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Application of the Tagged Neutron Method for Elemental Analysis of Sinter

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The results of the application of the conveyor analyzer AGP-K based on tagged neutron method at a metallurgical company are discussed. The method of tagged neutrons makes it possible to determine the mass concentrations of the sinter elements in real time without taking probes. The large penetrating power of fast neutrons allows obtaining information of large layer of sinter, up to 300 mm. A comparison of the obtained data with the values of chemical analysis is given.

1. Introduction

For many smelters, it is important to provide elemental content of the raw materials constant with time. For example, for the smelting of iron and steel, it is important that the basicity, the ratio CaO/SiO_2, of the sinter be as stable as possible over time. However, at present, the elemental composition of the sinter is controlled by sampling and subsequent chemical analysis of the samples. This is a labor-intensive process that takes a long time, requiring at least several hours. The AGP-K conveyor analyzer allows obtaining data on the elemental composition of material on the conveyor every 40-60 seconds.

The analyzer used tagged neutron method (TNM) [1-4] which allows non-destructive elemental analysis of materials remotely. The principal scheme of the TNM is shown in Fig.1.

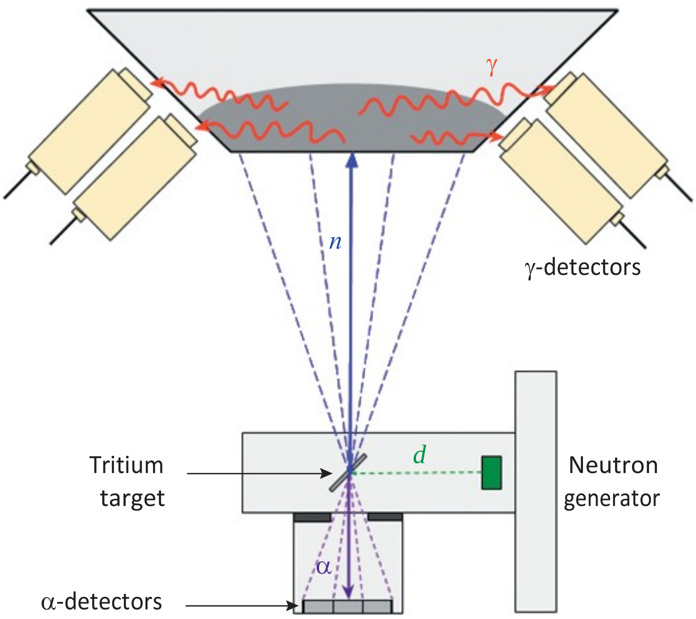

Fig.1. Principal scheme of tagged neutron method.

The object to be analyzed is irradiated with a beam of fast neutrons with an energy of 14.1 MeV produced by the reaction d + ^{3}H → ^{4}He + n. In this reaction, neutrons and α-particles travel in opposite directions. Therefore, by detecting the α-particle, the direction of the neutron momentum can be determined. This procedure is called neutron tagging. A fast neutron with an energy of 14.1 MeV interacts with the nuclei of the material under study in inelastic scattering reactions (n, n'γ). The excited nuclei emit γ-quanta. Since each chemical element has its own characteristic γ-spectrum, it is possible to perform elemental analysis of the object.

Main advantage of the TNM other standard technique of neutron activation analysis, like PGNAA (Prompt Gamma Neutron Activation Analysis), is a drastic suppression (on factor 200) of the background events. That is due to selection of γ-quanta only from the investigated object. For that only γ-quanta, which come to the detector within narrow time window (on the order of 100 ns), which starts from the arriving of α-particle in the α-detector, are used for the analysis. The TNM is the only neutron method which provides time information about arriving of γ-quanta.

2. Description of the apparatus

The AGP-K analyzer consists from the neutron module, electronic cabinet and computer of the operator. The neutron module is installed under the conveyor belt (see, Fig.2). The neutron source is portable neutron generator ING-27 produced by VNIIA named Dukhov (Moscow). It provides constant flux of 14 MeV neutrons with intensity 5×10^7 s^{-1}. Gamma quanta from inelastic scattering reactions are detected by a system of BGO scintillation detectors. The data are transmitted to the electronic cabinet and processed by the operator's computer.

