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The power of passive sonar technology

Real-time, entrained air measurement improves process optimization and efficiency.

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In the 1950s, the U.S. Navy and British navy began to investigate passive sonar, in which an array of sensors detects noises from a target submarine. Prior to this, navies used active sonar, whereby a submarine emitted a signal that reflected off a target submarine. Unfortunately, this let the target know it was monitored. Passive sonar systems allow the submarine to become stealthy by "listening" to noise emitted from a target submarine and by utilizing a series of sensors — equally spaced on a cable — to receive signals from a target passively. Powerful sonar algorithms convert the signals (pressure fields) into actionable information.

Passive sonar flow technology is the newest flow measurement technology since vortex, Coriolis and ultrasonic flowmeters were introduced in the 1960s and 1970s. Engineered for a wide range of multiphase and single-phase flows, the technology is especially well-suited for erosive and corrosive slurry flows, such as in the mineral processing industry, since the flowmeter installs and measures from outside the process pipe and does not contact the process media. The ability of the sonar technology to passively measure flows from the outside the pipe enables unprecedented measurement performance and reliability in highly aggressive slurries and fluids, which is designed to virtually eliminate maintenance costs associated and process downtime experienced with traditional slurry flow technologies such as electromagnetic flow and ultrasonic meters.

Dual measurement capability

Passive sonar flow technology provides two distinct but synergistic measurements: volumetric flow and entrained air percent by volume. This provides process engineers, metallurgists and operations personnel with a combination of unique, real-time and value-based tools to reduce process variability and help optimize the process. Efficient operation of each key process stage in a minerals processing facility, as an example, requires accurate information of the process production rate through an accurate mass balance calculation.

Often flow measurement offsets and reliability issues experienced with conventional flow instrumentation are caused by the nature of the meter technology, which requires contact with the process media. Whether issues are caused by slurry abrasion — which leads to wear and drift in measurement or changes in material or magnetic properties of the ore being processed — plant personnel have no practical way of knowing which process variable is contributing to the error or anomaly. Air bubbles (entrained air) in the slurry or fluid also negatively affect the measurement and performance of conventional flowmeters. With all these variables, it is difficult for personnel to identify the exact nature of the problem so the root cause can be determined.

Unlike the electromagnetic meter, the sonar flow and entrained air meter is externally mounted onto a pipe and does not contact the process media, eliminating two variables that process engineers have to deal with: flow and entrained air. Correlating these two measurements with tank levels, pump output, density and other process equipment metrics, process engineers and metallurgists are better positioned to help determine root causes of process upsets and be assured of flow accuracy.

Sonar flowmeters have been in service for more than 14 years with zero maintenance and no need for recalibration. Besides measuring flow from outside of the pipe, the passive sonar array-based technology can measure the percent air by volume in a slurry or liquid stream. Entrained air in slurry streams can lead to appreciable offsets in mass balance calculations and make it difficult to optimize the process for increased efficiencies in production. So how is this unique combination of synergistic measurements made and how are they utilized in practice to provide process and operational efficiencies that conventional flowmeters cannot provide?

Sonar technology principles of operation

Passive sonar flow processing employs two techniques. The first technique measures volumetric flow rate by monitoring the turbulent "eddies" within the process flow. Passive sonar flow technology provides a direct measurement of the average bulk velocity and a full-bore measurement. The volumetric flow is derived when the inner diameter of the pipe is known.

The second technique measures the speed at which sound propagates through the fluid to provide compositional information. The sound speed measurement made by the passive sonar meter is a real-time, direct measurement from which the gas void fraction (entrained air percent by volume) measurement is derived. Volumetric flow and entrained air measurements can be provided as separate outputs to the distributed control system. The entrained air measurement is particularly synergistic with the sonar volumetric flowmeter because the measured sound speed can be used to determine the volumetric fraction of the two-component mixture, whereby the total volume of the flow can be adjusted to a "true" flow measurement of the slurry or liquid flow, as shown in Figure 1.

