FLOTATION: MACHINE CHARACTERIZATION AND OPTIMIZATION

Abstract ID: 2078

(KEYNOTE) Froth Recovery Factor - What is it, and Why is it so Difficult to Measure?

J. Franzidis and M. Harris. 1University of Cape Town
Presenting from 8:00:00 To 8:25:00 - Wednesday
The past twenty to thirty years have seen unprecedented research activity aimed at understanding the performance of flotation froths. In 1990, Finch and Dobby coined the term froth recovery factor, Rf, to represent the efficiency of the froth in delivering particles from the pulp-froth interface to the concentrate. Originally defined for flotation columns, Rf has also been found useful in modeling mechanical flotation cells, and a number of techniques, based on quite different approaches, have been developed for measuring the froth recovery in industrial flotation cells. None of these techniques is universally successful. This paper reviews the concept of the froth recovery factor, and the basis of each of the techniques that have been proposed to measure Rf, and examines the reasons for this parameter being so difficult to pin down.

Abstract ID: 2076

On the Carrying Capacity Limitation in Large Flotation Cells

J. Yianatos and F. Contreras. 1Universidad Tecnica Federico Santa Maria
Presenting from 8:25:00 To 8:50:00 - Wednesday
Mineral carrying rates across the pulp-froth interface in the range of 1.4-3.2 tph/m² and bubble surface coverages between 7 and 22 %, have been determined in large rougher flotation cells operated under normal conditions. To evaluate these variables, measurements of bubble size distribution, bubble load and size distribution of particles collected by true flotation, were performed at different concentrators. A model for estimating the bubble surface coverage at the pulp-froth interface level as a function of bubble load, Sauter mean bubble diameter and particle size distribution of the mineral collected by true flotation, was developed. Bubble loadings in the range 24-70 kg/m³, bubble sizes between 1.5 and 3.2 mm and superficial gas rates between 1.2 and 2.0 cm/s, were measured in copper rougher flotation cells under normal operating conditions. Estimated bubble surface area fluxes were in the range 31 to 62 cm²/s/cm². Results of carrying rates and bubble surface coverage, at the pulp-froth interface, were significantly lower than the maximum carrying rate for the collection zone, indicating that in this case is difficult to achieve maximum carrying rate at the pulp-froth interface level. The main constraints regarding carrying capacity limitations are then related to the froth transport characteristics (i.e. cell design, froth residence time, froth stability, froth recovery).

Abstract ID: 2030
Gas Distribution in Mechanical Flotation Machines: Data Interpretation


Presenting from 8:50:00 To 9:15:00 - Wednesday

The metallurgical performance of a flotation cell is strongly influenced by the features of the bubble population, characterized by the gas dispersion properties, a collective term including bubble size, superficial gas velocity and gas holdup. It is required that gas be well distributed throughout the cell. Gas distribution is estimated here by simultaneous measurement of gas velocity (Jg) at different distances from the center (radial Jg mapping). This communication describes a technique to perform radial Jg mapping together with fundamentals for the interpretation of the data.

Abstract ID: 2071

Gas Dispersion Characterization of TankCell®-300 at Chuquicamata Concentrator

A. Yanez, M. Pedro, F. Coddou, H. Elgueta, J. M. Ortiz, C. Perez, G. Cortes, J. A. Finch, C. Gomez and P. Morales. Outotec Chile Ltda., Codelco, McGill University, Codelco Chile

Presenting from 9:15:00 To 9:40:00 - Wednesday

A campaign to perform characterization tests in a TankCell®-300 flotation cell installed at Chuquicamata Codelco’s concentrator was conducted. The campaign included integrated gas dispersion measurements (gas velocity radial mapping and single point gas holdup and bubble size) and determination of frother concentration. Cell streams were sampled to assess metallurgical performance at the same time. The experimental program was designed to establish the bubble surface area flux operating range and its effect on performance, and the effect of using longer residence times and of a device designed to enhance mixing in the collection zone (FlowBooster™). The gas dispersion results and their relationship to metallurgical performance are discussed.

Abstract ID: 1974

The Relation Between the Aeration Characteristics of Flotation Columns and Metallurgical Performance


Presenting from 10:00:00 To 10:25:00 - Wednesday

A relationship between gas dispersion parameters, namely gas rate (Jg), gas holdup (εg), average bubble size (db) and bubble surface area flux (Sb), with the metallurgical performance (e.g., grade and recovery) has been established.. Results of eleven columns operating at five concentrators of Grupo Peñoles (Mexico), ranging between 1.52 to 3.35 m in diameter and performing in the cleaning stages of lead and zinc circuits, are presented and discussed. The results showed that the effect of gas dispersion parameters was consistent and that both, Sb and εg, correlate well with recovery particularly when the influence of feed pulp density is also considered.

