



OUTOTEC HYDROMETALLURGICAL NICKEL PLANTS AND PROCESSES

Our expertise and experience provide the path to optimized solutions and complete plants for the production of high-quality nickel, from a wide range of nickel raw materials. Outotec offers innovative and proven leaching, precipitation, solution purification, solvent extraction and electrowinning technologies, as well as concentrator, sulfuric acid and pyrometallurgical plants and processes, such as flash smelting, direct flash smelting and converting (DON), Ausmelt nickel smelting and converting, and slag cleaning furnaces.

Outotec offers unique technology solutions including laboratory testing, engineering and delivering proven plants, processes, equipment and automation as well as unbeatable service and support. We are committed to co-operating and continuously developing our products and processes with our customers, from environmentally sustainable unit processes to the delivery of entire turnkey plants. Customer needs and the unique characteristics of the raw materials are at the heart of our process design.

BENEFITS

- Tailored and optimized technology solutions from raw material to end product
- Unique laboratory facilities and expertise
- Process guarantees
- Environmentally friendly
- One-stop shop concept: testing-engineering-process-equipment-automation-services
- Proven references

A COMMITTED PARTNER FROM THE START

Outotec operates globally through an extensive network of sales and service centers. Outotec provides its customers with an unrivalled combination of process expertise, equipment and services, and focuses on developing its technology solutions and services for the mining, metallurgy and chemical process industries. We continuously strive to build long-term relationships with our customers, ensuring that they receive the very best solutions for their operating environment. Our expertise covers the whole chain of nickel production, from concentrator to nickel recovery. Involving Outotec in your projects at an early stage ensures you get the most profitable and competent solutions.

We provide world-leading technologies, technology selection expertise based on laboratory test programs, feasibility studies, basic and detailed engineering, technology-specific equipment supply, training, erection supervision and start-up assistance, as well as follow-up and technical support services. This level of involvement from a single partner gives you the chance to enhance your production processes and minimize operating costs throughout the lifetime of the plant.

Caring for the environment

We are committed to working together with our customers in designing our nickel technologies to minimize their environmental impact. We constantly strive to make effective use of raw materials, maximize the formation of stable or re-usable residues and reduce water and energy consumption.

Outotec nickel technologies comply with environmental legislation and requirements. Involving Outotec in your projects at an early stage ensures the smooth environmental performance of the nickel production chain. Outotec will design the most favorable and environmentally compatible solution for your operating conditions.

Tailor-made solutions and process guarantees through metallurgical testing

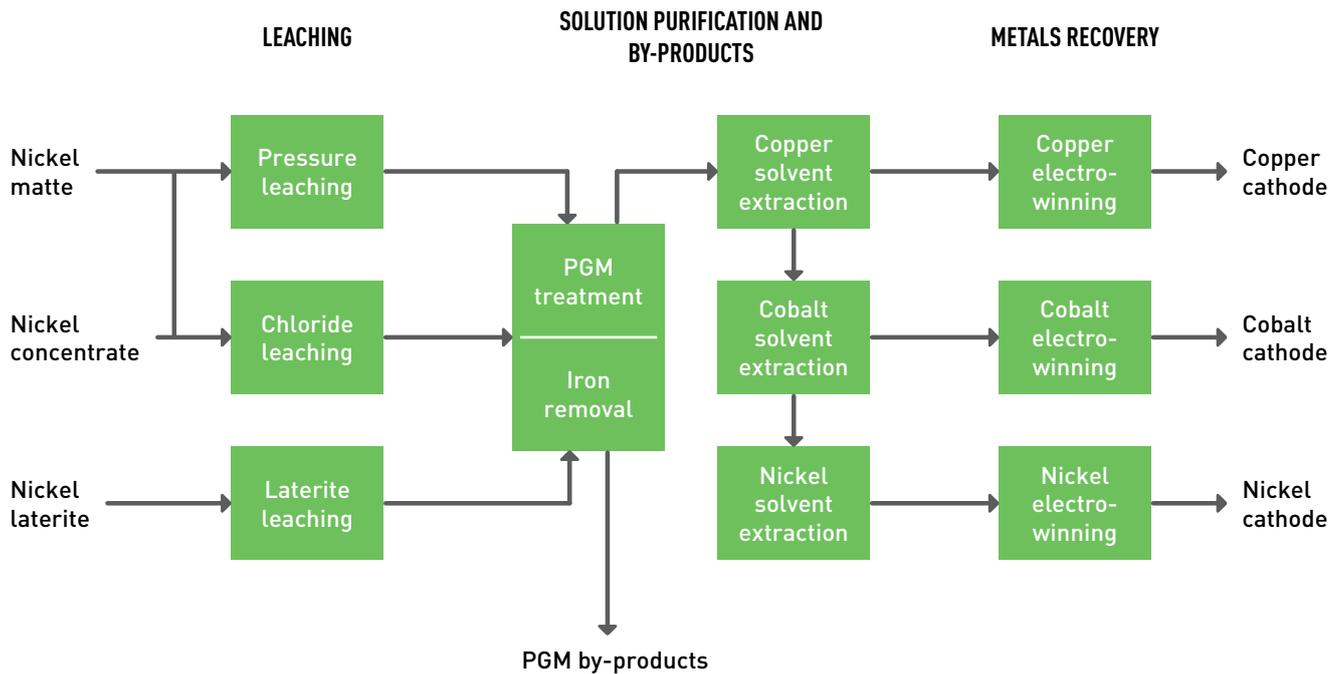
At the start of each project, we test our customers' raw materials and feedstock and tailor our processes accordingly. Outotec's in-house research centers have a unique set of research facilities and pilot plants, from test bench to industrial scale, well-equipped laboratories and an extensive network of research subcontractors. Laboratory testing on the mineralogy and chemistry of raw materials, and for example the solid-liquid separation properties of leached or precipitated feedstock enables us to define optimized production processes and equipment as well as bleed treatments and impurity handling processes.

