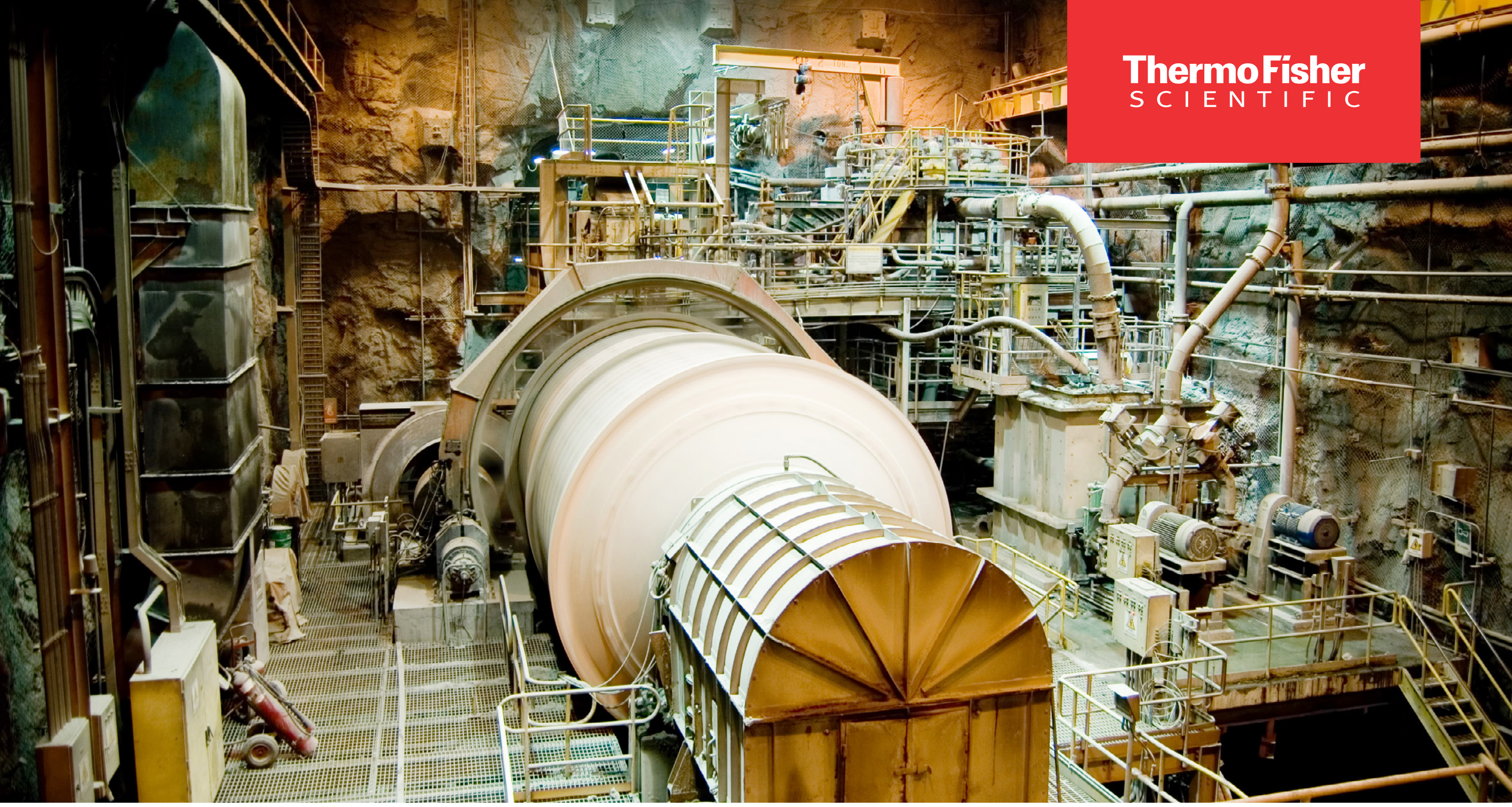


Optimizing slurry sampling and analysis to improve concentrator recovery

Introduction

The vital role of the concentrator in producing saleable product from mined ore makes it a primary target for optimization. Via unit operations such as grinding and froth flotation the concentrator processes the incoming ore into concentrate and waste tailings. Concentrator feedstocks mineral grades may vary from less than 1% to several % depending on the ore body characteristics. The concentrator upgrades feed ore with a chemical and mechanical separation process known as forth flotation into a sellable product. Forth flotation allows selective separation of valuable sulfide minerals from the host rock into a concentrate and a waste stream known as tailings. Concentrates may contain more than 20% by weight of the target mineral while material that is not recovered as concentrate goes to a waste stream where it is placed in a permanent storage facility called a tailings impoundment. In contrast to the concentrate the tailing stream has zero-value and carries significant potential for health, safety and environmental impacts. Ideally the concentrator converts as much of the value bearing mineral to a sellable concentrate at the lowest possible cost while minimizing losses to tailings. Recovery, the percentage of valuable metal in the feed stream that reports to the concentrate, is a common benchmark of performance.