Abstract ID: 1758

Applying Fractional Factorial Design in Optimizing Barite Flotation of Jig Tailing at Dorrin Kashan Mine
M. Zavvari\textsuperscript{1}. \textit{University of Birjand}

Presenting from 10:25:00 To 10:50:00 - Wednesday

Flotation, as with most engineering disciplines, involves testwork. Commonly this means going from lab scale to pilot scale to industrial scale. It is important to conduct tests to identify key parameters and to optimize even at the lab scale. To reduce the number of tests while maximizing the information, it is necessary to use Design of Experiment and Statistical Analysis. In this communication Fractional Factorial Design was used to identify the effect of 7 main factors on barite flotation recovery from jig gravity tailings at the Dorrin Kashan operation. The factors include: pH, collector and depressant dosage, impeller speed (RPM), pulp dilution, particle size and flotation time. By analysis of the output with Minitab software all factors were shown to have an effect. Among the factors, pH and flotation time have an interaction effect but the others have wise effect as an interaction effect and main effect. Finally, reliability tests at pH = 9, RPM = 1000, collector 1000g/ton, depressant 1750g/ton, particle size 90 μm, flotation time 90 s, pulp dilution 23 % solids, the optimum level of each factor, were done. At the optimum level a barite concentrate with average specific gravity 4.308 g/cm\textsuperscript{3}, average grade 93.72% and average recovery 90.04% was produced from the jig tail.

Abstract ID: 2023

\textbf{Evaluating the Effect of Operational Changes at Vale Inco’s Clarabelle Mill}

J. Doucet\textsuperscript{1}, C. Price\textsuperscript{1}, R. Barrette\textsuperscript{1} and V. Lawson\textsuperscript{1}. \textit{Vale Inco Limited}

Presenting from 10:50:00 To 11:15:00 - Wednesday

In an industrial setting, operational changes are continually introduced, driven by new technologies or changing economics. Because of day-to-day variability, quantifying the impact of these changes based on metallurgical performance requires long trial periods to achieve statistically significant results. Tools and techniques developed by the mineral processing group at McGill University have allowed for direct measurement of process variables (e.g., bubble size, gas and solid holdup). Two case studies are described where direct measurement techniques were used to evaluate: a) a new rotor stator mechanism; and b), the introduction of a new frother type. Application of these methods has accelerated the evaluation of process changes and improved confidence in results.

Abstract ID: 2020

\textbf{Gas Dispersion Studies at Highland Valley Copper}

J. Hernandez-Aguilar\textsuperscript{1}. \textit{Highland Valley Copper}

Presenting from 11:15:00 To 11:40:00 - Wednesday

This paper discusses three case studies conducted at Highland Valley Copper mine (HVC) that illustrate operational improvements and insights which resulted from using the McGill University gas dispersion sensors. In the first study, the superficial gas velocity (Jg) sensor was used to implement a gas profiling control strategy for the rougher, scavenger and first cleaner cells in the Cu/Mo separation circuit. The data showed a 40% reduction of down-the-bank Cu recovery at constant Mo recovery which resulted from operating the cells at the target profiles. In the second study, the bubble size analyzer was used to better understand two mechanisms of bubble formation in the two flotation columns that make up the final Mo cleaning stage: the conventional rubber-sleeve sparger and the MicrocelTM system. The data showed a considerable reduction of bubble size in the Microcel column which resulted in a significant increase in
concentrate quality (1-2% Mo absolute) and a dramatic (4-5 fold) increase in concentrate production rate compared to the typical operation. The estimated economic benefit resulting from the improved column flotation operation was an overall 4% increase in Mo circuit recovery. In the third study, real-time measurements obtained from the gas holdup and bulk density sensors were used to infer the pulp density (% solids) in a rougher cell of the bulk flotation circuit. Validation tests demonstrated that this approach provides reliable pulp density measurements. Although promising, more work is required before implementing this approach at HVC.

