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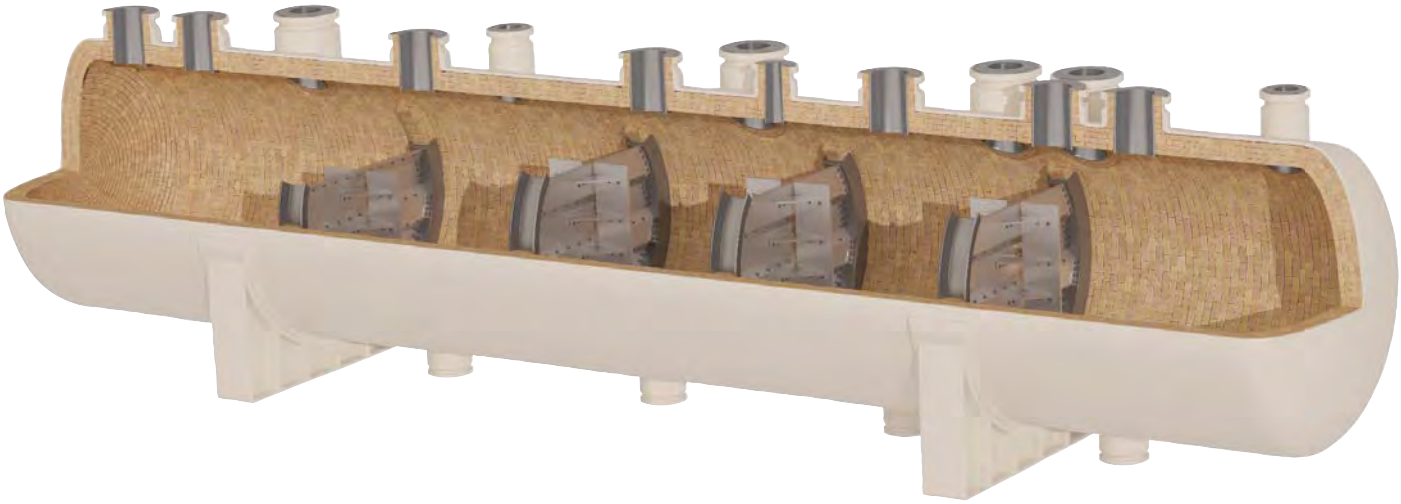

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Steuler Industrial Corrosion Protection	Booth 4-5
Teck Resources Limited	Booth 35
TOMRA Sorting Solutions	Booth 30
Velan	Booth 31
Western Areas - BioHeap	Booth 34

Gold Contents

ALTA 2013
25 May - 1 June
Perth, Western Australia

Page

Keynote Address

GRAVITY GOLD RECOVERY – LESSONS LEARNT FROM 15 YEARS OF LABORATORY AND PLANT STUDIES 2
Professor Jacques Eksteen, Manager Gold Technology Group, Curtin University (Australia)
Authors: JJ Eksteen, WP Staunton, GM Wardell-Johnson, Curtin University (Australia)

Refractory Gold Ores

UPDATE ON MICROBIAL LEACHING AT ELEVATED pH USING BIOHEAP™ TECHNOLOGY 17
Shawn Seet, Tim McCredden, BioHeap Ltd (Australia)

POKROVSKIY PRESSURE OXIDATION (POX) HUB 33
Petr Zaytsev, Yakov Shneerson, Victor Fedorov, Petropavlovsk (Russia), **John O'Callaghan**, Timo Haakana, Ari Kaartti, Outotec (Finland)

PRESSURE OXIDATION OF DOUBLE REFRACTORY GOLD CONCENTRATES 72
Ilia Fomenko, Peter Zaytsev, Michael Pleshkov, Lev Chugaev, Yakov Shneerson, SRC Hydrometallurgy, LLC (Russia)

THE ROLE OF MODELLING IN POX PROJECT DEVELOPMENT 85
Karel Osten, **Ryan Harrison**, AMEC (Australia)

