Maintaining Optimal Setpoint Voltage in Smelter Pots Using Digital Technologies and ML Algorithms

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Abstract

The voltage/resistance setpoint (VRsp) of a smelter pot is an important design setpoint at which the pot is meant to ideally operate. The setpoint is a function of the pot design and is an optimized trade-off between pot operating conditions such as instability, bath temperature, metal production, energy consumption, etc. Although a pot is initialized into service at its design setpoint, this value usually changes during pot operation due to daily procedures such as metal tapping, anode change, instability treatment, etc., as well as long-term aging of the pot. Continuously determining and operating at the optimal VRsp for a pot over the course of its life can yield best production and energy benefits in a potline. The population of pots in a potline typically tend to fall into the following categories:

(Type A) Pots operating within a small acceptable band of design V/R setpoint,
(Type B) Pots operating well above design V/R setpoint,
(Type C) Pots operating well below design V/R setpoint.

Pots of Type B are identified using modern data analytics techniques and machine learning (ML) algorithms which are ideal candidates for setpoint reduction and energy saving if they are otherwise good pots in terms of noise, instability, bath temperature and metal production. Such pots are recommended for squeezing into Type A to save on energy consumption without sacrificing their good characteristics. Although the recommended squeezing is by a tiny amount it can provide significant energy savings aggregated over time over a whole potline. Pots of Type B that are squeezed into Type A can over weeks and months drift into Type C operation and become cold, sludgy, noisy and unstable with poor metal production. The same analytics are used to identify such pots as well for un-squeezing by a tiny amount to correct them back into Type A operation and rectify their metal production.

Keywords: Smelter analytics, Data science, Predictive analytics, Voltage setpoint, Industry 4.0.

1. Introduction

Process decisions and optimizations driven by data analytics solutions present a huge opportunity for enhanced business outcome for a wide range of industrial domains. These digital solutions represent the crux of the digital transformation in Industrial Internet of Things (IIoT) and can be profitably applied in the aluminum smelting industry to achieve increased business value. This paper specifically discusses one such solution implementation by General Electric Digital (GED) in collaboration with the Mytilineos Group at their AoG aluminum smelter site in Greece. We first provide an overview of the scope of such digital solutions and their application to exploit the wealth of operational data at a smelter plant to achieve both bottom-line (energy and material cost savings) and top-line benefits (increased metal production). We describe these solutions briefly and indicate how they are enabled and delivered to a smelter plant using cognitive and cloud computing technologies.

2. Digital Solutions and Smelter Analytics

2.1 Aluminum Smelter Opportunity

An Aluminum Smelter plant represents a large and complex industrial ecosystem. In addition to the core metal production process in the electrolytic cells of the potlines, there are important operational adjacencies upstream and downstream such as the alumina refinery, the carbon plant, the metal cast house, the gas treatment centers, power rectification and transmission, etc. In some cases, the plant derives its energy from a captive or dedicated power plant that requires a large power-generation and grid infrastructure also to be in place.

The above ecosystem can derive benefits from data analytics based digital solutions both for the physical assets (reduced equipment downtime, predictive maintenance strategies, etc.) as well as for the process (energy and material cost savings, increased production). In this paper we discuss only process targeted digital solutions for the process heart of a smelter plant, namely the electrolytic potline where the most energy consumption takes place.

Digital solutions for the potline aim to maintain as close as possible to ideal equilibrium conditions in the potline with stable voltage operation and minimal noise and instability. Such solutions combine metallurgical principles with machine-learning algorithms that exploit historical plant data to identify patterns and behaviors unique to the potline to provide advisories and alerts for optimal potline operation. In this manner they provide long-term data based holistic “wisdom” on the pots, which perfectly complements the installed potline control system that dictates real-time operational settings over a shorter-term time horizon.

Furthermore, the nature of digital solutions is such that they are most effective when deployed in close partnership with the smelter plant thereby creating a fundamental cultural change in the plant workforce to align with and adapt to modern Industry 4.0 operations and practices. In the AoG plant in Greece which already has a strong data driven culture, these digital solutions have further empowered the plant operators and given them the confidence to look to these solutions daily to help them prioritize their tasks and get the best outcomes.

2.2 Plant Data and Solution Philosophy

The potline in a smelter plant generates vast amounts of data. The data comes from various sources at varying frequencies and is stored in various forms. For instance, we can have everything ranging from fundamental sensor-based voltage and resistance data measured and recorded at a per-second level, to per-minute instability data, to per-hour dosing data, to per-shift temperature data, to per-day tapping data, to per 2-3-day bath chemistry data (as examples). In addition, we have event data that record say anode effects, anode changes, beam movement, pot leaks/stoppages, etc. Some of this data exists in electronic form while others are in manual logs. A well digitalized plant like AoG has all its historical data digitized and aggregated in an organized fashion, and ideally stored electronically on servers in an easily accessible manner going back in time as far as possible.

All the above potline data represents a treasure trove of wisdom at the disposal of the plant. Typically, a plant consists of multiple potlines with a total of hundreds of pots which represent assets which are nearly identical in make-up/build, even though each pot in fact has its own unique character. However, the data they generate is too vast and complex to be humanly assimilated and implemented actions after the recommendation and the minimum modification of the pot's base resistance (-0.1 μΩ for type B and +0.1 μΩ for type C pots). These constraints will be fine-tuned in future trials and better results are expected.

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6. References

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