Circular Economy and Waste Management

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Waste Management

Tailings Complexities for the Next Years

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Abstract

Tailings deposits have always been of special attention to mining operations, however, in the last 5 years due to catastrophic failures of tailings deposits in companies with a great mining tradition and size, the mining industry has had to demonstrate to communities, authorities, investors, insurance companies, among other stakeholders, that the management of tailings systems is done safely.

Demonstrating everything that is done, how it is done, how the design, construction, operation and closure of tailings deposits is controlled, based not only on national regulations but also on good industry practices, will be a challenge for the industry for the next 2 to 4 years. However, the challenges that the industry will face in subsequent years will be of much greater scope, impact and significance in the sustainability of the mining business.

For the challenges of society, it needs mining, but we must demonstrate that the mining industry will be able to meet this need in the standards that society demands.

Evolution of Chilean Tailings Deposits and Dams after El Cobre Tailings disaster in 1965.

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Abstract

The tailings system facilities vary significantly along the Chilean territory depending of geography and climate including tailings transport systems depending also of the distance from concentrator, in some cases exceeding 80 km. Evolution of water recovery systems are also discussed. The most critical elements in the Chilean TSF are the tailings dams due to the extremely high seismicity of the country. Most of tailings dams have been subjected in their lifetime to a major earthquake of magnitude larger than 7.5 and at short distance from epicentre. Information regarding seismic performance of tailings dams will be discussed with mention to the major failures of Barahona dam in 1928 and that of El Cobre tailings dam in 1965. A description of the evolution of Chilean TSF and tailings dam design and operation will be presented covering from 1965 to the present time with representative examples of different types of tailings dams.

Non-Conventional Tailings Technologies Challenges and Opportunities for Large Copper Mines to Reduce Facility Risk

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Abstract

High performance dewatering technologies have existed for years in the form of centrifuges, vacuum filters, filter presses, and belt presses and these technologies have been widely applied at high-grade, lower throughput operations. However, until relatively recently, aside from the cost of water, there has been little incentive for high-throughput, lower-grade operations such as copper or iron-ore to dewater their tailings. Dewatering to create paste or filter cake removes residual process water from the tailings which can reduce the risk and consequence of a storage facility failure. It also allows process water to be returned to the concentrator for reuse, helping mines to drive down their water consumption rates and operating costs. However, with these opportunities also come challenges, which include the choice and scale of the dewatering equipment, how to best transport the dewatered tailings to the TSF, and the deposition method used for placing the tailings. Each mine is unique and understanding these opportunities and challenges is key to the successful implementation of non-conventional tailings technologies, particularly for large copper operations.

Intelligent system to assess of physical stability of closure-stage medium-sized mining tailings deposits

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Abstract

The development of an intelligent system capable of periodically evaluating the physical stability of tailings deposits from medium-size mining producers would provide a robust tool for such facilities transitioning to closure. We propose one such intelligent system to evaluate five possible failure mechanisms: seismic liquefaction, slope instability, static liquefaction, overtopping, and internal erosion. Here, the Support Vector Machine (SVM) and Random Forest (RF) algorithms – which can solve data classification and regression problems – are used to estimate potential failure mechanisms. The SVM algorithm seeks to create an optimal hyperplane that allows two or more classes to be separated, and establishes the minimum margins between them, while the RF algorithm is composed of decision trees that are trained to generate predictions of possible failure mechanisms. Models were trained on real data, obtained from closure plans, design projects, environmental evaluation reports and operational controls of tailings deposits; as well as on automatically generated synthetic data from the Physical Stability Guide of the National Geology and Mining Service (SERNAGEOMIN). Preliminary results of the intelligent system show good performance and high success rates in evaluating potential failure mechanisms, exceeding 95% accuracy with the methodologies used.

Seismic performance of Chilean tailings dams

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Abstract

Chile is known as one of the most seismic countries in the world, being responsible for more than 40% of the seismic energy liberated globally. The Valdivia earthquake (EQ) of 1960 with a magnitude Mw=9.5 is the greater EQ ever registered. In February 2010 occurred the Maule EQ of Mw = 8.8 which is among the 6 world bigger earthquakes. During the last 20 years 15 earthquake of Mw>7.5 has been occurred in Chile.

The paper presents a summary of the performance of tailing dams in Chile (heights ≥ 15 m). Special attention is given to sand tailings dams that representing good examples of local development in dam engineering. In the case of sand tailings dams constructed with the downstream method, there is already a 200 m high dam that ended its operation and another one designed for a height of 240 m. The paper analyses design criteria, local dam safety legislation and dam design and construction practices.