AUTOCLAVE TECHNOLOGY OF REFRACTORY GOLD-BEARING PYRRHOTITE CONCENTRATES AND RESIDUES OF BIOLEACHING 98
JM Shneerson, LV Chugaev, **A Markelov**, SRC Hydrometallurgy, Russia; MT Zhunusov, Polyus Gold International (Russia); S Drozdov, ZAO Polyus (Russia)

HPGR

THE HRC™: TAKING HPGR EFFICIENCY TO THE NEXT LEVEL BY REDUCING EDGE EFFECT 111
Victoria Herman, Metso Corporation Inc (USA)

Process Technology

PRECIOUS METALS RECOVERY IN KGHM: GŁOGÓW COPPER SMELTER & REFINERY 122
Władysław Wroński, **Tomasz Walkowiak**, Stanisław Nosal, Zbigniew Gostyński Piotr Poks, KGHM PM SA (Poland)

NEW TECHNOLOGIES FOR PGM RECOVERY FROM REFINING STREAMS 132
Grant Mascini, PhosphonicS (South Africa/UK)

OPTIMIZING HYDROFOIL BLADE GEOMETRY FOR SLURRY TANK AGITATORS 143
Richard Kehn, SPX Flow Technology (LIGHTNIN) (USA); **Graham Seal**, SPX Flow Technology (LIGHTNIN) (Australia)

MINTEK AUSIMPRO: GOLD PROCESS ADVISOR 152
Sonestie Janse van Rensburg, Marthie Kotze, Mintek (South Africa)

PROCESS MODELLING OF GOLD LEACHINGCIP/CIL FOR PLANT OPTIMISATION 166
JJ Eksteen, WP Staunton, GM Wardell-Johnson, A Bax, Curtin University (Australia)

Environmental

ASSESSING SOME ENVIRONMENTAL IMPACTS OF MINING, MINERAL PROCESSING AND METAL PRODUCTION 177
Nawshad Haque, Terry Norgate, Minerals Down Under Flagship, CSIRO (Australia)

Cyanide Alleviation Forum

DEVELOPMENT OF GOLD CHLORIDE PROCESS 187
Ville Miettinen, Mika Haapalainen, Riina Ahtiainen, Janne Karonen, Outotec (Finland) Oy (Finland)

MEETING THE CHALLENGES OF SUSTAINABILTY: UTILIZATION OF CHEMICALLY MODIFIED PURE CELLULOSE FOR QUANTITAIVE SEPARATION OF GOLD FROM MIXTURES OF BASE METALS IN ACIDIC SOLUTION 203
Manju Gurung, Birendra Babu Adhikari, Xiangpeng Gao, **Shafiq Alam**, Memorial University of Newfoundland (Canada); Katsutoshi Inoue, Saga University (Japan)

FACTORS AFFECTING GOLD LEACHING IN THIOSULFATE-O2 SOLUTIONS 214
Hongguang Zhang, Xianwen Dai, Paul Breuer, CSIRO Minerals Down Under National Research Flagship (Australia)

THIOSULFATE PROCESSING: FROM LAB CURIOSITY TO COMMERCIAL APPLICATION 223
Yeonuk Choi, Barrick Gold Corp, (Canada)

INTEGRATING SART INTO METALLURGICAL FLOWSHEETS FOR CYANIDE RECOVERY 235
David Kratochvil, Nelson Chan, Andrew Hall, BioteQ Environmental Technologies (Canada)

TECHNOLOGIES FOR CYANIDE EFFLUENT TREATMENT OF TAILINGS IN GOLD MINING 245
Stephen Gos, Andrea Christiansen, **Bernd Gloeckler**, CyPlus GmbH (Germany)

COMPARISON OF AVR AND GAS MEMBRANE TECHNOLOGY IN CYANIDE RECOVERY 253
X Dai, **P Breuer**, CSIRO Minerals Down Under National Research Flagship, CSIRO Process Science and Engineering (Australia)

GEKKO DETOX PROCESS DESIGN 269
Nick Katsikaros, Gekko Systems (Australia)

CYANIDE DESTRUCTION RECOVERY OPTIONS AND MANAGEMENT STRATEGIES FOR GOLD PLANT TAILINGS 288
D Connelly, Mineral Engineering Technical Services Pty Ltd (METS) (Australia)

