Precise Air Flow Measurement Improves Efficiency of Mining Froth Flotation Cells

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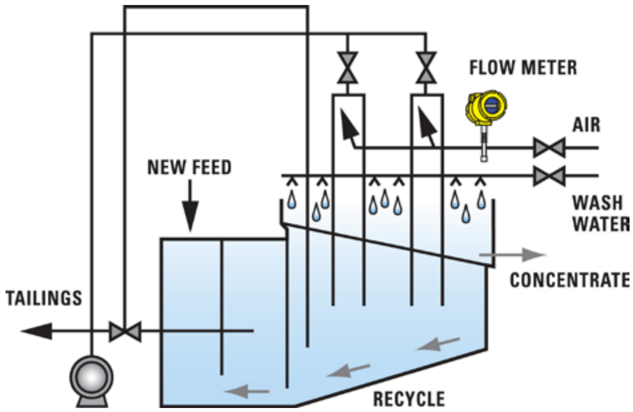

Figure 1: Typical froth flotation cell process with flow meter

A major international mining operator extracting precious metals wanted to optimize its froth flotation cell's performance at one of its mines. The flotation cell was experiencing production efficiency issues that were resulting in lower than ideal yields at higher costs.

Froth flotation cells separate minerals from pulverized ore slurries based on the difference in the hydrophobicity of the minerals and the ore waste tailings. The froth flotation process separates the lighter minerals from the heavier waste tailings.

In froth flotation cells, the pulverized ore particles are fed downward via a pipe into a large tank where they are mixed vigorously with water, a reagent that promotes bubble attachment and compressed air or inert nitrogen gas. The result is a slurry mix of mineral laden bubbles that travels upward to a collection zone where the valuable minerals are gathered and are next sent on for further processing *(Figure 1)*.

Froth flotation cells rely on precision froth handling for increased recoveries in roughing, scavenging and cleaning applications. Accurate and repeatable mass air flow measurements are vital for the efficient operation of large flotation tank cells and reduced reagent costs.

The Problems

The mining operator performed a careful process review of its flotation cell performance and determined that the compressed air flow meters were not always delivering an accurate and repeatable reading. The inaccurate readings meant that sometimes not enough compressed air was being piped into the frother unit.

The operator's existing flow meters were volumetric and not mass flow measurement meters. As the pressure and temperature of the compressed air changed, the volumetric flow meters could not adjust for the change in mass air flow. There also was not enough pipe straight-run to create a repeatable flow profile, which again affected accuracy and consistency of measurement.

Measuring mass air flow (rather than volumetric flow) is critical to the efficiency and stability of the frothing process due to the large variations in ambient air temperature that occur in comparison to the smaller changes in slurry temperature. The measured air flow is closely related to the air or bubble volume within the flotation tank. Therefore, measuring mass air flow rather than volumetric air flow increases the frothing process performance efficiency.

Flotation cells are "aerated" with compressors or blowers and often with very little pipe straight run, which can affect the accuracy and consistency of flow meter readings. Larger mining operations also utilize modern process control systems (DCS, PLC) to optimize their operations, and the flow meters must be able to communicate with them.

In this case, the mining operator's frother cell utilized 3-, 4- and 6-inch compressed air lines *(Figure 2)*. The mining operator's process review had revealed that the amount of unobstructed pipe straight run was insufficient and affecting the accuracy of the flow meters.

Figure 2: Froth flotation cell installation

The mining operator's froth flotation cells required an air flow rate that varied from 35 SCFM to 1,050 SCFM depending on the location and production volume, and at pressures from 4 psig to 7 psig [0,3 bar(g) to 0,5 bar(g)]. Typical process temperatures were 32 °F to 140 °F (0 °C to 60 °C).

Flotation cells require the precise control of compressed air because the frothing process efficiency is based on the speed of the froth as it moves from the surface of the slurry to the recovery area. The speed of the froth is controlled by the air bubbles induced into the flotation cell, tank level and reagent dosages.

Frothing flotation cell technology is based on the operational principle that the frothing speed setpoint controls the concentrate grade. For example:

Concentrate Grade Control

1. If the concentrate grade is too low, then decrease the frothing speed setpoint.
2. If the concentrate grade is too high, then increase the frothing speed setpoint.

Frothing Speed Control

1. If the frothing speed is higher than the desired speed setpoint, then decrease the airflow, or decrease the pulp levels, or decrease the frother dosage.
2. If the frothing speed is lower than the desired speed setpoint, then increase the airflow, or increase the pulp levels, or increase the frother dosage.

