Handling increasing impurities

Increasing industry concerns over the transporting and smelting of concentrates with high impurity levels, especially arsenic, have led some to focus on removal of impurities rather than total hydrometallurgical processing. Incentives include significant freight savings, long term protection from penalties and competitive market advantage.

The decline of copper ore grades in Chile and Peru, home to the world's largest copper reserves, has driven companies towards new higher-copper-grade ore deposits containing arsenic. This requires costly cleaning, as arsenic is a health and safety risk for copper smelters with smelters limiting arsenic content to a maximum of 0.5% arsenic in the concentrate. The ALTA Short Course 'A-Z of Copper Ore Leaching' includes hydromet processes for copper sulphide concentrates:

Processing of sulphides

The **NONOX Process** utilises a combination of copper metathesis and hydrothermal leach mechanisms to remove or reduce impurities from copper sulphide concentrates while significantly upgrading the copper content. Primarily chalcopyrite and bornite minerals are reacted with copper sulphate which displaces iron and produces chalcocite/digenite. The result is a copper in concentrate of 50-60% together with the gold. The iron passes into solution accompanied by other impurities. The process can be carried out in sulphate or sulphate-chloride media. The latter is reported to be more suitable for the mobilisation of impurities. The upgrading process is carried out in an autoclave in a non-oxidative (NONOX) environment) at 180-220°C. The discharge slurry is filtered to separate upgraded concentrate from the spent leach solution which is neutralised for disposal. Copper sulphate solution is typically generated by treating a portion of the upgraded concentrate in a pressure-ox autoclave. Oz Minerals is conducting a PFS for a NONOX type facility as part of its Carrapateena project in South Australia with a view to establishing a commercial operation in 2019. Successful pilot and demonstration plant campaigns and smelter trial tests have been carried out.

The **Toowong Process** is being developed by Core Resources in Brisbane, Australia. It is a patented alkaline leach process for the removal of arsenic, antimony and other penalty elements from copper, lead and nickel sulphide concentrates. The flowsheet consists of an atmospheric tank caustic leach followed by filtration and washing of the cleaned concentrate. The filtrate is treated in a pressure oxidation autoclave and any gold and antimony is precipitated, after which arsenic is precipitated from the solution in a disposable form. The final solution is concentrated by evaporation and recycled to leach. The process was successfully piloted in small and larger facilities in 2011 and 2012 which achieved >90% arsenic removal from concentrates containing 1.1% As. Claimed advantages versus existing alkaline leaching technology include nil to low sodium sulphide addition, low polysulphides, low sulphate bleed, and low gold dissolution from the concentrate. Further development work and engineering studies are envisaged.

The **GlyLeach™ Process**, under development at Curtin University, Australia, is an alkaline-based process utilising glycine, a non-toxic, non-corrosive, environmentally benign amino acid for leaching copper, gold and silver from primary copper sulphide concentrates as well as secondary sulphide, mixed and oxide ores. The flowsheet typically includes ultrafine grinding, pre-oxidation with oxygen, atmospheric tank leaching at <100°C, and solid liquid separation. Copper is recovered from the solution by SX/EW (or sulphide precipitation), followed by pH adjustment and precipitation of silicates/carbonates with lime, then gold recovery in carbon columns before recycling to leach.

Other than losses in leach residues, the glycine is recovered and recycled for leaching. Caustic make-up is added to pre-oxidation and glycine make-up to leach. Tests indicate that over 90% copper recovery can be achieved in 17 hours. Iron dissolution is insignificant in the pregnant leach solution. Iron in pyrite is unaffected, whereas iron in chalcopyrite is precipitated as a readily a filterable iron hydroxide. No elemental sulphur is formed. The process is particularly suitable for ores containing acid-consuming gangue, concentrates with high arsenic or halide contents and for copper-gold ores with significant sulphide mineralisation. Further optimisation work and improvement work is planned, leading to a pilot scale program. An exclusive license has been signed with Mining and Process Solutions in Perth, Australia.

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This article is mainly based upon an ALTA MetBytes information bulletin published by ALTA Director Alan Taylor in July 2016.

ROL pilot plant being installed in Utah, USA. Photo: FLSmidth

The Rapid Oxidative Leach (ROL) Process being developed by FLSmidth in the USA utilises a series of stirred media reactors (SMRt) in tandem with conventional agitated leach tanks with ferric sulphate lixiviant and oxygen sparging at 80°C. Copper recovery of 97-99% is achieved in about six hours for chalcopyrite concentrates and 12 hours for enargite. The inter-stage placement of the SMRt reactors gives the advantages of mechano-chemical activation and surface cleaning with only a minimal addition to base-line processing costs. Leaching is followed by solid/liquid separation and SX-EW for copper recovery. The patented process is said to cost-effectively overcome the slow leach kinetics and poor copper recoveries commonly experienced with ferric sulphate leaching due to surface passivation issues. Tests indicate about 68% of the sulphur reports as elemental to the residue with the remainder as sulphate. Gold reports to the residue.

It was announced in February 2016 that a pilot plant facility is being built onsite at FLSmidth's Minerals division headquarters located in Salt Lake City, Utah. The new lab will include four scaled reactors which enable batch and continuous operation of the ROL process. The company has signed a joint R&D agreement with BASF to expedite commercialisation. BASF will focus on innovative SX extractants with high degradation resistance and increased copper selectivity. FLSmidth is already in cooperation with four customers, and expects to implement the ROL technology in large scale at a customer site in 2017.

The ROL technology also makes it possible to develop mineral deposits containing arsenic for recovery of copper, gold and silver, while complying with stringent environmental regulations. As the new technology operates at atmospheric pressure, a concentrate can be treated at the mine location with complete control over the arsenic-bearing residues generated after leaching. This makes it possible to avoid the potential of arsenic contamination of sea, air and land while en route from the mine to the smelter.

www.flsmidthminerals.com