Good references, laboratory testing and process simulation - the Outotec way of working - gives you the benefit of an optimized process with process guarantees. Outotec has patented its innovative hydrometallurgical nickel processes with a comprehensive set of patents and patent applications.

Outotec offers:

- Innovative and proven technologies
- Laboratory test programs and pilot test campaigns
- Scoping and feasibility studies
- Basic and detailed engineering
- Proprietary and key equipment supply
- Process automation and instrumentation
- Turnkey plants
- Training, commissioning and start-up services
- Operation and maintenance services
- Spare parts
- Plant audits, retrofits and equipment upgrades





OUTOTEC NICKEL TECHNOLOGIES:

Beneficiation:

- Physical separation
- Grinding
- Flotation

Leaching:

- Nickel matte sulfate leaching
- Nickel matte chloride leaching
- Nickel concentrate sulfate leaching
- Nickel concentrate chloride leaching
- High copper content nickel matte chloride leaching
- Nickel laterite leaching

Solution purification:

- Iron precipitation and iron residue treatments
- Recovery of precious metals, such as gold, silver and PGM
- Solvent extraction
- Sulfide precipitation
- Hydroxide precipitation
- Gypsum or sulfate removal

Nickel and by-products recovery:

- Cathodes via electrowinning
- Briquets via hydrogen reduction
- Precipitates via sulfide precipitation
- Crystals via crystallization

Pyrometallurgical nickel technologies:

- Nickel flash smelting
- Nickel direct flash smelting and converting (DON)
- Ausmelt smelting and converting
- Nickel slag cleaning furnaces
- Ferronickel plant

Sulfuric acid plant

Effluent treatment

Services

Outotec Process Equipment

Outotec Process Automation and Analyzers



FROM RAW MATERIAL TO END PRODUCT

Outotec is the only technology provider who can offer technology and equipment for the entire nickel production chain from the mine to metal with project scope ranging from equipment packages to turnkey delivery.

We have several process options, such as pyrometallurgical versus hydrometallurgical nickel production, and our experts, who have broad and deep metallurgical knowledge, can offer our customers optimized and reliable process design based on their particular raw materials.

With a global reputation for offering premier technologies for processing nickel concentrates, Outotec has recently developed new technologies for leaching ores, concentrates and tailings.

Not only do our nickel processing solutions help you achieve primary end products such as nickel briquettes and cathodes, but we can also recover valuable by-products such as copper, cobalt and sulfuric acid.

Outotec Hydrometallurgical Equipment:

- Outotec OKTOP® Reactors for atmospheric and pressure leaching
- Outotec® Thickeners
- Outotec Larox® Filters
- Outotec® Scrubbers
- Outotec® Cooling Towers
- Outotec VSF® Solvent Extraction
- Outotec® Tankhouse Equipment
- Courier® and OTI® Analyzers
- Procon® Process Control System
- Process instrumentation and electrification



EFFECTIVE LEACHING METHODS

Nickel matte and concentrate sulfate leaching

Pyrometallurgically produced nickel matte is leached in atmospheric and pressure OKTOP® reactors with the help of oxygen and sulfuric acid in process solution. The leaching circuit typically includes pulping, pre-leaching, pressure leaching in autoclaves, feeding, solid-liquid separation and scrubbing stages. The leaching reactions are exothermic. Particular attention is paid to safety issues in both process design and equipment design. The leaching process results in an aqueous nickel sulfate solution. This solution is further pumped to the iron removal and solvent extraction stages. The solid residue from the leaching is cake containing precious metals, which can be further treated as a precious metal product.

