The high performance XRF on-stream slurry analyzers

State-of-the-art technology

Courier® SL analyzer systems offer unrivalled sensitivity and the shortest cycle times for process management, monitoring and control of all types of mineral processing plants. Outotec is the leading supplier of advanced process automation systems, control solutions and intelligent instruments to the mineral and metal processing industries. We are both a market and technology leader, having delivered more than 1000 on-stream slurry analyzer systems worldwide.
Timeliness of assays

The speed of accurate assaying provided by the Courier on-stream analyzers enables an immediate reaction to changes in the metallurgical behavior of the flotation circuit while monitoring the effect of such a reaction in real time. Frequent manual sampling, sample preparation and laboratory assays, as required for 24/7 real-time process control, is prohibitively expensive in terms of manpower and equipment.

If assays are based on strongly filtered or averaged measurements over a long period, they cannot be used for process control. A long time delay between actual process changes and the control action makes feedback control unstable and reported process trends misleading.

What can a Courier® analyzer do for you?

- Sampling and analysis are performed unattended in the same consistent way around the clock. This creates savings in assaying costs and metallurgical sampling.
- Recoveries are improved, as process upsets are detected early and solved rapidly. Frequent assays are necessary for real-time process monitoring and control.
- Concentrate quality is controllable and undesired variations are minimized. Plant operation is optimized with smaller circulating loads resulting in higher throughput.
- Taking into account sampling and sample preparation, assay accuracy is comparable with a routine manual sample-laboratory procedure as Courier on-stream analyzers use the same wavelength dispersive X-ray fluorescence (WDXRF) technology as high-performance laboratory analyzers.
- Results from process tests and changes are readily available, which motivates and speeds up process development.
- Modular Courier analyzer systems can be easily upgraded and expanded as plant requirements change.
Analyzer network

The local Courier user interface displays the assays, trends and analyzer status information. It can also be used to set up and modify the operation of the Courier analyzer. The local user interface collects analyzer system calibration and diagnostic data for local and remote support. Log and scheduled assay reports can be generated in the user interface PC and shared through the plant network with operators and metallurgists.

Several Courier analyzers can be networked to share common remote user interface PCs. Local and remote user interface operation are very similar in order to minimize learning and configuration time. Outotec’s Outocal™ calibration program can run on one of the networked PCs to access calibration data and calculate the best models for assay calculations. Two redundant process control system connections are available at the analyzer electronics for good availability of assays.
You have to measure it in order to manage it!

**Flash flotation control**

Monitoring the grinding circuit flash flotation concentrate grade helps to produce high-grade concentrate, which is easy to clean or mix directly with final concentrate, providing significant overall recovery improvement.

**Primary rougher flotation control**

Monitoring the primary rougher concentrate grade enables the production of high-grade concentrate.

**Rougher control**

The rest of the flotation circuit is much easier to run, if the rougher section is working properly. Roughers should produce optimal grade rougher concentrate with an acceptable recovery rate.

Rougher tails must be monitored for recovery control. If the rougher tail grade is too high, there is often insufficient scavenger circuit capacity to prevent a recovery loss. Concentrate grade is controlled by flotation cell air, level and reagents. The optimal concentrate grade depends on the feed grade, mineralogy, circulating loads and cleaner capacity. On-stream analysis provides vital information for optimizing rougher concentrate production.

FrothMaster™ 2 froth cameras are used to complement Courier assays to optimize concentrate pull in each cell in a row.
Cleaner control

Maintaining final product quality is critical, while keeping an eye on circulating loads in the cleaner section. The Courier system is able to measure low assays of penalty elements in the presence of a high main element grade to ensure consistent production of the best quality concentrate.

Scavenger control

Since the rougher tails are already controlled based on the Courier assays, the scavengers simply lower the final tails assay. Accurate tails assay measurement is important for recovery monitoring and requires a highly sensitive and accurate analyzer. The scavenger concentrate assay is monitored to keep the circulation load under control.

Flotation circuit control

Typical basic control loops used in flotation are illustrated below. Successful assay control requires that the key operating parameters of a flotation machine are managed.

Basic control loop setpoints are determined by the process operator or an expert system. The Outotec Advanced Control Tools package (ACT) can be used to optimize circuit operation. See left for an example of a typical grade-recovery optimization scheme.

The operation of each flotation cell in a rougher row is balanced by froth speed measurements to meet rougher concentrate grade target with best possible recovery.
Courier® slurry analyzer system

Primary sampling

A representative primary sample of the process stream is sent to the multiplexer for secondary sampling. A range of proven Outotec primary samplers is available for various process designs. The low head required by the Courier analyzers usually allows transportation of sample flows by gravity without the need for pumping. Small process flows can be fed through the analyzer secondary sampling system without sampling. Depending on the process requirements, the primary sample flow can be continuous, with or without automatic periodic flushing. Alternatively, the sample flow can be stopped and the delivery line flushed automatically between measurements. This improves sample availability if the slurry contains trash, oversize particles or it forms deposits. Controlled primary sampling is a standard feature in the Courier analyzers.