Candelaria TSF-a holistic approach

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Abstract

The Candelaria mine, indirectly owned by Lundin Mining (80%) and Sumitomo (20%), is an open pit and underground mining operation providing copper ore to an on-site processing plant. This mine is located in Chile's Atacama Region, a semi-desert area in northern Chile about 20 km south of the city of Copiapó. Its main challenges for mine waste management were environmental (emission of dust and noise) and the economic disposal of mine waste rock. The site and mineral conditions defined the characteristics of tailings management where the abundance of waste rock favored the construction of the TSF dam shells with the waste rock, and the location of the TSF in the upper part of a ravine, on the edge of the waste rock dump (reducing the hauling distance) and also close to the open pit. Likewise, the topographic and hydrogeological conditions facilitated the control and recovery of the seepage. This TSF operated for 25 years (1994 to 2019) impounding a total of 541 Mt. It is currently in the post-operation period and with studies to place a waste rock dump that would cover it in its entirety. This paper presents the evolution of this TSF in all relevant aspects with special attention to the control of seepage, the water recovery (which is one of its greatest achievements) and the studies under development that integrate the need for more space for landfills with an effective and efficient closure plan.

Centinela Thickened Tailings: Challenges and Continuous Improvement

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Abstract

Minera Centinela (ex-Esperanza) pioneered and currently operates one of the largest thickened tailings facilities in the world at 750 Mt of capacity. Centinela began operation in 2011 and as pioneers in tailings thickening at large throughputs of 105 ktpd, Centinela faced significant unprecedented challenges with the thickening process resulting in lower than expected tailings underflow solids concentration (Cp) and a highly variable tailings stream. The low Cp and variability of the tailings stream impacted tailings deposition resulting in lack of beach control and irregular beach slopes.

In 2012 Centinela conducted a series of thickening and deposition trials to identify design and operational parameters associated with increased thickening of its tailings. As a result, Centinela has implemented significant thickening process improvements: adding 3 paste thickeners (PT) to the original 3 high density (HD) thickeners, changes to the feedwells of the HD thickeners and flocculant controls system, among others. An expert system was designed and implemented to maximize underflow solids concentration (Cp) and to ensure process stability. Improvements were also implemented in the processes upstream of the tailings thickeners, including better geo-metallurgical data obtained at the mine. Centinela has continued to add (and is continuously seeking) process control instrumentation to reduce uncertainties and improve process stability.

While the process improvements were being implemented, mitigation and contingency works were performed on the deposit to ensure operational continuity at the tailings storage facility (DRE), including tailings containment dams, paddocks and surface water management systems.

In parallel, a long tailings distribution system, based on spigot lines and spigot flow distributors, was developed to allow the formation of deposition beaches. Four perimeter dams were built to provide tailings containment and flood management capacity: Main, South, M-1 and M-2.

Since 2018, process and tailings deposition control improvements have resulted in stable Cp (greater than 65%) and controlled beach slopes (2 to 3 %).

Geotechnical characteristics of the deposit are also monitored to assess stability. Cone penetration test campaigns and tailings characterization tests are conducted regularly. Results have shown a stable and relatively homogeneous tailings deposit.
Personnel safety within the deposit has also been improved by implementing remote operation of equipment.

Centinela has also modified and improved its tailings governance system to facilitate tailings thickener process stability, ensure deposit stability and optimize tailings deposition. The governance for Centinela is aligned with the requirements of the Global Industry Standard for Tailings Management (GISTM).

Transformation of Mining Tailings into Raw Materials and Sustainable Products

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Abstract

The mining tailings are made up of three phases (solid, liquid and gaseous), two of which need to be fully considered when determining the technologies for their management and final disposal: on the one hand, the contained solids, which due to their mineralogical load They can give rise to the occurrence of complex physical, chemical and biological processes, among which the leaching of remaining sulfides predominates, generating acidic waters, once they are disposed of in the storage facilities and, on the other hand, the liquid phase that in turn It also contains elements that can potentially promote harmful processes and affect the environment.

SUMAT GROUP consortium has deployed the joint effort of the experience and knowledge of the Academy, with companies with a deep knowledge of mining operations and their technologies, to develop a sustainable integrated sequential flotation and magnetic concentration process with two fundamental objectives: demetallize the solids, chemical and physical inertization and simultaneously treating the waters to obtain raw materials and supplies.

Inverse long-range planning for mining projects: a way to assure an environmentally friendly project

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Abstract

Common way to get long range plans for mining projects usually starts getting the ore reserves. For that, the planner follows a sequence of tasks that consider some economics assumptions about metal prices and the costs of mining and mineral processing. When the mine plan is already fixed, the project team must perform the engineering studies of the project, including tailing disposition sites to get the economic evaluation that justify the investment. This paper describes a new approach to abord long range mine planning in an inverse way. Inverse planning of mines considers starting the planning process upstream from tailing disposition to get the ore reserves and then, it develops the project as usual with the ore reserves that fit that capacity. So, the project has from the beginning a tailing disposal compatible with the environmental conditions around the mine site.

