HARD ROCK SOLUTIONS SINCE 1927

On Stream Analyzer Systems for Mineral Processing

Heath & Sherwood The legend continues
Introduction – Topics To Cover

- Why are OSA Systems required
- Sampling Systems required for Analyzers
- OSA System Overview
- What is XRF
- Radiation Safety
- The BOXA-II
- BOXA Benefits and Advantages
- Next Generation – BOXA-III
- Benefits of OSA Systems
- Some $ Numbers
SHOULDER TO SHOULDER, SOLVING PROBLEMS

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The legend continues
Why are OSA Systems required

• Mineral Processing industry processes ore
• Ore contains metals of interest (Cu, Zn, Ag, …)
• Ore is upgrade to a concentrate in several stages, different circuits
• Each stage requires precise control to maximize a plants profitability (grade vs recovery)
• XRF measures element content (%Cu, %Zn, Ag ppm, …) at different stages which is used for process control
Why are analysis's required

• To control grade and recovery in a flotation circuit (Quality Control)
  – Grade – is the total element content in a sample (feed, conc., tails)
  – Recovery - % of element recovered from the ore

• Some flotation control parameters
  – Assay based control can be implemented for plant optimization
  – Air addition and level controls on flotation cells
  – pH (acidity) of the slurry
  – Density of slurry
  – Amount of flotation chemicals, collectors, frothers, etc.
Sampling Systems required for Analyzers
Sampling Points
Decide the type of Samplers Required

- **Metallurgical Samplers**
  - Metallurgical reconciliation (Feed, Concentrate, Tails)
  - Requires samples that represent actual metal grades
  - Composite samples for laboratory analysis

- **Process Control Samplers**
  - Concentrate and tailings of each stage of the flotation process
  - Requires sampling to verify tendencies in the process
  - Important for maximizing metal recovery
  - Feed for On Stream (OSA) and Particle Size (PSM) Analyzers
  - Requires 8 to 12 m$^3$/hr continuous sample

- **IMPORTANT NOTE**
  - Metallurgical Samplers can be used for Process Control but NOT VISA VERSA
Process Control Samplers - Bias Note

- **Process Control Samplers**
  - These kinds of samplers contain a bias
  - This bias changes over time due to changes in feed tonnages, particle size, densities, flow rates, pressure, etc.
  - There can also be a constant bias plus a fluctuating bias

- **NOTE OF INTEREST**
  - There was paper (Measurement Issues In Quality “Control”) presented by Brian Flintoff in 1992 at a CMP conference which stated: “Clearly, no bias can be accepted” as it pertains to OSA composition measurements
  - If the sample feed to the OSA is biased, the result is biased!!!
  - Not sure where the idea of PCS came from!

Allowing that the scenario described above is reasonable, and in particular the grade (~±1%) and recovery (~±0.5%) changes could be typical, it is possible to comment on the allowable noise in the OSA composition measurements. Clearly, no bias can be accepted (a most difficult condition to meet in view of matrix, particle size and pulp density effects).
Decide Type the of Samplers Required

- Proper sampling engineering is required to ensure samples are readily available to the OSA and are representative.
- Sampling systems require periodic maintenance.
- Sampler cutters can get plugged.
- Sampling lines and pumps can sand out.
- These factors affect the OSA and its assay availability.
Metallurgical Samplers

They cut completely across the stream

Linear Sampler

Rotary Vezin

Very Easy to Install
- no special tools required
- ensured high operating time with low maintenance

Continuous Electric Drive System
- ensures uniform cutter velocity throughout the material stream
- non-wearing motor (long lasting)
- intermittent and continuous operation

Cutters and Cutter Caps
- designed to suit each application
- ensures correct movement without obstruction and reduction
- construction materials:
  - carbon or abrasion resistant steel
  - molded polyurethane
  - stainless steel
  - others on request

Drip Rings
- eliminates contamination of sample
- inside and outside of sample chamber

Top Mounted Inspection Doors in Three Places

Rotating Sample Cutter
- independent cutting
- radial openings with minimum 1.5% cutter opening
- 1 to 4 cutters available

Multiple Installation Configurations
- can be open bottom for mounting on pump box

Transition Connection
- pipe flange also available

Cutter Cap Technology
- latest improvements
- easily replaceable one-piece cap is always installed correctly

Extra Large Inspection Doors
- convenient for cutter maintenance
- hinged with latches for easy access

Low Profile Extra Heavy Duty Carriage and Frame
- cutter carriage mounted on rail supported by steel rollers and urethane thrusters

Rubber Lined Inner Surface
- natural rubber and neoprene material
- other special lining materials available on request

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The legend continues
Process Control Samplers

Thief cutters

Pressure Pipe Sampler

- Sample Out
- Sample Connectors:
  - Replaceable rubber-lined sample nozzle
  - Computer modelling for sizing each nozzle to the application
- Process Flow Out to Next Stage
- Process Connections:
  - Installs on a vertical process line near pump discharge
- Slurry Mixing Rods:
  - Turbulence rods promote proper mixing
  - Replaceable (UHMW) polymer covers
- Typical Applications:
  - Modelling streams in concentrate
- Process Flow In from Pump