MATERIALS - Materials Development and Performance of Sulphur Capture Plants
Presentations from 8:30:00 AM to 12:10:00 PM - Room F336

MATERIALS DEVELOPMENT AND PERFORMANCE OF SULPHUR CAPTURE PLANTS

Abstract ID: 1931

(KEYNOTE) What Corrosion Costs Canada; Or, Can We Afford to Ignore Corrosion?
S. Shipilov, 1Metallurgical Consulting Services
Presenting from 8:30:00 To 9:20:00 - Wednesday
In this paper, the annual direct cost of corrosion in Canada is estimated to be approximately $41 billion. The figure does not include the indirect (user) costs of corrosion, sometimes referred to as social costs, which would essentially double the amount. Also, corrosion is shown to be a major contributor to environmental pollution, including when it results in the leakage of hazardous materials from pipelines, vessels and nuclear reactors. Industrial accidents caused by corrosion kill and injure hundreds of people annually. At present, corrosion is at the core of safety and risk analysis in several major industries such as energy generation, oil/gas production and transportation, chemical processing and petroleum refining. With the recent steam pipeline explosion during rush hour in New York killing one man, the collapse of the bridge in Minneapolis killing 13 people and another two years ago in Montreal when 5 people were killed, infrastructure corrosion is increasingly being acknowledged as a public safety concern.

Abstract ID: 1748

The Corrosion of Steel in an SO2 Environment: A Review
E. Asselin, 1University of British Columbia
Presenting from 9:20:00 To 9:45:00 - Wednesday
The state of knowledge pertaining to the corrosion of steel in SO2 environments is summarized. Corrosion rates as a function of temperature and degree of fouling are discussed. The importance of temperature on the condensation behaviour of SO2 is also discussed and the thermodynamics of condensate corrosion are presented in terms of the known and relevant phase behaviour. It is shown that acceptable and safe operating temperatures are difficult to determine based on a generally poor understanding of the phase behaviour of the SO2-H2O system.

Abstract ID: 1879

A Review of Experiences with AL-6XN and ZERON 100 Alloys in Air Pollution Control Equipment
D. Wachowiak and J. Wilson. Rolled Alloys
Presenting from 9:45:00 To 10:10:00 - Wednesday
A variety of metallic alloys are currently used in pollution control systems. This paper reviews the use of AL-6XN (N08367) and ZERON 100 (S32760) alloys in various flue gas desulphurization (FGD) and wet electrostatic precipitator (WESP) applications. Experimental data will be reviewed that supports the use of the alloy in the high chloride, sulfuric acid containing environments encountered by many components of the pollution control system. Examples of the application of AL-6XN and ZERON 100 in actual service will be presented. AL-6XN and ZERON 100 alloys have proven to be cost effective materials of construction that fill the gap between the lower alloyed stainless steels, such as the 317L, 904L and 2205, and the high Mo nickel based alloys. As AL-6XN and ZERON 100 alloys are established materials of construction, they are readily available in product forms necessary to complete an FGD or WESP system.

Abstract ID: 1848
Cyclic Corrosion Behaviour of Stainless Steels in Concentrated Sulphuric Acid
S. Jones, J. Kish and K. Coley. McMaster University
Presenting from 10:30:00 To 10:55:00 - Wednesday
Stainless steels are widely used to handle concentrated sulphuric acid solutions produced in the manufacturing process. The corrosion resistance of these alloys relies on the formation of a protective passive film. However, this protective passive film is not stable under open-circuit conditions, since it tends to breakdown on a periodic basis. Electrochemical and gravimetric experiments were conducted using a range of stainless steels immersed in concentrated sulphuric acid to better understand the influence of the major alloying elements on this cyclic corrosion behaviour and the relative corrosion resistance amongst the various grades. This paper documents the results of this effort.

Abstract ID: 1786
Influence of Silver Content on Corrosion Resistance of Lead Anodes During Potential Decay by Electrochemical Noise Measurements
W. Zhang, A. M. Lafront, E. Ghali and G. Houlachi. Laval University, LTE-Hydro-Quebec
Presenting from 10:55:00 To 11:20:00 - Wednesday
The potential decay of three lead anodes containing 0.5-0.7% Ag after polarization at 50 mAcm⁻² in acid zinc sulphate - manganese sulphate electrolyte at 38°C was investigated by electrochemical noise "ENM" using the zero resistance ammeter set-up (ZRA). Intensive variations of potential and current values can be observed on the three specimens during the first hour followed by constant current and very slight oscillations in potential values. Three plateaux can be identified (1, 2 and 3) as function of their appearance and potential. Obtaining several parameters in situ by ENM is beneficial to characterize the decay from high positive to stationary open circuit potentials. The amplitude variation-oscillation of $\Delta E/\Delta t$ during the decay follows a certain pattern as a function of the plateau and decay time; however that of $\Delta I/\Delta t$ is almost similar from one plateau to another which can suggest certain corrosion rate pattern. Analyses of time and frequency domain of ENM indicate that the corrosion rates of the plateaux have certain different characteristics from that of the following region of potential decay. Every plateau had higher corrosion rate "1/Rn", higher slope of ratio "Sr" than that in its following decay period. It is then
assumed that the corrosion behaviour of lead anodes during their potential decay can be better understood by ENM studies.

