Applications of Prompt Gamma Neutron Activation Analysis (PGNAA) in copper mining

Introduction

Squeezed by growing demand and increasingly complex ore bodies of declining grade, copper mining companies are highly incentivized to embrace new technology and smarter ways of working. Heightened scrutiny of environmental impact, water and power consumption intensify the need for change. Online analyzers for the measurement of composition and particle size have proven benefit for concentrator monitoring and control, but, in many instances their potential for upstream transformation has still to be tapped. Online elemental analysis can be a valuable tool from the mine head through to the flotation circuit.

Prompt Gamma Neutron Activation Analysis (PGNAA) enables the real-time determination of elemental composition with high accuracy and is emerging as a technique of choice for the industry. Thermo Scientific pioneered the application of PGNAA and offer the Thermo Scientific™ CB Omni Agile Elemental Analyzer a fully customizable system for in-process use that is installed directly onto aconveryor belt. This established and valued solution can be tailored for a range of copper mining applications to support efficient ore sorting and routing, grade control and stockpile management, and efficient operation of the concentrator.

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PGNAA for elemental analysis

PGNAA is a non-destructive tool for elemental analysis that involves bombarding materials with thermalized neutrons and measuring the resultant, prompt gamma rays emitted as they return to a stable state (see figure 1).

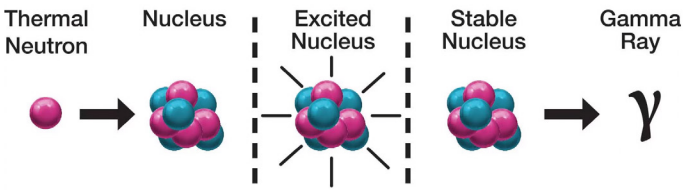

Figure 1: Schematic showing the measurement principles that underpin PGNAA

Every element has a characteristic prompt gamma ray finger-print. By detecting and measuring the composite energy spectrum – from counts of energy release at specific intensity – produced by a sample, a PGNAA system can therefore identify which elements are present and at what concentration.

The high penetrability of PGNAA makes it especially suitable for online elemental analysis in mining applications. Source neutrons have sufficient energy to penetrate and interact with even dense materials such as rock, as do the emitted, small wavelength, high energy prompt gamma rays. Unlike surface analysis techniques such as X-ray fluorescence (XRF) and X-ray diffraction (XRD), PGNAA therefore measures the entire flowing material volume equally and accurately.

The accuracy and precision of individual PGNAA systems varies depending on the strength of the source, the efficiency of the detectors, and configuration. The CB Omni Agile generates source neutrons either electrically via Pulsed Fast Thermal Neutron Activation (PFTNA) or by using up to 78 µg of ^{252}Cf, a naturally occurring isotope and uses between 1 and 4 large volume, NaI, scintillation detectors to capture the emitted gamma rays. The strength of these sources, coupled with exemplary detection capabilities, deliver accurate and precise measurement and short measurement times, allowing the robust and reliable determination of elemental composition in real-time.

Deploying PGNAA

There are multiple points within a copper mining operation where the capabilities of the CB Omni Agile can directly impact processing efficiency and the economics of asset operation. Key applications include:

Preconcentration via bulk ore sorting

The ability of PGNAA to sensitively and rapidly classify ore relative to a defined cut-off grade enables operators to route ore exiting the mine either towards the concentrator, to stockpiling and milling, or directly to waste. In this way, head grade can be maintained in the face of dwindling copper grades, or significant heterogeneity in the ore body, and processing capacity can be preserved for economically viable material. Additional benefits include extension of the mine life of an existing asset bulk ore sorting or reduction of the size of concentrator needed to establish a new mine with a low-grade ore body, an increasingly common occurrence as more easily worked mines become exhausted. In an analogous way bulk ore sorting can also be used to identify and recover valuable ore in previously unsorted materials routed to waste.

Stockpile blending and optimization

Establishing PGNAA to characterize material exiting the primary crusher enables the informed routing and blending of material for efficient stockpile management and to maintain a consistent feed to the concentrator to stabilize processing. In addition, it provides an overview of composition and grade that can be used for proactive control, for feedback to the mine, or for the feedforward adjustment of downstream process parameters.

Figure 2: The CB Omni Agile Elemental Analyzer

Mill feed analysis

While a primary role for elemental analysis is to track copper i.e. value through the processing plant it can also detect and differentiate gangue minerals such as talc and clay that can negatively impact flotation performance. Deploying PGNAA for mill fee analysis provides the information that operators need to experiment with the flotation circuit, establish optimal control strategies and implement responsive control to potentially problematic materials.

For example, talc, a major gangue material in sulphide ores, is challenging to separate from valuable minerals by flotation due to its hydrophobicity and floatability. Solutions include the use of floatability depressants, though these can be costly, or a pre-flotation circuit to remove hydrophobic impurities. Clay in the ore feed, in contrast, can negatively impact the performance of the flotation circuit by compromising froth stability, slime coating mineral surfaces, and increasing air entrainment. Remedial strategies include the use of binders or dispersants to control clay behavior by either inducing agglomeration or preventing aggregation, respectively.

In either case compositional data ensures a secure basis for establishing an effective strategy for dealing with incoming ore exhibiting natural variability. Using elemental analysis, operators can study 'cause and effect' to learn how to optimize the dosage of costly reagents, economically process problematic feedstocks, and maximize metal recovery.

Pebble circuit analysis

In the semi-autogenous grinding (SAG) circuits that precede separation, over-sized material is recycled into the feed via the pebble circuit with recirculating load constituting as much as 25 % of the feed depending on ore characteristics. Lower grade ore with a high gangue content is often over-represented in this recirculating stream due to its high Bond Work Index so routing to waste may, in fact, be preferable. PGNAA provides the compositional data required for informed decision making to maximize the throughput of the SAG mill with respect to processable mineral and simultaneously improve the grade/quality of the flotation circuit feed, thereby delivering additional processing benefits.

Conclusion

Using the powerful technique of PGNAA the CB Omni Agile provides real-time bulk elemental analysis to drive efficiency improvements from the mine, through milling, to the froth flotation circuit. It allows operators to track valuable copper, eliminate waste at the earliest opportunity, and preserve processing capacity for economically viable material. At the same time, it provides data for informed decision making as to optimal processing strategies for ores associated with problematic gangue materials such as talc and clay. In this way, the CB Omni Agile can help operators to optimize recovery, drive down reagent and energy consumption, and maximize the value of each tonne of ore mined.

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