Process industries around the world have realized the full value that a real-time, entrained air measurement can provide in terms of process optimization improvements and efficiencies. Passive sonar entrained air measurements are used across diverse industries to correct the density measurement from a nuclear density gauge when entrained air is present, enabling the accurate calculation of true mass flow rates. Depending on the specific gravity of the process media, even a small amount of entrained air in a slurry or fluid can cause exponential errors in the density measurement (see Figure 2). With sonar flow technology, process engineers, metallurgists and operations personnel can rely on two variables — flow and entrained air — when performing a mass balance and in daily monitoring and control situations.

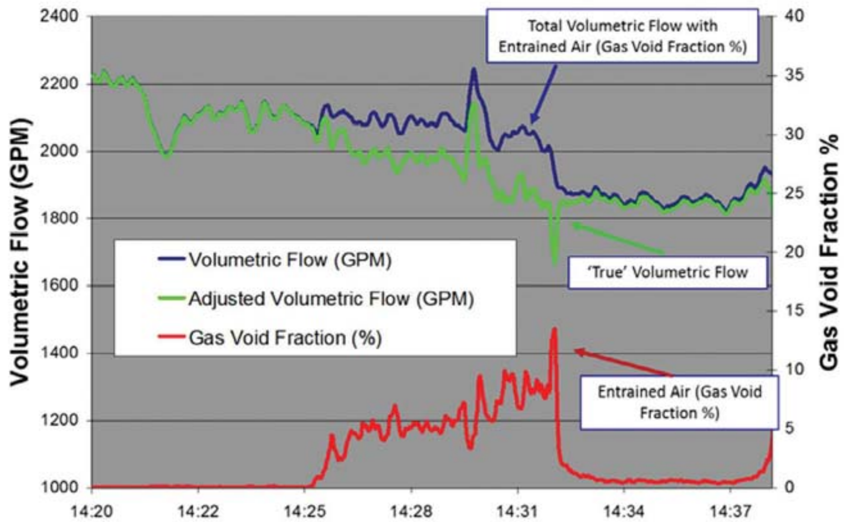

Figure 1. Measurement of air volume and volumetric flow correction. This chart shows how passive sonar is utilized to adjust the volumetric flow to a "true" flow when entrained air is present in slurry and liquid flows. *All graphics courtesy of CiDRA*

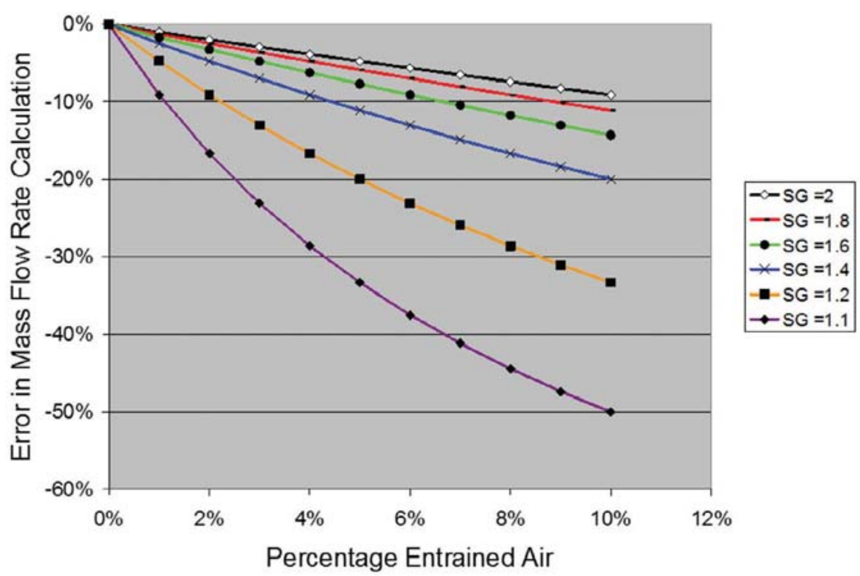

Figure 2. Entrained air corrects errors in density caused by the presence of entrained air/gas.

