New Processes for Cleaning Up Copper Concentrates

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Alan Taylor, a well-known metallurgical consultant and managing director of ALTA Metallurgical Services, recently commented in his new blog *MetBytes* about how the industry is looking at ways to handle the problem of impurities in copper concentrates. He wrote: “Some new players have joined the list of hydromet processes for copper sulphide concentrates. A key driving force is increasing industry concerns in the transporting and smelting of concentrates with high impurity levels, especially arsenic. This has led some to focus on removal of impurities rather than total hydromet processing.” The following is his summary of new developments in this area of hydrometallurgy.

Lower-cost, more efficient methods for removing impurities from copper concentrates could enable hydrometallurgical processes to make inroads against the dominance of traditional smelting.

Impurity Removal Processes

NONOX Process–The process utilizes a combination of copper metathesis and hydrothermal leach mechanisms to remove or reduce impurities from copper sulphide concentrates while significantly upgrading the copper content. Chalcopyrite and bornite minerals react with copper sulphate, which displaces iron and produces chalcocite/digenite. Covellite also reacts to form chalcocite/digenite. The

result is a copper in concentrate of 50%-60% together with the gold. The iron passes into a solution accompanied by other impurities such as cobalt, nickel, zinc, lead, bismuth, thorium and its daughter products, and uranium and its daughter products. The process can be carried out in sulphate or sulphate-chloride media. The latter is reported to be more suitable for the mobilization of impurities and is subject to patent application.

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 neutralized for disposal. Consideration could be given to recovering potentially valuable impurities such as uranium. Copper sulphate solution is typically generated by treating a portion of the upgraded concentrate in a pressure-ox autoclave. The chalcocite/digenite is converted to copper sulphate and the gold reports to the residue. The discharge slurry is fed to the NONOX autoclave. Alternatively, copper sulphate could be produced by processing oxide ore or tailings by leach-SX-EW.

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. Potential benefits include significant freight savings, long-term protection from penalties and competitive market advantage.

Toowong Process–The Toowong Process is being developed by Core Resources, 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, and antimony from gold 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, achieving >90% arsenic removal from concentrates containing 1.1% As. Claimed advantages vs. 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 progressing toward commercialization assisted by a licensed early adopter of the process with a suitable project.

Total Leaching Processes

ROL Process–The Rapid Oxidative Leach (ROL) Process is being developed by FL-Smidth. It utilizes 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 interstage placement of the SMRt reactors provides 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 that a pilot plant facility is being built at FLSmidth's Minerals division headquarters located in Salt Lake City, Utah, USA. The company also signed a joint research and development agreement with BASF to expedite commercialization. BASF will focus on innovative SX extractants with high degradation resistance and increased copper selectivity.

GlyLeach Process–The GlyLeach Process, under development at Curtin University, Australia, is an alkaline-based process utilizing 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 makeup is added to pre-oxidation and glycine makeup to leach. Tests indicate that more than 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 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 sulfide mineralization. Further optimization work and improvement work is planned, leading to a pilot scale program. An exclusive license has been signed with Mining and Process Solutions, Perth, Australia.

In conclusion, Taylor said, "While hydromet has yet to make a significant inroad into the dominance of smelting, the impurities issue may well open the door wider. Also, the lower cost and reduced risk of impurity removal processes may provide added incentive."

MetBytes (www.altamet.com.au/metbytes) are metallurgical commentary and insights written by Alan Taylor, who has 40-plus years of experience in the metallurgical, mineral and chemical processing industries. He has worked in metallurgical consulting, project development, engineering/construction, plant operations, plant start-up and technology development. Projects and studies have involved copper, gold/
silver, nickel/cobalt, uranium, base metals, phosphates and alumina.

According to Core Resources, the Toowong Process achieves more than 90% arsenic and antimony removal from many copper, lead and nickel concentrates. Process testing has included a pilot plant operation for Tampakan concentrate, successfully reducing arsenic content from 1.1% to 0.1%.