Gravity Flow Sampler

- Inspection Door:
  - Positive seal
  - Threaded handle nuts
- Process Connections:
  - Installs on horizontal process lines
  - Flanged or weldable connections
- Cutter Cap:
  - Replaceable while process is flowing
  - Available with various cutter openings, sample flow adjustment
- Cutter Body:
  - Removed from top
  - Interchangeable cutter cap
  - Replacement without stopping process
- Rubber Lined Inner Surface:
  - Prevents wear
  - Special lining materials are available
  - Hot vulcanized process eliminates the problems associated with cold vulcanizing
- Sample Exit:
  - Non-restricted flow
  - Backwashing is eliminated by allowing all slurry entering cutter body to exit
  - Takes part of the stream all of the time

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The legend continues
Poor Samplers
Home Made

- OSA analyzes what it is presented
- Biased samples produce biased assay results
- “Garbage In - Garbage Out”
ANALYZING MINERALS FOR METAL CONTENT

The BOXA System

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The legend continues
OSA System Overview

- Samplers provide sample to the MXA’s
- Return lines go back to the process
- MXA’s direct a single sample to the probe to be measured
- CSA Sampler for calibration
- Assay results generated and sent to plant’s DCS and displayed locally
Interlocking safety
Electromagnetic/Mechanical
Visual Indication
Radiation safety

Certified By

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The legend continues
Electrical safety

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Country: China
Country: China
Contact: Mr. Wang Shihan
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Standard for Safety requirements for electrical equipment for measurement, control, and laboratory use
Part 1: General requirements
UL 61010-1, Ed. 3, Rev. 5/11/2012;
CNS/CSA C22.2 No. 61010-1, Ed. 3, Rev. 5/11/2012

Product: On-Site Reactive Fluorescence Analyzer
Brand Name: 
Models: BOXA-II

ATM for Report 15030100S6HA-001 Page 1 of 1
ATM Issued: 22-Oct-2015

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The legend continues
What is XRF

- X-Rays are part of the electromagnetic spectrum
- They interact with matter – ionizing.
What is XRF

• **The basic principles**
  – Excite the characteristic x-rays of the elements
  – Measure their intensities
  – Calculate concentrations from intensities

• **The energy (or wavelength) -> the element**
  – Each element’s (Cu, Zn,…) energy is unique

• **The element intensity -> the assay of element**
  – The higher the intensity, the greater the % of element

• **Equations are derived to calculate assays from intensities. This is called calibration.**
Measuring Range
ED & WD Measuring Principle
Amptek Detector

- Compact integrated system
- Used for XRF Instrumentation
- Si-PIN and SDD types used
- 2-stage thermoelectrically cooled
- Energy range 1keV to 40 keV

- Si-PIN resolution 145-260eV FWHM @ 5.9keV
- Si-PIN Maximum count range 200,000 cps

- SDD resolution 125eV FWHM @ 5.9keV
- SDD Maximum count range 100,000 cps
Spectrum Displays (ED & WD)

- Photons go into a detector and are converted to an electrical pulse, where the amplitude of the pulse is proportional to the photon’s energy.
- Thousands of pulses produce a spectrum.
- Energy dispersive channels have a continuous spectrum of all energies.
- Wavelength dispersive channels have a filter to reject unwanted energies.
• From the spectrum results, the count rates (intensities) of each element are calculated. At the same time a sample is taken from the analyzer and assayed by the lab.

• These count rates and lab assays are then used to calculate the element content in the slurry based on a derived formula
  – \%Cu = A + B* Cu Counts
  – \%Zn = A + B* Zn Counts + ........

• Formulas are derived using a regression analysis program
Channel Sets and X-Ray Tube

WD and ED Channels
Dedicated Channel Processor
Probe Electronics

- Houses XRF excitation and detection electronics, control electronics, calibration sampler and slurry flow cell
Probe Control Set

- Houses controllers for MXA’s, main controller and a display for operators
Multiplexers

- Used for sample preparation, de-aeration of sample, and feeding sample to the probe
- MXA and probe flow cell are flushed with water after each sample is measured
- Used for composite / shift samples
## DCS Modbus – Assay Data

<table>
<thead>
<tr>
<th>Address</th>
<th>Data</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>30001</td>
<td>MV 1 of SN1</td>
<td>F</td>
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<tr>
<td>30002</td>
<td></td>
<td></td>
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<tr>
<td>30003</td>
<td>MV 2 of SN1</td>
<td>F</td>
</tr>
<tr>
<td>30004</td>
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<td></td>
</tr>
<tr>
<td>30005</td>
<td>MV 3 of SN1</td>
<td>F</td>
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<td>30006</td>
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<tr>
<td>30007</td>
<td>MV 4 of SN1</td>
<td>F</td>
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<tr>
<td>30008</td>
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<td>MV 5 of SN1</td>
<td>F</td>
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<td>30010</td>
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<tr>
<td>30011</td>
<td>MV 6 of SN1</td>
<td>F</td>
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</table>
## DCS Modbus – Assay Data