WATER MANAGEMENT FOR GOLD RECOVERY USING ALTERNATIVE LIXIVIANTS TO CYANIDE 298
S R La Brooy, Ausenco (Australia); P Smith, Proxa Australia (Pty) Ltd (Australia)

Gold Proceedings

Keynote Address

GRAVITY GOLD RECOVERY – LESSONS LEARNT FROM 15 YEARS OF LABORATORY AND PLANT STUDIES

By

J.J. Eksteen, W.P. Staunton and G.M. Wardell-Johnson
Curtin University, Australia

Presenter and Corresponding Author

Jacques Eksteen

Gold Proceedings

Refractory Gold Ores

UPDATE ON MICROBIAL LEACHING AT ELEVATED pH USING BIOHEAP™ TECHNOLOGY

By

Tim McCredden & Shawn Seet

BioHeap Ltd, Australia

Presenter and Corresponding Author

Shawn Seet

ABSTRACT

Many low grade metal sulphide ores are hosted in gangue containing high levels of magnesium silicates, which consequently consume a large amount of sulphuric acid in conventional microbial leaching scenarios where solution pH's below 2 are required. Operating at elevated pH has the dual advantage of significantly reducing the acid consumption and reducing limestone demand for iron disposal.

In 2012 BioHeap outlined its development of a saline tolerant bacterial culture, Ni-S-J069B, using patented methods that is capable of operating at elevated pH's at levels where ferric iron precipitates out of solution. Since its introduction, culture Ni-S-J069B has been subject to a series of tests to provide an understanding on its bioleaching ability. This paper will provide an update on the development of BioHeap's culture Ni-S-J069B and findings from the recent series of test work.

POKROVSKIY PRESSURE OXIDATION (POX HUB

By

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John O'Callaghan

ABSTRACT

The Russian Federation contains numerous operating gold mines; however like most of the world these mines are encountering refractory ore which requires additional pre-treatment prior to cyanidation for gold recovery.

It has been reported that about 75-80% of known gold reserves in Russia are refractory or partly refractory(1.

Petropavlovsk is the second largest gold producer in Russia with assets located in the Far East. The company currently has four open pit mines and alluvial operations and employs about 15,000 people (total group(1. Half of Petropavlovsk's JORC compliant reserves are refractory(2.

For the treatment of refractory ore from Malomir and Pioneer mine sites autoclave Pressure Oxidation (POX has been chosen as the pre-treatment technology (after comparison with biological oxidation and roasting. Oxidised concentrate from both mine sites will be further treated in existing RIL facilities for gold recovery at Pokrovskiy.

Extensive batch autoclave testwork and flowsheet development has been completed by SRC Hydrometallurgy in St Petersburg. Pilot facilities have also been built and operated in Blagoveshchensk to support the POX design.

Outotec has supplied all major equipment for both the Malomir concentrator and the Pokrovskiy POX Hub plant and continues to work assist Petropavlovsk with project implementation.

Outotec employs 4805 personnel in 25 locations around the world. Continuous technology development and innovation since the 1890's has led to a technology and equipment portfolio that in many areas is market leader.

Outotec as part of Outokumpu developed considerable knowledge and technology related to autoclave matte leaching and continues to supply autoclave technology for the leaching of nickel mattes. Recently with the design and equipment supply for the Pokrovskiy POX plant Outotec has now also provided modern pressure oxidation equipment for the treatment of sulphidic refractory gold concentrates.

Construction of the Malomir concentrator and Pokrovskiy POX plant is currently underway with commissioning of the Malomir flotation plant expected in Q3 2013 and Pokrovskiy POX plant planned for Q1 2014. The Pioneer concentrator is scheduled for future development

Development and description of the Pokrovskiy POX Hub is described in this paper.

PRESSURE OXIDATION OF DOUBLE REFRACTORY GOLD CONCENTRATES

By

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ABSTRACT

The reasons for gold-bearing materials refractory nature and behaviour features of carbonaceous matter during pressure oxidation of concentrates were discussed. The chemical processes that lead to gold losses during high pressure hydrometallurgical treatment of double refractory materials were examined. The influence of organic carbon content in the concentrate on the pressure treatment performance was investigated. The influence of chloride ion content in the liquid phase of pressure oxidation slurry on the gold extraction from materials containing organic carbon was noted and researched. The pilot tests results of double refractory concentrates pressure oxidation were introduced. The pressure oxidation approach that allows obtaining high gold recovery from double refractory materials was proposed.

