation, the required flexibility and the need to increase efficiency and output, the SmartFurnace system by AMI was commissioned in 2015 with a new DigitARC PX3 Electrode Regulator together with the Electrical & Chemical Energy Optimization modules.

The results include a reduction in the Power On time, and the electrical and chemical energy consumptions while avoiding stress in the transformer.

Keywords: EAF Optimization, DRI, HBI, Chemical Energy

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INTRODUCTION

The operation in the Electric Arc Furnace is bound to the changing conditions and requirements of the process. KWT Steel presented this challenge as variations on the proportions of charged material and its characteristics are very common. With the addition of a second casting line, there was a need of increasing the furnace output. Originally, the furnace design considers an operation with mostly HBI and DRI, condition that changed to include up to 80% scrap. On their electrical power equipment, in particular the transformer, there were signs of excessive stress in the period before the installation of the new electrode regulator, which needed to be taken into consideration. Special attention and monitoring of the transformer evolution helped to develop an optimization strategy that allowed increasing the power input without compromising the transformer conditions. The EAF has the following characteristics:

- 6500 mm shell internal diameter
- 120 tons
- 130 MVA Transformer
- 6 burners
- 3 Carbon and 4 Oxygen injection points

The main objective of the optimization task in KWT Steel, was to adapt the furnace response to an increasing amount of scrap. The operation with DRI and HBI which was originally in place requires high levels of hot heel, melting on almost flat bath conditions during most of the heat. The instability that comes with higher levels of scrap, together with events such as scrap Cave Ins, Non Conductive charges and the wide variations in the scrap quality were new situations for this furnace. Additionally, the constraint of the transformer conditions needed to be evaluated, and required changes in the optimization strategy.

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CONTROL SYSTEM DESCRIPTION

The scope of the installation included the DigitARC PX3 Electrode regulator and the SmartFurnace modules for electrical and chemical energy optimization. The architecture of the system implemented in KWT Steel is described in Figure 1.

DigitARC PX3 Electrode Regulator

The Electrode Regulation System provides a fast control through complex algorithms. It consists of two processing units, one for control, and another for logging, diagnostics, and connectivity. This dual setup allows a fast execution of the control program with zero delay on the control commands sent to the proportional valves. It also provides dedicated I/O for high speed data logging used for both control and diagnostics like the electrode arm pressure and electrode position. It also includes a user friendly graphic interface with high resolution logs and advanced diagnostic tools.

One of the most useful performance optimization tools are the electrode tests. With the installation of precise position sensors it is possible to evaluate the behavior of the electrode movements. Differences in the results of the tests overtime may indicate changes in the dynamics of the hydraulic system, or mechanical issues.

