# Advanced Process Control with Smart Smelter Sensors at EGA

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**Abstract**

EGA's Midstream vision was to start operating the smelter in a more predictive than reactive mode. This was supported by financial analysis of potential gains of advanced process control with big data and Industry 4.0. In the first step, EGA successfully built a prediction model for anode spikes detection in 2020, using pot-measured data. Anode spikes are a critical anode problem in the smelters, which significantly decreases current efficiency and associated business benefits. It has always been a challenge to timely identify the spikes with manual checks as they have many causes, and delayed action rapidly increases pot performance. Big and reliable data is fundamental for artificial intelligence and machine learning (AI/ML) models. Thus, high frequency (minutes) pot control data have been the base for the spike prediction model. EGA has successfully developed the spike detection model for each pot technology and has been using the model since 2021. The models have brought the spike detection time from 2-3 days to less than a shift using bath temperature prediction as a soft sensor. The model includes more than 30 base parameters summarised each hour. Several iterative versions of the model were developed to reach the desired accuracy and continuous use of the model. The model has a user-friendly dashboard displayed in the control room of every potline. In addition, an audio announcement and SMS to the relevant operator are also used to communicate the prediction and ensure rapid spike removal. The spike detection tool has proven that AI/ML is the way to unleash the smelter's hidden opportunities. Other prediction models are being developed to enhance smelter performance as part of EGA's journey to Industry 4.0. The focus is on enriching the data and ensuring advanced usage of big data for prediction and prescription systems.

**Keywords:** Industry 4.0 in EGA smelters, Big Data, Machine learning, time series, data science, soft sensor, Spike prediction model, Bath temperature

## 1. Introduction

EGA is the world's biggest ‘premium aluminium’ producer with business from mining and refinery to smelting and casting. EGA produces around 2.5 million tonnes of hot metal annually from its two production sites, Jebel Ali and Al Taweelah. Potlines in both production sites comprise seven technologies (D18+, CD20, D20, D20+, DX, DX+ and DX ultra) with 2843 pots. This paper presents EGA's journey to develop soft sensors to solve pressing operational issues like anode spike detection [1].

At EGA, all technologies have increased amperage to much higher than originally designed for, resulting in smaller anode-cathode distance which makes the pot operation susceptible to anode problems. Historical data indicate that anode spikes are the highest contributor to anode problems in EGA potlines [Figure 1b] for various reasons, one of which is high anode current density. Additionally, once the spike starts, it becomes a chain reaction which burdens the potline operation for removal of the spiked anode and increases anode consumption.

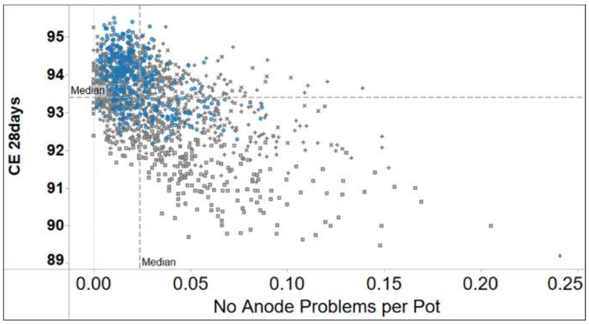


**Figure 1a. Impact of anode spike on Current Efficiency [2].**

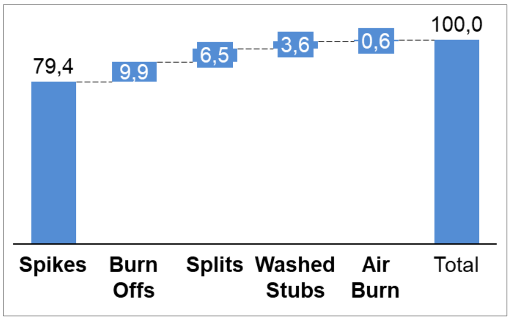


**Figure 1b. Anode Problems 2019.**

As illustrated in Figure 1 c, the loss of current efficiency is directly proportional to the time the spike spent in the pot. This shows the importance of identifying the abnormal condition earliest to minimise the current efficiency loss. This observation was further studied at EGA and it was found out that anode spikes affect alumina feeding in pots before spike removal. Change in Alumina dumps from baseline (Loss of current efficiency) is directly proportional to the time the spike spent in the pot. Early spike detection minimizes the current efficiency loss

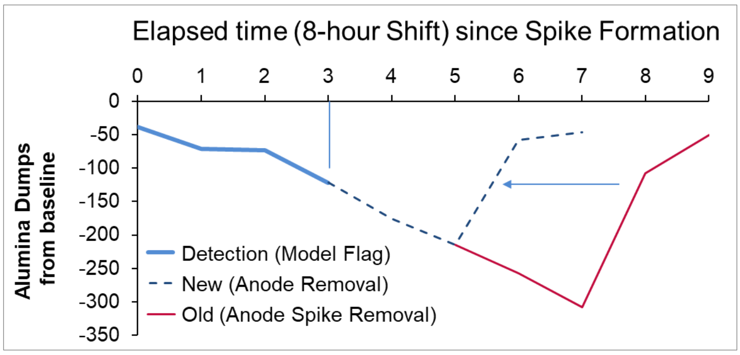


**Figure 1c. Impact of early detection anode spike on alumina feed (proxy CE).**

EGA has tested various traditional approaches to find spikes, such as high bath temperature and low alumina dumps, but these are delayed responses and depend on rigorous manual checks. Therefore, in 2020, EGA technical division decided to experiment with upcoming technologies of artificial intelligence/machine learning (AI/ML) and develop an innovative solution for spike detection. Furthermore, with the significant growth of data science and big data technologies, it has been possible to build advanced detection/prediction systems for proactive actions based on the data.

Although spike detection sounded like a value-adding business case that could be solved with AI/ML, another critical aspect for success is the availability of reliable data since it is the foundation of any successful data science project. Unfortunately, in potlines, data is available at the frequency of seconds and minutes and only kept for a few weeks for investigation in some potlines. Therefore, first, the parameters in Pot Control Systems were proactively stored for 12 new learnings, strictly driven by time. Ultimately, the much rewarding success boosted the confidence to progress with other AI/ML uses in the company. To sum up, below are the key takeaways from this prestigious project.

- EGA has well demonstrated the use of Big Data/ AI/ ML with limited hard sensors and its scalability different technologies at EGA.
- The end goal should be always clear with defined business impact and aimed at actionable predictions.
- Data science must be coupled with in-depth process expertise to tailor the use to the desired outcome.

EGA has set a path to develop other soft sensors based on the successful development of bath temperature prediction and anode spike detection model. In addition, other initiatives are being developed and tested, using AI/ML approach:

- Excess $AlF_3$ soft sensor, shifting the excess AlF3 updating from 8 days (measurement) to one hour (soft sensor)
- Pot failure prediction model to predict end burst/side burst failures.

**Acknowledgement**

The team would like to acknowledge the encouragement, endorsement and trust of EGA leadership and the collaboration of all the smelter, IT, Finance, Procurement, Legal, transformation teams and and external vendors (C2V, Musigma, Siemens) with whom we partnered in this journey. Our special thanks to the IT team – Solaimalai, Mamatha Reddy Shyamala, Rama Mohan, Mohamed Shafi, Muhammad Sajith for their tireless support in execution. Without such support from multiple stakeholders, these fantastic results would not have been possible.

## 8. References

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