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<thead>
<tr>
<th>Address</th>
<th>Alarm ID</th>
<th>Alarm Information</th>
<th>type</th>
<th>Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>31101</td>
<td>1</td>
<td>[1] Caution light for X-ray failure</td>
<td>I</td>
<td>normal</td>
<td>abnormal</td>
</tr>
<tr>
<td>31103</td>
<td>3</td>
<td>[3] Meas cell close failure</td>
<td>I</td>
<td>normal</td>
<td>abnormal</td>
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<tr>
<td>31104</td>
<td>4</td>
<td>[4] X-ray tube not on the right position</td>
<td>I</td>
<td>normal</td>
<td>abnormal</td>
</tr>
<tr>
<td>31105</td>
<td>5</td>
<td>[5] X-ray tube inner temperature over upper limit</td>
<td>I</td>
<td>normal</td>
<td>abnormal</td>
</tr>
<tr>
<td>31107</td>
<td>7</td>
<td>[7] Insufficient air pressure</td>
<td>I</td>
<td>normal</td>
<td>abnormal</td>
</tr>
<tr>
<td>31108</td>
<td>8</td>
<td>[8] X-ray tube surface temperature too high</td>
<td>I</td>
<td>normal</td>
<td>abnormal</td>
</tr>
<tr>
<td>31109</td>
<td>9</td>
<td>[9] Analyser temperature too high</td>
<td>I</td>
<td>normal</td>
<td>abnormal</td>
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<td>31110</td>
<td>10</td>
<td>[10] X-ray tube current lower than the set value</td>
<td>I</td>
<td>normal</td>
<td>abnormal</td>
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<tr>
<td>31111</td>
<td>11</td>
<td>[11] X-ray tube voltage lower than the set value</td>
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<td>31112</td>
<td>12</td>
<td>[12] X-ray tube current upper than the set value</td>
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<td>31113</td>
<td>13</td>
<td>[13] X-ray tube voltage upper than the set value</td>
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<td>normal</td>
<td>abnormal</td>
</tr>
</tbody>
</table>
Installation Example

Doe Run - Fletcher Mill

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The legend continues
BOXA Benefits & Advantages

• New construction
  • Majority of critical electronics' parts are from proven US suppliers
  • Cabinet is large enough to allow easy access for maintenance, not cramped - Rittal
  • Si-PIN / SDD detectors output spectrum to ARK PC, no requirement for separate HV, Pre-amp, and pulse processing – Amptek (they have a detector on the mars probe)
  • Reference is outside and mechanism is air driven, easier maintenance, no springs (fatigue), more reliable, no extra openings in x-ray tube housing (radiation and tight tolerances)
  • System is air cooled
  • X-ray tube is oil cooled, oil is air cooled, one unit - Varian
  • Database is SQL, open to customer, not proprietary
50+ yrs of XRF experience within H&S (Minexan 151, Beltcon 200, Courier 10/20/30/300/30XP/6/6i)
- Economical Investment with comparable quality
- Easy to install, calibrate and maintain
- Reliable system operation
  - stability of measurement cabinet & internal reference
  - improved calibration software BCRBGRIMM
  - power regulation - UPS
  - solid construction
  - current hardware & software
- Service & Engineering network to assist with measurement and sampling problems
Next Generation BOXA-III

- Designed in collaboration between BGRIMM and H&S
- PCS Control panel is removed
- Replaced with adjustable display
- MXA Controls moved into Probe set.
- Digital I/O wiring to MXA’s replace by communication line
- Reduces installation foot print
- Redesigned MXA/CSA by H&S
Benefits of OSA Systems

- Daily reconciliations and balances are accurately calculated (shift composite samples)
- Mass balancing can be done online (requires 3rd party software)
- Reagents can be adjusted online to control grade and recovery efficiently. Reagent consumption and their cost is reduced
- Process upsets can be quickly noticed and corrected
- Areas in the plant where losses are occurring can be identified and the required changes made
Benefits of OSA Systems

- Improved process production/recovery and quality/grade.
- Reduce process variability
- Economic optimization
- A small 1% process improvement in a $100M/yr. (small plant) production plant is $1M/yr. OSA system and installation is paid for in one year
- Think about $500M/yr. or more.

“Can you really afford not to have an OSA System”
Some $ Numbers

- $250K reagent savings – Kidd Creek [Thwaites, 1983]
- $1.5M improved grade and recoveries – Buick [Deister, 1985]
- Non-Optimal control effect of analysis cycle speed, Pyhasalmi Mine [Elsevier article, 2007]

With no OSA, measurement delays are in hours or days!!!
Thank-you from HEATH & SHERWOOD & BGRIMM