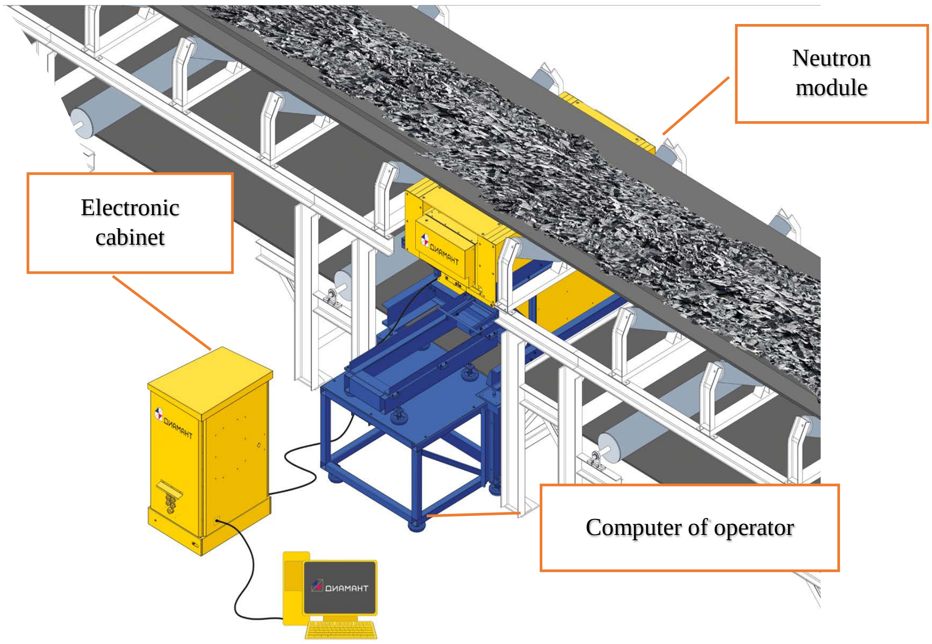

Fig.2. General scheme of the analyzer AGP-K.

Elemental analysis is performed for all ore material on a conveyor belt from 40 up to 300 mm thick. The mass concentrations of Al, Ca, C, Fe, Mg, O, and Si are measured at the same time and converted to the corresponding mass oxides ratios.

3. Results

In Fig.3 the measured behavior of basicity of sinter during two hours is shown.

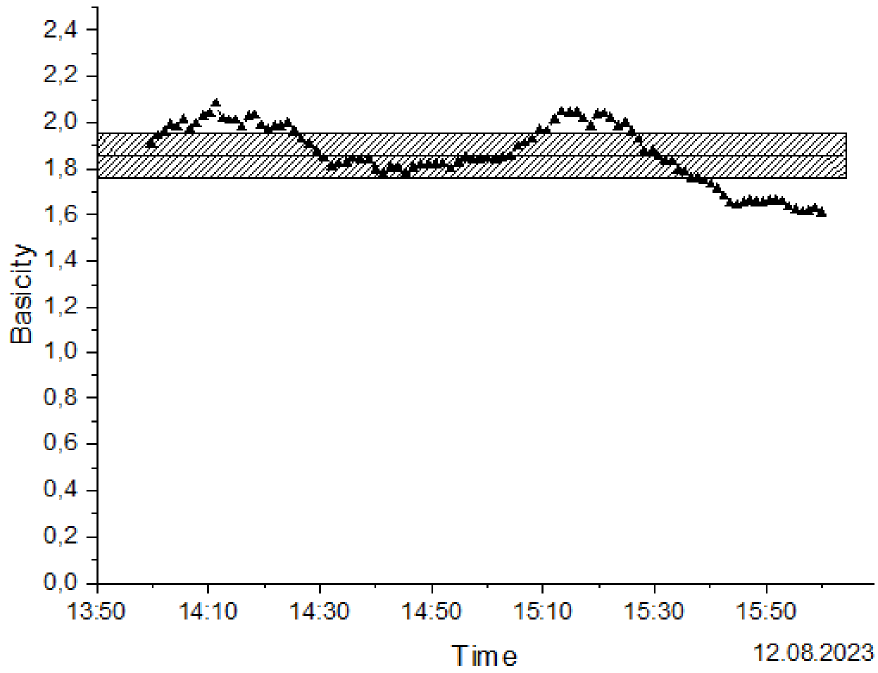

Fig.3. Measurements of sinter during two hours. The time between neighboring points is 40 s.

The operator must keep the basicity values within the shaded area. However, our measurements show that the rapid oscillations of basicity are taking place. The operative information about these changes of basicity signals the operator to take some actions to correct the basicity. It allows operator to decrease the fluctuations of the basicity which is important for the steel production. Decrease of sinter basicity RMS by 0.01 leads to coke saving by 0.13–0.19% and increase of steel production by 0.22–0.33%. Exploitation of the analyzer during first year resulted to decreasing the RMS of basicity by 0.04.

In Fig.4 a comparison between results of chemical analysis and data of AGP-K analyzer is shown.

One could see a general satisfactory agreement between chemical analysis and AGP-K data, however, there are some periods of disagreement. To solve these problems a special recalibration procedure is created. This procedure permanently performs for comparison with chemical analysis data and automatically changes the calibration parameters in case of significant disagreement.