Selection of the place for tailing disposition is based on the Dynamic Spatial Modeling (DSM) which allows categorizing the territory from levels of highest to lowest environmental risk. DSM generates a sustainable plan setting the best place and time for tailings disposition derived from the integration of analytic hierarchy processes, geographic information systems and cellular automata.

Circular Economy

Challenges and Opportunities with WEEE Treatment in Copper Smelting Processes

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Abstract

Strict environmental and waste management legislation, in most countries around the world, do not allow disposal of the waste electrical and electronic equipment (WEEE). At the same time, the significant amount of valuable metals in WEEE generates a strong incentive for recycling of these materials and recovery of the metal values. The metallic and ceramic components of WEEE are different than those found in ores/concentrates; hence, the smelting processes need to be tailored to allow efficient recovery of metals, and management of the undesired elements/components of the system. A considerable amount of WEEE is treated in the primary copper smelting or black copper production routes, where special measures need to be taken to allow recovery of metals such In, Au, Ag, Pb, Zn, Sn, Sb, Ni, Bi and control the adverse effects of elements such as As, Cr, Mg, and Al.

The current paper reviews the recent developments made in copper smelting to allow an increased recycling of WEEE and highlights the remaining challenges and opportunities that copper smelters are facing.

Tailor-made thermodynamic process solutions for metallurgical treatment of high-organic shredder-residues and WEEE material

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Abstract

Küttner GmbH & Co. KG has been engaged in developing thermodynamic technologies that create sustainable benefits for recyclers and their plants. Special attention was paid to the avoidance of disposal, landfill, and incineration of residues and wastes (WEEE scrap). The development of a tailor-made recycling process fulfils all needs for the economic recovery of valuable metals (such as copper, other non-ferrous metals, and precious metals) and the thermal usage of combustibles from residual wastes inside an autothermal process. The energy obtained from the off-gas treatment could be used inside the recycling plant or sold to local facilities for heating purposes or electrical applications. In addition, a stable mineral fraction is also produced and can be integrated into existing raw-material productions lines.
Keywords: Shredder residues; WEEE recycling; autothermal melting; integration of energy; mineral stabilization

Processing of copper tailings – transforming environmental liabilities into economic assets

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Abstract

The world is grappling with urgent concerns to protect the environment. In the global race to decarbonize and meet climate goals, copper has a central role to play. However, significant supply challenges are being identified due to the decline in existing ore grades and the greater difficulty of bringing scarce new deposits into production, including, but not limited to, permitting challenges. These combined factors are conducive to a paradigm shift under which copper tailings would cease to be regarded as environmental liabilities and would instead be identified as sustainable business opportunities. Economically recovering copper from tailings is a viable alternative, with potentially lower costs than traditional extractive mining and lower mining risk. Tailings have the potential to become a cornerstone of green copper mining, a new way of mining in which miners sustainably supply the copper required to support global development while reducing environmental footprint. This paper will present Amerigo's 30-year technical and operating experience in copper tailings processing, showing a real-life example of how mining companies can reduce, reutilize, and recycle their tailings, incorporating them to the circular economy, thus transforming environmental liabilities into economic assets.

A novel thermodynamic approach to understand Circular Economy applied to mining and metallurgical processes.

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Abstract

The Circular Economy is an economic concept linked to sustainable development and the green economy, but it goes much deeper into it. It aims not only to reduce the environmental impact of industries and reduce the amount of waste generated, but also to produce goods and services through the sustainable management of materials and energy sources. We consider that this approach is based on the observation of the behavior of the markets and that it can be enriched with theoretical aspects from Thermodynamics. To do this, we propose the inclusion of some concepts such as Gibbs Free Energy and the irreversibility of the processes. We believe that adding ideas allows to emphasize the deep link that can be established between the Circular Economy and Thermodynamics. The objective of the work is to investigate the way in which Thermodynamic definitions allow broadening the view on the flows related to the Circular Economy. Cases of the metallurgical and mining fields are presented and are briefly commented with this new approach. It concludes by presenting the concepts of Thermodynamics as an extension of the theoretical aspects of the Circular Economic approach.

Recovery of rare earth elements from Chilean tailings: Relavesconvalor® Project

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Abstract

Since 2011, the rare earth elements (REE) belong to the list of critical raw materials (CRMs) defined by the European Union (EU). The main world producer of these elements is China, and some market studies shows an emerging deficit due to growth in its uses, such as electro-mobility and non-conventional & renewable energy industries.