Secondary sampling

The full primary sample flow is switched between bypass and level controlled analyzer feed tank by a two-way air cylinder actuated sample hose. The same cylinder moves the hose in opposite direction across a cutter, at programmable intervals in order to collect a representative composite sample. Trash is removed from the samples by self-cleaning screens and entrained air is minimized in a level-controlled constant head feed tank. The tank provides a stable sample flow to the analyzer flow cell. Primary sample availability and flow rate are monitored for diagnostic purposes. The multiplexer is designed to minimize sample changeover times in large systems. While a sample in one multiplexer is being measured, the next sample is already being conditioned in the second multiplexer unit. This allows a fast measurement cycle for all streams. The measurement sequence is fully programmable. For example, critical streams can be measured more frequently and longer measurement time can be used for low grade tailings streams. The switching time between samples is used for internal reference measurements, which are used for monitoring and automatic drift compensation.

Assaying

The Courier 5i and 6i SL analyzer probes combine the high-performance wavelength and energy dispersive X-ray fluorescence methods in a unique and cost-effective way. Automatic reference briquette measurements between sample measurements compensate for drift and provide on-line self-diagnostic tool. The analyzer probe contains the core analytical components of the analyzer in an IP56-rated (NEMA 4X-compliant) stainless steel enclosure.

Features of Courier® SL analyzers

- Unrivalled sensitivity
- Short cycle time
- Lower assaying cost
- Modular system can be tailored for any site and updated as required
**Calibration sampling**

The built-in calibration sampler enables an operator to take a truly representative and repeatable sample from the actually measured slurry for comparative laboratory assays. The calibration data can be read from the analyzer into a networked PC for the Outocal™ calibration program.

**De-multiplexing**

With high grade samples, optional de-multiplexing can be used to divert the small intermittent 25 l/min measured flow to the desired return line.

**User interface**

The analyzer local user interface panel high resolution touch screen shows the most recent assays, assay trends, sample line and analyzer status information. Some control switches and indicator lamps complement the panel. The sampling and analyzer control cabinet houses interface and control modules for primary and secondary sampling system monitoring and control.

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**Courier® 5i SL medium power analyzer model**

Courier 5i SL analyzer is designed for accurate and reliable on-stream X-ray fluorescence (XRF) measurement of element concentrations in slurries for up to 12 sample streams and normal concentration levels. It has a lower power X-ray tube than Courier 6i SL, which allows the use of smaller power supplies and a Peltier cooling system.

**Courier® 6i SL high-power analyzer model**

The Courier 6i SL is a high-performance member of the Courier on-stream XRF analyzer family for the real-time assaying of slurry process streams. This high-power analyzer system offers unrivalled sensitivity and the shortest cycle times for process management, monitoring and control of all types of mineral processing plants.
The secrets of high performance

Sample presentation

The patented JetCell™ technology ensures that a representative fresh sample is always presented for assaying at the window surface. The flow cell window is kept clean and free of scaling caused by active slurry contact. The window can be changed manually or automatically using the AWC 4030 Automatic Window Changer option.

Analysis

Courier excites the sample in the flow cell sensitive layer using a high-intensity X-ray tube. Atoms in the sample react by emitting fluorescence radiation, characteristic of each individual element in the sample.

Courier 5i and 6i SL analyzers use high-resolution wavelength-dispersive analyzer technology for critical assays. Complementary energy-dispersive technology is used to increase the range of elements analyzed and to extend the capability of the system to measure up to 12 assays per stream.

Analyzer system control

The primary and secondary sampling system and analyzer measurements are controlled by electronics in the PCS 6750 cabinet. The modular system includes several ICM 4300 Interface and Control Modules connected by a high speed serial bus. Each multiplexer unit is controlled by its own ICM module. Primary sampling is controlled by the I/O available in the multiplexer control ICM modules or dedicated modules in large analyzer systems.
Wavelength-dispersive technology
The wavelength-dispersive detection channel measures only the narrow element peak (blue). A high-resolution spectrometer separates the peak before it reaches the detector. Nearby element peaks do not overlap and the background signal is minimal. Because the full capacity of the detector is used for the relevant peak only, a high-power X-ray tube can be used and analysis speed and sensitivity are high. Wavelength-dispersive detection is deployed by high-performance laboratory analyzers. Several element-specific wavelength-dispersive channels are used in Courier analyzers for the simultaneous measurement of all critical elements.

Energy-dispersive technology
The energy-dispersive detection channel ([Si]Li, Si-PIN, SDD or proportional counter) measures the whole spectrum (blue). Measuring a small Zn peak (green arrow) is a challenge, since most of the detected counts cannot be used for the specific assay. Limited resolution and its deterioration with count rates above 10 kcounts per second usually limit useful X-ray intensity. Analysis speed and sensitivity are low. Energy-dispersive detectors can be used for less critical measurements of high-grade assays, as a cost-effective complement to wavelength-dispersive detectors. One energy-dispersive detector can measure several element peaks at the same time.

