Achieving a new level of process efficiency in EAF steelmaking with sample preparation free slag analysis based on Laser OES

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INTRODUCTION

Resource as well as energy efficiency is one of the most important factors for economical success in today's highly competitive steel making industry. To reach a maximum energy efficiency an effective raw material procurement, motivated employees, modern equipment and last but not least the optimized process control is the key to success. In order to monitor the steelmaking process, a variety of measures and sensors have been introduced in the past. However, the composition of the slag, which is much more important for process control than the analysis of the actual steel itself, could not be analyzed quickly enough to correct the process within the required time. Especially in the electric furnace, important information like the basicity or content of elements like Cr, S and F is missing.

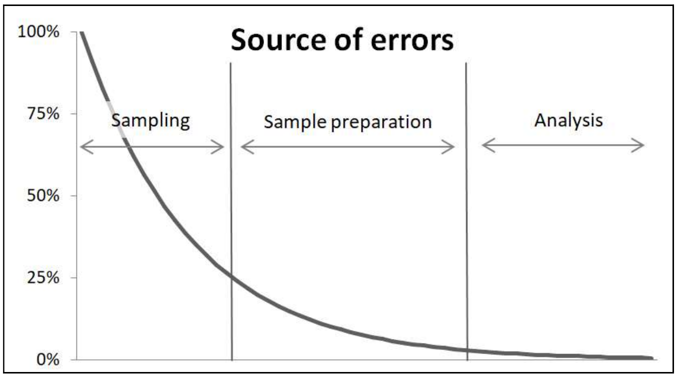

Fig. 1 Impact of single errors to the representativeness of the analysis results

FIRST SECTION

In the event of a deviation, a defective basicity leads to significantly higher energy consumption due to inadequate foaming behavior of the slag and thus to a lack of insulation resulting in high energy losses. Furthermore, it can cause a high consumption of refractory material and thus, lower equipment lifetime on the one hand and lower product quality e.g. due to impurities on the other hand. Especially since EAF steel making is undergoing a significant change within the context of the decarbonization of the steel industry, this is an important point. Among other things, the use of Direct Reduced Iron (DRI) will lead to extended phases of foaming slag, which in turn will increase the negative effect of the delay of slag analysis.

Moreover, the long analysis times of the slags are caused by their heterogeneity. Therefore, they have been analyzed with X-ray-based methods with prior sample homogenization for more than 50 years. The common approach to homogenize heterogeneous materials, samples were crushed, grinded, demetallized and pressed or re-melted. This took 6-30 minutes on average depending on the degree of automation and it was therefore costly due to the amount of equipment required. In addition, each sample preparation also leads to a sample preparation error. This additionally compromises the representativeness of the result and thus the usability.

Due to that complexity steel making slags have been analyzed mostly in central laboratories somewhere on the steel mill site rather than near the furnace. In contrast to that, steel samples for example are increasingly analyzed in the control room close to the melt shop. Thus, in addition to the analysis time, time must be calculated in for cooling, packing and shipping the sample, usually by pneumatic tube.

Only a few steel mills can wait that long for LF and EAF slag analysis results. Therefore, in most of the cases the steel further treated and transferred to the following treatment stages without having the slag composition on hand. The results of the analysis can then only be used for post-mortem evaluation and, if necessary, for adjusting subsequent melts. Thus, further optimization of the process control is very limited.

2ND SECTION

Laser-based optical emission spectroscopy (laser OES) is becoming increasingly established as an alternative to existing analysis approaches. It works equivalent to spark spectrometry but with the essential difference that the plasma is not ignited by an electric spark but by a laser. The energy pulse created by the laser transforms minimal amounts of the sample material into a plasma, which emits a light during degeneration which is specific to the elemental composition of the sample at that point.

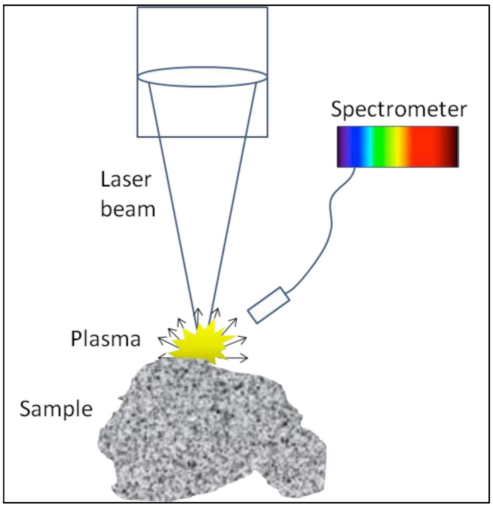

Fig. 2 Laser OES principle on heterogeneous sample

The light is then detected by a spectrometer and converted into a digital signal. Since the laser OES is capable of generating thousands of measurements in a few seconds, the tremendous amount of data can be evaluated on the basis of an appropriate calibration. In addition to its speed, the laser as a plasma excitation source is also particularly stable and hence far more durable than the available radiation sources for X-ray-based analysis. Furthermore, the non-contact measurement minimizes negative effects on the measurement such as dust and dirt contamination or high temperatures.

RESULTS

In this way, it is possible to analyze the heterogeneous slag at many thousands of individual points and to digitally homogenize these measured values to one stable analysis result.

Physical homogenization of the sample is no longer necessary. This is not only efficient but also smart in regards to Industry 4.0. Thus, an overall measurement time of less than 2 minutes is achieved, which enables direct and precise process adaption in the EAF.

Another advantage of Laser OES is that light elements or halogens such as fluorine can also be analyzed. Thus, the CaF content can be adjusted more precisely, which is due to more and more strict environmental requirements relevant. Thereby slag can reliably sold as a byproduct instead of costly disposals in land filling

CONCLUSION AND OUTLOOK

Summarizing, steel mills do have the opportunity now to use their resources even more efficiently. They can produce higher quality, increase the operating life of their equipment and minimize the disposal costs of slag. All this can be achieved without significant changes to the production facilities, simply by adapting the analysis strategy and to adjust their melt shop process control. In line with the motto "those who know a lot can optimize a lot", savings of over €1 per ton of steel produced can be achieved. With production volumes of over 1 million t / year, savings in the mid seven-digit € range can be targeted in this way. This increase in efficiency is an important factor for the competitiveness of steel mills worldwide.