In Chilean tailings, it is possible to find REE in trace amounts (parts per million, ppm), therefore, the metallurgical process design to extract them must be polymetallic, considering others elements with solid market in Chile, such as Cu or Mo, in order to achieve the economic feasibility.

In 2018, the Relavesconvalor® project began to develop a metallurgical testing campaign in order to recover REE from a composite of three samples of old tailings deposits, located in the ferriferous strip of the Atacama and Coquimbo Regions of Chile.

First, laboratory-level tests were developed, defining a process scheme for the polymetallic recovery of concentrates of Fe, Cu and REE oxides (REO). Later, this scheme was tested at pilot (bench) scale, in order to validate the sequence process and evaluate improvement opportunities. Finally, from a tailings composite with approximately 400 ppm of REE, it was obtained a concentrate of REO with 4% grade, which is equivalent to an enrichment ratio of 100.

The next step is to continue improving the process and, hopefully, test it in a deposit of the small or medium Chilean mining.

Antimony Recovery in the Copper Industry: a circular economy approach.

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Abstract

The production of high purity copper is becoming increasingly difficult as the purity of mineral ores gradually decreases after several decades of intensive mining. The difficulties caused by the presence of metal impurities in copper metallurgy have already been described in the literature. To reduce the damaging effect of these impurities, processes have been added to purify the electrolyte on the electrorefining process. However, this practice results in the loss of valuable metals as antimony, what is not associated to a circular economy idea, where waste occurring during the production phase could be recycled and therefore become a resource. Besides, antimony is listed as a critical raw material in the US and in the EU, being a material considered as one with limited availability, both because of the environmental footprint of its supply and because of the geopolitical and social pressure for some ores and elements. Therefore, technologies to recycle antimony from the wastewater generated during the copper production must be evaluated. This work addresses the challenging subject of applying a membrane process in the processing of copper sulphide minerals and of copper low-grade mining tailings, not only to purify the electrolytes, but also to recover antimony. The achievement of reuse and recycling of raw materials in a circular economy is important, since the copper metallurgy must be sustainable, balancing profit, safety, social acceptance and environmental protection.

Concentration of valuable elements from tailings through hydrometallurgical techniques

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Abstract

The Copper mining industry has produced large volumes of tailings over time, which has led to huge amounts of these byproducts being disposed of and accumulated in the northern and central Chile. Valuable species and metals present in these tailings could be concentrated and recovered. The use of hydrometallurgical techniques will be studied to concentrate copper from a sample of thickened tailings. A two-step acid leaching of the sample, and the synergic use of oxidizing agents, such as hydrogen peroxide (4 – 8% v/v) and ferrous ions (2.5 g/L), resulted in a dissolution of 91.96% of iron, and a much lower leaching of copper (10.89%). Copper species are expected to be concentrated in the gravels produced during the second leaching stage. Finally, the use of two-step leaching allows an optimized dissolution of iron and comprehends the role and behavior of peroxide hydrogen as an oxidant in copper sulfides ores surfaces.

Solvometallurgical extraction of copper from waste printed circuit boards

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Abstract

Hydrometallurgy is based on aqueous processing and involves vast amounts of water and often toxic chemicals to achieve satisfactory metal extraction from primary and secondary resources. As natural resources deplete over time, this practice has resulted in increased volumes of aqueous effluents which need to be treated and disposed off. Furthermore, in places with acute water scarcity, hydrometallurgy faces challenges due to the lack of fresh water. In this work, we report on the solvometallurgical extraction of copper from waste printed circuit boards. Our innovative approach is a water- and acid/base-free process that requires similar operating conditions and equipment as hydrometallurgy. Instead of water, solvometallurgy uses eutectic mixtures of common, inexpensive, non-toxic, and biodegradable salts as the solvent instead of water thus ensuring a near zero-waste approach. Our results show that solvometallurgy is a potential game changer for mineral and metal processing, especially as we transition towards a green zero-waste (urban) mining future.

Keywords: sustainable processing; solvometallurgy; copper; urban mining; printed circuit boards; waste valorization

Investigation of chemical stability of metallic aluminum piece trapped in molten fayalite slag

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Abstract

The amount of e-scrap, such as waste printed circuit boards (PCBs), charged into the copper smelting process, is increasing, and the problem of impurity elements derived from secondary raw materials has become apparent. One of the smelting impurity elements is aluminum. Metallic aluminum is used as heat sinks and capacitors. Alumina is contained in the glass fibers of the glass epoxy substrate of PCBs. When the PCBs are incinerated during their pretreatment, it is assumed that the oxidation of metallic aluminum is progressing. However, the unoxidized metallic aluminum is remained and also charged into the smelting furnace. In addition, e-scrap is directly charged into the bath smelting furnace. In this study, we focused on the reaction behavior between the molten fayalite slag and the metallic aluminum. The chemical stability of the metallic aluminum piece trapped in the molten fayalite slag was investigated.

