Advanced Data Analytics Tools to Identify the Root Cause of Filter Clogging During Casthouse Operation

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Abstract

During DC casting of aluminium, some products require filtration to remove impurities and inclusions from the liquid metal before solidification. Various technologies exist for this filtration, ensuring adequate cleanliness of the metal. The advanced compact filter (ACF) is an online filtration system using porous ceramic filter tiles, directly installed upstream of the casting unit. This system is widely used in the industry, offering numerous advantages such as its high and consistent filtration efficiency. However, the filter priming quality is critical. In some cases, the filter could clog prematurely and reduce the flow of liquid metal that could result in aborting the cast. The casthouse that produces rolling ingots using the ACF filtration technology experienced a significant increase in clogging frequency during a given period. A comprehensive data analysis approach was conducted to diagnose and identify the main factors associated with this phenomenon. The objective was to identify the root cause and implement corrective actions and resume the initial casting performance.

To achieve this objective, advanced data science tools were successfully applied. A systematic and methodical approach was used to analyze several inputs. Each step of the process was scrutinized in detail, including batch preparation, liquid metal chemistry and various process parameters. Several key process indicators were defined and calculated. Different data science tools were selected and applied, including Seeq® Dataiku™, and Minitab® The analyses provided a better understanding of the fundamental causes and mechanisms of clogging. Furthermore, it was possible to identify a specific change in the operational practice that played a crucial role in increasing clogging frequency. This better understanding of clogging phenomena, using powerful data science tools and data-driven decisions, leads to more targeted corrective actions. It is worth mentioning that the data valorisation represents the first step that makes possible the use of these analytic tools. This article will present the integration of available analytic tools combined with a deep understanding of the process parameters as key elements to solving complex operational challenges by fully leveraging valuable data assets.

Keywords: DC Casting, Filter clogging, Root cause, Data driven decision, Advanced data science tools.

1. Introduction

Various configurations exist for the semi-continuous DC casting process of rolling ingots. Basically, these include batching furnaces, in-line metal treatment units and a casting pit. All these elements must function adequately to ensure both the quality of the final product and the productivity of the casthouse. One of the critical elements in the production line is the filtration unit. This equipment is required on certain products to remove impurities and inclusions. The proper functioning of the filtration unit is crucial for the overall productivity and cast ingots quality. In some cases, the filter could clog prematurely and the casting must be immediately stopped. Several factors might influence the quality of filtration including thermo-physical parameters of the metal, type of alloys, the initial metal cleanliness and some thermal aspects. Consequently, all these governing factors must be compliant to ensure a good cast start and to maintain a high-quality filtration.

Figure 1 shows a typical diagram of a casting centre. The filtration unit, located upstream of the casting table, is a critical element to ensure the quality of the metal, and its proper functioning is required for a successful casting. At the site of interest, the filtration system used was an advanced compact filter (ACF). This type of filter, widely used in the industry, is explained in detail by Breton [1]. The filter priming upon cast start-up is a critical step particularly sensitive to clogging.

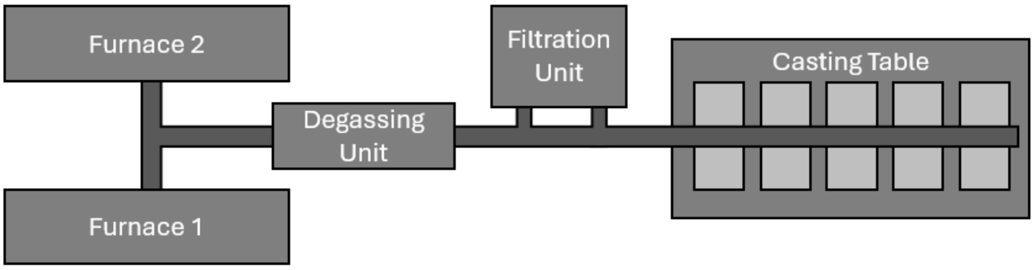

Figure 1. Diagram of a casting center, showing the furnaces, in-line metal treatment, and the casting pit.

