Improving Productivity and Safety Through More Efficient Separation and Leaching

Advanced diagnostics are the key to reliable pH and ORP measurements

By Dave Joseph

Today's smart liquid analysis systems make controlling separation and leaching processes in gold and copper operations far more reliable than ever before, enabling compliance with environmental regulations while increasing yields, reducing costs and improving safety.

When the pH and oxidation reduction potential (ORP) values in process fluids are correctly maintained based on accurate instrumentation, the release of cyanide gas is prevented, and the destruction of dissolved cyanide in wastewater is assured. When operators can count on the validity of every measurement, they don't feel the need to apply extra chlorine to assure cyanide removal, saving money and avoiding potential problems with excess chlorine in effluent streams. In addition, the continuous record of online measurements taken on effluent streams can be most useful in providing proof of compliance if required by regulators.

However, accurate and reliable measurements are not always easy to obtain in separation and leaching operations because the sensors are regularly subjected to coating and/or breakage when immersed in harsh mixtures. In some cases, they may not even be immersed. Measurement accuracy is greatly increased by using advanced, microprocessor-based instruments with state-of-the-art sensors designed to withstand the rigors of these processes. Reliability is assured through diagnostics that inform operators if a sensor is coated or broken and needs to be cleaned or replaced.

The real value of monitoring pH and ORP in metals processing is realized when mine personnel are able to rely fully on their instruments for better process control, resulting in:
- Maximum yield/throughput;
- Reduced separation costs with minimum waste;
- Stable process operations;
- Better protection of personnel and the environment; and
- Lower labor and maintenance expenses based on latest calibration techniques and good training.

Instrumentation

Effective use of analytical instrumentation in separation and leaching minimizes costs and maximizes yields. When mine personnel have confidence in the reliability of their analytical instruments, they can more effectively control the use of chemicals in mining slurries. Without that assurance, they may disregard the measurements altogether. In this case instrument maintenance could suffer, leading to even poorer performance.

Flotation is the most common method of concentrating crushed copper ore, whereby iron and other contaminants are separated from the copper sulfide slurry. In this process, copper sulfide particles latch onto bubbles in a froth created by foaming agents and air injected into the flotation cells. The copper-rich froth is skimmed off and dried to form a copper concentrate. The effectiveness of this concentrating step depends on maintaining a specific pH range so the bonding action can take place. With the recent drop in copper prices, a more efficient concentration process may be the key to continued profitability.

A well-regulated flow of lime slurry is used to keep the pH in the flotation cells within an acceptable range. If the pH is too high, iron will be entrapped with the copper, decreasing the value of the copper concentrate. If too much lime is added, the result is a diluted froth that requires further concentration in subsequent stages, wasting lime and increasing operating costs. This is why accurate and reliable pH measurements are so necessary.

Both accuracy and reliability are likely to be altered if the pH sensor becomes coated, which is a very real possibility when immersed in the frothy liquid. A "best practice" is to use sensors specifically designed to resist coating. Also, the analyzers mounted near the flotation cells should transmit continuous diagnostics to alert plant personnel if a sensor has become coated, causing erroneous signals. The operators will then know the readings are unreliable, and the sensor should be cleaned.

