



# STABILIZING MATERIALS' CHEMISTRY BY IMPLEMENTATION OF REAL TIME ELEMENTAL LASER- INDUCED BREAKDOWN SPECTROSCOPY (LIBS) ANALYSIS<sup>1</sup>

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## Abstract

A chemical raw material for steel industry varies considerably. This is definitely one of the main problems of the industry. Automatic quality control - a new Laser Distance Analyzer Spectrometry (MAYA), which provides data on the chemical composition in real time to solve these problems, allowing you to: i) monitoring of pollutant concentrations in the major elements and crushed ore or concentrate. This allows you to take appropriate measures for the classification of materials; and ii) automatic dosing of the components by sintering the mixture flow and thereby stabilize the basicity of the sinter and coke consumption reduction in blast furnaces.

**Key words:** On-line analysis; Stabilization; Sintering; Dosing.

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## 1 INTRODUCTION

As widely known, one of the main factors increasing efficiency of the blast furnace performance is improving the quality of iron ore materials (sinter and pellets). Stable chemical composition of sinter and its basicity in particular is a quality feature which is as critical as reducibility, CRI and CSR. Reduction of sinter basicity fluctuations allows reducing the slag yield per ton of hot metal, and due to this cutting the coke rate and improving the production capacity of Blast furnaces.

Sinter basicity fluctuations depend not only on stable chemical analysis of charge materials, but also on their efficient blending at the stock yard and their subsequent dozing.

For decision of this problem Novolipetsk Steel, Russia, implement automatic system of control of chemical composition (SCADA), which has real-time access to the data on the elemental composition of the iron ore mix fed from storage to Sintering machine No.1 before dozing fluxes (limestone and dolomite). This system based on laser optical-emissive elemental analyzer «MAYA», designed by Laser Distance Spectrometry (Figure 1).



Figure 1. Laser analyzer installed at NLMK

The production capacity of Novolipetsk Steel's Sinter plant is 14,5 million tons per year (2011). The Sinter plant includes 4 sintering machines with total sintering area of 1248 m<sup>2</sup> (312m<sup>2</sup>×4). Science 2011 «MAYA» analyzer installed at sintering machine №1 has been operating in continuous mode and has been included into existing process control system.

## 2 DISCUSSION

The basicity level of sinter at Novolipetsk Steel is 1,2-1,6 units and it is adjusted based on information on the chemical analysis of the iron ore mix, coming from the storage area by adding fluxes. CaO and SiO<sub>2</sub> contents in the iron ore mix fluctuate significantly, due to poor blending and material segregation in the pile. The inconsistency is greatly propelled by addition of lime as much as 25-35 kg/t into the sinter pile. Chemical analysis of the iron ore mix coming from the storage area is performed once every 4 hours, for fluxes – once every 8 hours and for sinter once every 2 hours. It is obvious, that the above specified time intervals for transmitting data on the chemical composition is only an indirect estimation of chemical composition of the charge mix at the time of its proportioning. Therefore, real-time



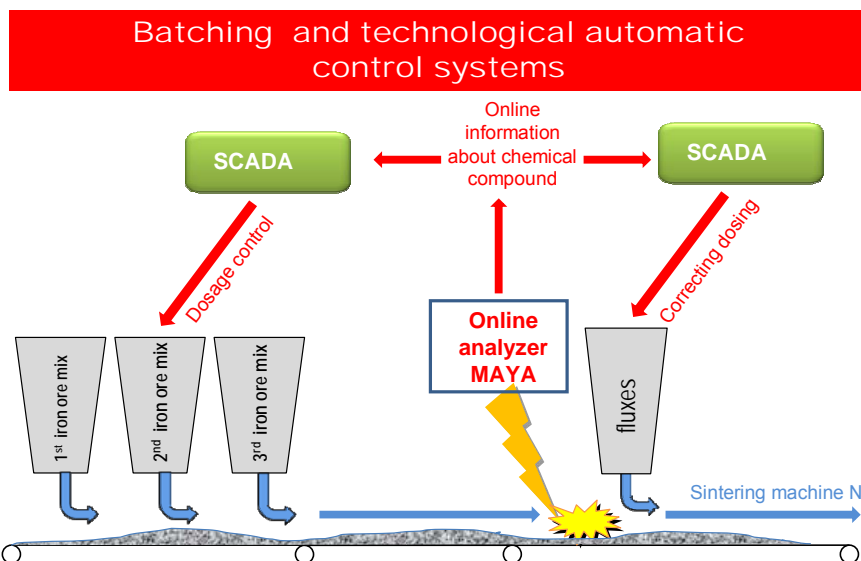
adjustments of the sinter basicity with the existing at that time proportioning pattern for the fluxes was impossible.

