Mineral Processing
Complete Project Solutions

New ore deposits are becoming more difficult to exploit profitably: locations are sometimes remote, grades are lower than in previous years, and the extraction metallurgy is increasingly complex. Existing operations face similar issues since the higher grade and easy-to-process ore has already been exploited. Older operations often have outdated equipment that can result in less than optimal recoveries or availability.

Hatch’s mineral processing experts provide innovative solutions to challenging processing problems and can help create value from new and existing operations through robust, reliable, practical, safe designs with fast start-ups. Clients benefit from early revenue generation and enhanced productivity.

For six decades Hatch has been serving the world’s metals industry. We undertake feasibility studies, designs for greenfield and brownfield facilities, new technologies, global procurement; project and construction management, commissioning, maintenance management, and on-site operational services.

Our primary differentiator is the ability to deliver a complete solution including all operations from mining to port. This service includes the design and optimization of open pit, and underground mines, tunnels, processing plants, tailings dams, pipeline systems, power supply, water supply, and treatment (including desalination plants), hydro resources, ports and marine terminals, and environmental and mine closure services.

The Hatch mineral processing group has executed projects throughout the world, focusing on base metals and precious metals including copper, lead, zinc, nickel, molybdenum, gold, silver, platinum, and palladium. Hatch also offers specialist expertise in aluminum, coal, diamond, iron and steel, tin, phosphates, and rare earths. Our process engineers have experience in all aspects of mineral processing operations, including geometallurgy, development, and management of testwork programs, process optimization, conceptual process designs, detailed design, as well as due diligence and commercial evaluation.

In many projects we incorporate design expertise and experience into the development of social, environmental, and sustainable development plans, as these are becoming increasingly important in the execution of our clients’ projects.

Energy efficiency and water usage optimization are currently two key drivers in the development of mining projects, and in many cases these determine the feasibility of a project. The industry faces constant challenges in the search for efficient and innovative solutions to help reduce energy and water consumption. Hatch encourages and promotes innovation, research and collaboration in an effort to develop best practices in all aspects of mineral processing.

We strive to design and implement cost-efficient projects which are safe to operate and easy to maintain.
Services

Hatch offers a full range of services for mineral processing projects. These include scoping studies and conceptual engineering, prefeasibility studies, feasibility studies, basic engineering, detailed engineering, project planning and cost control, capital and operating cost estimating, in addition to construction management, plant commissioning and start-up, maintenance planning, and operational support.

In the study phase, in cooperation with the client, Hatch evaluates alternatives and determines the optimum process design, equipment, site suitability, and costs. In most cases this involves developing capital and operating costs, as well as conducting trade-off studies. We collaborate with clients and vendors so that the most suitable and cost-effective technology is selected to meet the needs of the project.

Geometallurgy and Ore Testing

Geometallurgy and ore testing is a critical component in the initial development of metallurgical and mineral processing projects. At the onset of new projects, geological drill cores are taken from a large area in order to assess the size and grade of the resource. Geometallurgy focuses on making a geologically informed selection of a number of ore samples. After testing these to determine the best mineral processing flowsheet, the parameters are distributed throughout the ore body using an accepted geostatistical technique, so that a mine plan can be developed with mineral processing models to generate a good prediction of the process plant behavior.

The first metallurgical tests typically use selected samples from the initial drill program, for a suite of exploratory bench-scale tests, identifying key minerals and potential process options. A good understanding of the chemical and mineralogical makeup of the deposit is essential to be able to develop a good flowsheet. Many new mineralogical tools, such as quantitative evaluation of minerals using scanning electron microscopy (MLA) are available to project metallurgists and are widely used in Hatch. Our mineral processing team has a comprehensive range of skills with outstanding experience in mineral processing, ranging from initial ore body testing and characterization to on-site optimization of operation performance.

With good experience in testing base metals, precious metals and iron ore, we frequently manage laboratory test programs. This work usually has a lot of early interaction between metallurgists and exploration geologists. A close coordination between the two is continued as the initial, conceptual testwork progresses to detailed pilot plant work. Frequently this process involves testing samples that are collected specifically for metallurgical testwork.

