BIOLEACHING MOVES INTO NICKEL

February 2017

Bioleaching has finally moved into the treatment of nickel sulphide ore and concentrates, with commercial heap and tank systems now in commercial operation in Finland, and a commercial tank system planned for Western Australia. The projects have undoubtedly benefited from the experience gained in heap bioleaching in the copper industry and tank bioleaching in the gold sector, as well as the downstream processing and product recovery technology applied in nickel laterite pressure acid leaching projects.

Heap Bioleaching

Terrafame Operation

The operation involves heap bioleaching of a low grade complex nickel polymetallic ore in Finland. It was initiated by the Talvivaara Mining Co. in 2008 following a successful 17,000 tonne pilot heap program(1). The subsequent commercial operation suffered major technical, environmental and economic problems, and closed in late 2014. It was restarted by new owners Terrafame in August 2015(2). Challenges include sub-zero winter operation and a net positive solution balance due to rainfall and melting snow, and long leach cycle time.

The flowsheet comprises fine crushing and agglomeration with sulphuric acid, followed by two-stage heap bioleaching with air sparging. An on-off pad system is used for primary leaching and a multi-lift permanent pad system for secondary leaching. Retention times are around 450 and 1100 days respectively(2). Net acid consumption is relatively low.

Product recovery involves sequential precipitation of copper, zinc and nickel-cobalt as sulphides using H_2S. The target production is 50,000 tpa nickel from ore with an average content of about 0.23% Ni. A facility to recover uranium by SX was installed in 2012(3).

The pyrrhotite content of the ore provides useful heat generation for winter operation, but changing heap structure is an issue. New owners Terrafame are testing buried drippers instead of the original covers which suffered problems due to wind. Provision for removal and treatment of excess solution is included. The heap Irrigation system suffers from gypsum precipitation due to temperature drop in winter, and drip lines have to be changed a number of times during the primary leach cycle.

Former Radio Hill Semi-Commercial Operation

A semi-commercial heap bio-leaching facility with two 5000 tonne 5 m high heaps was successfully operated at Radio Hill, Western Australia by Titan Resources during 1999-2002[4]. The leaching system used proprietary BioHeap™ technology, now owned by Western Areas, Perth, which involves proprietary bacteria cultures. The ore was disseminated sulphide grading 0.75% nickel plus copper and cobalt as potential by-products. The heaps were aerated and attained an operating temperature of 50-80°C due to the presence of pyrrhotite, which enhanced leach extractions and kinetics, and the relatively hot climatic conditions. Various downstream processes were tested including electrowinning and precipitation with iron for copper recovery, and hydroxide precipitation and IX for nickel and cobalt recovery. The level of magnesium, the main acid consumer in the ore, was relatively low at 1.64%. The process did not proceed to commercialization due to the lack of available suitable deposits with sufficiently low magnesium or other acid consumers.

Tank Bioleaching

Mondo Minerals Operation

Mondo Minerals, Netherlands, are operating a small tank bioleaching plant in Finland designed to produce 1,000 tpa nickel as mixed nickel-cobalt hydroxide (MHP) from 12,000 tpa of nickel sulphide concentrate by-product from their talc mining operations, previously sold to smelters. Construction was completed in 2015, and the plant is currently being optimized and ramped up to full production[5]. The bioleaching technology is licensed from Mintek, South Africa, who carried out bench scale and pilot plant testwork[6]. The Mondo operation is the first commercial application of the Mintek technology and the world's first nickel sulphide concentrate bioleach plant.

The flowsheet involves magnetic separation, flotation and regrinding, resulting in a bioleaching feed containing about 10% Ni. Downstream processing includes iron-arsenic precipitation with limestone, dewatering, then precipitation of MHP with MgO. The bioleach circuit consists of eight tanks, with an overall residence time of seven days at the design throughput. Four of the tanks are configured as primary oxidation reactors, followed by four tanks configured as secondary oxidation reactors. Each tank is fitted with an agitator for dispersing air, suspending solids and maintaining homogeneity, an air sparge ring for injecting air supplied by a blower, a separate pipe for adding gaseous carbon dioxide (CO_2), and a number of vertical cooling coils which perform a dual function as baffles[5].

Western Areas Cosmic Boy Project

Western Areas Ltd are building an expansion to their Cosmic Boy Nickel Sulphide Concentrator in Western Australia to treat an impurity stream which is high in nickel, using the BioHeap® tank bioleaching technology to recover the nickel while rejecting the arsenic as a stable iron/arsenic hydroxide[7]. Sodium sulphide is used to precipitate the nickel as high grade nickel sulphide (at approximately 50% nickel) that can be blended with final concentrate to improve nickel grades and recoveries, while simultaneously reducing impurity levels. The project development program included both bench scale and pilot plant testwork[8].

The bioleaching circuit consists of three parallel primary leach tanks, followed by three secondary tanks in series. An extra tank is provided to allow any one tank to be taken out of the circuit for maintenance without affecting the operation. Cooling is required throughout primary and secondary leaching. A detoxification circuit using Caro's acid has been included to eliminate cyanide in the feed from the flotation operation. Although the BioHeap® bacteria have demonstrated resistance to elevated cyanide levels, there is the potential for cyanide levels to affect leaching kinetics.

While the current low nickel price has delayed construction of the project, engineering and procurement of long lead items has continued, and many key equipment items have been delivered to site, ready for construction to start. The additional time has allowed for significant refinement of the design, and additional testing of materials and unit processes that otherwise would have been deferred to project commissioning.

Possible future opportunities for bioleaching of nickel sulphide ores include low grade or complex ores unsuitable for flotation, existing or new operations with impurity issues such as arsenic, lack of toll smelting capacity or high toll smelting charges, and remote operations with high concentrate transport costs.

An update paper on the Terrafame Heap Bioleaching Operation will be presented at ALTA 2017, which will be held 22-26 May in Perth, Australia.

For more information on Heap Bioleaching, attend the *Heap Leaching and Its Application to Copper, Gold, Uranium and Nickel Ores* scheduled for 27 May in Perth, as part of the conference. The manual is available from ALTA Publications

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MetBytes are metallurgical commentary and insights written by Alan Taylor who has 40+ years' 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.

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