Atmospheric Scorodite Process for Fixation of Arsenic in Copper Smelter Waste Acid: From Laboratory Study to Commercialization

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Abstract

With increasingly stringent regulations for transportation and environmental disposal of arsenic-containing solid waste, copper smelters processing concentrate feed with a high level of arsenic need to develop a sustainable technology for arsenic control in process and arsenic stabilization on site. To meet the challenges, Zijin Mining Group initiated a R&D program in late 2017. A new process for immobilizing arsenic in acidic stream as an environmentally stable material was developed in laboratory study. It involves limestone neutralization of waste acid to produce a clean gypsum product, arsenic oxidation, precipitation of scorodite under atmospheric condition, and a polish step to generate arsenic-free water for re-use or discharge. Following successful demonstration of the process through pilot testwork, a commercial plant with design capacity of treating 600m^3/d waste acid containing 15g/L As and 150g/L H_2SO_4 was built in 2019. It was commissioned in December 2019 and reached full performance in two months. The plant operation results up-to-date indicate that the process developed is technically and economically viable. The scorodite-based material produced contains arsenic up to 25% and can meet both the TCLP (As<5 mg/L) and Chinese (As<1.2 mg/L) standards for disposal. The overall cost for arsenic stabilization including waste disposal was only 2000~2500$US per ton of arsenic.

Thermodynamic study for obtaining Fe-Si alloys from copper slags

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Abstract

Currently, economics and environmental issues along with metals consumption have imposed the development of effective and inexpensive method for the recovery of valuables metals from secondary sources. Chile produces more than 3.5 million ton/year of copper slag containing Fe and Si ranging from 43% to 48% and 12% to 14% respectively. In this regards, copper slag exhibits an economical potential for recycling by using metal extraction processes. Thermodynamical calculations were done by using ThermoCalc software to study the conditions to obtain Fe-Si alloys. The effect of coke addition and temperature on the reduction of fayalite, magnetite and silica was studied. The ranges studied were, temperature between 1200 – 2000°C and coke addition between 0.5 and 1.5 of stoichiometric ratio. For a stoichiometric level of 90% at 1700°C the Si content was 19,6% with a minimum impurity content, and under this conditions, the maximum recovery of Fe-Si alloy is close to 93%.

Metal removal simulation from acid mine drainage by a subsurface limestone bed for 13 mine sites in Japan using geochemical models including surface complexation reaction

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Abstract

Passive treatment (PT) using natural geochemical and biological processes is the one of techniques to remove toxic trace metals (e.g., Zn, Cd, Cu, and Pb) from acid mine drainage (AMD) in active and abandoned mine sites. Various PT techniques have been developed such as open limestone channel and aerobic/anaerobic wetlands; thus, administrators should select PT techniques based on chemical evidences obtained from AMD quality and quantity rather than by rules of thumb. In our previous study, we have investigated the chemistry changes of AMD flowing in a subsurface limestone bed (SLB) and examined a geochemical model to evaluate its metal removability (Fuchida et al., 2021). X-ray absorption fine structure of sediment collected from the SLB has revealed biogenic δ-MnO_2 production, which mineral shows a high affinity to Zn and Cd. Thus, surface complexation reaction was included in our geochemical models: adsorption equilibrium constants (log K) for the surface complexation reaction with δ-MnO_2 were 2.9 for Cd (Fuchida et al., 2021) and 2.3 for Zn (Tajima et al., submitted), respectively. This geochemical model can represent the effective removal behaviors of Zn and Cd by δ-MnO_2 formation in the SLB and calculates the SLB size required to treat each AMD completely. In this presentation, we will introduce this geochemical model in detail and also discussed the possibilities of SLB installation to 13 mine sites in Japan based on the calculation results for each AMD.