Abstract ID: 1849

**Some Aspects of Concentrated Sulphuric Acid Storage Tank Corrosion**

*J. Rodda¹, S. Jones¹ and J. Kish¹. ¹McMaster University*

Presenting from 11:20:00 To 11:45:00 - Wednesday

Carbon steel has been widely used to fabricate concentrated sulphuric acid storage tanks. To increase the awareness of the comprehensive literature available, this paper highlights some of the major aspects associated with the corrosion performance of these tanks. Topics include a description of the major corrosion modes observed, and the underlying mechanisms responsible. It also addresses the principles and use of anodic protection and organic coatings, as effective corrosion control measures.

PYROMETALLURGY - Advances in the Processing of Nickel, Cobalt and PGMs Using Pyrometallurgical Techniques

**Presentations from 8:30:00 AM to 12:00:00 PM - Fraser Upper Right**

**PROCESS OPTIMIZATION**

Abstract ID: 1890

**Converter Aisle Improvements at Xstrata Nickel's Sudbury Smelter**

*B. Salt¹ and E. Cerilli¹. ¹Xstrata Nickel*

Presenting from 8:30:00 To 8:55:00 - Wednesday

In 1978 the converter aisle as Xstrata Nickel Smelter consisted of four standard Pierce Smith converters operating in parallel as single stage vessels. A number of changes have been made in the aisle over the last 30 years to develop a counter current multi stage converting process. This has required the development of two unique converters; the Slag Cleaning Vessel (SCV) and the Slag Make Converter (SMC). This has resulted in a unique three stage converting process that enables treatment of secondary materials as well as resulting in a slag that can be discharged without further treatment. This paper will describe the changes made to modify the productivity, improve plant hygiene and reduce fugitive emissions.

Abstract ID: 1862

**Quality Control Improvements in Bessemer Matte Production at the Vale Inco Copper Cliff Smelter**

*D. Cooke¹, D. Wong¹ and M. Zanini¹. ¹Vale Inco*

Presenting from 8:55:00 To 9:20:00 - Wednesday

Metals market improvement in 2004 drove the desire to increase nickel throughput at the Vale Inco Copper Cliff Smelter. Beginning in October 2006, the treatment of higher grade nickel concentrate at the Smelter represented a significant change in Bessemer Matte composition (Cu:Ni ratio) which impacted quality control and several downstream processes. In addition, the loss of technical and operational expertise during the previous market downturn contributed to the challenge of adapting to this change. Several improvements have been made in the Converter Aisle by focusing on employee engagement and
standardization of best operating practices for a whole new generation of operators. This paper documents these initiatives, which seek to balance the "art" and science of converting.

Abstract ID: 1888

**Hot Gas Generator and Rotary Kiln Burner Technology**

*M. Vaccaro*\(^1\), *Fives Pillard*

Presenting from 9:20:00 To 9:45:00 - Wednesday

Nickel laterite ores typically have high moisture content. Dehydration by means of rotary dryers equipped with combustion chamber delivering hot gases and pre-reduction of the ore in a rotary kiln are generally used to reduce the electrical energy demand of the smelting process into the electrical furnace. This paper will present the Fives Pillard expertise and State of the Art combustion equipment when firing various solid, liquid and gaseous fuels by means of hot gas generators for the ore drying stage and rotary kiln burner for the ore pre-reduction stage.

Abstract ID: 1899

**Use of Dust from Dryers - A Solution to Guarantee the Mechanical Strength of Agglomerates in the Calcining Process**

*A. Souza*\(^1\), *Vale Onca Puma*

Presenting from 9:45:00 To 10:10:00 - Wednesday

For RKEF technology to FeNi production, the solution adopted for recovery and handling of generated dust in dedusting system is the main challenge for this process. Onça Puma project is on commissioning phase and has a process capacity of 2.5 Mt of ore/year (dry basis) and produces 50.000 t of Ni/year, adopted one agglomeration process called extrusion; the collected dust in kiln is mixed with dust from dryers whose function is act like a binder for extruders to guarantee the mechanical strength during the calcining process. This work describes the tests which defined the process above mentioned.