Installation of laser optical-emissive analyzer «MAYA» at the conveyor feeding the iron ore mix to Sintering machine No.1 before flux proportioning allowed monitoring of the trends of chemical composition (Fe, CaO, SiO<sub>2</sub>, MgO) of the iron ore on a real-time basis (Figure 2).



**Figure 2.** An example of changing the content of Fe and CaO shown in the interface of the system MAYA.

In 2011 after successful pilot tests based on «MAYA» analyzer specialists of Novolipetsk Steel developed the system of automatic flux dosing in the sinter charge. The system is based on communication of data on CaO and SiO<sub>2</sub> contents in the iron ore mix using «MAYA» analyzer making continuous automatic adjustment of the flux flow rate during subsequent proportioning, therefore reducing the fluctuations of the sinter basicity. Schematic diagram of the Automatic dosing system using LIBS method is shown in Figure 3.



**Figure 3.** Schematic diagram of the Automatic dosing system using LIBS method.

In Laser Induced Breakdown Spectrometry (LIBS) pulsed laser serves as the excitation source of examined substance. Nd:YAG laser beam normally with frequency from 1



to 20 times per second is been focused on the surface of the analysed material immediately creating short-time (for several seconds) temperature increase up to 30,000°C with some portion of the substance turning into plasma. Plasma is practically electrically neutral, but highly ionized gas, containing atoms and ions of chemical elements, the material is comprised of, as well as electrons. Within the plasma there starts the processes of recombination of positively and negatively charged particles, accompanied by photon emission – plasma “glow”. Each atom emits photons with specific wave length in wide optical range from 170 до 900 nm. Optical emission is registered by CCD spectrometer, transmitting digitized information on the spectrum composition to the analyser PC [1-3].

Based on the processing of received set of spectra for a preset time period, normally, from 20 sec. to 1 minute, direct calculations for concentrations of all required elements is taking place immediately. The results are taken and communicated to the process control system (SCADA) on a real-time basis. Afterwards, based on calculations performed in line with the algorithm developed by Novolipetsk Steel’s specialists the required level of flux dosing (t / hour) is determined.

Block diagram of laser analyzer operation and typical spectrum of sinter charge mix obtained using this equipment is given in Figures 4 and 5.

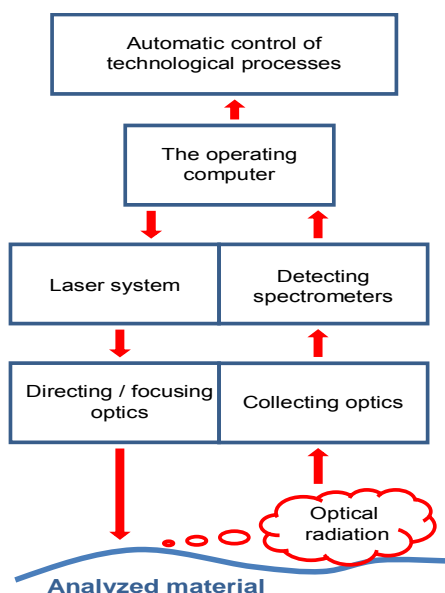


Figure 4. Block diagram of laser analyzer operation.

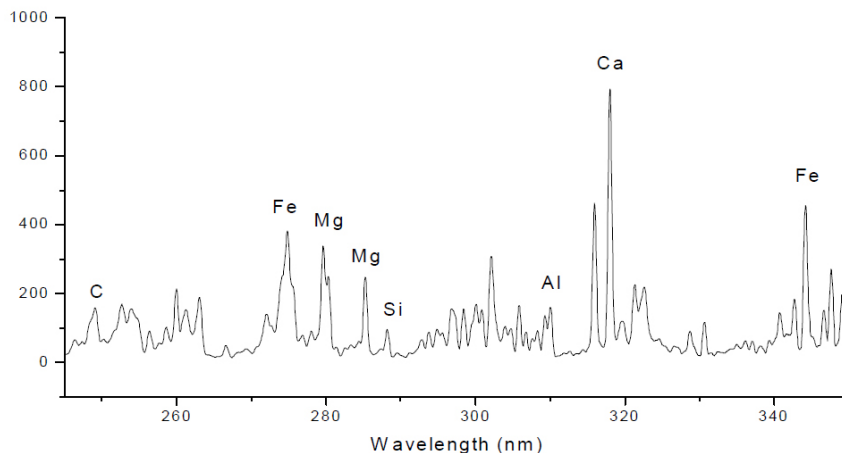


Figure 5. Typical spectrum of sinter charge mix obtained using this equipment.