Online elemental analysis is widely used by minerals processors to drive up concentrator recovery and simultaneously reduce OPEX. Their real time assays of multiple process streams provide a secure foundation for process control, by allowing operators to observe and react to trends in process changes impacting recovery in real-time. On-line analyzers support efforts to, for example, dose collector reagent based on metal content in the feed, to improve concentrate value and, more generally, to establish a knowledge-led, highly efficient approach to concentrator operation.

The challenge of concentration

Mineral grains of interest, typically in the size range 10 to 100 µm, are heterogeneously distributed in the blasted, crushed rock that forms the feed to the concentrator (see figure 1). Liberating these grains involves comminution, grinding of the rock to progressively finer particle sizes, and subsequent separation of those particles that are waste from those that contain valuable mineral content.

Mineral liberation is rarely achieved in a single stage of size reduction and most commonly through multiple steps of comminution and froth flotation separation as shown below for a copper concentrator (see figure 2). Particle size is progressively reduced from < 30 mm in the feed, to less than 500 µm in the primary grinding circuit and then to ~50 µm in the regrind/cleaner circuit.

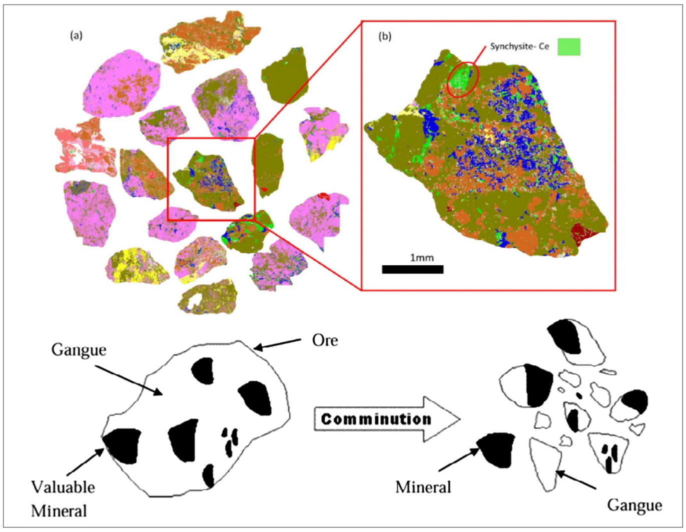


Figure 1: Valuable mineral grains are heterogeneously distributed in blasted, crushed mineral ore making comminution essential to their release