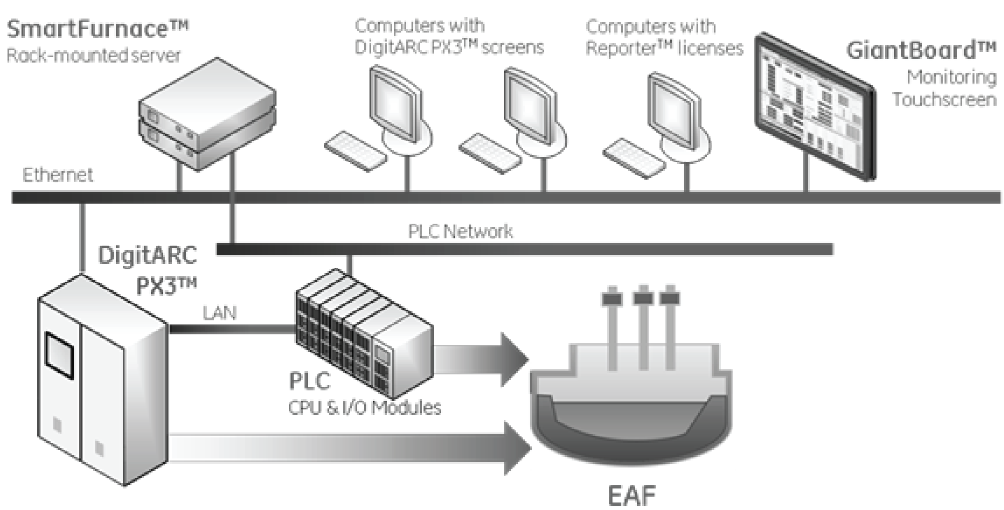

Figure 1. Architecture of the control system

Other available diagnostic and control features are the output filtering, that modifies the control signal in order to decrease arm vibration; the advanced Non Conductive Charge detection that automatically changes its sensitivity according to the electrode weight; and the Preemptive Cave In tool to respond faster to any scrap fall, preventing damage to the electrodes.

SMARTFURNACE MODULES

The concept of a modular system was developed in order to provide a custom made solution for the optimization of a particular EAF. While every module is designed with the capacity to work by itself, their main strength is the possibility to interact with all the modules that are available. This design allows an installation to be made progressively in separate steps. In the case of KWT Steel, the complete set of modules was installed at the same time.

The modules that integrate the system are SmartARC, for optimization of electrical energy; Oxygen Module, for control of burners and lances, decarburization and carbon injection; The Slag Module, which provides recommendations of fluxes to promote the formation of foamy slag; The DRI Module to control the feeding of DRI/HBI; and the Energy Balance Submodule, which is a tool that displays the distribution of the total energy use. A more detailed description of the modules is below.

SmartARC

This module for electrical energy optimization, based on an expert system with a built in graphic development platform, is used to create dynamic power profiles, which adapt the operation parameters such as voltage and current set points and regulation mode, to the current heat conditions. Arc stability is used as one of the heat performance indicators that are taken into consideration to calculate the optimal combination of parameters. The available information and the flexibility of this system allow having several tools for EAF optimization such as:

- Balance Control: For better distribution of the heating energy in the EAF. The distribution of the heat on the interior surface is affected by the hot and cold spots, created by the position of burners, carbon and oxygen injection points, and the falling point of the fed material.
- Water Cooled Panels protection. Taking into consideration the level and rate of change of the cooling water temperature, it is possible to take preventive measures in the power input to avoid any damage.
- Furnace refractory protection. During the last stages of the heat, the slag conditions which are affected by scrap chemistry, fluxes, etc.- are continuously monitored, and the power input is adapted to provide the maximum possible without damaging the bricks.
- Variable arc length. With different scrap compositions and quality, it is necessary to rapidly compensate the electric power input for an optimal melting stage, which helps achieve more stable conditions later in the heat and avoid un-melted scrap to cause late scrap cave ins cooling the steel bath and hurting efficiency.

Oxygen Module

This module is designed to provide a robust control system capable of handling different furnace conditions, scrap mixes, practice changes, etc. The use of the automatic heat performance indicators allow the modules to take decisions during the heat in order to optimize the process, as opposed to follow a simple set of steps as a conventional burner program based on energy levels. This module for chemical energy control is capable to predict the steel bath temperature and the carbon content based on the consumables information in order to arrive with a good carbon content at the end of the heat.

DRI Module

The DRI/HBI control needs to consider two goals. First, to find the best moment to start feeding, and second, to find the optimal speed to keep a constant bath temperature. Too fast feeding might cause accumulation of unmelted DRI in the furnace, and too slow would increase the heat time. The module for DRI control automatically sets this parameters based on the energy consumption and stability of the arc. It also makes automatic corrections when temperature samples are taken.

Among the automatic functions of this module, are several process variations such as energy losses due to delays, and the actual chemical energy input. More specifically, it takes into consideration the details about DRI/HBI quality, to automatically compensate for variations in the raw material.

Slag Module

The optimization of Lime and Dolo Lime control is performed using the actual results of the slag analysis. It recommends the quantity of fluxes that should be added to achieve an optimal saturation of MgO in the slag. This control promotes the foaminess of the slag, which helps to stabilize the arc, and protect the refractory. The module integrates logging capabilities of previous slag data, giving valuable information to define the optimal slag basicity for the furnace. A good control of the slag minimizes the FeO losses, and reduces energy losses required to create slag. The main screen of the modules for slag control is shown in Figure 2.

