Operation of LIBS element analyzers in the recycling industry

Precision recycling of metal scrap
- Analytics
- Classification
- Sorting

Multi element analysers for fast quantitative surface inspections
Corporate profile
SECOPTA analytics GmbH

SECOPTA analytics GmbH is a medium-sized company located in Berlin and Brandenburg. The company's focus rests on the preparation of robust laser-spectroscopic measurement systems designed for fast and precise process analysis. In the field of laser induced breakdown spectroscopy (LIBS) SECOPTA is the leading supplier.

Particularly the industrialised positive material identification (PMI) and precision recycling benefit from the outstanding advantages of LIBS technology.

A big advantage of LIBS technology lies in the quick and contact-free measurement of materials even in highly automated processes, such as operations on fast-moving conveyor belts.

Apart from robust, low maintenance and reliable hardware, SECOPTA offers outstanding and unique software modules that are embedding the most innovative chemometric methods.

Precise analyses of the elemental composition of samples or material streams makes online process monitoring in real-time, inline quality control and the varietal sorting of different types of material into fractions with quantitatively predefined fractions of alloying elements possible.

To achieve perfect results for the different applications of the industry, various product series are available, that have been optimized according to our customers' needs.

In the field of quality control mostly the multi-element analyzers of the FiberLIBS inline series come to use. The exceptionally fast MopaLIBS sensors usually are applied for the classification and analysis of metal alloys in precision recycling tasks and for the online analysis of primary raw materials.
Cooperation with Partners from engineering and plant construction industry

To perfectly meet the requirements of the recycling industry, SECOPTA works closely with the leading players in the fields of engineering and machine building. In this regard our partners integrate the LIBS sensor systems from the MopaLIBS series as an OEM part into the sorting concept of their machines. Particularly in the field of recycling, where optical sensors are commonly used since many years, SECOPTA has proven to have distinct advantages over conventional optic applications.

Compared to optical standard applications, that are currently available on the market, our OEM components at the same time are feature the following benefits:

- Fast.
- Precise.
- Robust.

Progress in the field of recycling means the application of modern techniques to sort complex material streams. By using innovative process and analysis technology nowadays in any phase of the recycling process an objective evaluation of the material has become possible. Thus, a consistent and high quality of all discharged material streams may be guaranteed accordingly.

From an economic and at the same time ecologic point of view particularly the recycling of steel, aluminium and other metals is of importance, as those materials may pass the recycling process as often as desired without any quality loss.

The MopaLIBS analysis technology can make an important contribution here.
The utilisation of LIBS systems to solve problems of the recycling industry

Laser induced breakdown spectroscopy (LIBS) makes quick, precise, non-contact multi-elemental analysis possible. An intense laser pulse is focussed on the surface to be investigated. Within the point of measurement of about 100-micron diameter, a plasma is generated whose emission is a characteristic of the material being analysed. Through spectral analysis of the plasma emission and evaluation of characteristic spectral lines, qualitative and quantitative statements can be made within a few milliseconds regarding the elemental composition at the point of measurement. The method is universal and flexible, since the spectral fingerprint of all elements is captured simultaneously.

The detailed determination of the processed material is of outstanding significance in many industrial processes. By using preliminary ablation lasers, even polluted surfaces can be analyzed quickly and precisely without prior sample preparation.

Special advantages of the LIBS technology:

- Online - data analysis in milliseconds
- Inline - non-contact measurement and compact measurement heads for easy integration into the existing machine infrastructure
- Insitu - direct measurement without time-consuming sample preparation

Highlights of SECOPTA’s LIBS technology

- Results within milliseconds
- High sensitivity even for the analysis of low concentration levels
- Simple integration into the existing machine infrastructure
- Optimized for industrial applications, even under harsh operating conditions
- Simultaneous measurement of all elements
- Non-contact measurements and results in real time
- Analysis of moving objects, e.g. on a conveyor belt (3m/s)
- Parallel preliminary ablation to clean surfaces
- Quantitative analysis methods in combination with customer-specific material classes
- Qualitatively functioning classification methods by determining the significant “spectral fingerprint”
- Industry 4.0-Ready
MopaLIBS element analysers

The multi-element analysers of the MopaLIBS series were developed for application in industrial environments to analyse the chemical composition of material streams. The application possibilities are broad and focus particularly in the areas of material sorting and volume flow analysis.

