On-Stream Analysis – The need for performance

Author: Eric Hendrix

The on-stream analyser has become a crucial tool for optimising the recovery of valuable minerals from fine bulk ores, particularly in the case of metal flotation circuits. On line assays are able to indicate process disturbances that can be dealt with both manually and in many cases, through automated control, to optimise grade and recovery, thereby maximising the economic value of the ore body.

Output from the analyser is used to manipulate flotation process variables such as level, air rates and reagent dosage to achieve the optimum grade setpoint and thus maximum economic recovery. In this type of control, assay based trends are important in both determining the course of action to be taken and the success of this action. Two factors of importance in this process are assay precision and speed.

As with any control system, error in the measurement instrument and delay in measurement cause inaccuracy and sluggishness in the control. Hence, there is a direct relationship between revenue lost and assay accuracy and speed. The greater the error and slower the response, the larger is the loss of revenue. The key to accurate and fast analysis, and the heart of all analysers, is the x-ray tube and detector system.

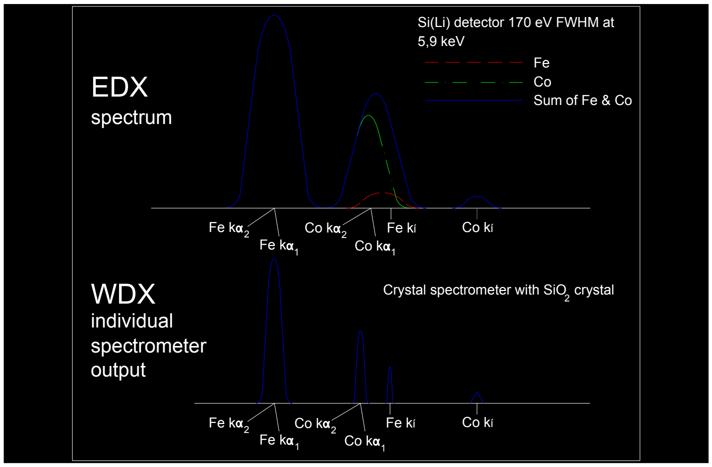
WD and ED detectors – What's the difference?

When energy in the form of radiation "excites" an atom, inner shell electrons are knocked out of the sample atoms. An electron from a higher energy shell then fills the electron vacancy and in doing so releases energy as a fluorescent photon. The wavelength of this photon is characteristic to the particular element and the number of photons represents the concentration of that element present in the measured sample. This is the principle of XRF analysis.

With WD (wavelength dispersive) detectors, a spectrometer is used to isolate the fluorescent radiation from a specific element. The technique is highly selective with excellent resolution. By comparison, ED (energy dispersive) detectors measure the entire spectrum of elements. Resolution is relatively poor and count rates are spread over many elements.

As a result, WD systems are able to be both selective in their analysis of individual elements and detect lower concentrations with greater accuracy and speed due to higher count rates.

The difference between the two techniques is illustrated by considering the measurement of Cobalt in low concentrations when in the presence of high levels of iron. While WD detectors can separate the Co and Fe peaks, it is virtually impossible to detect cobalt with ED detectors in this situation due to the closely overlapping peak of the dominant iron element.



EDX vs WDX Resolution for measurement of cobalt and iron Wavelength Dispersive Technology, 0.12% Zn

WDX also has an advantage over EDX systems when looking at the minimum detection limit (MDL) in slurries. While WDX systems can typically achieve down to 10ppm, EDX systems with solids state detectors can only see 100ppm and PIN detectors may see only 200-500ppm. This can have significant implications for dilute concentrations such as tailings and for samples containing elements whose atomic number are closely spaced.