Abstract ID: 1851

**Front Line Planning and Scheduling at Vale Inco’s Ni-Cu Matte Processing Plant**

*U. A. Dorigo*\(^1\) and *T. Yalcin*\(^2\), *Vale Inco*, *Laurentian University*

Presenting from 10:30:00 To 10:55:00 - Wednesday

Front Line Planning and Scheduling (FLPS) is a contemporary management tool designed to assist in the smooth running of plant operations so that production targets can be achieved consistently and reliably. It provides a suitable communication platform for individual work teams to plan and coordinate their activities together and aims to ensure uninterrupted operation between scheduled downtimes. This paper will explain the fundamentals of FLPS and discuss its application at Vale Inco’s Matte Processing Plant in Sudbury, where the method has been implemented since the spring of 2007. A brief description of the Matte Processing Plant will also be provided.

Abstract ID: 1818

**Optimization of the Xstrata Nickel-Sudbury Smelter Converter Aisle Using Discrete Element Simulation**
During the last few decades, the Xstrata Nickel Sudbury Smelter has significantly improved operating capacity and overall performance. In the quest for further plant enhancements, a new dynamic simulation model incorporating the overall smelter mass balance together with converter aisle logistics was developed based on the ARENA™ software platform. The model, which includes a number of animation features along with plant metallurgical data, is described in the present paper. Tested against a "base case" representing current operations, the model was found to reflect operating conditions very well. The model was used to evaluate a number of potential plant enhancements including the impact of the following: use of larger ladles, impact of higher converter blowing rates and also the impact of potentially larger converter vessels. It was found that in many instances, so-called plant bottle-necks can often be "coupled" and hence multiple decisions would need to be taken together to significantly improve converter aisle capacity. The model was found to be very useful in validating a number of plant improvements developed by senior smelter staff, in particular, in terms of the quantification of the actual benefits derived from alternative operating scenarios.

Abstract ID: 1960

Four Years of DC Arc Smelting of PGM-Containing Oxide Feed Materials at Mintek

I. Geldenhuys and R. Jones. 1Mintek

Presenting from 11:20:00 To 11:45:00 - Wednesday

Mintek has demonstrated the versatility and robustness of the ConRoast smelting process for platinum group metal (PGM) production on a pilot-scale DC arc furnace. Between April 2004 and August 2008, more than 37 000 tons of PGM-containing oxide feed materials were smelted in a DC arc furnace at power levels up to 1.5 MW. The furnace was able to treat low-sulfur, high-chromium materials that could not readily be smelted elsewhere; these included low-grade concentrates, converter slag, and revert tailings. Very high recoveries of PGMs to the iron-rich alloy product were obtained. Technical details of the process are presented in this paper.

PYROMETALLURGY - Advances in the Processing of Nickel, Cobalt and PGMs Using Pyrometallurgical Techniques

Presentations from 8:30:00 AM to 12:00:00 PM - F443

LATERITE ORE PROCESSING AND FeNi REFINING

Abstract ID: 2113

Thermodynamic Model of Feni Refining, Mineraçao Onça Puma

T. Marin and A. Vahed. 1Vale Inco Limited

Presenting from 8:30:00 To 8:55:00 - Wednesday

For the purpose of creating a metallurgical process simulator for the Vale Inco Onça Puma FeNi refining, a thermodynamic model for the removal of C, Si, P, O, S and Al, was developed. Instead of assuming pure liquid Fe as solvent, the behaviour of these impurities in dilute liquid Fe and liquid Ni was used to calculate the change of Gibbs free energy of dissolution and interaction coefficients in the liquid FeNi
alloy for varying Ni concentrations in the metal. Oxygen solubility for the whole range of Ni composition in the liquid ferronickel metal was calculated and it was found that at 25 wt% of Ni, the solubility of oxygen slightly decreases compared to the value of oxygen solubility in liquid Fe. At this Ni content Fe would oxidize preferentially, thus, no NiO would form during oxygen blowing. Equilibrium composition curves for C and Si as a function of oxygen in the metal were calculated at different process conditions. It was found that assuming liquid Fe as the solvent, instead of the liquid FeNi alloy, would overestimate the equilibrium composition. Partition coefficients as a function of slag composition and basicity were calculated for basic CaO–SiO₂–FeO and CaO–Al₂O₃–CaF₂ slags in the case of P and S, respectively. For deoxidation, the equilibrium composition of O as a function of Al content in the metal was calculated. It was found that the equilibrium curve shows a minimum O value at an Al concentration close to 0.1 wt%, higher than in the case of steelmaking. The model will be calibrated when the Onça Puma FeNi plant begins operation.

