SpectraFlow On-Line Analyzer
Applications in the Coal Industry
SpectraFlow Minerals Online Analyzer Timeline

2006: ABB started development for near infrared online Crossbelt Analyzer

2007 - 2010: First test and commercial installations in Cement & Iron Ore applications in Europe & USA

2010: Development of Airslide Application

2011 - 2012: Commercial installations around the globe

2013: SpectraFlow Analytics incorporated as an independent company & management buy-out of the NIR Online analyzer technology from ABB

2013 - today: >45 orders received for Cement, Iron Ore, Bauxite, Platinum, Gold clients globally, since 2016 approved supplier with FLS
SpectraFlow Coal Analyzer
Objective and Benefits

- Process Improvement
  - Mine Feed Monitoring
  - Gasifier Feed Monitoring
- Use safe and proven method
  - NIR method uses no ionizing radiation – safety first
  - Reliable systems for fast real time on-line analysis for
    - Moisture, CaO, MgO, FeO, SiO$_2$, SO$_3$, Carbon, Ash, Volatiles
- Easy to use equipment

- Return on Investment Objectives
  - Have a very low cost of ownership
  - Easier Stockpile Blending
  - Less Gasifier Downtime
SpectraFlow On-Line Analyzer
A new development
SpectraFlow Coal Analyzer
NIR Analysis Technology

Rails for lamp positioning

Light and dust shield

8 lamps 50 Watt each

FTIR Spectrometer

Entry lens of spectrometer

Bulk Material

MR-11 Lamp

Lamp holder

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SpectraFlow Coal Analyzer
Minerals have a NIR signature

SpectraFlow Coal Analyzer
Spectral information comparison

- Discrete lines for each element
- Calibration based on integral intensity of elemental line
- Total information of the material
- Minerals and organic Molecules
- Model based calibration for each element according to the occurrence as a phase in the raw material to be analyzed
Each of the measurements per sample gives a spectrum.

The chemical composition for each sample is given by the laboratory analysis.

The final step is now to correlate, for each constituents, the spectra with the laboratory values. The procedure is called multi-linear regression.

The calibration models are loaded into the SpectraFlow system and are ready to use when the analyzer is delivered.

After 1 or 2 month of operation a fine tuning is performed, possibly remotely and does not require an engineer on site.
## SpectraFlow Coal Analyzer
### Comparison of different analytical methods

<table>
<thead>
<tr>
<th></th>
<th>XRF</th>
<th>PGNAA</th>
<th>SpectraFlow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurement method</strong></td>
<td>Off-line</td>
<td>On-line</td>
<td>On-line</td>
</tr>
<tr>
<td><strong>Goal</strong></td>
<td>Quality Control by DIN/ASTM</td>
<td>Process Control, Trending</td>
<td>Process Control, Trending</td>
</tr>
<tr>
<td><strong>Operational Expenses</strong></td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Analysis Basis</strong></td>
<td>Electron Shells</td>
<td>Nucleus</td>
<td>Molecules and Minerals</td>
</tr>
<tr>
<td><strong>Elements possible</strong></td>
<td>Depends on calibration: F(WDX) or Na (EDX)</td>
<td>From Na (Cf source) or from O (neutron tube)</td>
<td>All elements incl. H, moisture</td>
</tr>
<tr>
<td><strong>Dependency</strong></td>
<td>Vacuum / Helium, sample preparation</td>
<td>Belt speed, belt load</td>
<td>No nonlinear layering</td>
</tr>
<tr>
<td><strong>Analysis timeframe</strong></td>
<td>40 – 60 Minutes</td>
<td>Rolling average</td>
<td>1 Min. with avg. of 48 measurements</td>
</tr>
<tr>
<td><strong>Depth of Analysis</strong></td>
<td>µm</td>
<td>Up to 500 mm</td>
<td>µm - mm</td>
</tr>
<tr>
<td><strong>Area of measurement</strong></td>
<td>Laboratory</td>
<td>Conveyor belt</td>
<td>Conveyor belt, Air-slide</td>
</tr>
<tr>
<td><strong>Reports</strong></td>
<td>Elemental Analysis</td>
<td>Elemental Analysis</td>
<td>Molecules and Phases</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td>Low energy x-rays, local legal requirements</td>
<td>Ionizing radiation, legal requirements!</td>
<td>No radiation at all, no legal requirements</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytical precision</td>
<td>Very High</td>
<td>High to low depending on element</td>
<td>High</td>
</tr>
<tr>
<td>Sampling acc.</td>
<td>Medium to Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Total accuracy</td>
<td>Medium</td>
<td>Medium to High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Consumables</strong></td>
<td>X-ray tube</td>
<td>Radioactive source or neutron tube</td>
<td>Halogen light bulbs</td>
</tr>
<tr>
<td><strong>Annual cost</strong></td>
<td>USD 40,000 – USD 60,000</td>
<td>USD 1,000 – USD 2,000</td>
<td>(C) SpectraFlow</td>
</tr>
</tbody>
</table>
SpectraFlow On-Line Analyzer Crossbelt Application
SpectraFlow Coal Analyzer