Nickel matte and concentrate chloride leaching

Chloride leaching is an alternative way to treat nickel raw materials. Matte or concentrate is leached at a high acid concentration with hydrochloric acid and oxygen in multiple steps in atmospheric OKTOP® Reactors. The high acid concentration is needed to keep iron in the solution. Oxygen is fed in to prevent reductive conditions due to hydrogen formation. The solids are removed from the solution with a thickener and the output of the thickener is a pregnant leach solution which moves forward in the process to iron precipitation.

Nickel laterite leaching

Outotec is continuously testing and developing an optimum atmospheric leaching process for nickel laterites. In the process, different nickel laterites are leached in several co-current stages in atmospheric reactors, depending on ore mineralogy. A viable option for concentrating and washing the leaching solution is the Outotec counter-current decantation circuit. Optimal tailings treatment and effluent processes are one of the key areas of success. The process is designed and engineered for safe operation, including minimizing the environmental impact.



EXTENSIVE PORTFOLIO OF ADVANCED SOLUTION PURIFICATION AND METALS RECOVERY

We offer an extensive selection of processes for solution purification and by-products for nickel production. During leaching, other metallic components, such as iron, zinc, copper and cobalt, are dissolved and must be removed before nickel electrolysis. The quality of the solution purification process is the key to producing a chemically and physically high-quality nickel end product. Our famous Outotec VSF® Solvent Extraction process has impressive references in metals production.

For nickel and by-products recovery, our portfolio includes electrowinning, precipitation, hydrogen reduction and crystallization technology options enabling nickel recovery from intermediate nickel products to ultra-high-purity nickel crystals.

Iron removal

Depending on the leaching and iron removal design properties, iron can be removed either in atmospheric or overpressure conditions as jarosite, hematite or goethite. Our expertise in iron precipitation offers an efficient and reliable solution to nickel producers for environmentally acceptable iron residue storage or further use. From iron

removal, the pregnant leach solution is pumped to the solvent extraction or other solution purification stages.

Solvent extraction

In the solvent extraction phase of the process, incoming pregnant leach solution is concentrated and purified, and a pure aqueous nickel sulfate solution is led to metal recovery, typically by electrowinning. In the same solvent extraction plant where nickel is extracted, cobalt and a number of impurity metals, such as iron, aluminum, zinc, cadmium, copper, calcium, manganese and magnesium, may also be treated. All metals for which an extraction reagent is available can be extracted with the advanced Outotec VSF® Solvent Extraction technology.

After solvent extraction, cobalt and copper can typically be recovered as cathodes or sulfide cakes. The other impurity metals can be recovered in the desired form. Outotec has delivered some of the biggest nickel/cobalt extractions in the world.



Other precipitation processes

Leach solution purification as well as nickel and by-products recovery can also be achieved via various sulfide precipitation, oxidative precipitation, neutralization, cementation and reduction technologies utilizing Outotec OKTOP® Reactors. Our technologies are a fully integrated part of the total plant and provide environmentally sustainable precipitation with minimal consumption of additive agents.

Precious metals recovery

Nickel sulfide ores or matte may contain valuable amounts of precious metals. Outotec offers process solutions to recover such metals, for example from the anode slime produced in an electrorefining plant. This type of precious metals recovery consists of leaching and alternative Outotec® Kaldo Furnace and Outotec® TROF Converter steps, as well as steps to recover silver, gold, PGM and platinum metals.

Another way to recover precious metals is further treatment of leaching residue, for example with further leaching and gold extraction with the novel Outotec® Gold Solvent Extraction.

Nickel metal recovery via electrolysis

Outotec is the right partner for delivering an efficient, productive and safe electrowinning plant with optimized cathode and cell sizes, current densities, busbars, and an automatic material flow of cathodes. Significant advances and benefits for tankhouse operations can be secured with the Outotec CellSense® electrolytic cell performance monitoring system. Also, metallic nickel powder can be produced by using hydrogen reduction technology.

The new Outotec anode bag technology in nickel electrowinning offers an environmentally friendly electrowinning process by significantly reducing nickel emissions and notably improving the working hygiene of operators. This new technology reduces operating costs and enables fully automated process and oxygen recovery from the electrowinning process.

Nickel crystals recovery via evaporation and crystallization

Nickel crystals with various purity ranges are mainly used in the battery industry. The process includes evaporation and crystallization stages.

Outotec

Outotec provides leading technologies and services for the sustainable use of Earth's natural resources. As the global leader in minerals and metals processing technology, we have developed many breakthrough technologies over the decades for our customers in metals and mining industry. We also provide innovative solutions for industrial water treatment, the utilization of alternative energy sources and the chemical industry. Outotec shares are listed on NASDAQ OMX Helsinki. www.outotec.com