Hatch has worked extensively with all of the well known metallurgical laboratories, and often our staff will spend time in the laboratory supervising throughout the testing period.
Process Modeling and Studies

Computational simulation packages for the mining and metals sector focus on capacity planning, debottlenecking, and optimization to ensure design capability, capital effectiveness, and operational efficiency of the integrated production chain.

Simulation and modeling is a major tool in optimizing both the plant design as well as the subsequent operation. This analysis is a central platform in Hatch's approach to flowsheet development.

Hatch combines process and engineering know-how with modeling and simulation expertise to help develop optimum designs. Benefits derived from a typical simulation study may include the following:

- Improved production capability
- Robust design to attain capacity targets
- Overall plant optimization instead of area optimization
- Consistent, reliable performance
- Capital effectiveness
- Elimination of unnecessary capital investments
- Optimal timing of investments: deferment or cancellation of intermediate investments that provide little value and acceleration of investments that optimize overall payback
- Compatibility with future expansions
- Operational efficiency
- Best operating strategies and practices defined to manage constraints
- Reduced operating costs
- Shorter commissioning time
- Developing a solid process design in a short timeframe.

Available computational simulation packages include:

- Mass and energy balances (Metsim, Syscad, LIMN)
- Dynamic sequence modeling (Arena)
- Discrete element modeling
- Equipment sizing software (JK SimMet, Bruno)
- Computational fluid dynamics.

These simulation tools support all phases of the project life cycle and include:

- Water and mass balances
- Alternative flowsheet evaluations
- Pilot plant data evaluation
- Full-scale plant design impact
- Operational philosophy optimization
- Operating plant improvement studies
- Process plant debottlenecking
- Plant operations and control
- Operations dynamic simulation (batch or continuous)
- Comminution unit operations
- Equipment availability impact on plant capacity
- Development of costs.
Crushing
Hatch has considerable experience in all areas of crushing including:

- Primary crushing
- Secondary crushing
- Tertiary crushing.

Crushing systems include fixed, mobile and semi-mobile, in-pit, pit rim, and in-plant. Hatch’s crushing plant design services include process flowsheet development, process modeling, equipment sizing and selection, plant monitoring, and control systems for:

- Gyratory, jaw, and cone crushers
- Multi-stage crushing circuits
- Water flush crushers
- High-pressure grinding rolls (HPGR).

Prediction of the embankment surface on a pump box which is fed by water, tailings lines and SAG mill discharge. The design made by Hatch engineers enabled the solids concentration in the pulp was homogeneous in the output of the pump box.

Pebbles Circuit Modification project, Minera Candelaria, Chile

Crushing station and conveying system construction, Escondida Norte project, BHP Billiton, Chile
Grinding

Hatch has developed a number of major grinding circuits for mineral processing plants with capacities exceeding 300,000-tpd.

Our grinding system experience includes:

- Ball mills
- Rod mills
- SAG mills
- Pebble mills
- Numerous regrind technologies including Vertimills, Isa Mills and others.

Hatch's grinding design services include grinding circuit design and optimization, equipment selection, circuit layout, and process control. Projects often incorporate operability, maintainability and expandability into the design philosophy with the expertise to develop circuit capacities that range between 500 tpd and 300,000 tpd.
**Materials Handling**

Hatch’s integration of strong process teams, proven systems and advanced technologies ensures quality design and installation of state-of-the-art materials handling facilities, enabling quicker ramp-up, and enhanced operability and maintainability.

Clients draw on Hatch’s diverse knowledge in resource operations, the flow of bulk solids and the understanding of the crucial link between handling, processing, storage systems, and transport design to maximize efficiency and productivity.

Hatch’s experience includes:

- Conveying
- Stockpiling and stacking
- Loading and unloading facilities.

The Hatch Materials Handling Group designs facilities using innovative technology, progressive computer-aided design, and process tools. When combined with a wealth of operating experience and a strong focus on well proven practical designs, this results in designs that achieve a competitive edge and optimum performance.