Periodic table of elements

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X-ray fluorescence (XRF) analysis of slurry samples
Slurry and air attenuate strongly the low energy XRF signal from light elements. This makes on-line analysis of elements lighter than calcium (Ca) impractical. With flow cell technology, the analysis of heavier elements is possible as the fresh representative sample is brought right onto the surface of the measurement cell window.
Specifications

Analysis method
The wavelength-dispersive X-ray fluorescence method uses X-ray tube excitation. Energy-dispersive channels are available. No radioactive isotope sources are used, minimizing exposure, fire and disposal risks.

Number of sample streams
One Courier 6i SL analyzer system can measure up to 24 sample streams ( Courier 5i SL 12 streams). Each multiplexer module handles up to 6 sample streams.

Number of simultaneous assays
The Courier 5i and 6i SL analyzers can provide up to 12 simultaneous assays for elements from calcium to uranium (atomic numbers 20 to 92) and solids content from each process sample. Assay calculation models can be automatically switched according to changing mineralogy.

Sample measurement time
The sample measurement time is selectable for each sample, the typical time being 15–30 seconds (Courier 5i SL 60 seconds).

Analysis cycle
The normal analysis cycle for 12 samples is 12 minutes, and 16 minutes for 18 streams (13–16 minutes for 12 stream Courier 5i SL), depending on the measuring time for each sample. Assays are calculated and reported based on freshly measured data for a true, real-time analysis.

Measurable concentration range
The typical measurable concentration range is 0.004%–100% by weight for slurries.

Stability
The analyzer’s short-term stability under the specified conditions is better than 0.1% relative. Automatic internal reference measurements compensate for long-term drift.

Minimum detection limit
The WDXRF-measurement channel’s detection limit is 3–30 ppm for most elements in slurry samples. Using the EDXRF-measurement channel, the minimum detection limit is typically 100–500 ppm.

Accuracy
Outotec’s accuracy specification is based on the measurement of flowing slurry samples using measurement times for real applications. Briquette measurements and long measurement times give unrealistic results. Accuracy of measurement is a function of sample parameters such as matrix composition, mineralization and particle size. Typically, under normal operating conditions, a 3–6% relative standard deviation for minor concentrations, and a 1–4% relative standard deviation for major concentrations, is achieved for individual slurry sample measurements of concentration levels well above the minimum detection limit.

Analyzer calibration
An optional integrated calibration sampler takes a repeatable and representative sample for analyzer calibration. The Outocal™ software is available for interactive calibration model design.

Maintenance
The Courier 5i and 6i SL analyzers are designed for minimal maintenance. Analyzer probe window change is automatic, with an Automatic Window Changer option. The analyzer system has built-in self and remote diagnostics capabilities. Continuous training, proactive and corrective service agreements are available.

Installation requirements
The Courier 5i and 6i SL analyzers can be installed on one level ( low–head) or two levels. Analyzer has to be protected from direct sunlight preferably in a prefabricated shelter.

Flushing water
Sand-filtered raw water, 2–6 bar (30–85 psi) average 30 l/min (8 gal/min) peak 100 l/min (26 gal/min).

Instrument air
Pressure 5–10 bar (75–145 psi) 16 l/min (0.6 norm. cuft/min) average consumption.

Power supply
Single phase AC, 230 V +10%, -15% at 10 A 50/60 Hz or 115 V ±10% at 20 A 50/60 Hz. Double conversion 3 kW UPS, 10 minutes minimum (Courier 5i SL 1200 W).
Operating ambient temperature at sea level
+5 – +45°C (41–113°F), no condensation. Temperature control is based on an air-cooled chiller. [Courier 5i SL has Peltier cooler] Local and remote operator interfaces up to +32°C, with cooling option up to +45°C ambient temperature.

Storage temperature
-25 – +60°C (-13 – 140°F)

Environmental classification
Analyzer multiplexers, probe and probe control set, IP56 (designed to meet NEMA 4X).

Shipping and installed weight
The typical total shipping weight is 1000 kg (2200 lbs) for a 12-stream system, and 1250 kg (2750 lbs) for an 18-stream system. Each 6-stream multiplexer unit weighs 225 kg (500 lbs). Primary samplers and sample transportation are not included in the above weights.

ISO 9001 quality assurance
We are ISO 9001 certified and have a rigorous quality management policy to ensure that the customer’s quality expectations are met.

The analyzer is certified according to the EMC, LVD and MD directives.

Note:
These specifications are for a typical configuration and project scope only. Actual scope and performance data vary according to individual plant and project specifications and product variations. Please see the product data sheets and installation manual for details.
Outotec develops and provides technology solutions for the sustainable use of Earth’s natural resources. As the global leader in minerals and metals processing technology, Outotec has developed over decades several breakthrough technologies. The company also offers innovative solutions for the chemical industry, industrial water treatment and the utilization of alternative energy sources. Outotec shares are listed on the NASDAQ OMX Helsinki.