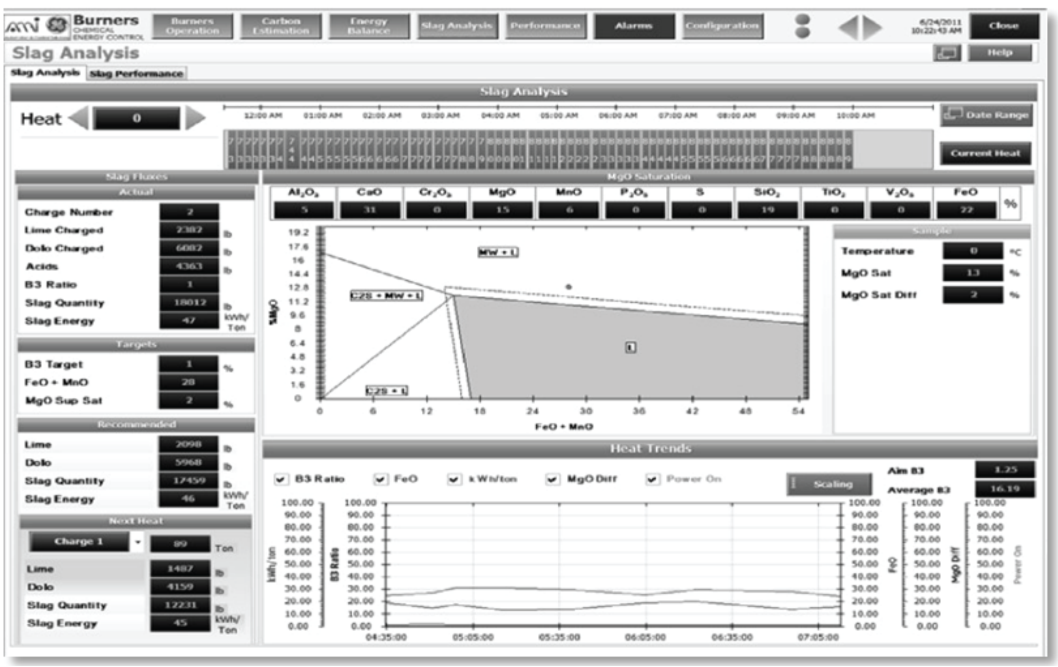

Figure 2. Typical screen of the module for slag control.

TRANSFORMER MONITORING

The TransformerCare service was designed as a remote monitoring tool with a technology that is applicable to all oil cooled power system components. It is based in the analysis of the results of the periodical oil analysis samples taken to all oil filled compartments of substation transformers, furnace transformers, reactors, etc. Periodic analysis allows the identification of any changes on the conditions or trend of life expectancy of any of these components that can relate to internal changes of any electrical power system element or operating conditions, like overloads, transients, single phasing, unbalance, etc. It allows detecting, with some anticipation, any abnormal tendency and preventing unscheduled shutdowns. As part of the system, the VM2 Remote Monitoring collects the electrical parameters from the KWT Steel EAF primary electrical circuit. It also stores some of the key heat data from the PLC network. The Information is then sent to the Web Server where it is stored. This data is accessible by the customer via a secure Internet website, where only designated personnel including the expert team has access to the Information either through a PC or the mobile phone or tablet applications. The distribution of the system is displayed in Figure 3.

