Dr. rer. nat. Christoph Gehlen
Laser Analytical Systems & Automation GmbH
Aachen/Germany
www.LSA-systems.de

Having studied physics at RWTH Aachen University, Christoph Gehlen earned his PhD as part of his work as scientific assistant at the Department of Laser Technology at RWTH Aachen University. In 2009 he joined the company Laser Analytical Systems & Automation GmbH, at which he heads the research and development department.

Snapshot

Automated online analysis

Summary: For large mass flows, found, for example, in the form of primary raw materials (coal, ores etc.), real-time analysis of element content is of crucial importance. Over the entire process chain – from extraction of the raw materials, through processing, to loading of the "product" for transport to the customer – it is necessary to control and adjust individual process steps accordingly. In this connection, besides the analysis of purely physical properties (moisture content, weight etc.), automated monitoring of the chemical composition is also possible in real time, as the following report explains.

1 Introduction

As a versatile method for online analysis of chemical values, laser emission spectroscopy or, as it is otherwise known, laser-induced breakdown spectroscopy, (LIBS for short) has proven highly effective. But so far this has not been available to the market in the form of an automatically operating module. With the help of this technology, it is possible to continuously monitor the chemical composition and therefore the quality of material flows that up to now could only be incompletely or not monitored at all. With the availability of the online measurement results, the efficiency of extraction machinery can be improved and the costs of the raw material extraction lowered.

2 Laser-induced breakdown spectroscopy for automated online analysis

The Aachen-based company LSA GmbH has developed an automated analysis system based on laser-induced breakdown spectroscopy. The advantage of this measurement method is that the respective object can be analysed in a non-contact process over large distances and without any need for sample preparation. In this process, it does not generally matter whether the object is conductive or non-conductive, solid, liquid or gaseous in form. Core component of this analysis method is a laser system with which light pulses are generated. These pulses are focussed with a lens and directed at the object to be analysed (**Fig. 1**).

Laser-induced plasma on rock sample

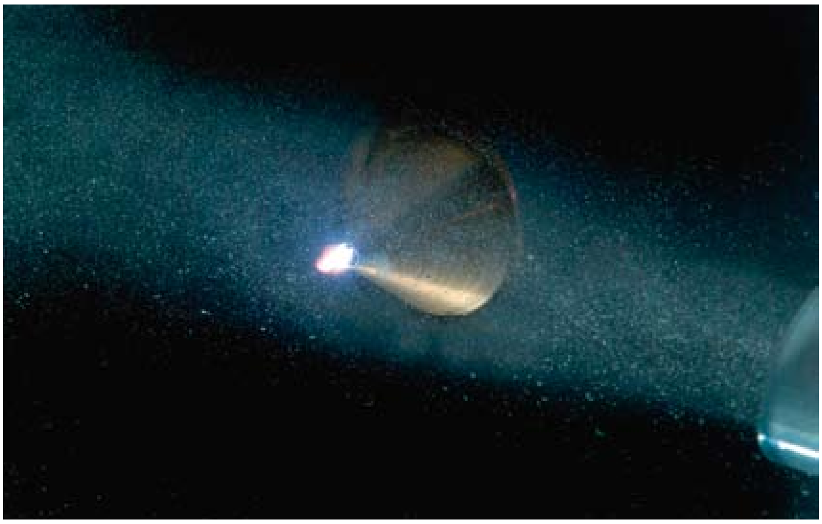
As a result of this focussing, an area measuring just a few µm² on the surface is heated, the material is evaporated and ionized. This leads to the formation of laser-induced plasma, which measures only a few millimeters in size and emits radiation characteristic for the elements contained in the respective material. This radiation is broken down spectrally and the elements detected with the help of a spectrometer. On the basis of the resulting intensity conditions of different wavelength ranges, it is possible to conclude which elements are contained in the material and in what concentration they are present.