THE ROLE OF MODELLING IN POX PROJECT DEVELOPMENT

By

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Ryan Harrison

ABSTRACT

Modelling is used as a tool to simulate processes for the purposes of design and optimisation. This paper discusses the development of a pressure oxidation model from input data such as throughput, feed composition, and testwork results. The model is used to explore and demonstrate the impact of various processing alternatives such as feed sulphide sulphur content, feed density, autoclave operating temperature, and direct versus indirect cooling.

AUTOCLAVE TECHNOLOGY OF REFRACTORY GOLD-BEARING PYRRHOTITE CONCENTRATES AND RESIDUES OF BIOLEACHING

By

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ABSTRACT

Bacterial leaching is widely used by gold companies as a method of processing of refractory gold concentrates. At present this method is used by more than 10 companies worldwide

In this paper, two variants of the possible upgrade of the existing technology of processing refractory sulfide concentrates are considered:

Laboratory tests were conducted on the autoclave oxidation of bioleaching products and flotation concentrate. A mathematical model of the continuous process was generated based on this data, parameters for pilot testing were calculated and preliminary calculation for the industrial process was made.

As a result of the pilot test it was shown that the additional autoclave oxidation of bioleaching products can significantly improve gold recovery to 96% and reduce cyanide consumption from 50 kg/t to 6.4 kg/t. It was shown that the optimal parameters of POX for bioleaching products are - temperature 225°C and oxygen partial pressure 5-7 bar.

The data obtained will be used for technical and economic evaluation, which will select the optimal scheme for the modernization of the technology for processing refractory gold concentrates

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THE HRC™: TAKING HPGR EFFICIENCY TO THE NEXT LEVEL BY REDUCING EDGE EFFECT

By

Victoria Herman

Metso Minerals Industries Inc., USA

Presenter and Corresponding Author

Victoria Herman

Gold Proceedings

Process Technology

PRECIOUS METALS RECOVERY IN KGHM: GŁOGÓW COPPER SMELTER & REFINERY

By

Władysław Wroński, Tomasz Walkowiak, Stanisław Nosal, Zbigniew Gostyński Piotr Poks

KGHM PM S.A., Poland

Presenter and Corresponding Author

Tomasz Gabka

ABSTRACT

Polish copper concentrates in Lower Silesia are characterized by a high silver and low gold and platinum content, hence the production of precious metals in the Legnica - Głogów region (mainly silver) is associated with copper smelting. Precious metals (silver, gold and platinum group metals) contained in the copper concentrates are collected in the main products of each pyrometallurgical stage used in the copper smelters.

Despite the high degree of recovery of precious metals in the subsequent stages of copper production, their content in copper anode, the final product of the pyrometallurgical process, is low, and the content of the main metal represented - silver - generally does not exceed 0.3%. Only in the copper electrorefining phase during the anode dissolution process is a product with a high content of noble metals obtained. After copper electrorefining, anode slimes become the basic material for the production of silver, from which it is possible to obtain good recovery. Anode slimes mainly contain silver (35 - 45% Ag), lead and other precious metals as well as selenium.

NEW TECHNOLOGIES FOR PGM RECOVERY FROM REFINING STREAMS

By

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Presenter and Corresponding Author

Grant Mancini

OPTIMIZING HYDROFOIL BLADE GEOMETRY FOR SLURRY TANK AGITATORS

By

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Presenter and Corresponding Author

Graham Seal

ABSTRACT

Solids suspension mixing applications exists within the gold and mineral processing industry in general. The hydrofoil impeller is the impeller of choice for most applications due to its axial flow pattern and low torque requirements. Although often lumped together as one style of impeller, regardless of specifics, the exact combination of hub chord angle, blade twist and thus tip chord angle lead to different torque requirements for a given suspension application. Minimizing both power and torque leads to an optimized mixer design.