In the leaching and extraction of precious metals where cyanide is commonly used, both pH and ORP measurements are essential for efficiency and safety of personnel. For example, pH values below 11 may allow the formation of hydrogen cyanide (HCN) which is a highly toxic, yet colorless gas. Since the formation of HCN removes active cyanide from the leaching process, effective pH control both improves the leaching process and minimizes the risks to the environment and mine personnel.
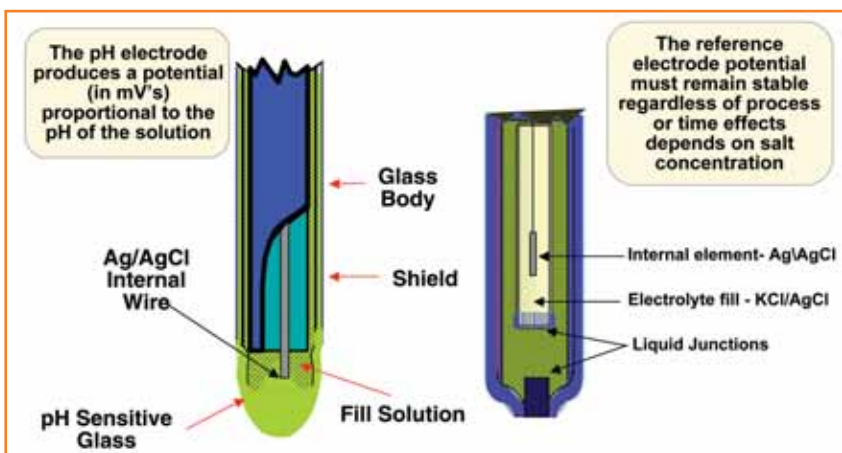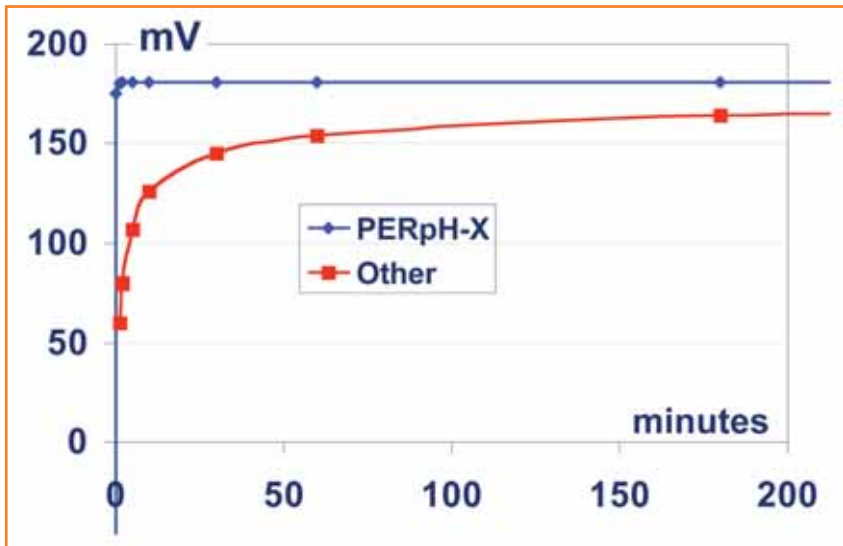

Figure 1: Conventional pH sensor.

The pH electrode produces a potential (in mV's) proportional to the pH of the solution

Ag/AgCl Internal Wire

pH Sensitive Glass

Glass Body

Shield

Fill Solution

The reference electrode potential must remain stable regardless of process or time effects depends on salt concentration

Internal element- Ag\AgCl

Electrolyte fill - KCl/AgCl

Liquid Junctions

Figure 2: Graph showing response time for the Rosemount Analytical PERpH-X sensor.

Figure 3: pH Model 3300HT.

However, continuously measuring pH with inline sensors in this environment is complicated by the abrasive nature of the leaching solutions. The glass measurement electrodes can be abraded and coated with lime. The pH sensor must be rugged enough to withstand abrasion, ward off attack by the cyanide and resist coating.

In waste treatment, it is very important for personnel to know both the ORP as well as the pH to control and verify the total destruction of waste cyanide streams. An oxidant, typically chlorine, is commonly used to prevent cyanide from entering waste streams, and the ORP indicates whether the solution is under oxidizing (high ORP) or reducing (low ORP) conditions. Since cyanide cannot be present under oxidizing conditions, an oxidant is added to the appropriate stream, causing the ORP to rise and the cyanide to be converted to cyanate and then to harmless nitrogen and carbon dioxide.

By carefully watching the pH and ORP readings, mine personnel are able to maintain a proper balance between the amount of chlorine used and cyanide destruction. The reaction is complicated but is best managed when mine personnel receive accurate information from dependable instrumentation. Having accurate pH improves the accuracy of ORP readings by removing interference from other chemicals. In addition, maintaining the correct pH is necessary to protect against a discharge of hydrogen cyanide gas which can be generated during the multi-stage process by the addition of too much chlorine.