Conveyors are the mainstay of materials handling. Hatch designs conveying systems with emphasis on safety, the environment, operability,
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We have designed and installed single conveyor systems with capacities up to 12,500 tph and multiple conveyor systems above 20,000 tph with 2,000 kilowatt (kW) single and 4,800 kW multi-drive heads, horizontal curves, and bidirectional transport. Our studies have involved single conveyors up to 12 MW and 15 km long and systems that integrate conveyors, road, rail, and shipping for extended transport of bulk materials. We evaluate different conveying systems against other methods of transport such as road, rail, and/or barge to arrive at the most economical and operable solutions.

We design stockpile systems featuring inventory control, minimization of product degradation, yard drainage, and sediment separation. Dust and noise mitigation are also common issues, and solutions are tailored to the materials and methods of materials handling.

Flotation

In developing flotation projects, we have used innovative approach towards project management, in order to deliver projects at lower cost with shorter construction and ramp-up schedules. Well designed control systems and layouts have led to improved plant performance with lower water and energy requirements.

Our mineral processing specialists have a comprehensive range of skills and outstanding experience in flotation circuits, including:

- Flash flotation
- Conventional flotation
- Tankcell flotation
- Column flotation.

Hatch’s flotation circuit design services include process flowsheet development, process modeling, equipment sizing and selection, plant monitoring, and control systems. Hatch has extensive project and study experience incorporating all types of conventional and column flotation equipment including 300 m³ flotation cells. This experience covers a diverse range of projects with concentrators operating at 240,000 tpd or more. These projects have involved a complete range of metals and minerals, varying from base metals such as copper, nickel, zinc, and iron ore to precious metals including gold, silver, platinum, and palladium.

Flotation circuit design identifies the need for fine grinding on certain applications, to ensure optimum recoveries and high-grade concentrate production in order to meet market requirements. In many cases this is complemented with flash flotation to recover liberated mineral species early and prevent over-grinding, or with the use of cyanide as a depressant to improve the quality of concentrates and reduce related thickening, filtration, and shipping costs. Differential flotation of bulk concentrates to recover valuable by-products is necessary in many operations to help improve project value.

Ministro Hales mine project, Codelco, Chile
Many design aspects are considered in flotation including scale-up factors from testwork and the proper use of froth factors in launder design and pumping systems. As a global company, we have designed flotation circuits in hot outdoor conditions as well as indoors in cold climates. We have accumulated good experience on layout issues, materials of construction, level of automation, vendor support, and other environment specific factors.

**Gold Leaching**

Hatch’s mineral processing group has significant experience in the various gold leaching techniques and carbon treatment, including the following unit operations:

- Cyanide leaching
- Carbon-in-pulp (CIP)
- Carbon-in-leach (CIL)
- Carbon management in the leach circuit
- Carbon acid treatment and stripping
- Thermal regeneration of carbon
- Gold electrowinning and smelting to produce doré
- Safety issues related to cyanide handling and storage

Our expertise includes knowledge of the Merrill-Crowe zinc precipitation process, used in precious metal recovery where the cyanide leach solution contains high silver concentrations, and the various components of solution clarification, deaeration, precipitation, and filtration.

Additional areas of expertise include the requirements for mercury removal from the gold precipitates prior to smelting to eliminate potential health and environmental hazards due to mercury volatilization during smelting.

Mine projects may require the tailings process stream be used for backfill production in underground mining operations. Stringent environmental standards are required for cyanide tailings disposal hence gold recovery operations frequently include:

- A cyanide recovery process to recycle cyanide solution within the leach operation
- Cyanide detoxification of tailings.

Hatch has experience in both these key areas and can provide clients with cost-effective cyanide management solutions to meet the project’s environmental standards.
Dewatering and Separation

Dewatering and solid-liquid separation is an important part of mineral processing plants. Water recovery from tailings is important when water is a scarce commodity. Hatch has considerable experience in both thickening and paste generation. The disposal of tailings has become a sensitive environmental issue and is critical to both the development of new projects as well as ongoing operations. Dams have to be designed environmentally and recovery has to be maximized prior to pumping to the tailings facility. This is particularly important in Chile where Hatch has executed many projects in high mountain ranges with arid climates and limited access to water.