1 "Snap shot" of the analysis of slowly moving scrap steel

2 Excavator with analysis module

3 Characterization of large material flows

One application of a laser-based measuring system is the automated analysis of material flows, like those found, for instance, in raw material extraction and processing. Examples of this are the analysis of primary raw materials coal, ores, etc.) and secondary raw materials (aluminium and steel scrap). Of interest here is the continuous monitoring of the material composition of the material so as to obtain an as accurate as possible analysis of its as-is state (Fig. 2).



3 Image of a laser-induced plasma in an air current with a concentration of boring dust

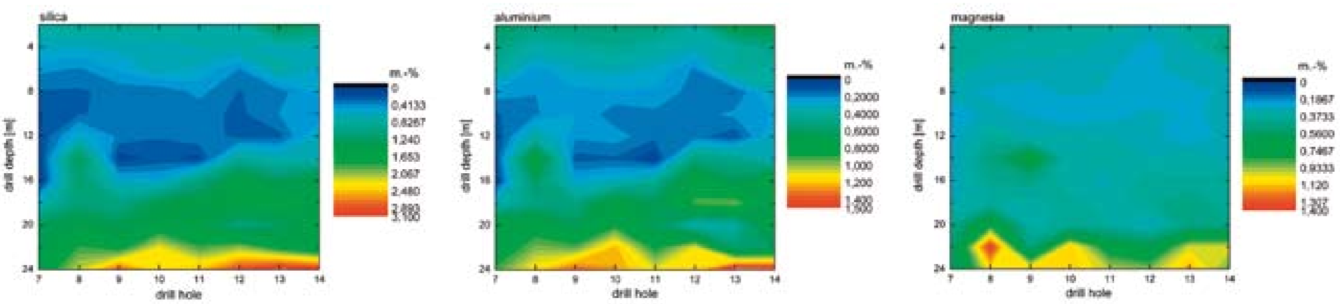
Up to now, in mineral processing, for example, samples have been taken from the material stream at hourly intervals, transported to a laboratory and analysed. The result of the analysis is then returned after several hours at best, but in many cases only after several days owing to the sometimes long transport distances and the necessary sample preparation. On this basis, only very rough adjustments can be made to the further processing operation, which is either slowed down or not efficient as it could be.

The situation is made more difficult by the natural variations in the composition of the raw materials. With the installation of the laser-based analysis system, e.g. above the belt conveyor on which the raw material is conveyed at several m/s, a rapid and flexible response to variations in concentration is possible. Accordingly, feedback is available for optimizing the upstream processing stage and continuous monitoring of the as-is state is ensured. If required, 100 measurements can be performed per second, in which up to 25 elements can be detected at the same time. Unlike with the analysis method available so far, i.e. based on isolated samples, heterogeneities within the sample material can be balanced out by averaging over several measurement pulses.

4 Exploration drilling and automated control of the extraction machinery

Before the transport and further processing of the material streams comes material extraction, and before this exploration boreholes are drilled in order to create a model of the deposit. With the current procedure, drill dust samples are taken at different depths. Here too, there is a time delay between sampling and return of the analysis results. In contrast, the use of an automatic analysis system permits the direct generation of a deposit model. Here the dust produced during drilling of the boreholes is extracted and passed with the current of air in front of the analysis module (Fig. 2). Fig. 3 shows the principle of the process for analysis of the dust streaming past. The element content of the dust is characteristic of the material found, so that with online analysis of the dust, conclusions can be made with regard to the composition and concentration of the elements at the respective boring depth. The results which are obtained online with the help of an installed analysis system are shown in Fig. 4 for the elements silicon (a), aluminium (b) and magnesium (c). Here the element content of adjacent boreholes for various depths are plotted in pseudocolours. The diagrams shown are results obtained in the scope of a joint project conducted in collaboration with the BGMR (Excavation and Mining Equipment Group) at RWTH Aachen University and the Fraunhofer Institute for Laser Technology during analysis of a deposit.

A feasible next step is the integration of such a system in an excavator so that the excavator operator receives a visualized report of the raw material composition during the work process or the excavator operates completely self-sufficiently, with the percentage of low-grade rock being minimized in both cases.



4 a-c Element maps of the exploration boring campaign for depths between 2 m and 24 m, which are generated in an automated and online process