Sensor Selection

Conventional pH sensors have a measurement (typically glass) electrode and a reference electrode to complete a current loop (See Figure 1). Both must be in contact with the process solution, but any coating build-up around either electrode will degrade performance, slow the response, and eventually render the sensor unusable.

The glass membrane is very thin and can be broken if hit with a sharp or hard object. Thicker glass is more resistant to impact damage, but more likely to be damaged by temperature swings. Interestingly, fewer pH sensors are damaged by impact than one might think. The hemispherical dome of the glass bulb is actually quite strong. The reference electrode uses a small flow of salt solution (electrolyte) to complete the current loop through the process. If the reference is blocked by coating, the current is disrupted and the pH sensor is no longer functional.

Speed of response with pH and ORP readings is critically important in cyanide applications (See Figure 2). Since pH and ORP measurements are nonlinear, controlling processes can be a challenge. Frequently, readings will change little until almost enough chemical has been added, and then a large change occurs. If the sensor does not respond quickly to a change, the reading will overshoot and unstable oscillations can occur. Older pH sensors and coated pH sensors will respond slower than new clean sensors, but with conventional sensors the operators cannot easily determine the source of the problem.

Visual inspection rarely reveals faulty sensors. They can be checked in a buffer where a slow responding sensor can be identified. However, this takes time, and mine personnel rarely remove sensors to check their condition.

State-of-the-art sensor technology overcomes these issues by delivering longer life sensors that respond very quickly to process changes and need cleaning less frequently. This is very important in protecting both the environment and mine personnel from possible exposure to the
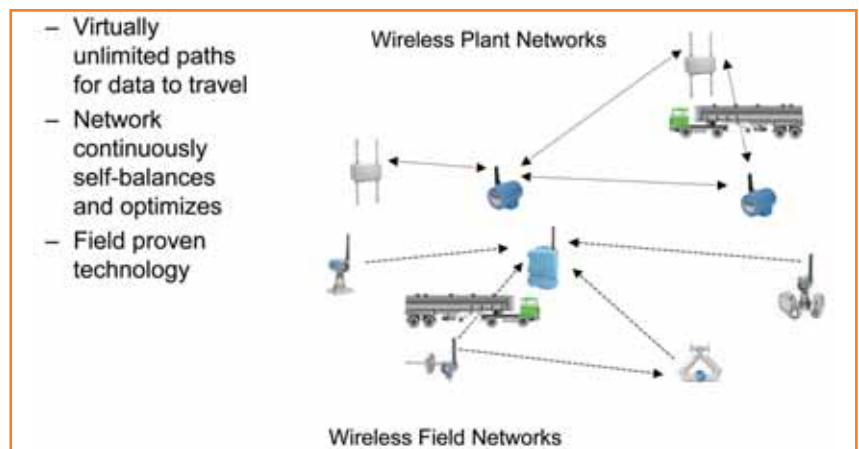

- Virtually unlimited paths for data to travel
- Network continuously self-balances and optimizes
- Field proven technology

Figure 4: Smart wireless networks based on self-organizing technology.

Key Features
- HART v.7 *Wireless*HART Compliant
- Encrypted Data Transmission
- Omni-Directional Antenna
- Power Optimized Electronics
- I.S. Power Module; 2+ Years @ 1/min. update rate
- Intrinsically Safe design
- Compatible with Existing non-preamp pH Sensors
- Supports Multiple Menu Languages

Figure 5: Rosemount Analytical Model 6081-P wireless pH transmitter.

dangerous effects of the chemicals involved, and the Rosemount PERpH-X sensor is designed for just such service (See Figure 3). Both pH and ORP measurements are made with similar sensor designs, differing only in measurement electrode.

New analytical devices generate online diagnostics, providing additional value by informing users when a sensor is not immersed, needs cleaning, or is broken and needs to be replaced. They can even tell if sensor performance is below expectations.

The usual response from operators is that diagnostics sound nice, but end-users are unable to separate an important alarm (i.e., "failure-disregard reading") from a simple warning. Rosemount offers both failure and warning diagnostics that are appropriately labeled, so diagnostic messages are easy to understand and can be acted upon in a preventive or reactive manner as desired. Detailed explanations are available at the analyzer, giving users options on how to proceed.