Copper recovery from multiwire tinned cable using pyrolysis with alkali hydroxide

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Abstract

In this study, covered PVC was pyrolyzed with alkali hydroxide, NaOH and $Ca(OH)_2$, to capture the generated HCl gas as alkali salts, NaCl and $CaCl_2$, and to carbonize the covered PVC to generate fuel gases, such as H_2 and CH_4, simultaneously, to recover copper from the multiwire tinned cable. With increasing the temperature, the covered PVC released HCl gas around 300 ^oC and carbonized to generate fuel gases around 500 ^oC. By pyrolysis with NaOH and $Ca(OH)_2$, the covered PVC can be converted into powdered carbonaceous material, and carbonaceous cover with NaOH is more brittle than that with $Ca(OH)_2$. The amount of released HCl gas decreases by capturing HCl gas as NaCl and $CaCl_2$, and higher amount of HCl can be captured using NaOH than $Ca(OH)_2$. The amount of generated fuel gases increases using NaOH, while that using $Ca(OH)_2$ are almost same as that without alkali hydroxides. The covered PVC can be removed from tin copper wire by formation of carbonaceous material and alkali salts, and the carbonaceous residues after adding distilled water contain calcite ($CaCO_3$) and corundum (Al_2O_3) to be used as cement additives. These results can suggest that a novel environmental-friendly effective process with capturing HCl gas and conversion into carbonaceous material and fuel gases is feasible for copper wire recovery from miltiwire tin cable using pyrolysis with alkali hydroxides, and pyrolysis with NaOH is superior to that with $Ca(OH)_2$.

The DOM-TEC® system, a multipurpose electrolytic process to recover metals from mining and metallurgy industrial solutions from different medias.

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Abstract

DOM-TEC®, a new electrowinning (EW) process and other metals as antimony and zinc in chloride media, has been developed and tested at 600 L/min industrial scale. The electrolytic cell system consists of several-sealed individual cell based on the electro-electrodialysis (EED) concept. Each cell has an ionic membrane that separates the electrodes. During the tests, the leach liquor containing between 5 and 30 g/L of copper flows from a tank to the cell where potential-controlled or a current-controlled electrolysis are carried out. The resulting grade A copper cathodes are extracted in a horizontal mode. The resulting electrolyte leaves the cell and flows back to the leaching circuit. By controlling the fluid flow, the cell can operate at higher current densities compared with SX-EW tank houses. The direct EW with DOM-TEC® does not require additives and accepts higher levels of impurities such as chloride, iron, arsenic and others.

Based on extensive laboratory, pilot and industrial scales measurements of the rate of copper electrodeposition, the process concept was developed, aided by process modeling and simulation. The industrial scale installation built in Calama City, Chile, consists of 214 cells in compact and horizontal mode, operating in line inside a container, with a designed capacity of 100 tons of cathodic copper per months working at 40 g/L of the cation and 600 A/m2 current density. The experiences are discussed on the basis of different industrial leach liquors and the results are proven to be effective in producing metallurgical test data of sufficient reliability to scale up to the industrial level.

Solvometallurgy: a short review

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Abstract

Solvometallurgy is defined as a technique for extracting valuable elements from material sources through the use of non-aqueous leaching solutions, such as organic solutions. This area of metallurgy is conceived as a sustainable process, with a decrease in water consumption, energy optimization and purification stages, and high leaching selectivity; even in low grade minerals; e-waste; mining tailings; metal waste; among others. This technique would allow, according to some research, a high recovery of valuable and critical elements e.g., Cu, Co, RREE, et cetera. A short review of solvometallurgy will be reported. It is necessary to expand research on this matter, to promote sustainable metallurgy and with the least possible environmental impact, taking care of non-renewable natural resources and at the same time maximizing the extraction, recovery and obtaining of metals from different material sources.

Development of physical separation process of electronic scrap for copper smelting and refining

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Abstract

In recent years, JX Nippon Mining & Metals (JX-NMM) is promoting the treatment of secondary materials such as Electronic scrap (E-scrap) utilizing the copper smelting process. Increasing the throughput of secondary materials from urban mines contributes to the circulation of metal resources. However, impurities contained in E-scrap, including antimony, aluminum, and some other elements, are unfavorable for the copper smelting process. Therefore, JX-NMM decided to remove these elements from secondary materials at the pre-treatment stage. In 2019, the company introduced the physical separation process at Hitachi Works to separate aluminum scrap and plastics containing antimony and other elements from E-scrap. This process consists of various separation equipment, such as Picking Robot, Screen, Wind Separator, Magnetic Separator, Eddy Current Separator, Metal Sorter and Color Sorter, etc. Introduction of the process has removed impurities for the copper smelting process and contributed to the stabilization of the secondary materials treatment. This paper describes the pretreatment separation technology developed for the E-scrap treatment in the copper smelting process.

Preliminary study on adsorptive performance of organic acid-functionalized Mg-Fe LDHs for arsenic removal from contaminated water.