Standard applications are available for the analysis of metal alloys as well as for mineral industry products. The SECOPTA sensor works with high analytical precision and reproducibility of the archived results.

The "MineralLIBS" series has been especially optimized for the analysis and sorting of non-metallic materials.

The MopaLIBS measurement systems are available in two different configurations:
- MopaLIBSline (measurement in one line)
- MopaLIBSscan (measurement on width)

The MopaLIBSline version can be optionally upgraded by additional preliminary ablation laser (PA) and many material class may be sorted in parallel by side-discharging.

MopaLIBS measurement systems are distinguished by their:
- Robustness
- Flexible use
- Short measurement and analysis times
- Precise elemental analysis, also at low concentrations
- Rapid provision of results

The MopaLIBS instruments are usually installed above a conveyor belt. Varying sample heights of up to 120 mm are compensated for by fast autofocussing technology. Robust measurement lasers are used that work with a repetition rate of 20 kHz at constant laser power. Optionally, this may be extended up to 100 kHz or a second laser can be introduced for preliminary ablation. Accordingly, the short measurement times guarantee non-contact measurement of even small objects at belt speeds of up to 3 m/s. All measurement results are promptly transferred over an industrial interface to a control unit (SPS, etc.). This manages the output into the predefined material groups.

Operation in recycling - element analyser MopaLIBS

Side-discharge with MopaLIBSline
Sorting application example
Grouping of aluminium alloys

The sorting of aluminium scrap into the alloy
groups, 1.xxx – 7.xxx has until now not been
practical on an industrial scale for aluminium scrap
since no inline industrial analytics were available
to do this. With the MopaLIBS element analyser,
these materials can be sorted into close specifi-
cation categories quickly and reliably. Through
single-origin separation into aluminium alloy
groups 1.xxx to 7.xxx, the reutilization at the
same level of value is possible.
For the customer, that means a distinct added
value compared to the starting material. The
introduction of this technology in recycling allows
to achieve closed raw material cycles.

The calibration methods stored in the instrument
analyse the concentrations of the elements Cu,
Fe, Mg, Mn, Si, and Zn per the measured spectra.
By investigating the concentration ratio, the
object will be assigned to a customer-defined
class.

Advantages of the technique
- Analysis also of the light elements Si, Mg
- Sorting into many fractions
- Simple integration into the existing sorter

Customer benefits
- High added value
- 24/7 operation accompanied by low
maintenance costs
- No material preparation, cost savings

Possible sorting categories for bulk flows of
aluminium:
- Analysis of the elements Cu, Fe, Mg, Mn, Si,
Zn, and Cr
- Creation of customer-specific material
classes, depending on the mass fraction of
the previously analysed alloying elements

Sorting examples:
- Al groups, 1.xxx - 7.xxx
- Al wrought alloys / Al cast alloys
- Materials with high Cu content
- Special Fe alloys
- Possible sorting into Al sub-groups, such as
e.g. 7050 / 7075
Sorting application example
Assorting low-alloy steel scrap

During the production of spheroidal graphite iron, only steel scrap with low Mn content can be used; this applies almost without exception. On the receiving dock of foundries, the alloy composition of small quantities of material is being controlled by spot checking. Accordingly, the reported chemical composition can deviate significantly from the alloy composition of the entire volume of a scrap delivery.

With a new technique for precise sorting of new scrap and old scrap optimized for production requirements, these material streams can be analysed with the MopaLIBS process measurement system before they are used in foundries.

