Real-Time Crucible Chemical Composition (LP-LIBS) Analysis Implementation at a Casthouse

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Abstract

Implementation of real-time chemical composition analysis of crucibles at a primary aluminum casthouse using liquid-phase laser induced breakdown spectroscopy (LP-LIBS™) will be reported. The company DTE has developed first in-industry analyzers that analyze the chemical composition of the molten aluminum at every process point. DTE offers both portable analyzers for reduction cell monitoring in primary production and in-situ analyzers for casthouse operations including crucible, furnace, and launder monitoring. DTE's first fully automatic analyzer was installed at one of Nordural's crucible skimming stations in 2017. At Nordural, samples are taken from all crucibles entering the casthouse for process and quality control. Samples are also taken frequently from furnaces and launders. Conventionally, samples would be collected and processed by an operator, with the inherent risk of error, and then taken to a laboratory to analyze the chemical composition, using spark optical emission spectroscopy (OES) [1]. Conversely, DTE's analyzer is fully automated and eliminates the need for any operator involvement. A robot at the skimming station feeds liquid aluminum directly from the crucible to the analyzer, which chemically analyzes the sample and delivers the results in real-time through DTE's online platform. This measurement process takes less than 60 seconds. With DTE's analyzer, Nordural's process control obtains real-time chemical composition results from each crucible, which is vital for furnace control, e.g. preventing high-iron crucible usage in low iron alloys and therefore avoiding furnace being out of specifications. This avoids furnace process delays, including measures to dilute the furnace content to bring the batch to within specifications. With DTE's solution, the time it takes to obtain the chemical analysis result from a single crucible was reduced by 79 %. By reducing the sampling time, and therefore bringing hotter metal to the furnaces, the energy consumption in the furnaces should subsequently be significantly reduced.

DTE constructed a simulation model of the production flow in Nordural's casthouse. Simulation provides insights into complicated system dynamics that cannot be obtained with other techniques [2]. Six different hypotheses were tested, each simulating different scenarios of implementing DTE's solution, with real-time analyzers replacing the manual sampling. It was found that by implementing one DTE's analyzer at a single skimming station (Figure 1), the average duration of crucibles in the casthouse was reduced by 8.4 %, and the total time required by operators to handle solid samples was reduced by 78 % [1]. Another hypothesis tested the installation of DTE's solution for all crucible skimming stations, furnaces, and launders. That resulted in eliminating the need for manual sampling altogether, as well as reducing crucible cycle time by 37 % with the process running more smoothly, and avoiding four hours of process delays due to sampling. By avoiding this process delay, the casthouse throughput could be increased. Shortening the cycle time increases crucible utilization and allows for having fewer

crucible vehicles and drivers in operation. Eliminating the manual sampling also greatly improved operator safety with reduced exposure to hot metal and vehicle traffic. Furthermore, Nordural employees reported that with real-time analysis in furnaces and launders, they could immediately respond if a batch is heading out of specification. This would limit the amount of aluminum needed to be remelted, reducing energy demand and avoiding process delays.

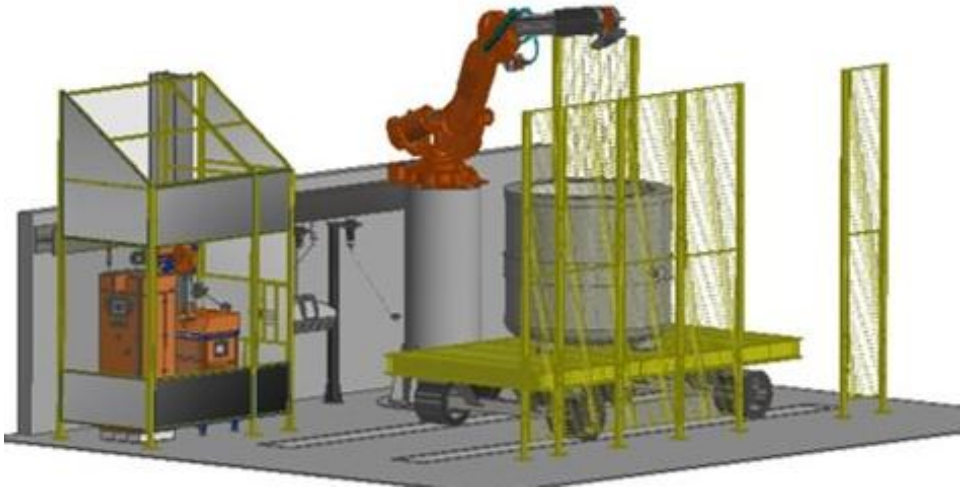

Figure 1. DTE's analyzer next to the skimming station.

An additional advantage of DTE's liquid-metal analyzers is that even when operating in harsh conditions on the plant floor, the requirement for standardization is much less than for OES devices. DTE's devices have run for months without standardization, showing no drift of analysis results. Figure 2 shows results of Fe concentration measurements from the crucible analyzer at Nordural, compared with laboratory analysis using OES of metal from the same crucible, over a 300-day period. During this period, the calibration of DTE's analyzer was not modified. Over the full period, the average deviation was below 20 ppm and the standard deviation was 64 ppm, as indicated with solid and dashed red lines, respectively, in Figure 2.

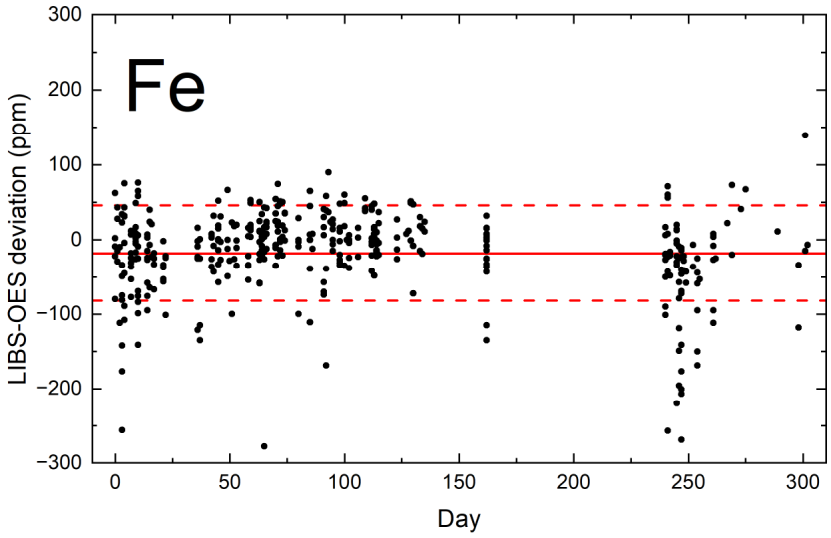

Figure 2. Comparison DTE versus OES; difference in concentration measurements.

In 2022, Nordural signed a contract with DTE to supply real-time analysis on four fully-automatic crucible treatment stations at Nordural's new billet casthouse. Nordural reported that this decision was driven by the performance of the current device in their operation, choosing DTE as a strategic partner and slowly implementing the solution throughout the production process [3]. The instant chemical composition of liquid aluminum and DTE's intelligence platform for decision support enables faster decisions, optimized process control, increased operator safety, and increased throughput.

Keywords: LIBS, Chemical composition analysis of liquid aluminum, Casthouse process control, Casthouse digital transformation.

References

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