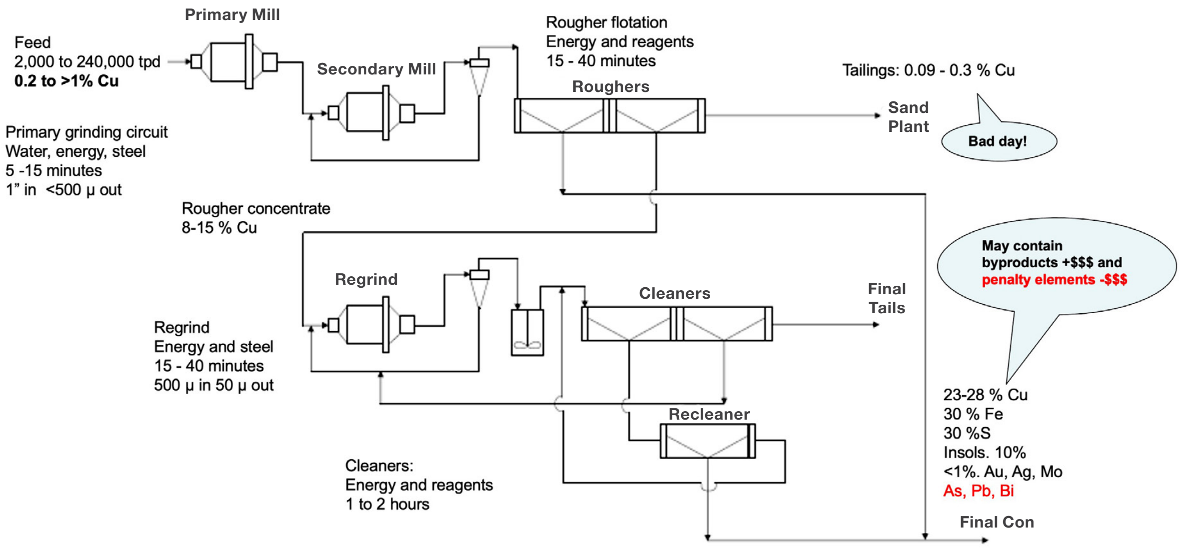


Figure 2: Schematic for a copper concentrator showing rougher and cleaner circuits

Grinding to a finer particle size increases the chance of a mineral grain being liberated from the host rock so it can be separated from the host rock and selectively upgraded to a concentrate. Not all mineral grains are fully liberated by grinding to a finer particle size and some particles containing smaller mineral grains will remain locked with host rock minerals. Therefore, it is not possible or economically viable to process ores to the point of being solely valuable mineral or solely waste and achieve 100% recovery.

Grinding to a finer particle size reduces throughput in the milling circuits while simultaneously increasing power and grinding media costs. Froth flotation efficiency can be compromised by fines and in addition value bearing mineral grains held in certain types of host rock cannot be effectively separated.

Furthermore, pushing the flotation circuit to recover too much of these value bearing mineral(s) pulls over undesirable minerals, increasing levels of impurities. For example contaminates such as arsenic, lead and bismuth in a copper concentrate compromise its value to the smelter such that the concentrator's net smelter returns will be reduced due to presence these penalty elements.

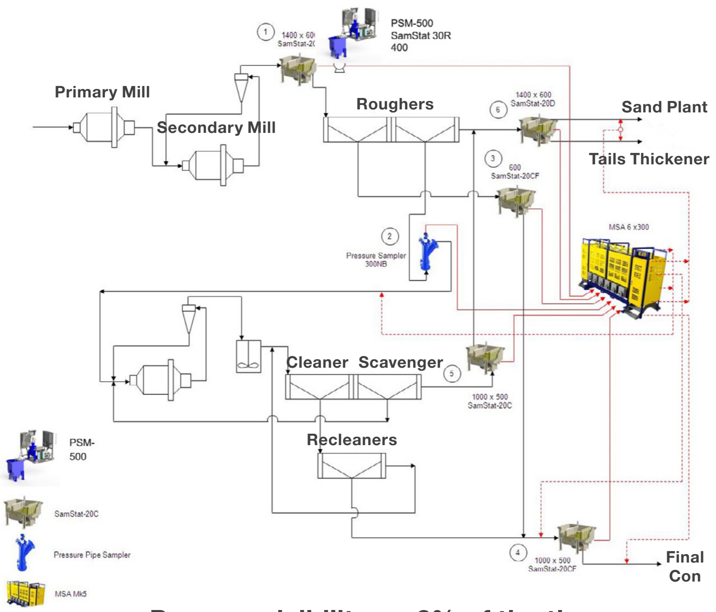
Using real-time online analysis operators can study, experiment with, control and optimize each process step to address these issues and robustly balance grade and recovery to maximize profitability.

Considerations for online sampling and analysis

An optimal solution for sampling and analysis judiciously deploys centralized and dedicated analysers to meet the need to monitor each step of the concentration process. Centralized analyzers measure multiple process streams sequentially while dedicated analyzers are committed to a single stream.
Key issues include:

- Process dynamics – how quickly does the process change and what are the implications for the required measurement frequency?
- Measurement cycle time – how long does a complete measurement take and if a centralized analyser is used then what will be the cycle time to sequentially measure all the streams feeding the analyzer?
- Sample transport – can either a dedicated or centralized analyser be gravity fed to avoid relying on pumps? Can long transport distances be avoided to reduce the risk of blockages?

