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Inline intermix detection by laser spectroscopy, increasing the metallurgical output in continuous casting strands

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Continuous casting has long been the most efficient method for converting liquid steel into solid semi-finished products for hot rolling. While over 90% of steel becomes high-quality slabs or bars, some are inevitably downgraded or scrapped during sequence starts, ends, or transition zones because of alloy changes within a casting sequence. Traditionally, the transition zone length is estimated based on online models and operator experience, often conservatively resulting in large buffer zones, which are either scrapped or downgraded. Laser-Induced Breakdown Spectroscopy (LIBS) enables real-time chemical analysis of steel strands, allowing precise identification of the position of transition zones and eventually minimizing downgrading or scraping.

KEYWORDS: LIBS; INLINE ANALYSIS IN CASTING STRAND; TRANSITION ZONE DETECTION; HOT SLAB AND BLOOM ANALYSIS; FIBERLIBS CONTINUOUS CAST; QUALITY ASSURANCE IN STEEL MAKING;

INTRODUCTION

As steel markets shift toward more diverse grades and smaller production lots, continuous casting operations face increased stoppages or grade transitions during casting sequences. This creates a transition zone where steel properties change, requiring either downgrading or removal to maintain product quality, which reduces yield and profitability. Traditionally, this zone is estimated to use online models based on casting parameters and alloy compositions. Currently, validating these models is only possible by cutting slabs in slices and analyzing the chemical composition of these slices.

Unfortunately, this validation method requires very high efforts and is destructive. Further, it is only possible post-mortem. Due to this missing validation in practical processes users tend to add large buffer zones to the result of online models, often causing more material loss than necessary [3, 4]. Laser-Induced Breakdown Spectroscopy (LIBS) enables real-time tracking of alloy and trace element concentrations, allowing accurate detection of transition zone boundaries [1, 2]. This minimizes waste and enhances both productivity and resource efficiency.

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PRINCIPLE OF LIBS-METHOD

Laser-Induced breakdown spectroscopy (LIBS) is performed by focusing a laser beam on a sample. A small part of the material is ablated and transformed into plasma. The breakdown of the plasma emits element-specific light, which can be detected relative to the wavelength with a spectrometer. The acquired spectrum is analyzed with computational methods, determining which elements are present by comparing the wavelength of spectral peaks with databases. Furthermore, the intensity (height) of each peak can be linked to the concentration of said elements by calibrating a LIBS-device with reference material with known chemical compositions [1, 2].

INDUSTRIAL IMPLEMENTATION OF LIBS

Recently, Secopta implemented the first reference system on an industrial scale. A development from several, already industrial proven applications and hardware configurations. So far transition zones between different steel grades have been measured successfully, showing precise stop and end position of the transition zone. These measured results can be directly transferred into the production control system of the user to automatically control the cut-position of flame cutters.

For the practical application the LIBS-sensor was mounted directly over the continuous cast strand in the horizontal part after the secondary cooling zone. In this way continuous measurements of the chemical composition of the strand are possible. Additionally, the hardware was protected by heatshields and a refractory lance (see picture figure 1).

Further the sensor was equipped with a pre-ablation laser to clean the surface from growing scale or other disturbances before measuring the chemical composition by the LIBS-sensor.

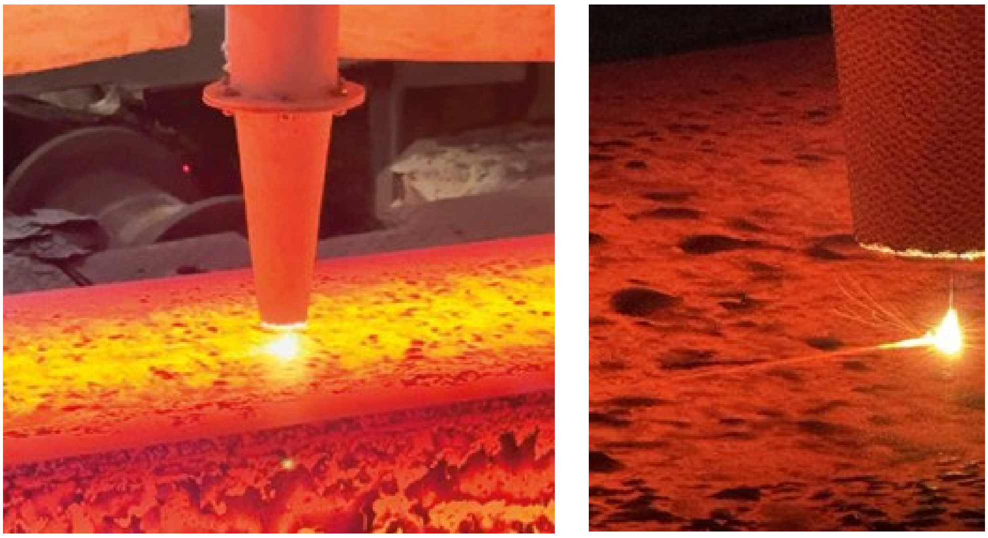

Fig.1 - Refractory Lance over the hot strand and LIBS-plasma in detail (right side).