The piece-by-piece analysis for Mn, Cr, Al, Ti and Cu gets standardised, and if necessary other alloying elements can be included in future. Based on the values determined by this analysis, the measured objects can be assigned to predefined customer categories and then sorted accordingly.

**Advantages of the technique**
- Precise determination of Mn and Cr content
- Fully automated sorting
- No surface preparation required

**Customer benefits**
- Reliability of the input materials to be used
- High added value

**Possible categories for use in separating bulk flows of steel:**
- Analysis of the elements Mn, Cr, Al, Ti, and Cu
- Creation of customer-specific material categories depending on the mass fraction of the previously analysed alloying elements

**Sorting example:**
- Mn-containing steels into 3 groups
  - <0,2 m% / 0,2 - 0,4 m% / >0,4 m%
Sorting application example
Separation of stainless steel scrap

Through the homogeneous separation of high-alloy stainless steel scrap into its alloy groupings, a distinct added value improvement can be achieved in recycling compared with unsorted material. To fulfill the requested recycling throughput, quick industrial inline analytics are needed.

The MopaLIBS element analyser carries out piece-by-piece analysis of stainless steel scrap during processing to achieve quick and reliable sorting results. By introducing this technology, the potential for closed raw material cycles of high-alloy stainless steel scrap from recycling is maximized.

Calibration methods analyse the measured spectra by default to determine the concentrations of the elements Cr, Ni and Mo that are present. If necessary, additional alloying elements can be explored as well. Accordingly, the analysed object will be assigned to a customer category (here the stainless-steel alloy group) based on the individual analysis results, and can be sorted subsequently.

Advantages of the technique
- Universally adaptable
- Sorting into many fractions

Customer benefits
- High added value
- 24/7 operation and low maintenance costs
- No need for pre-cleaning, cost savings

Possible separation categories for stainless steel bulk flows:
- Analysis of the elements Cr, Ni, Mo, Cu, Nb, Ti, V, W, and Ta
- Creation of customer-specific material categories, depending on the mass fraction of the previously analysed alloying elements

Sorting examples:
- Steel groups 1.40 – 1.49
- V2A / V4A
- Specific Alloys (corresponding to the material numbers)
- Nickel-based alloys

High-grade steel from incineration plants
Sorting application example
Materials from bulk flows of NF metals

The elemental composition of NF scrap metal parts within a material stream can be determined using the MopaLIBS multi-element analyser made by SECOPTA. Premium-quality material groups with high copper, zinc, tin or silver content can be classified and separated from one another during the inline production process by subsequent sorting.

The technique can be used for bulk flows in these sectors:
- New scrap / production waste
- Consumer waste / industrial waste
- Scrap metals after incineration

The separation of the mixed scrap into varietal fractions makes effective recycling with high added value possible for recycling companies.

Advantages of the technique
- Universal and flexible since all elements may be analysed
- Fast measurement
- No sample preparation
- Fully automated processing

Customer benefits
- 24/7 operation with low maintenance costs
- High added value due to fraction purity

Mögliche Trennkategorien für NE-Metall-Massenströme

- Klassifikation nach Reinfraktionen (Al, Cu, Messing, Bronze, Mg, Zn, Ni, Pb u.a.)
- Klassifikation von Zinkschrotten in Guss- und Blechfraktionen
- Klassifikation von Aluminiumschrotten in Knet- und Gussfraktionen
- Klassifikation von Aluminiumschrotten nach Legierungsgruppen 1000 - 6000
- Klassifikation von Titanschrotten nach Legierungsgruppen
- Klassifikation von Kupferschrotten nach Legierungsgruppen

Pure NF metal fraction: zinc sheet
Titanium is used as a high-performance material by many market segments because of its quality characteristics. During the manufacture of titanium parts, large amounts of this material get lost in the form of chips. Such shavings are currently “recycled” by usage for paint manufacturing or as alloying additive in steel production. These methods, called down-cycling are not economically viable. On the other hand, reuse of the shavings as primary material (up-cycling) is currently critical because the buyers of titanium parts place very high demands on the quality of the products to be manufactured. By introducing the MopaLIBS, titanium production waste can be sorted quickly and reliably into narrow specification categories.