Investing in dedicated analysers increases CAPEX but allows optimal positioning for a given sampling requirement, thereby reducing the need for pumping and the risk of blockage, both of which attract OPEX in the form of energy costs and manual input. At the same time, it maximizes measurement frequency and availability which may be essential to deliver effective process control. Rigorous economic assessment taking into account engineering and constructions costs, implementation timelines and OPEX over the life of the installation is the key to deciding which streams should have dedicated sampling and analysis and where it is possible to reduce CAPEX using a centralized analyser.



Process visibility = ~8% of the time

Figure 3: A low CAPEX sampling and analysis solution with a shared elemental analyser

Comparing the performance of alternative sampling and analysis strategies

Figure 3 shows a sampling set-up for the previously discussed copper concentrator.

This set-up has two analysers: one for particle size control of the primary grinding circuit feeding the first stage of flotation called the rougher circuit, the other for elemental analysis. The elemental analyser measures six streams from across the concentrator. Each stream takes 1 minute to analyse but the total measurement cycle time is 12 minutes. In other words, every 12 minutes the operator gets 1 minute of assay for each stream. Overall process visibility is just ~8%.

SamStat samplers are chosen to maximize accuracy while minimizing head loses in order to enable samples to gravity flow to the centralized analyzer and eliminate sample transport pumps. The centralized analyzer location is chosen to allow gravity flow of sample return back to the circuit. In some cases, a sample return pump may be required to higher value streams back to the circuit from which they were taken.

Using this set-up to improve manual process control delivered a $316,000 per month increase in profit for a customer operating a 50,000 tpd copper concentrator.

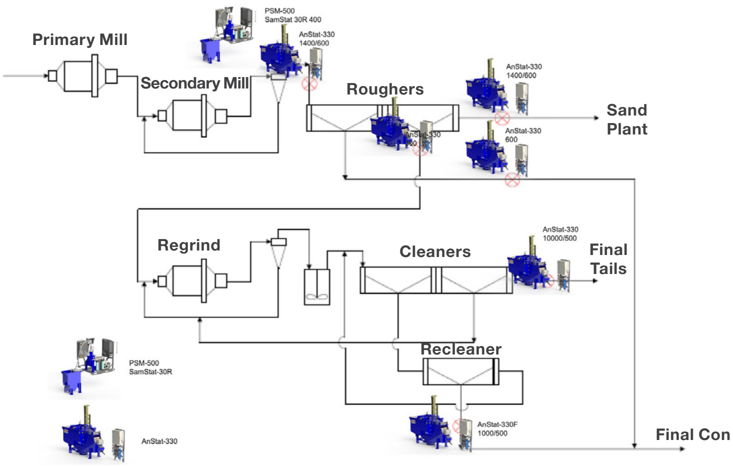


Figure 4: A high measurement frequency sampling and analysis solution with dedicated elemental analysers

Figure 4 shows an alternative, best case sampling and analyser setup, where each stream has dedicated elemental analysis. The additional CAPEX associated with this solution relative to the preceding one is $1M; OPEX is however lower as there are no sample transport lines or pumps to maintain, and process visibility is now 100%. Process control strategies can be implemented without complex logic to take into account measurement delays and cycle times of the centralized approach shown in Figure 3.

From published literature linking measurement frequency with Net Smelter Returns (NSR) we can estimate that this system would deliver a 2.6% further increase in NSR, leading to an estimated payback time for the $1M CAPEX in the order of just a few months [1]. After which time profitability would continue to be higher for the lifetime of the concentrator.

Conclusion

Online sampling and analysis provide a robust platform for automated concentrator control and can deliver substantial economic benefit in the form of better and more consistent concentrate quality and lower operating costs. Developing a successful strategy for the implementation of online sampling and analysis relies on careful consideration of the deliverable value and the steps necessary to achieve it. Equipment choice – notably the use of dedicated or centralized analysers – maintenance, operational practice, data use and training all have a significant role to play in achieving the availability required, typically more than 95%, for truly optimal concentrator control.

References

1. Remes, A et al 'Effect of speed and accuracy of online elemental analysis on flotation control performance' Minerals Engineering 01/01/2007

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