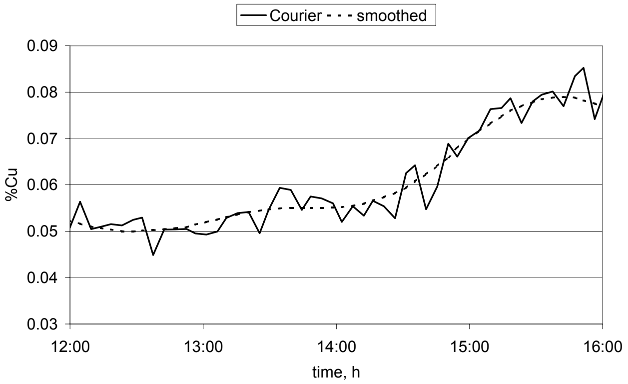
What does it cost to have inaccurate assays?

Saloheimo (2001) estimated the economic significance of running a plant with inaccurate assays as opposed to real concentrations. This comparison is reproduced below;

Let us pose the question: how much money do I lose at the plant if I run it according to inaccurate analyser assays, instead of real concentrations?

Figure 1 shows an actual plant trend produced by a high-powered on-stream analyser with a 5-minute cycle time. The smoothed line has been reconstructed from the trend data, to simulate the 'actual concentration', and the fluctuations around the line amount to ca. 0.0025% standard deviation, or around 5% relative precision.

Figure 1



If the tailings assay is noisy the control makes setpoint changes only when a change is clearly larger than the noise level. A good measure of the noise is the 2-sigma or 95% limit – when the signal gets above that value there is only 5% probability that no change ever happened. This means that, on an average, the control is behind the actual changes of the process, the difference being one sigma error on average.

To quantify this economically, let us assume for simplicity that the control can adapt to concentration changes accurately and promptly so that the recovery can always be held, say, within 0.5% of the optimal point. The measurement error adds to the fluctuations around the optimal operating point. If we assume that for most of the time the recovery is drifting somewhere between the optimal point and the 2-sigma limit, the loss is, on average, one sigma below what it could be with an ideal system.

Some numerical examples of the value of lost metal, scaled to 1 Mton/a ore feed, are given in Table 1. Two analyser examples are used with the relative accuracies,

- Analyser 1: 3% in concentrate, 3% in feed, 5% in tailings
- Analyser 2: 3% in concentrate, 5% in feed, 10% in tailings

In the calculation, average metal prices and treatment charges of Q4/2000 and typical transport costs have been used as base data.

Table 1. Accuracy losses due to decreased recovery, for 1 Mton/a production.

Case	Recovery	1-sigma error in recovery		Value of metal lost USD/annum due to analysis error	
		Analyser 1	Analyser 2	Analyser 1	Analyser 2
Cu circuit with 1.5% feed, 23% concentrate and 0.12% tails	93%	0.5%	0.9 %	$28 000	$81 000
Ni circuit 1.5% feed, 15% concentrate and 0.20% tails	88%	0.9%	1.7%	$136 000	$397 000
Zn circuit 4% feed, 45% concentrate and 0.45% tails	90%	1.0%	1.9%	$84 000	$221 000

This simple exercise has shown that there is significant value in understanding the performance of the analyser system with respect to accuracy and timeliness of analysis. In the above example, Analyser 1 performance is typical of a system utilizing Wavelength Dispersive (WD) detector technology combined with a high powered x-ray tube. Analyser 2 performance is typical of a system utilising Energy Dispersive (ED) detectors and a low powered X-ray tube or radiation source.

Clearly in today's modern concentrators where sophisticated control and optimisation systems are becoming the norm, assay quality in addition to reliability of on-stream analysers must be carefully considered.

Eric Hendrix is currently Manager - Automation for Outotec in Australia with over 20 years of experience in minerals processing. For the past 5½ years he has specialised in automation product sales, service and engineering for Outotec.

In recent years Eric has undertaken the development of automation installations for Outotec. His most recent project in this area is the supply and installation of the Outotec Courier®6 SL On Stream Analyser for Perilya Broken Hill. He also has extensive experience in process sampling and sampler design.

If you would like more information, click here to contact

Eric.hendrix@outotec.com