For many years, conventional thickening of tailings has been the primary treatment method. Large-diameter thickeners, with center or peripheral drive mechanisms have been used extensively. These thickeners usually produce underflow densities in the range of 45–55% solids, with the thickener overflow returned as process water. A large part of the water in the underflow, however, is subsequently lost by evaporation, seepage, or retention in the tailings dam.

High-capacity thickeners incorporate auto-dilution and control flocculants to achieve acceptable underflow densities in much smaller diameter thickeners. In the last decade, there has been further development of thickened tailings, using deep-cone thickeners. These thickeners utilize compression to obtain thickener underflow densities as high as 60–65% solids, significantly increasing the recovery of water at the plant site.

With the advent of paste systems, slurries are thickened and/or filtered to produce a paste containing 75–80% solids. As a result, slurries can either be deposited in underground stopes as fill or deposited in tailings areas that quickly drain to create a stable deposit.

With the development of paste, new filters are continually being developed, (predominantly plate and frame and belt filters) with larger capacities that allow for the treatment of large tonnages of plant tailings.

Another important aspect of solid-liquid separation is the preparation of concentrates. In base metals operations such as copper concentrates, the final flotation concentrate is dewatered prior to smelting. Initially, the concentrates are thickened to a slurry density of about 60% solids by weight. Traditionally, this thickening was carried out in vacuum drum filters, sometimes using filter aids to produce a cake with moisture content of between 8% and 11%. In recent years, the drum-type filters have increasingly been replaced with higher-capacity pressure filters. These high-capacity machines can normally reduce the moisture content to 10% or less with a small number of units. Ceramic-type, rotating-disc filters are also sometimes used to reduce the moisture content to levels acceptable for shipping.

Copper Mountain project, Similco Mines, Canada, Includes a thickener 16 m (53 feet) in diameter
Global Experience

Sierra Gorda Moly plant  
**KGHM International Ltd, Sierra Gorda, Chile**

The Sierra Gorda mine project has a 22 year estimated life and the molybdenum ore grade can be 900 ppm, which is significantly higher than most other operations. Hatch was required to develop the detailed engineering and all the deliverables involved in the procurement and construction of the molybdenum plant.

Ministro Hales mine  
**Codelco, Calama, Chile**

The Ministro Hales mine project is a greenfield, open-pit copper mine with a concentrator design capacity of 50,000 tpd. Hatch’s scope included basic and detailed engineering, procurement and construction support services. The project includes a SAG mill and two ball mills.

El Morro feasibility update project  
**Goldcorp, Vallenar, Chile**

The El Morro project scope included an update to the previously developed feasibility study as well as basic engineering and early works. The project involved the production of copper–gold concentrate with a mill capacity of 90,000 tpd and included a transmission line, a 30 km overland conveyor system, a desalination plant, a 30-inch water pipeline measuring 200 km, a 6-inch concentrate pipeline, filtration plant, a SAG mill, two ball mills and the related infrastructure for the facility.

Meadowbank gold project  
**Agnico-Eagle Mines Ltd, Nunavut, Canada**

Hatch provided detailed engineering, procurement, and construction management support for the 8,500 tpd gold processing facility of the Meadowbank gold project. Hatch’s services included primary crushing and conveying, covered ore storage stockpile, SAG/ball milling, leaching, refining, and tailings detoxification treatment and disposal. The infrastructure included a 28 MW diesel power generating plant, freshwater supply, reclaim water supply, overland piping and 40,000-litre diesel storage facility (portside) for a remote location. Hatch also provided construction and logistics support for the project.
Hatch is an employee-owned, multidisciplinary professional services firm that delivers a comprehensive array of technical and strategic services, including consulting, information technology, engineering, process development, and project and construction management to the Mining, Metallurgical, Energy, and Infrastructure sectors. Hatch has served clients for over six decades with corporate roots extending over 100 years and has project experience in more than 150 countries around the world. With more than 11,000 people in over 65 offices, the firm has more than $35 billion in projects currently under management.

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