This study compares the performance of the LIGHTNIN A510 hydrofoil impeller in a solids suspension application where the tip chord angle is varied from 12 degrees to 32 degrees. Two different solid sizes were modeled, 600 and 250 micron glass beads at a solids weight percent of 2%, with the liquid being water. A 445 mm diameter tank with a dished bottom and four 38 mm wall baffles was used for the test set up. Three different sized diameter A510 impellers were tested. The just suspended speed was determined visually in each case and the data was used to compare the performance of each on a power and torque basis. The results were then scaled up using geometric similarity and a constant power per unit mass basis in order to compare relative mixer costs (both capital and operating) for a 43 m^3 tank. Although only a qualitative study due to the small sample size, this study demonstrates how small differences in hydrofoil design can lead to a more optimized mixer selection in the full scale.

MINTEK AUSIMPRO: GOLD PROCESS ADVISOR

By

Sonestie Janse van Rensburg and Marthie Kotze

MINTEK, South Africa

Presenter and Corresponding Author

Sonestie Janse van Rensburg

ABSTRACT

The current gold price and the general depletion of free milling gold deposits have prompted an increase in gold projects. These include the expansion of existing mines, reclamation of dumps, and the processing of complex and refractory low grade ore bodies. The processing of such sources is becoming the norm in the gold industry and the treatment options available are dependent on factors such as site location, availability of water and power, and environmental regulations. Many gold projects are under time and budget constraints, which necessitate the execution of focussed development and test work programs to provide the relevant information for the comparison of available processing options and economic trade-offs.

Against this background, MINTEK has developed the AuSimPro Gold Process Advisor. At the core of AuSimPro is a growing database in which MINTEK's knowledge on historical as well as current projects is captured. Such information includes gold grades, site location, mineralogical information on the ore and occurrence of gold, treatment steps applied, and gold recovery, amongst others. AuSimPro uses a proprietary algorithm to provide suitable baseline options for any new gold project by comparing the input pertaining to mineralogy, ore type and metallurgical information from scouting tests against the database. As further information becomes available and is entered, AuSimPro updates and refines the treatment approach to be followed. This algorithm was designed to incorporate historical project outcomes as well as MINTEK expert rules rather than just theoretical or constant parameters. AuSimPro has sufficient flexibility to allow for integration of certain process steps, otherwise discarded by the algorithm, if required. Basic capital and operating cost estimates are being developed and will be included in order to assist in identifying the most suitable processing option for a specific ore.

The result is a powerful tool for gold process development. The knowledge contained in AuSimPro results in better decision making and both cost and time saving by increasing the efficiency and focus of the development work. This paper explains the AuSimPro concept in detail and illustrates the successful application of MINTEK's expert rules incorporated in AuSimPro.

PROCESS MODELLING OF GOLD LEACHING-CIP/CIL FOR PLANT OPTIMISATION

By

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Jacques Eksteen

Gold Proceedings

Environmental

ASSESSING SOME ENVIRONMENTAL IMPACTS OF MINING, MINERAL PROCESSING AND METAL PRODUCTION

By

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Presenter and Corresponding Author

Nawshad Haque

ABSTRACT

Life cycle assessment studies of mining, mineral processing and metal production have been carried out at CSIRO Process Science and Engineering in recent years. This work has included iron and steel, copper, nickel, aluminium, lead, zinc and titanium both by pyrometallurgical and hydrometallurgical routes. The studies have also included gold, ferroalloy, and magnesium production, and the uranium nuclear fuel cycle. An overall review of the published results from these LCA studies is presented in this paper. An overview of some on-going LCA research is also mentioned briefly, with a particular focus on biomass application in metallurgy. The case study of gold LCA is presented in further detail including in-situ leaching mining method. This LCA research is being conducted under the Minerals Down Under Flagship and is being used to identify opportunities for reducing environmental impacts including greenhouse gas emissions, water consumption, resource depletion and waste generation, and to improve energy efficiency over the mining, mineral processing and metal production life cycle.