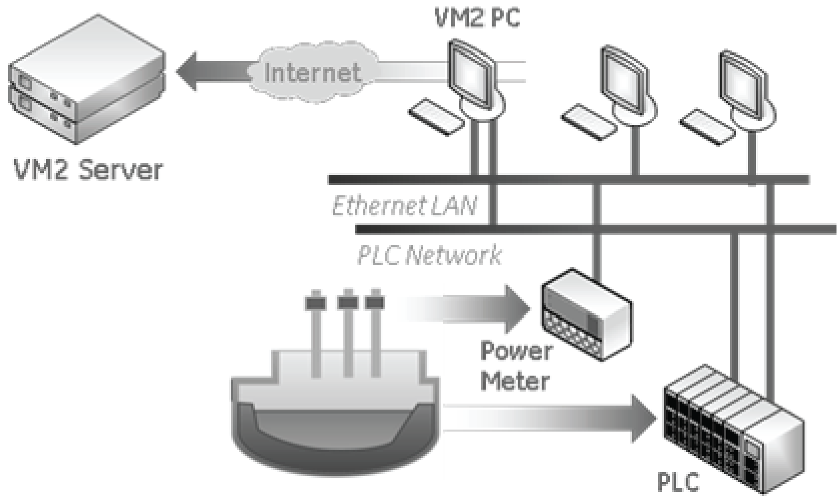

Figure 3. TransformerCare VM2 Remote Monitoring System.

RESULTS

The first step in the implementation of the furnace optimization was the performance evaluation of the transformer. The potential problems of the equipment were identified with the oil samples and the observations of the KWT team. Before the installation of SmartFurnace, the collaboration focused on stabilizing the situation of the transformer in order to reduce the overload. The DigitARC PX3 regulation system together with SmartFurnace were commissioned afterwards, focusing first on increasing stability and improving the transformer conditions, and then to decrease Power On time and energy usage, and increasing productivity.

Using the remote monitoring tool it is possible to follow the evolution of all the variables that reflect the performance of the system. As an example, on Figure 4, it is displayed on one of the graphics, the trending of the Carbon Monoxide ppm from the transformer oil samples. This gas is a major indicator of thermal effects that might compromise the isolations of the transformer. A clear downwards tendency is shown from the end of September, which maintains to this day, indicating less effect on the insulation.

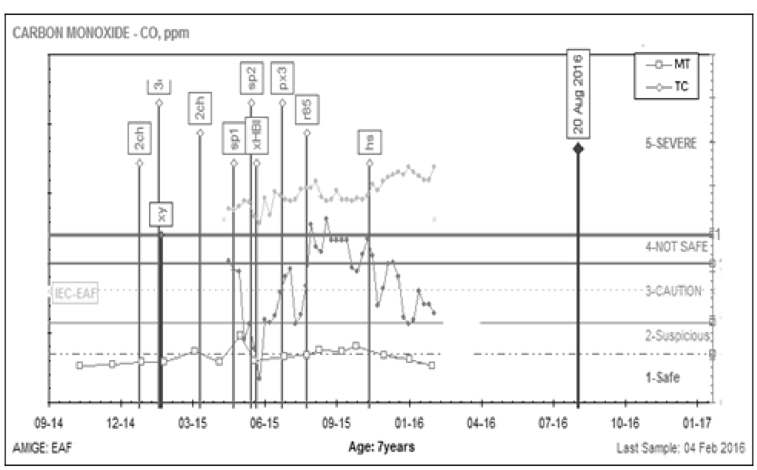

Figure 4. Carbon Monoxide levels (blue) monitoring for over a year

Since the installation period of the system on September 2015 up to March 2016, the main operational results are as follows:

- Power on time: reduced 4%
- Power consumption: reduced 4%
- Flux (Lime + Dololime) : reduced 8%
- Injection carbon : reduced 20%
- Electrode consumption: reduced 5%
- Yield: increased 0.5 %

The implemented optimization tools such as the arc stability monitoring gave significant flexibility in controlling the power input at the different stages of the process, allowing a power input increase at very earlier stages of the heat to the maximum power, or optimizing secondary current closer to maximum permissible current. Also, it was possible to use a higher tap at the start of the melting stage.

ACKNOWLEDGMENTS

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REFERENCES

1) I. VALDEZ, G. FERNANDEZ, J. HICKS, Experiences standardizing optimal operational practices at Nucor Steel Arkansas EAFs, AISTech (2014).