New solutions for nickel sulphides

Whilst the eyes of most in the nickel industry have been focused on the progress being made by the various Australian laterite projects using high pressure acid leaching, it should be remembered that important technical innovations are under way in the processing of nickel sulphides as well. The laterite projects may be revolutionising the industry as a whole, but the new developments in the processing of sulphides could have an equally startling impact. Most of these new processes revolve around the oxidation of nickel sulphides using methods other than pyrometallurgy.

Of the various processes under development perhaps the most advanced is Billiton's BioNIC™ process. BioNIC™ has its origins in the BIOX™ process developed by Gencor for the treatment of refractory gold ores in South Africa during the 1980s (*MJ*, January 12, 1990, p.29) when it commissioned its first commercial-scale processing plant at the Fairview gold mine in 1986. Since then, BIOX™ has been used at the Wiluna mine in Western Australia, at the Sao Bento mine in Brazil and, most notably, at Ashanti's Obuasi mine in Ghana.

Billiton's endeavours

BIOX™ has spawned three other processes, BioNIC™, and BioCOP™ (*MJ*, March 10, p.189) and BioZINC™, all now under development by Billiton (formed in 1997 from Gencor's coal and base metal assets). BioNIC™ is the most advanced and, according to QNI, Billiton's nickel subsidiary, it will go into commercial use once a large enough nickel deposit is found.

At the core of the BioNIC™ process are bacteria. At present, QNI is using mesophiles – bacteria that live quite happily at relatively normal temperatures. However, the company is investigating the use of thermophile strains of bacteria whose natural environments are volcanic hot springs. These high-temperature strains can improve metal recoveries, and QNI believes that by using them it can boost nickel recoveries to an average of 97% against 92-95% achieved using mesophiles.

The bacteria are kept in a reactor cascade under acid conditions (pH 1.0 to 2.0) at a controlled temperature (30-45°C), and are provided with a steady supply of oxygen, carbon dioxide and nutrients. A concentrate slurry is passed through the reactor cascade where the bacteria digest the sulphides and produce nickel sulphate in solution.

After bio-leaching, the pregnant solution in the BioNIC™ process goes through an iron precipitation stage in which ferric iron is removed using limestone. The solution is then passed through a 'polishing' plant where the iron concentration is reduced to less than 2 parts per million.

Once the iron has been removed the solution undergoes solvent extraction; first the nickel is removed and then cobalt, along with copper. The nickel liquor then passes to an electrowinning circuit to produce nickel cathode. The cobalt-copper solution requires further treatment to separate the metals. Alternatively, rather than undergoing solvent extraction and electrowinning (SX-EW), mixed sulphides can be produced and refined using modified Caron refining technology (using ammonia and steam to produce a nickel carbonate which is then reduced to produce a nickel oxide product).

According to QNI, BioNIC™ offers a number of important advantages for the processing of nickel sulphide when compared with the conventional pyrometallurgical route, in terms of both cost and environmental impact. QNI estimates that, for an operation processing 167,000 t/y of concentrate, the cost of a BioNIC™ plant producing mixed sulphides would be 25-50% that of a smelter processing the same amount of ore to produce nickel matte. BioNIC™'s operating costs are also said to be lower – some 85-95% of those of a smelter. As a result, QNI says that total operating costs (allowing for amortisation) are in the range of US$0.70-1.00/lb lower than those of smelting. Because of the cost savings, it believes that relatively small nickel sulphide deposits could support a BioNIC™ processing plant.

The process offers obvious environmental benefits. Most notably, and unlike smelters, there are no sulphur dioxide and dust emissions to contend with. Furthermore, the inert leach residue produced by the process has been shown to conform to US Environmental Protection Agency standards for stability, and QNI expects that BioNIC™ effluents will also conform.

Titan tests heap leaching

Another important bioleaching development is taking place in Western Australia. Titan Resources is developing a heap-leach process for its Radio Hill mine for the treatment of relatively low-grade sulphide ores.

The initial work was carried out in Canada by the Research Productivity Council (RPC) of New Brunswick, which isolated a strain of bacteria that has a particular affinity for chalcopyrite and pentlandite. This work is now being developed by Titan through a jv company, Pacific Ore Technology Pty Ltd, in which Titan has a 75% interest. The remainder is held by Dr Colin Hunter, a consulting metallurgist who was head of process research at Gencor and who was involved in the original work on the process with the RPC. Batch tests of milled ore have achieved nickel recoveries of over 90%, and column tests of crushed ore have produced nickel recoveries in excess of 80%.

However, for heap leaching, Titan is expecting recoveries of 70%, and to test this the company has constructed a pilot plant at its Radio Hill mine. The plant will test metal recoveries from a maximum of five 5,000 t heaps. After crushed ore has been placed on a pad it is irrigated with an acidic solution containing nutrients to provide the optimum conditions for bacterial reproduction. The bacteria adhere to the ore where they use enzymes to break down the sulphides (including chalcopyrite and pentlandite). In addition, iron-oxidising bacteria oxidise soluble ferrous iron to ferric iron.

This, in turn, attacks the sulphide minerals and oxidises them. The combination of direct and indirect attack dissolves the sulphides and puts copper, nickel, cobalt and other metals into solution. The resulting solution undergoes iron precipitation to