Gold Proceedings

Cyanide Alleviation Forum

DEVELOPMENT OF GOLD CHLORIDE PROCESS

By

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Outotec (Finland) Oy

Presenter and Corresponding Author

Ville Miettinen

ABSTRACT

Chloride leaching of gold is very old invention but it still has only a few applications. Use of chloride for gold leaching is found to be feasible only in processes where gold content of feed material is very high like in anode slime processing. Practically the only process option for gold ores and concentrates has been cyanide leaching. Cyanide leaching has some disadvantages like relatively long leaching time and difficult gold recovery process. Cyanide leaching is also banned in some countries because of environmental risks of using poisonous cyanide. Outotec has developed chloride leaching processes for copper, nickel, cobalt, silver and gold concentrates. Based on these studies Outotec has developed a new feasible and environmentally friendly chloride leaching process for gold ores and concentrates. The new process combines effective gold leaching with a new type of gold solvent extraction process. High oxidation power in gold leaching provides very fast leaching kinetics and also good gold recovery. Gold can be extracted from PLS using selective solvent extraction with high recovery degree. Very pure gold product can be precipitated directly from the stripping solution. The process is suitable for free-milling gold ores and for refractory ores after pre-treatment like pressure oxidation or roasting.

MEETING THE CHALLENGES OF SUSTAINABILTY: UTILIZATION OF CHEMICALLY MODIFIED PURE CELLULOSE FOR QUANTITAIVE SEPARATION OF GOLD FROM MIXTURES OF BASE METALS IN ACIDIC SOLUTION

By

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Shafiq Alam

ABSTRACT

In continuation of our effort to develop sustainable materials and methods for recovery and recycling of precious metals, a number of adsorbents were developed by simple chemical modification of pure cellulose. The adsorption materials were prepared by crosslinking the pure cellulose with either epichlorohydrin or concentrated sulfuric acid, followed by surface modification with guanidine or N-aminoguanidine functional groups. The adsorption behaviour of these materials with regards to Au(III) within the multi-component mixture of some other precious metal ions as well as base metal ions were studied in hydrochloric acid medium. All adsorbents exhibited outstanding selectivity towards precious metals, with the selectivity order being Au(III)>> Pd(II)> Pt(IV), over base metals in a wide range of acid concentration. As these materials contain positive centres in the HCl medium, the chloroanionic species of Au(III), Pd(II) and Pt(IV) were adsorbed on these materials by anion exchange coupled electrostatic interaction. The sulfuric acid crosslinked materials exhibited improved selectivity and superior adsorption capacities over epichlorohydrin crosslinked materials. The sulfuric acid crosslinked materials were so effective with regards to Au(III) recovery that 1 kg of the material possessed the capacity to load nearly 9.2 moles, i.e. 1.8 kg of Au(III). In such cases, the adsorbed Au(III) was subsequently reduced to elemental form and metallic gold particles were observed. The outstanding effectiveness of these chemically modified cellulose materials for adsorption and recovery of Au(III) from acidic medium, is a result of adsorption coupled reduction phenomenon which occurred in the case of Au(III) adsorption.

FACTORS AFFECTING GOLD LEACHING IN THIOSULFATE-O_2 SOLUTIONS

By

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Presenter and Corresponding Author

Hongguang Zhang

ABSTRACT

The research into leaching of gold with thiosulfate as an alternative lixiviant to cyanide has predominantly involved the use of copper in the presence of ammonia which serves as the oxidant. However, there are concerns about the health and environmental risks of ammonia (or ammonium). At CSIRO continued research has been carried out to look for different oxidants for the thiosulfate leaching processes. Despite the typically poor gold leach rate and recovery achievable with oxygen, results have indicated that it is potentially viable to treat some gold concentrates without the need for ammonia. To understand the fundamentals of this process, experiments have been conducted to investigate the effects of various factors on gold leaching, including copper, temperature, co-existing cations and the presence of sulfide minerals. This paper presents the results of leach rates measured with pure gold under various conditions and gold recoveries from the leaching of various ores or concentrates. It is found that copper has the greatest effect (though different from the Cu-ammonia system) while other factors, particularly sulfide minerals, are also important for the leach performance. However, identifying the optimum leach conditions (and combination of these factors) to maximise gold recovery remains a challenge due to the nature of these leach solutions.