The main advantages of Laser Induced Breakdown Spectrometry method as compared to other analytical methods employed for on-line analysis of elementary composition are as follows:

- high sensitivity, low detection limits and high accuracy due to vivid spectral lines of the most elements in wide visual range with their practically zero interference;
- possibility of simultaneous analysis of all required elements, including light-weights (C, Si, Mg, Al and etc.);
- absence of ionizing emissions of any kind (neutron, gamma, X-ray), absolute safety for personnel and no need for special permissions and regular monitoring by national nuclear authorities;
- analysis results are not influenced by material surface condition, lump size and the material bed height on the conveyor.
- Implementation of analyser, based on LIBS method on the conveyor for the purpose of sinter charge dozing at Novolipetsk Steel allowed to:
- receive and transmit to the process control systems (SCADA) completely in automatic mode the data on chemical composition of iron ore mix and to use them for on-line control of technological process, excluding any human factor during taking decisions regarding flux proportioning;
- analyse even small amounts of material on the conveyor belt (down to 20-30 m) and take quick decisions in case of severe but short-time violations of the process;
- completely exclude human factor with regard to any lab analysis errors, primarily related to sample taking and blending procedures.

### 3 CONCLUSIONS

On Novolipetsk Steel analyzer MAYA is working more than 1 year in 24/7/365 regime in real industrial environment with high level of dustiness, vibrations, temperature range -10 - +40 C and etc.

After installation technicians of Laser Distance Spectrometry have calibrated MAYA with accuracy closed to laboratory data.

One year later after commissioning of «MAYA» analyser the inspection of its current calibration (validity of its readings) was performed, which proved the validity and stability of the readings for that period (Figures 6-7). This is the effect of high consistency of parameters of laser emission and implemented optical charts, provision of efficient protection for the analyser from industrial exposure during continuous operation.

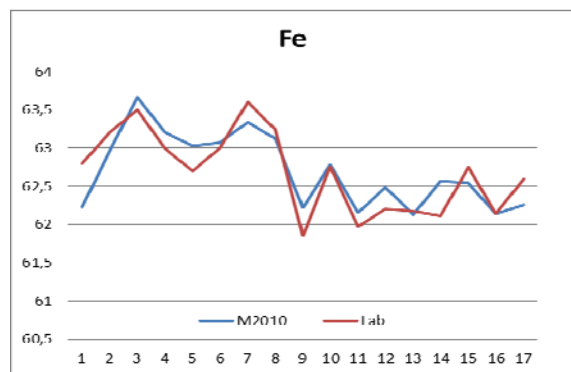


Figure 6. Calibration results for Fe.

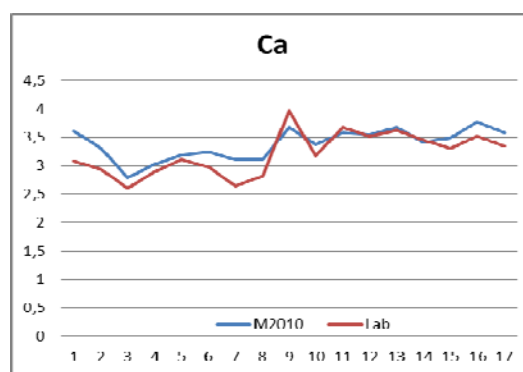


Figure 7. Calibration results for CaO.



Next results was achieved after implementation of SCADA system based on MAYA in Novolipetsk Steel:

- reduce sinter basicity fluctuations at Sintering machine No.1, reduction of mean-square deviation of basicity on average made 0,01 units;
- cut the coke rate at the blast furnaces on average by 0,6 kg/t of hot metal.

Novolipetsk Steel is presently undertaking a lot of research and design activities aimed at implementation of LIBS method for meeting a wide range process challenges, including for monitoring of sinter, flux, coals and coke.

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