For some reason, the site has experienced a significant increase in clogging frequency, resulting in premature casting abort. Two types of clogging were observed: at the start (casting length < 500 mm) and during steady state (casting length > 500 mm). Figure 2 shows the monthly clogging frequency for the site. A significant increase in clogging frequency was observed starting from the fifteenth month, rising from nearly 0 % to 0.49 %.

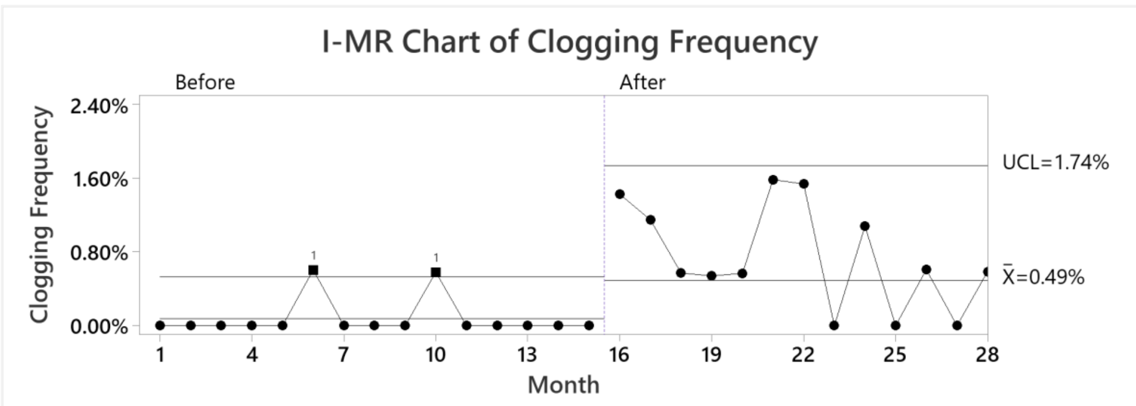

Figure 2. ACF monthly clogging frequency.

The objective of this study was to identify a correlation between process inputs and the head loss/clogging of the ACF through data analysis. We were aiming to gain a better understanding of the root causes to implement effective data-driven solutions.

To conduct the analysis, a brainstorming session was first held to identify the process inputs that could potentially impact ACF clogging. Next, the data from the past two years for these inputs were collected. An initial data preparation step was required to clean and transform the data. In

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6. References

1. Francis Breton, Peter Waite and Patrice Robichaud, Advanced compact filtration (ACF): An efficient and flexible filtration process, *Light Metals,* 2013*,* 967–972.
2. Sheldon M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, 5th Edition, Elsevier, 2014, 670 pages.
3. Janice Abel, Advanced analytics, machine learning, and situational awareness for manufacturing data, *Blog*, https://www.arcweb.com/blog/advanced-analytics-machine-learning-situational-awareness-manufacturing-data (Accessed on 23 April 2024).
4. Anne Kvithyld et al., Aluminium filtration by bonded particle filters, *Light Metals,* 2019, 1081–1088.
5. Lucas Nana Wiredu Damoah and Lifeng Zhang, Removal of inclusions from aluminum through filtration, *Metallurgical and Materials Transactions B,* Volume 41, Issue 4, August 2010, 886–907.
6. D. Corleen Chesonis, A Holistic Approach to Molten Metal Cleanliness, *Light Metals,* 2017, 1411–1417.
7. Merton C. Flemings, *Solidification Processing*, McGraw-Hill, 1974, 364 pages.
8. Jiawei Yang et al., The Influences of Grain Refiner, Inclusion Level, and Filter Grade on the Filtration Performance of Aluminum Melt, *Metallurgical and Materials Transactions B,* Volume 52, Issue 6, December 2021, 3946–3960.
9. M.P. Silva and D.E.J. Talbot., Oxidation of limited aluminium-magnesium alloys, *Light Metals*, 1989, 1035–1040.
10. Francis Breton et al., Rotary Flux Injector (RFI): Recent development towards an autonomous technology, *Light Metals,* 2015, 901–904.
11. G. Béland et al., Rotary flux injection: Chlorine-free technique for furnace preparation, *Light Metals*, 1998, 843–847.