THIOSULFATE PROCESSING: FROM LAB CURIOSITY TO COMMERCIAL APPLICATION

By

Yeonuk Choi

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Presenter and Corresponding Author

Yeonuk Choi

INTEGRATING SART INTO METALLURGICAL FLOWSHEETS FOR CYANIDE RECOVERY

By

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Presenter and Corresponding Author

David Kratochvil

ABSTRACT

As the industry continues to tackle challenges associated with cost-effective extraction of gold from complex ore bodies rich in cyanide-soluble base metals, the issue of cyanide recovery and recycle has become very important. This is because base metals such as copper and zinc consume cyanide, interfere with downstream unit operations including electrowinning of gold, and impact the performance and cost of cyanide destruction processes. Most of these challenges can be addressed by the SART (sulphidization-acidification-recycling-thickening) process, which breaks the base metal cyanide weak acid dissociable (WAD) complexes, recovers the base metals as high-grade sulphide concentrates, and recovers and regenerates cyanide for re-use in the gold extraction process

The SART process is a commercial technology that was developed primarily for heap leach applications due to the fact that SART cannot handle solids and can be applied only to pregnant leach solutions (PLS) free of solids. One of the key issues with the successful integration of SART into non-heap leaching applications is the exposure of SART to relatively large fluctuations in feed composition compared to heap leach applications. The SART plant at the Mastra mine, designed and commissioned by BioteQ, is an example of a non-heap leach application of SART. The operating data from the plant is presented and the robustness of the process control system is discussed.

There are other limitations of SART technology that represent potential challenges to the wider adoption of SART and its integration into metallurgical flowsheets. These challenges include the sensitivity of the SART plant capital cost and footprint to hydraulic capacity, and the incapability of SART to concentrate the regenerated cyanide into a small volume of more concentrated cyanide for recycle. Process options that include combining SART with cold stripping in ADR (adsorption-desorption-regeneration) plants and SART with AVR (Acidification, Volatization and Recovery) are analysed and discussed.

TECHNOLOGIES FOR CYANIDE EFFLUENT TREATMENT OF TAILINGS IN GOLD MINING

By

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CyPlus GmbH, Germany

Presenter and Corresponding Author

Bernd Gloeckler

ABSTRACT

CyPlus has developed several Cyanide Effluent Treatment (CET) processes suitable for the treatment of cyanide-containing ore pulps, since conventional treatment methods like H_2O_2 are mostly not feasible due to prohibitively high reagent consumption because of product decomposition. After collaborating in the field of Cyanide Effluent Treatment with Inco Tech, Canada, for many years, CyPlus GmbH developed the CombinOx® process together with them and then acquired the know-how for designing and operating the SO_2/AIR process.

Feasibility studies conducted by CyPlus® in its laboratories in Germany on a regular basis compare various process options for the treatment of cyanide-containing ore pulps, including the following processes:

- CyPlus® Hot Caro's Acid process
- CyPlus® Cold Caro's Acid process
- CyPlus® SO_2/AIR process
- CombinOx® process

The feasibility study is performed on the effluent or generated effluent after leaching of representative ore samples. The feasibility study clearly illustrates which of the processes can reach the desired discharge limits for cyanide most effectively. It also compares the operating costs, mainly the consumption of treatment reagents as well as the investment costs. Ultimately, the most economic and suitable process that meets the requirements is usually chosen. The CyPlus® Cold Caro's Acid, the CyPlus® SO_2/AIR and CombinOx® processes are usually by far the most viable processes of the four processes above.

The feasibility study is performed in continuous mode to generate the process parameters that will enable meaningful scale-up for engineering. It is also important to use representative ore samples and chemicals as applied on a large scale to obtain representative results. After the feasibility study has been performed, a basic engineering package is prepared on the process of choice to accommodate a reliable up-scale to the site-specific conditions.

Finally, tailor-made equipment (e.g. CyPlus® Caro's Acid Generator) can be constructed, installed and commissioned on site. The design incorporates state-of-the-art safety features and modern reliable material of construction.

The CyPlus® processes are especially suitable for treating cyanide-containing tailings from ore processing operations in order to comply with stringent limits such as those set by the International Cyanide Management Code, the World Bank, EU Mines Waste Directive and local authorities.