Case study: Hydrocyclone feed line installation

Measuring volumetric flow rate on a hydrocyclone feed line in a copper concentrator is challenging for any conventional flowmeter. Doing so with highly abrasive slurry containing entrained air and, in some cases, magnetite, poses additional challenges.

Hydrocyclone feed line installation

Images 1 and 2 depict example installations for a passive sonar flowmeter (Image 1) and an electromagnetic flowmeter (Image 2). Though this is a challenging piping configuration, the passive sonar meter performs well, and since the flowmeter is installed outside the pipe, no possibility of leakage exists. Image 2 shows the leakage problems that can occur within a brief time in service.

As noted, the nuclear density gauge measurement is subject to error produced by entrained air in the slurry, which is typically caused by low sump levels that draw air into the slurry or by leaks in the pump feed pipe, to name a couple. It is extremely important that entrained air be eliminated from the slurry to the hydrocyclone because: (1) if entrained air is present, the lining wear rate will increase and cyclone performance will deteriorate and (2) more important to mineral recovery and throughput, entrained air can cause coarse particles to report to overflow.

Passive sonar flow technology's capability to provide a real-time, entrained air measurement can be used to monitor and measure entrained air in a slurry. Then, an operator can take preventive action for increased cyclone recovery and correct errors in the density measurement for improved mass balance accuracy.

Image 1. (Left) Passive sonar flow and entrained air meter

Image 2. (Right) Electromagnetic meter

Having a more accurate reading of flow will enable a more accurate control of the mill circulating load. A 1-percent tighter control of the circulating load will equate to a 1-percent increase in mill throughput. This mill throughput increase could translate to about $2 million per year (100,000 tons per day, copper grade of 0.5 percent, 85 percent recovery and 28 percent concentrate grade at $2.50/lbs). Tighter control of the slurry feed density to the hydrocyclone battery will translate to a tighter particle size distribution to flotation. The sensitivity of product recovery to particle size distribution is highly dependent on site-specific parameters. Assuming a 1-percent increase in recovery can be achieved by controlling feed density, this would translate to approximately another $2 million per year.

Passive sonar flowmeters provide savings related to maintenance expenses and process downtime. Typically, an electromagnetic flowmeter lasts anywhere from six months to five years and requires periodic recalibration depending on the ore body composition and the slurry velocity. The life cycle cost of an electromagnetic flowmeter in a concentrator is greater than just the initial capital cost, not including the cost of process downtime when the flowmeter must be removed for repair, recalibration and replacement.

Summary

The volumetric flow rate in a hydrocyclone feed line is an important measurement when processing ore in a closed-circuit milling operation. To optimize a circuit, reliable instruments are a must. Control systems depend on accurate measurements to reduce system variability and shift the operating point to the point of maximum efficiency. Flow measurement is integral to a flotation circuit control strategy. Entrained air measurement provides value in several ways:

- The passive sonar flowmeter is not subject to loss of performance because of entrained air or when magnetic ore such as magnetite, arsenopyrite and pyrrhotite is present in the slurry. (This is in contrast to electromagnetic meters.)
- Circulating load calculations improve when removing air from the calculation.
- Mass balance accuracy increases when removing air from the calculation.
- Frother addition rate may be adjusted using volumetric feed rate versus tons of ore in mill feed.

The accuracy gained by leveraging passive sonar's entrained air measurement can provide the mill with increased throughput and recovery gains. FC

John Viega serves as vice president, global sales and service at CiDRA. He has more than 30 years of experience. Viega also serves as president of CiDRA Oilsands Inc., which is focused on providing services and products to the mineable oil sands industry that enable increased production and efficiencies. He holds a Bachelor of Arts in economics and an MBA, and he has completed course work toward a Master of Science in international management.