Abstract ID: 1893

Factors Affecting Nickel Extraction from Reduction Roasting of Saprolite Ore in the Caron Process

J. Chen¹, E. Jak and P. Hayes. ¹University of Queensland, Australia

Presenting from 8:55:00 To 9:20:00 - Wednesday

Laboratory investigations have been undertaken to simulate conditions occurring during the reduction roast step of the Caron Process to obtain improved understanding of the factors influencing nickel extraction from Saprolitic ores. Serpentine samples have been treated at temperatures between 500°C to 800°C in H₂/N₂ and CO/CO₂ gas mixtures, and leaching tests on reduced samples have been undertaken. Phase and microstructure changes have been characterised using X-ray powder Diffraction (XRD), Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM) techniques. Nickel recovery has been shown to depend on reduction temperature, time and gas composition. A complex series of phase and microstructure changes has been observed with the formation of nickel-iron alloy nano-particles.

Abstract ID: 1766

Comparison of Ladle Refining in the Ferronickel and Steel Industries

D. Brosig¹, J. Young¹ and I. Candy¹. ¹Hatch Associates Ltd.

Presenting from 9:20:00 To 9:45:00 - Wednesday

Ladle refining is used extensively in the production of steel and ferronickel. The process consists of numerous ladle-based operations focused on improving the product quality by removing chemical impurities (e.g., carbon, sulphur and phosphorous), while also controlling the number of non-metallic inclusions and their composition. The technologies currently used in steel refining allow for large ladles (up to 350 tons) to be processed efficiently in typically less than 45 minutes. It appears that some of the steel ladle refining process improvements may be applicable to the processing of ferronickel and several of these enhancements are discussed in this paper.

Abstract ID: 2068

Ferronickel Desulphurization Using Waste Materials from the Aluminum Industry
Nickel is a strategic metal widely used in stainless steel, aerospace materials, catalysts, energy storage devices, fuel cells, batteries and the nuclear industry. The increase in demand for nickel and nickel-alloys together with a shortage of nickel resources constitutes a serious problem for the future of the materials industry. The world nickel reserves consist of approximately 30% sulphide ores and 70% oxide ores. However, despite the relative abundance of the oxide ores, 60% of the nickel and nickel alloys produced today are derived from sulphide ore bodies. Based on these considerations, the pyrometallurgical production of nickel and its alloys from low-grade oxide ores is becoming increasingly important. A major concern however in the production of ferronickel from oxide ores is the high sulphur level in the resultant alloy. For this reason, there is an incentive to develop low-cost, effective fluxes for the desulphurization of ferronickel produced from nickel oxide ores. With this in mind, experiments have been carried out to study the possibility of using waste materials from the aluminum industry as a basis of refining fluxes for desulphurizing ferronickel. The experimental results showed that more than 80% of the sulphur in the ferronickel could be removed when adding 60 gram flux containing aluminum waste to 600 gram hot metal containing 10% nickel and 0.05 to 0.1% sulphur. The presence of sodium oxide (5-15%) and calcium aluminate (>50%) in the waste material had a positive effect on desulphurization, while a small amount of titanium oxide (<5%) and silicon oxide (<2%) did not have a significant influence. The effects of temperature, aluminum addition, flux-melting behaviour and optical basicity on the desulphurization process have also been investigated. The findings from this research provide a foundation of fundamental knowledge for the design of environmental-friendly fluxes with optimum composition and high sulphide capacity for ferronickel refining. This in turn should help Canada’s minerals industry pursue economically and environmentally sustainable development in an increasingly competitive world.

Abstract ID: 2065

Start-up and Ramp-up of Metallurgical Furnaces to Design Production Rate

F. Stober, C. Walker, R. Veenstra, K. Belanger, N. Voermann, T. Koehler and B. Wasmund. 1Hatch

The successful preheat, bath formation and ramp-up to full production of metallurgical (especially large) furnaces, poses challenges that can be outside the normal day-to-day experience of most operators. The start-up methodology can have substantial and far-reaching impacts on the ability of the furnace to achieve the planned campaign life and its rated throughput in a timely manner. Understanding the underlying technical constraints, careful planning and close cooperation between the owner-operator, designer, constructor and third party advisors are the pre-requisites for a successful furnace start-up and ramp-up. This paper outlines the technical and empirically demonstrated principles behind optimising furnace start-up and ramp-up duration with furnace integrity and campaign life, including the inter-related expansion behaviour of the refractory and structural support (shell and/or spring-loaded bindings), principles of electrode baking and the effects of the rate of heat-up and initial bath building on the furnace integrity and ultimately campaign life. Typical furnace (new and after cold shut-down) start-up plans are presented with justification of the activities and major decision milestones encountered during start-up and ramp-up, citing specific examples from recent start-ups. The advantages of careful pre-planning and
the importance of making timely informed decisions through knowledge of the start-up process, and furnace design and construction basis, are also highlighted.