Position of Analyzer - Mine/Stockpile optimization

- Quarry / Area A
  - High Carbon
- Quarry / Area B
  - High Volatiles
- Quarry / Area C
  - Variable Quality

Raw Material delivery

On-line analysis
- Carbon
- Volatiles
- Ash
- Al₂O₃
- SiO₂
- H₂O

Decision by quarry management or Blending Software on material demand

Stockpile composition
- Carbon
- Volatiles
- Ash
- Moisture
- Tonnage normalized

Crusher

Belt scale

Blending bed
SpectraFlow Coal Analyzer
Position of Analyzer - Coal Mix

Stock Yard

Possible Homogenizer

NIR Analyzer

On-line analysis
Carbon
CaO
Al$_2$O$_3$
SiO$_2$
SO$_3$
H$_2$O

Decision by stockpile management or Blending Software on material demand

Coal Mix Silo

to Combustion / Gasification

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| Slide 12
SpectraFlow Coal Analyzer
Position of Analyzer - Combustion

Coal Mix Silo

NIR Analyzer

Coal Mill

On-line analysis
CaO, Al₂O₃,
SiO₂, Fe₂O₃,
MgO, Na₂O,
K₂O, TiO₂
Slagging Index
H₂O

Combustion

Air Intake

Decision by operator
or Expert System
SpectraFlow Coal Analyzer
Position of Analyzer - Gasification – Fixed Bed

Coal Mix Silo

NIR Analyzer

On-line analysis: CaO, Al₂O₃, SiO₂, Fe₂O₃, MgO, Na₂O, K₂O, TiO₂
Slagging Index H₂O

Coal Mill

Decision by operator or Expert System

Air Intake: Adjustment in steam / oxygen mix

e.g. Fixed Bed Updraft

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SpectraFlow Coal Analyzer

Position of Analyzer - Gasification – with flux addition

- Coal Mix Silo
- NIR Analyzer
- Flux Additive
- On-line analysis: CaO, Al₂O₃, SiO₂, Fe₂O₃, MgO, Na₂O, K₂O, TiO₂, Slagging Index, H₂O
- Gasifier
- Agent Intake
- Decision by operator or Expert System
SpectraFlow Coal Analyzer
Position of Analyzer - Gasification – with flux addition

[Diagram showing the flow of coal from the mill to the gasifier/combustion, followed by online analysis of carbon in ash, and decision making by operator or expert system.]

Decision by operator or Expert System

Information on ash quality for sales

Mill & Boiler settings

NIR Crosbelt or Airslide Analyzer

Gasifier / Combustion
SpectraFlow On-Line Analyzer Hardware Installation
SpectraFlow Coal Analyzer Analyzer Installation

- Spectrometer compartment
- Illumination unit and dust protection cover
- Electronic cabinet and communication unit
- Mounting frame supplied by the customer
SpectraFlow Coal Analyzer
Analyzer Pictures

Spectrometer Compartment
Service Flap, which can be opened to access the lights
Entry for the reflected Infrared into Spectrometer
Spots as Infrared Sources

Overall view
Service flap open

View on rails and lamps
Electronic cabinet

Interfaces
Power Supply for the spots
Industrial PC (IPC)
SpectraFlow On-Line Analyzer Calibration results
SpectraFlow Coal Analyzer Calibration Results for Coal

Coal Analysis Ash Model

\[ R^2 = 0.8812 \]

Coal Analysis Volatiles Calibration

\[ R^2 = 0.9684 \]

Coal Analysis Sulphur Calibration

\[ R^2 = 0.9928 \]

Coal Analysis Moisture Model

\[ R^2 = 0.9944 \]
SpectraFlow On-Line Analyzer

Benefits
SpectraFlow Coal Analyzer
Benefits

- No radioactive materials used
  - very low cost of operation and maintenance
  - no operational permits or extra personnel required
- Most accurate measurement for organic and inorganic constituents
  - Real time analysis of relevant operational parameters like slagging or fouling indices, Ca – Fe ratio
- Only analyzer usable for Boiler or Gasifier optimization due to highly accurate measurement
- Independent of belt load changes
- No sampling or by-pass required
- No re-calibrations required
- Low maintenance
SpectraFlow On-Line Analyzer
Operation Cost / ROI Objectives
SpectraFlow Coal Analyzer Maintenance

**Weekly:** Cleaning by compressed air (appr. 5 min)

**Bi-Monthly:** Referencing (appr. 20 min)

**Annually:** Changing of the source (light bulbs) (appr. 1 hour)

Under normal quarry conditions: no recalibration required

Remote service can cover 98% of all questions and assist local team in problem solving

Sources (light bulbs) are inexpensive and can be shipped internationally
SpectraFlow Coal Analyzer Maintenance

Crossbelt Analyzer:
Client reference: appr. € 3,000 p.a.
(experience over 5 years)

NIR technology has the lowest operating cost for any kind of online analyzer
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