When these analytical devices are used as components of Emerson's PlantWeb plant automation architecture and DeltaV control system, the field-generated diagnostics can be used for instrument reconfiguration and calibration without sending technicians out to the analyzers themselves. The Rosemount Analytical solution keeps mine personnel informed of the status of their sensors and whether they can be relied upon to deliver accurate readings.

Wireless technologies can have a dramatic impact on mining operations in two broad categories: wireless field networks for sensor and field device applications, and wireless plant networks for business and operations purposes (See Figure 4).

Self-organizing wireless field networks (WFN) are based on the WirelessHART communications standard which was adopted in 2007 by more than 200 member companies of the HART Communication Foundation.

The field devices in a self-organizing wireless mesh network actually communicate with each other, so there is no single point of failure. Every device serves as a network connector, automatically finding the optimum communication pathway to the network gateway. In the event a temporary obstruction blocks a direct connection, signals are automatically rerouted via an adjacent device, ensuring network reliability and data integrity.

Numerous WirelessHART field devices are available for a wide range of applications. Figure 5 is one example. Others are designed to transmit temperatures, pressures and flows; data from vibration monitors and analytical equipment; and valve position and deviation to process control and asset management systems.

Wireless plant networks (WPN) are based on IEEE 802.11 standards and use mesh WiFi technology to build cost-effective wireless networks for use in mine operations. The WPN is designed to provide a secure, high-bandwidth, reliable, and scalable way to access fixed and mobile applications, such as backhaul or bridging to process data, personnel or asset tracking, process and security video,, and voice communication. Typically, a wireless plant infrastructure is constructed from mesh access points, a LAN controller, and network management software.

Wireless devices can be installed quickly and easily where wired devices cannot—in hard to reach locations, areas hazardous to mine personnel, where power doesn't exist, and where running wires is not allowed, to name a few. Data retrieved from these devices enables mineral processors to respond to equipment problems immediately and even predict when problems will occur in order to make timely repairs and avoid unexpected downtime. With this will come process improvements and greater equipment availability. The ultimate benefit is a combination of lower costs and increased productivity.

Mines can save money by utilizing continuous online pH and ORP measurements along with the diagnostics available from today's smart analytical instruments. A return on investment in advanced technology can be achieved within one year (See Figure 6).
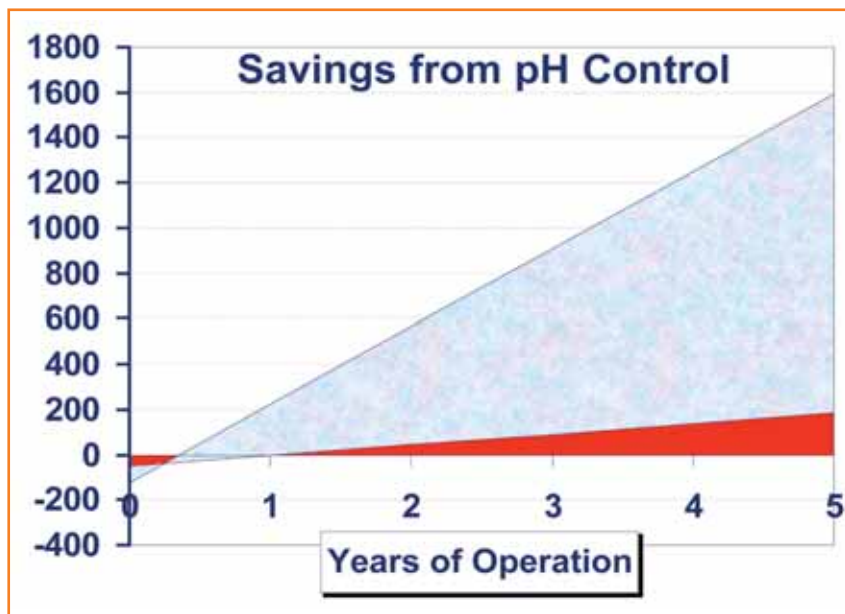
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Figure 6: Savings from pH control.