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Abstract

Layered double hydroxides (LDHs) have received great attention due to their ability to remove several harmful cations and anions from contaminated water. Recent studies have shown LDHs functionalized with organic materials exhibit higher sorption affinity for oxyanions. However, the interaction mechanism between the organic material and LDHs, which enhanced the adsorptive properties of LDHs is not yet fully understood, and most relevant studies often neglect the co-occurrence of several anions in contaminated water which could lead to underestimating the uptake potentials of these functionalized LDHs. Herein, we synthesized organic acid-functionalized Mg-Fe LDHs via the batch hydrothermal method. The synthesized LDHs were characterized using Fourier-transform infrared (FTIR) spectroscopy, X-ray diffractometer (XRD), BET surface area, and Scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS) to examine their functional groups, crystal structure, surface area and porosity, and morphology, respectively. Our preliminary results showed that the addition of organic acid increased the surface area of the LDHs by more than 50% by inhibiting their crystal growth and subsequently intercalating into their structure. Batch adsorption tests showed that the material exhibited fast kinetics as 1 mg/L arsenic in an acidic (pH 3) contaminated water was immobilized completely under 5 min. The adsorption capacity of organic acid-functionalized LDHs for arsenic with an initial concentration of 10 mg/L was 40% greater than the normal LDHs. These results demonstrate that the functionalized LDHs are promising materials for the selective removal of harmful oxyanions.

Circular Lean Mining(™), an integral approach to raise organizational awareness improve processes, and make them circular and sustainable.

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Abstract

This research explores Circular Lean Mining™ as an approach for a zero waste future in mining. Circular Lean Mining™ takes into consideration the principles of Lean Management and Circular Economy to move from a linear economy to a circular one. This practice focuses on "roundput" rather than "throughput" as a means to measure and keep waste in its highest state of value, by minimizing the use of resources, reducing carbon emissions, environmental footprint, as well as social impact of the mining process.

Specifically in the mining industry, a circular economy and a responsible supply chain are growing global trends. This paper will discuss a practical approach to measure the level of circularity using the 5Rs of sustainability, as a way to benchmark how Chilean mining companies are progressing toward their carbon neutrality by 2050.

Cobre Las Cruces runs “Circular Economy Project” reprocessing old copper tailings.

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Jorge Blanco, Cobre Las Cruces S.A., Spain
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Abstract

Cobre Las Cruces (CLC) company has been successfully operating its integrated copper mine and hydrometallurgical copper refinery since 2009 producing on-site 70-74,000 tpa of Grade 1 Cu cathodes. CLC's secondary copper sulphide ores has been one of the richest copper deposits in the world ranging 5-6% Cu grade. Unfortunately, the rich-copper ores were depleted in early 2021 and, as a result, CLC decided to develop and execute a Circular Economy Project focused on the reprocessing of old copper tailings generated in the 2009-11 period and stored at its dry-stacked disposal site. The tailings retreating project is operating profitably since February 2021 feeding directly 1.56 Mtpa of old tailings containing 1% Cu, approx. The results obtained at CLC's copper hydrometallurgical refinery are truly impressive, recovering over 80% Cu through its unique technology process that includes Cu tailings atmospheric leaching in stirred tanks, and next, solvent extraction and electrowinning producing more than 12,000 tpa of Grade 1 Cu cathodes. In addition, CLC will recover other critical raw materials from its old tailings, including Co, Zn, etc.

Integration of energy transition and circularity in copper production: A techno-economic and environmental study

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Abstract

Over the years, energy transition (fossil to renewable) and sustainable economy (from linear to circular) are being regarded as the key approaches to comply and implement the regional and international environmental protocols. Meanwhile, copper demand has been increasing in the past decade and will continuously expand in future. Hence, the objective of this work was to systematically investigate the energy transition-circular economy approach in copper production through optimizing technological, economic, regulatory and societal variables. In particular, the potential of Power-to-X technology in the existing copper production chain was investigated, with a particular focus on copper recycling. The HSC Chemistry software was used to model and simulate copper production processes using secondary raw materials (e.g. waste printed circuit boards and copper-containing waste cable). A simulation-based techno-economic and environmental impact assessment was performed to evaluate the integration of the renewable energies into the secondary copper production. The results showed that enhanced sustainability can be achieved through adopting this integration. Finally, challenges associated from flexibility (e.g., fossil to renewable energy) in copper production have been identified and further discussed.