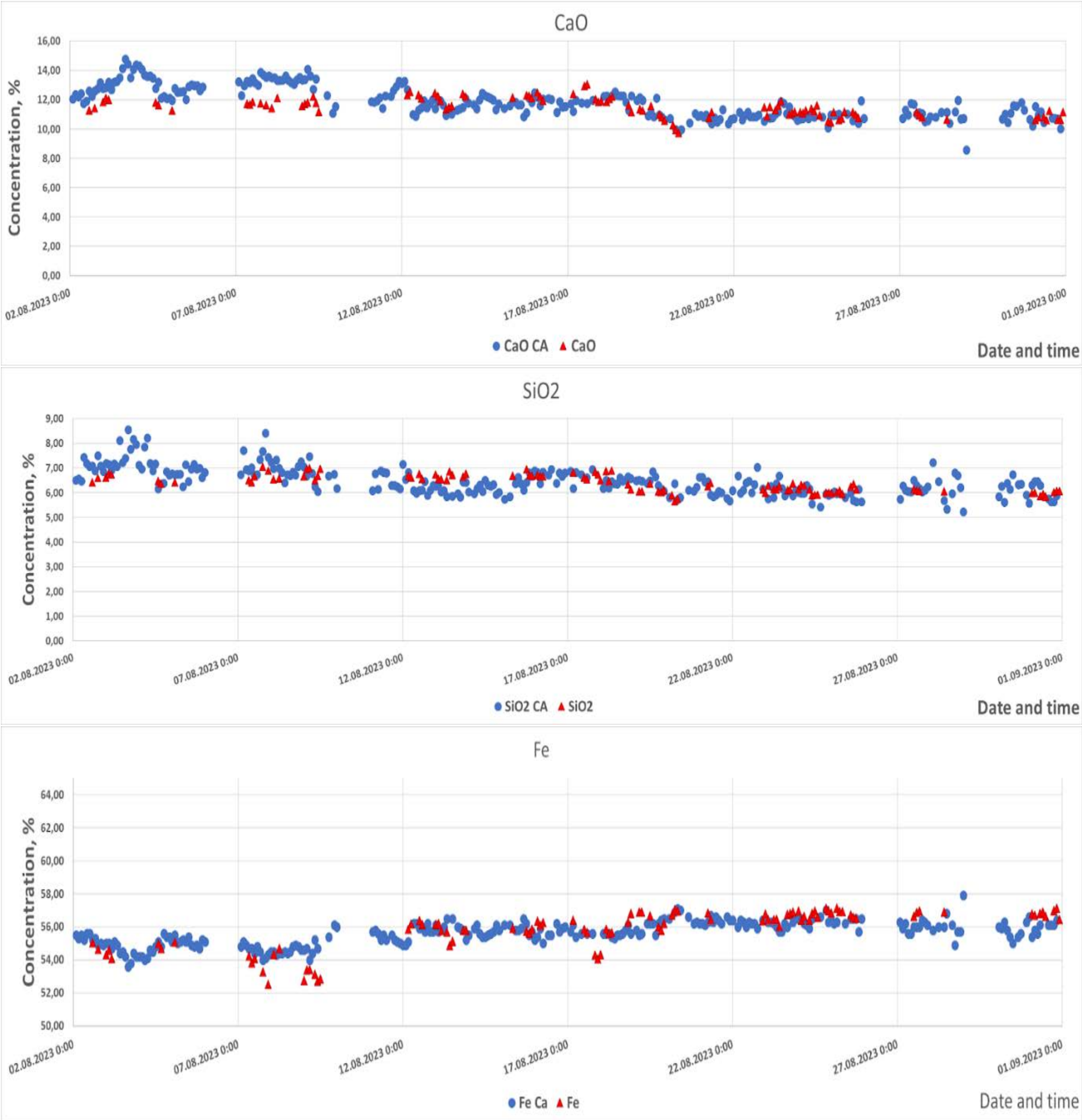

Fig.4. Measurements of mass concentration of CaO, SiO_2 and Fe over a month period. Blue circles are data of chemical analysis, orange ones correspond to results of AGP-K analyzer. Each data point corresponds to two hours of measurements.

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4. Conclusion

The AGP-K analyzer based on tagged neutron method is successfully worked in harsh conditions of metallurgical companies. It provides data on the elemental composition of sinter on the conveyor every 40–60 seconds. That allows performing a complete automation of sorting processes and quality control of material on conveyor. On-line analyzer AGP-K could be used as a sensor of elemental composition of the substance on the conveyor, providing basic information for systems of total digitalization of production.

References

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