Contaminations may result in inferior titanium alloy quality lead to catastrophic consequences e.g. in the aircraft industry. By varietal sorting the reprocessing of titanium becomes possible at the same level of the value chain.

**Advantages of the procedure**
- Precise multi-elemental analysis
- Fast measurements

**Customer benefits**
- Material reutilisation at the same level of the value chain
- Safety by prevention of impurities

**Possible separation categories for titanium production waste**
- Classification between Ti and other metals
- Classification between different titanium alloys such as
  - Pure Ti
  - Ti-Al6-V4
  - Ti-Al3-V2.5
  - Ti-Al4-V2.5-Fe1.5
  - Ti-Al6-Mo2-Zr4
  - Ti 0.8Ni 0.3Mo
  - others upon request

Titanium production scrap
Element Analysers For Recycling Applications

Sorting application example
Material analysis of refractory bricks

Refractory materials are broadly used in the metal, glass and cement industry, especially as facing for ovens and wells. The inorganic, non-metallic materials are subject to large temperature fluctuations and thus often have very limited service lives. After their breakdown, the refractory materials can be grinded and recycled into new component parts. However, a basic prerequisite for this procedure is a type-based and precise presorting of the materials, since that is the only way to achieve closed material cycle and an optimized recycling process.

With SECOPTA's MopaLIBS systems, refractory materials can be analysed precisely. In combination with a suitable sorting facility, type-based precision recycling with throughput of up to 10 tons/hour per measurement track becomes possible. During the process, sorting can be done into 10 or more fractions.

Our partners place their trust in our systems since several years for this challenging application.

Separation categories for bulk flows of refractory materials
- Analysis of the elements Al, Mg, Si, Zr, Cr, and Ca
- Classification into customer-specified groups of material, depending on the concentration of Al2O3, MgO, and SiO2

Advantages of the technique
- Fully automated sorting
- High precision
- Individually configurable sorting criteria

Customer benefits
- High added value
- Low sorting costs
- Reliable availability
Application example volume flow monitoring
Analysis of the chemical composition

Supervising the chemical composition of material streams with a monitoring technique is very important for many applications. Conventional techniques require time-consuming sampling and preparation procedures in order to generate a statistically valid measurement result for the quantities of material that are being processed. With the MopaLIBS element analyser, material analysis happens inline, directly on the surface of the moving stream.

Essentially, two areas of application can be differentiated:
- Capture of fluctuations in the chemical composition of the mass flow
- Capture of changes in the material composition within the mass flow (positive material identification)

By introducing the MopaLIBS for inline monitoring, the immediate systematic capture of predefined parameters in the form of observation, record-keeping and ultimately the monitoring of complete processes becomes possible. Based on that, one can intervene in the process and control it if the task does not follow the predefined specifications or exceeds or falls short of the defined threshold values.

Advantages of the technique
- Fully automatic measurement
- All elements measured simultaneously
- Automatic height adjustment (autofocus)

Customer benefits
- No time-consuming and error-prone sampling
- No downtime
- Positive material identification
- Full process control

Typical areas of application for volumetric flow monitoring:
- Analysis of chips of the most varied metals before or after briquetting (positive material identification)
- Analysis of metalliferous volumetric flow with small grain sizes
- Metal content of ores
- Ash content and elements in coal
- Positive material identification during the feeding of blast furnaces and in other metallurgical processes
- Control of treatment processes
- Preliminary sorting of salts (KCl, NaCl)

Volume flow analysis for a blast furnace of a partner