The CyPlus® Cyanide Effluent Treatment (CET) processes have become important technologies for CET over the last years, having found numerous applications world-wide. It has been proven that the economic success and a compliant operation of CET plants in the gold mining industry strongly depend on a reliable feasibility study comparing different treatment technologies, a reliable scale-up and the application of state-of-the-art and tailor-made equipment. It is the purpose of this paper to discuss these processes in more detail and to illustrate the importance of choosing the right process from the beginning.

COMPARISON OF AVR AND GAS MEMBRANE TECHNOLOGY IN CYANIDE RECOVERY

By

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ABSTRACT

The AVR (Acidification-Volatilisation-Reneutralisation) process is often considered for the recovery of cyanide from tailings and waste streams and has been implemented at a number of gold operations. Gas membrane technology offers an alternative to gas scrubbing and capture to transfer the HCN from an acidified solution stream to an alkaline stream. This paper presents a comparison of the cyanide recovery performances of these two processes and a discussion of the potential benefits and disadvantages in the context of industrial application. The processes have the same mechanism in recovering cyanide which can be described by a first order reaction model and allows a direct comparison of the performance of each process via a volumetric mass transfer coefficient. This volumetric mass transfer coefficient provides vital information for process scale-up. The volumetric mass transfer coefficient of a membrane contactor can be two orders of magnitude higher than that of an AVR reactor, which enables a significantly faster cyanide recovery rate and/or reduced capital (and operating) cost for the membrane technology.

GEKKO DETOX PROCESS DESIGN

By

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CYANIDE DESTRUCTION RECOVERY OPTIONS AND MANAGEMENT STRATEGIES FOR GOLD PLANT TAILINGS

By

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ABSTRACT

More and more gold plants around the world are being required by law to destroy cyanide in tailings. This paper evaluates the options and what influences the process selection for cyanide destruction and recovery. The cost effectiveness, comparison of common detoxification methods with advantages and disadvantages are explored. This paper also looks at the safety and hazards of cyanide and explores various cyanide degradation methods so as to make it safe to people and the environment upon disposal.

Fundamental aspects of the International Code for Cyanide Management are covered, and highlighted are references to all major Australian bodies who are consulting on the management of cyanide. Case studies are examined so as to illustrate major hazards and mitigations that may occur and be implemented in gold processing operations.

The various environmental issues pertaining to the usage of cyanide, including the effects on wildlife, monitoring procedures and strategies undertaken to prevent and control any risks due to exposure to the environment will be discussed. Treatment procedures, and methods, for cyanide poisoning are also briefly covered as well as standard transport and storage procedures for the handling of cyanide.

WATER MANAGEMENT FOR GOLD RECOVERY USING ALTERNATIVE LIXIVIANTS TO CYANIDE

By

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Stephen La Brooy

ABSTRACT

Research on alternative lixiviants for gold extraction is ongoing. This paper looks at where an engineering company fits into the matrix of people working on alternative lixiviant technology.

Typically developers focus on discrete aspects of a process. The big advantage that engineering companies bring is that they are used to looking at the complete process. Recycle streams and the effect of the impurities that they contain need to be taken into account.

Alternative lixiviants are typically applied at concentrations 50 to 100 times those required for cyanidation. Higher concentrations make recycle and what might happen in the TSF significant considerations. Further complications come with systems where preg-robbers are present so that no lixiviant can be tolerated in the comminution circuit.

Carryover of the approaches used with cyanide, such as lixiviant kill before water recycle would result in a huge operating cost. The solution to this could be to incorporate membrane treatment to provide clean water for the comminution circuit and also concentrate up lixiviant for recycle to the leach circuit. It is likely that at closure membrane treatment will again be required to recover the significant concentrations of reagent in the TSF back into the process, to minimize future liability.

Bleed streams can create significant issues at plant scale, especially if environmental pressures or climate preclude evaporation ponds. A solution to this could be to use a MVC falling film evaporator and crystallizer system to produce a mix of solids for recycle and offsite disposal.

To further increase what Ausenco can offer it has recently formed a joint venture with Proxa, a South African water treatment company specializing in custom solutions involving membrane processes, ion exchange and energy efficient zero discharge options.