Abstract ID: 1817

Studies on Recovery of Ni, Co & Cu from Polymetallic Sea Nodules by Direct Reduction Smelting
S. Agarwal\textsuperscript{1}, K. Sahu\textsuperscript{2}, R. Jana\textsuperscript{2} and S. P. Mehrotra\textsuperscript{2}. \textsuperscript{1}National Metallurgical Laboratory, \textsuperscript{2}National Metallurgical Laboratory
Presenting from 10:55:00 To 11:20:00 - Wednesday
A world-wide research is progressing on sea nodules as an alternative future source of various metals like nickel, cobalt, copper etc. which are fast depleting from the earth surface. Sea nodule collected from Indian Ocean containing 1.2% Ni, 1.1% Cu, 0.08% Co, and 24.3% Mn was treated to recover metal as alloy by direct reduction smelting. Various parameters like smelting temperature, reductant concentration, holding time etc. have been optimized to obtain an alloy of suitable composition. At a smelting temperature of 1400 °C, recovery of 92-95% Ni, 90-92% Cu and 85-90% Co is obtained in the form of alloy which can be further treated to recover these metals in pure form.

Abstract ID: 1819

Development of a New Mass Balance Model for the Xstrata Copper-Horne Smelter for Plant Optimization
P. Courso\textsuperscript{1}, N. Tripathi\textsuperscript{1}, P. Mackey\textsuperscript{1} and S. Morisette\textsuperscript{2}. \textsuperscript{1}Xstrata Process Support, \textsuperscript{2}Xstrata Copper
Presenting from 11:20:00 To 11:45:00 - Wednesday
The Xstrata Copper-Horne smelter, located in North-Western Quebec, has operated solely as a custom smelter for almost three decades. Specializing as a niche smelter with considerable flexibility as to the quantity and quality of feed materials, this land-locked plant has proven resilient on account of this proven operating flexibility. The development of an improved and flexible heat and mass balance model of the plant as an optimizing tool is described in this paper. This model allows, for example, ready evaluation of the impact of different feedstock materials on plant parameters such as fuel and oxygen requirements and smelter metal recoveries. Based on the METSIM software, the model includes the Noranda Reactor (main smelting unit), the Noranda Continuous Converter, the pyro-refining vessels, the anode furnaces and the slag milling and flotation plant, and includes all plant recirculating streams. The present modeling approach used in this work is described and discussed along with potential refinements.

HYDROMETALLURGY of Nickel and Cobalt Symposium including the Processing of Valuable By-Products Containing Materials
Presentations from 8:30:00 AM to 12:15:00 PM - Fraser Lower

LATERITES (8:30 TO 10:10)
MODELLING AND CONTROL (10:30 TO 12:10)

Abstract ID: 1773

Ambatovy Laterite Ore Preparation Plant and High Pressure Acid Leach Pilot Plant Operation
M. Collins1, K. Buban1, P. Holloway1, I. Masters1 and R. Raudsepp1. 1Sherritt International Corp.
Presenting from 8:30:00 To 8:55:00 - Wednesday
The Ambatovy Joint Venture is developing a laterite deposit in Madagascar to produce 60,000 tonnes of nickel and 5,600 tonnes of cobalt per year. Construction is ongoing and mechanical completion is scheduled for the latter part of 2010. The plant design, with a High Pressure Acid Leach (HPAL) step, is based on results from pilot plant testwork conducted by Sherritt in 2004, and on Sherritt’s commercial laterite processing experience. The paper presents results from recent Ore Preparation Plant (OPP) pilot plant campaigns conducted in Madagascar at the mine site, and a recent HPAL pilot plant campaign conducted in Fort Saskatchewan with the prepared ore. The work added insight into the behaviour of the ore chosen for plant start-up, and assisted in the selection of limestone and other reagents for the project.