The accurate and repeatable measurement of the compressed air delivered to the flotation cell improves ore yields, reduces reagent cost and provides a significant plant energy cost savings from reduced operation of the air compressors and blowers. The more efficient the frothing process, the less often the compressor runs, which reduces process energy costs. The amount of reagent consumed is also affected by the efficiency of the frothing process, which is another process cost savings related to the accuracy of the compressed air mass flow measurement. The repeatable control of the mass air flow therefore increases the frothing process efficiency.

Solution

The mining operator contacted the process applications team at Fluid Components International (FCI) for advice about its compressed air measurement accuracy problem. The FCI team recommended its thermal dispersion ST100 Air/Gas Flow Meter (mass flow measurement) combined with a Vortab Insertion Panel (VIP) Flow Conditioner to eliminate the problems with the insufficient pipe straight run.

Figure 3: ST100 Flow Meter

The meter's mass flow sensor, with its temperature-compensated design, eliminated the accuracy problem. Its adjustable 1- to 6-inch insertion length was compatible with all the pipe sizes in use and its Profibus PA digital bus communications were compatible with the plant DCS system.

The installation of the flow conditioner at 3 pipe diameters upstream of the meter locations on the frother unit solved the lack of pipe straight run availability. Conditioning the flow resulted in a highly repeatable flow profile across the entire required flow measurement range, which helped solve the accuracy and repeatability issues.

The mass flow meter *(Figure 3)* recommended to the mining operator is a next-generation advanced design, offering feature-rich and function-rich electronics. This highly adaptable meter allows mining operators to select a meter for today's measurement requirements, but have the flexibility to change in the future as process requirements or equipment changes.

The mining operator selected the new mass flow meter in part because of its Profibus PA digital communication capabilities. It also supports 4-20 mA analog, frequency/pulse, or other digital bus communications such as HART, Foundation™ fieldbus H1, or Modbus. If a plant's needs change over time, the meter adapts as necessary with a plug-in card replacement that can be changed out by plant technicians in the field.

The mass flow meter's unique graphical, multivariable, backlit LCD display/readout allows the mining operators technicians to view process information locally as necessary at the point of installation. It provides a continuous display of all process measurements and alarm status, and the ability to interrogate for service diagnostics.

This user-friendly mass flow meter stores up to five unique calibration groups to accommodate broad flow ranges, differing mixtures of the same gas and multiple gases, and obtains up to 1000:1 turndown. Also standard is an on-board data logger with an easily accessible, removable 2-GB micro-SD memory card capable of storing data for up to 90 days.

The mass flow meter chosen by the mining operators can be calibrated to measure compressed air or virtually any process gas, including wet gas, mixed gases and dirty gases. The basic insertion style air/gas meter features a thermal flow sensing element that measures flow from 0.25 SFPS to 1000 SFPS [0,07 NMPS to 305 NMPS] with accuracy of ±0.75 percent of reading, ±0.5 percent of full scale.

For safety, the mass flow meter is agency approved for hazardous environments, including the entire instrument, the transmitter and the rugged, NEMA 4X / IP67 rated enclosure. Instrument approvals in addition to SIL-1 include ATEX, IECEx, FM and FMc for product reliability.

To support the mining operator's frother cell facility layout, the insertion panel type flow conditioner *(Figure 4)* was installed upstream from the mass flow meters. The flow conditioner provides a low pressure loss solution to flow profile irregularities produced by elbows, valves, blowers, compressors, and other disruptions that commonly occur in pipe and duct runs.

The flow conditioner's design combines proven swirl removal technology with a unique mixing process to achieve the most thorough and efficient flow conditioning available. Tabs are located strategically within the conditioner that promote rapid mixing that creates a uniform flow profile for proper measurement by the meter.

Conclusions

The combined cost savings from reduced compressor run-time energy expense and lower reagent use, achieved more than 7% total cost reduction, which paid for the new flow instrumentation in only one month. The installation of the rugged mass flow meter and flow conditioner solved the frother unit's measurement accuracy and repeatability problems and increased the unit's output efficiency.

The easy to install single-tap insertion style thermal mass flow meter and the insertion panel flow conditioner also were compatible with the mining operator's existing piping for easy installation. The flow meter's PROFIBUS PA digital communications smoothly integrated directly into the existing DCS system with reduced wiring and commissioning cost.

The thermal dispersion flow meter's direct mass flow measurement and real time temperature compensation ensured accurate measurement. There also was no need to install additional temperature or pressure sensors, which are required by some flow meter technologies. With the thermal mass flow meter's no moving parts construction, there is nothing to break, clog or foul, and there is virtually no maintenance with excellent reliability, which is well suited for the harsh environment in mineral processing operations.

Figure 4: Vortab® Insertion Panel Flow Conditioner (VIP)