EVALUATION OF RESULTS

The system was tested at the industrial reference with several different steel grades and alloy-changes during sequences. As in an industrial process, grades cast sequentially on top of each other will always be as close to each other as possible, grades with close chemical compositions were picked. The variations were in the range of e.g. 0.2%Mo to 0%Mo and 1%Cr and 0%Cr (see the example in figure 2). When measuring the chemical composition over the length of the strand it was found that the composition of each element changes in the shape of an S-curve over the length of the strand.

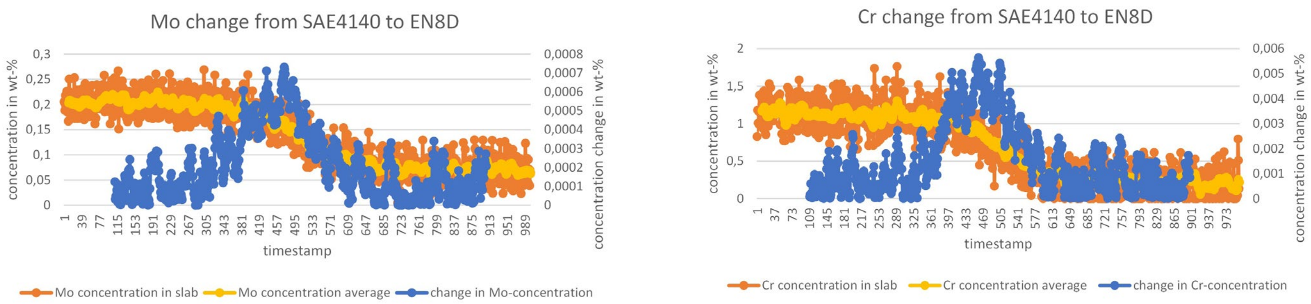

Fig.2 - The alloy change between a SAE4140 (42CrMo4) and an EN8D (C45) was measured, showing clearly the transition of Cr and Mo.

By calculating the change between each data point for each element a characteristic peak is formed, representing the derivative of the S-curve. This peak marks the beginning and the end of the transition zone for the respected element. By measuring Si, Mn, Al, Cr, Mo, Ti and V simultaneously, this peak is shown for several elements. Eventually all peaks will be normalized with respect to the mean concentration and added up (see figure 3).

By several statistical rules the beginning and the end of the transition zone can be derived from the added-up peak (see the dashed lines in figure 3). Eventually, the measured beginning and end positions of the transition zone were offset by the customer to account for the different position of the liquid phase tip by online simulations.

By several trials it was found that the length of the measured transition zones were around 4-5 meters depending on casting parameters and alloy compositions.

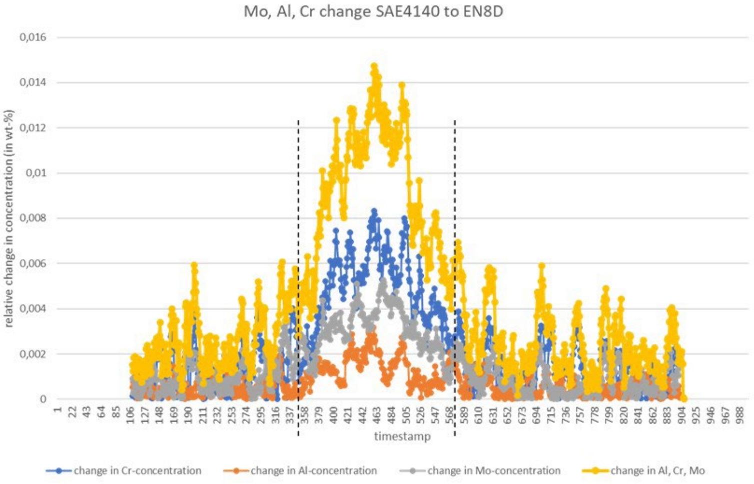

Fig.3 - Single peaks and added-up peak (yellow) for the elements Cr, Al and Mo for the transition of SAE4140 to EN8D.

CONCLUSION

In conventional process, to avoid intermixes, large safety zones with lengths of 8m (calculated by different models) are being cut as transition zones. Inline measurements with LIBS show significant potential to accurately detect the transition zones, realistically estimated to last between 4 to 5 meters long. With three sequential castings per day and a cross-section of 530 x 390 mm2 this decrease of about 3 meters per alloy change led to an increase of 3.600 to of steel production per year in one strand. Previously this material was wasted and had to be scrapped or sometimes sold with a lower market value.

Therefore, the online detection of the intermixed zone during the alloy change poses a clear possibility to reduce waste and cut costs and CO_2 emissions effectively.

In the next steps methods for defining the beginning and end of the transition zone by the LIBS measurement need to be refined to further improve the accuracy of the detection.

REFERENCES

[1] A. W. Miziolek, V. Palleschi and I. Schechter, "Laser Induced Breakdown Spectroscopy: Funda-mentals and Applications" Cambridge University press, 1st Edition, 2006, DOI: https://doi.org/10.1017/CBO9780511541261

[2] S. Musazzi and U. Perini, "Laser-induced breakdown spectroscopy: theory and applications" Springer, 2014, DOI: https://doi.org/10.1007/978-3-642-45085-3

[3] K. Taube, Stahlerzeugung kompakt: Grundlagen der Eisen- und Stahlmetallurgie, Braunschweig: Vieweg, 1998

[4] R. Stohn, Allgemeine Hüttenkunde, Leipzig: Fachbuchverlag, 1953

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