Metso Outotec eScrap: Converting a Waste Problem into a Business Opportunity

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Abstract

The responsible collection and recycling of material considered as waste products has become one of the key elements of the sustainability agenda. Each year tens of millions of tonnes of Waste Electrical and Electronic Equipment (WEEE) are generated across all areas of the globe and the recycling of this waste stream comes under ever more attention from consumers and regulators, yet this waste stream also represents a tremendous resource and potential business opportunity. With appropriate pre-processing, a particularly valuable fraction of e-scrap can be recovered, but this fraction also contains significant challenges to process in conventional primary copper smelting plants due to the presence of plastics, halides, heavy metals and aluminium/alumina. In this paper the authors describe the technical and commercial challenges in processing e-scrap and how these may be addressed with Metso Outotec suite of eScrap technologies. A high level economic analysis and discussion of the potential viability of smaller scale, local e-scrap processing plants is also presented.

ReAK- Reduction of arsenic in copper concentrates

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Abstract

ReAK (Reduction of arsenic in copper concentrates) is a binational project between Chilean and German partners. The overall objective of the research is to expand the existing processes of copper production in such a way that the increasing arsenic concentrations in the upcoming ores can be processed in a cost-effective and environmentally friendly manner, such that the excess in arsenic can be immobilized and disposed safely.

The project deals with different process steps along the copper production chain. For example, research is being focused on arsenic-selective flotation so that an arsenic-poor and an arsenic-rich fraction are produced right at the start of the process chain. The same goal is being pursued in the development of a sensor-supported separation of arsenic-rich ore fractions. This arsenic-rich fractions are now to be further processed by advanced roasting processes, as well as by leaching processes (sulfidic or microbiological).

In currently existing copper processes, the arsenic is loaded as arsenite in a gas scrubber. The project is researching new ways to oxidize that arsenite to arsenate, which can be precipitated as a less soluble compound and would therefore be more environmentally friendly to landfill.

Finally, possible landfill routes will be researched and the immobilization and mobilization processes of the landfilled arsenic will be investigated.

Proposed flowsheet and pilot experiments for an ammoniacal closed loop metal recovery and electrowinning system

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Zulqarnain Ali, University of Kentucky, United States of America
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Abstract

Building upon work of copper ammoniacal systems, a team of engineers at the University of Kentucky has conceived of and constructed a closed loop coupled leaching and electrowinning process for the recovery of copper from mixed metals. This work will present the fundamental framework of the proposed circuit, including its construction and operation, in addition to theoretical and observed performance. The intent of this presentation is to familiarize the scientist and engineer about the potential benefits and learnings from the operation of a closed loop ammoniacal copper recovery process.

Enabling Circularity – Recent technological advances at SMS to push resource consumption to its lower limits

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Abstract

The precise definition and modelling of the complex metallurgy processes taking place in our reactors of the recycling of non-ferrous metals. It enables an accurate prediction of the carbon and environmental footprint of furnaces as well as of complete plants.

Producing high quality materials from complex mixtures of minerals (geological) and functional materials (products) in the circular economy (CE) paradigm, requires detailed technological and thermodynamic understanding within detailed flowsheets embedded in the CE. True losses within the CE are best defined by exergy dissipation (lowering in quality of materials and energy) in addition to energy dissipation.

This paper discusses various advances within SMS to mitigate this degradation of quality of materials and energy and thence maximizing the resource efficiency of reactors and flowsheets as well as systems of flowsheets. With a focus on these fundamental aspects that define metallurgical systems i.e. the true losses, energy and exergy efficiencies of the system also as a function of flowsheet complexity, geographical location/supply chains etc., we will discuss: (i) use of hydrogen in various reactors, (ii) process and reactor intensification inclusive of lancing technology (e.g. SiS), (iii) reactor, process & system simulations, (iv) digitalization as well as creating digital twins of plant flowsheets but also CE systems (e.g. large system models for PV production (from primary and secondary resources).

This dynamic online simulation tool of the units/plants and provides guidance for the non-ferrous metals plants operators. The BlueControl App is now ready for applications in the non-ferrous metals market.

The Application of RKEF in the Recycling and Disposal of Industrial Sludge

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Abstract

This paper intends to introduce the sources and characteristics of several typical industrial sludge, to expound the goal of industrial sludge's recycling and disposal, and to analysis the adaptability and advantages of using RKEF to treat industrial sludge, and then gives the application practice of using RKEF to treat stainless steel sludge.

Keywords: Industrial sludge, Recycling and Disposal, RKEF, Stainless Steel Sludge

A way to reduce up 50% the volume needed to set tailings

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Abstract

Considering the urgency of having more sites for tailing disposal during the next decades, here is presented a technology that offer an opportunity to reduce 50% or more of that demand. This reduction of tailing deposit capacity is achieved using the crater of underground mine exploitation to set tailings paste. If the mine is developed under the old open pit built to exploit the upper part of the orebody, the volume achievable for tailing disposal may be even more than 50%. This paper describes the physical principles and the engineering concepts to get and set the paste of tailings into the open pit and or into the crater of a block caving mine.