Base Metals Process Development and Optimisation

MINTEK’S expertise in developing and evaluating various process flowsheets for the recovery and refining of base metals encompasses all unit operations and process steps from the mined ore to the pure metal or metal salt. In-depth research is conducted to assess and improve the latest technologies. Our key objective is to optimise recoveries while minimising operating costs and environmental impact.

Mineralogical evaluation
Quantitative scanning electron microscope techniques such as MLA and QEMSCAN are used to determine liberation characteristics, particle size distributions, phase compositions and abundances to yield information on the likely behaviour of the material during processing. These results are also used to evaluate if physical upgrading of the ore would be a process route to consider, especially where gangue components would make direct ore leaching economically less attractive. Hence, mineralogical analysis of the ore allows the development of a more focused test work program.

Analysis
Improved analytical methods to deliver better quality data for mass balancing in piloting of base metal circuits have been developed and validated. Instrumental analytical techniques include ICP-OES, ICP-MS and XRF. Other classical methods such as combustion, ion selective electrode, potentiometric titration and colourimetric analysis are also used. Mintek produces certified reference materials (SARM programme) in support of the analytical services offered.

Feed preparation
A fully equipped sample preparation facility supports small, medium, or large-scale projects, including crushing, milling, blending of samples, particle size analysis, and particle and bulk densities. Physical separations via flotation, dense media, gravity, electrostatic and magnetic techniques can also be done on laboratory or pilot-scale facilities. Novel optical sorting technologies are available for concentrating valuable minerals or rejecting waste prior to downstream processing.

Comminution and flotation
A variety of bench- and pilot-scale test facilities are available for characterisation, design of circuit configuration, reagents, and conditions, and to generate data in support of feasibility studies. Extended pilot-scale testwork can be conducted at feed rates up to 1 t/h.

Leaching
Mintek is able to select and optimise atmospheric and pressure leaching conditions for a variety of ores and concentrates, based on an in-depth understanding of the basic chemistry involved, mathematical modelling and process optimisation. Agitated tank leaching includes not only the selection of the most suitable lixiviant, but also the optimisation of a variety of process variables such as pH, redox potential, temperature, residence time and reagent consumption while maximising recovery. Bench-scale and pilot-scale heap leaching evaluations can be done, including rolling bottle and column leach tests to determine extraction and reagent consumption, geomechanical properties, and drain-down characterisation for environmental impact studies.

Precipitation
Advanced expertise is available on base metal refining using precipitation and redissolution techniques. This includes the oxidative precipitation of iron and manganese.

Biotechnology
Several bacterial cultures are maintained for a wide range of bioleaching environments
and applications. Batch and continuous leaching tests can be performed to optimise a bioleach process with regard to temperature, particle size, feed density, redox potential and residence time, from which process design criteria can be derived directly. Continuously operated plants can be integrated with purification and metals recovery steps, and an extensive database exists for conducting desktop economic studies for bioleach processes.

Solvent extraction
A wide range of laboratory equipment is available to provide design information on relative organic and aqueous flowrates for extraction, scrubbing and stripping, and the number of stages required. Mintek has mixer-settler equipment in a variety of sizes for continuous pilot-plant evaluations. Bateman Pulsed Column (BPC) testwork is carried out in a joint venture with Bateman Minerals & Metals. A nickel synergist reagent, Nicksyn™, has been developed to optimise nickel recovery and nickel-calcium separation.

Ion exchange
Mintek has developed world-class expertise around the design and piloting of ion exchange operations for:
* impurity removal, eg. removal of copper, zinc and nickel from cobalt process streams and copper and zinc from nickel electrolyte streams;
* recovery of gold from cyanided pulps and pregnant solutions. Mintek also developed the gold-selective resin that is used for these processes;
* recovery of valuable metals from effluent streams such as solvent extraction raffinates.

Fixed-bed columns are used for clarified solutions, fluidised bed (NIMCIX columns) for unclarified solutions (<500 mg/L solids), and continuous resin-in-pulp (RIP) technology for dense slurries.

Electrowinning
Mintek has particular expertise in the electrowinning of base metals such as cobalt, copper, nickel, and zinc. Laboratory-scale electrowinning cells are available for investigating both cathodic and anodic processes, as well as divided and undivided cells for pilot-plant testwork on both synthetic and real plant solutions.

Recent work
- Dutwa nickel laterite, Tanzania. Leaching testwork and mineralogical characterisation.
- Kalukundi, DRC. Flowsheet development, encompassing milling and sample preparation, leaching, and recovery of copper and cobalt by solvent extraction and electrowinning.
- Mopani Copper Mines, Zambia. Laboratory and pilot-plant testwork (on-site and at Mintek) for purification of the cobalt stream and cobalt metal recovery.
- Ruashi copper-cobalt project, DRC. Three pilot plant campaigns to design the solvent-extraction and electrowinning circuit for the phase II expansion.
- Tati Nickel, Botswana. Evaluation of the Mintek-developed nickel synergist (Nicksyn™) for optimising nickel recovery and nickel-calcium separation at the Activox® demonstration plant.
- KOV copper-cobalt project, DRC. Comminution and sulphide flotation, laboratory tests to determine the optimum leach conditions, integrated piloting of the leaching, copper solvent extraction and electrowinning circuit, Aspen simulation and mass balancing across the flowsheet.
- Idaho Cobalt, USA. Continuous atmospheric and pressure leaching, solution purification by precipitation, ion exchange and solvent extraction, and electrowinning of cobalt and copper.
- Sarcheshmeh, Iran. Large-scale on-site piloting of bacterial heap-leaching technology for low-grade chalcopyrite materials. Mintek led the feasibility study for a full-scale commercial operation.
- Aguablanca, Spain. Integrated piloting campaign for the bioleaching and recovery of nickel and copper.
- Sierra Mojada, Mexico, and Accha, Peru. Characterisation testwork, including mineralogical investigations, dense media separation (DMS) and flotation.

Specialists
Adrian Hinde – Comminution.
Mike Bryson – Floation.
Marthie Kotze – Hydrometallurgical processes.