Abstract ID: 1695
Acid Leaching of Laterites in Australia: Where Have We Been and Where are We Going?
J. Canterford1. 1Process Technologies Australia Pty Ltd.
Presenting from 8:55:00 To 9:20:00 - Wednesday
Although sulphuric acid leaching of laterites has been commercially practised for over 50 years there are still many metallurgical and engineering challenges to be overcome when implementing the technology, particularly in remote locations with limited infrastructure and an often hostile environment. This presentation provides an overview of the more significant laterite leaching developments in Australia with appropriate cross-references to projects in other locations, and includes details of approaches that both compliment as well as potentially displace the "best" known technology, high pressure acid leaching.

Abstract ID: 1738
Treatment of Nickel Laterites by Chloride and Hybrid Chloride-Sulphate Process
B. Harris1, C. White1, M. Dry2 and P. Evans3. 1NMR360 Inc., 2Arithmetek Inc., 3Consultant
Presenting from 9:20:00 To 9:45:00 - Wednesday
With laterites representing about 70% of the world’s nickel reserves, there continues to be an incentive to develop an economically and technically viable process for their treatment. A number of sulphate-based and chloride-based processes have either been built or have been proposed over the past fifteen years, but none has really been successful. PAL and HPAL (high pressure acid leaching) continue to be the favoured routes, but as long as the prices of sulphur and sulphuric acid remain high, it is doubtful whether such processes can be truly economic. A number of chloride-based processes have also been proposed, but these depend very much on the economic viability of both regenerating and recycling hydrochloric acid and controlling magnesium. The present paper briefly looks at the merits of both sulphate and chloride processing, and at the potential of hybrid chloride-sulphate circuits, nominally combining the best aspects of each. A number of potential scenarios are presented, with order of magnitude capital and operating costs for each. It is concluded that flowsheets which offer additional marketable by-products, such as hematite (iron ore) and magnesia, have a greater chance of being successful, provided that by-product values are included in the overall economic assessment.

Abstract ID: 1744
Heap Leaching Nickel Laterites - A Challenge and an Opportunity
The demand for commodity metals in recent years has led to the accelerated need to exploit additional ore bodies often lower in grade, more complex in mineralogy and requiring more sophisticated processing options. In the case of nickel this is definitely true and the "new", usually lower grade and almost always more complex minerals of choice are the laterites. CSIRO Minerals has been active in developing a fundamental understanding of the mineralogy of many Western Australian nickel laterites samples and their leaching performance under a variety of conditions. In this paper the variability of WA laterites is discussed in terms of mineralogy, grade, agglomeration and leaching performance, focussing on heap leaching and describing results associated with acid consumption, values recovery and impurity deportment. A predictive model for heap leach performance based on fundamental mineralogy has been developed and shown to be applicable across a wide range of ores. Further development of this is underway to incorporate prediction of major impurity deportment and acid consumption. The beneficiation of nickel laterites is seen as key to the wider uptake of heap leaching technology for nickel laterites and work in this area is progressing. In parallel, an alternative approach involving a thermal pre-treatment to dramatically accelerate the rate of nickel recovery under mild conditions is demonstrated.

Abstract ID: 1887

Applications of Leaching and Precipitation Modeling in Nickel Hydrometallurgical Process Design

J. F. Adams1. 1Hatch Ltd

Mathematical modeling of heterogeneous, two and three phase reactors in hydrometallurgical processes is not new. However, that does not mean that it is yet easy to do, nor that it is common practice. Piloting remains the method of choice for testing new processes or modifications to existing processes. Nevertheless, there may not always be budget available for expensive pilot testing, so that process designers and process operators turn to modeling as an investigative tool and use model results to plan a test program that is more cost effective (confirmatory rather than investigative) and can be completed in a much shorter period of time. This paper presents a simple yet rigorous method of modeling heterogeneous, two and three phase reactors in Excel using the classic Population Balance Model approach. The application and usefulness of the model will be demonstrated with three examples taken from nickel hydrometallurgy: nickel sulphide precipitation, gypsum precipitation during acid neutralization, and pressure oxidative leaching of nickel sulphide. The ability to interface the model with other process design tools such as METSIM® and OLI will also be demonstrated.

Abstract ID: 2056

Heat of Reaction of Aqueous NiCl₂ in Pyrohydrolysis

T. Utigard1, J. Liu2 and A. Vahed2. 1University of Toronto, 2Vale Inco

The Vale Inco Goro operation will be the first to commercially use a pyrohydrolysis fluid bed reactor to treat aqueous nickel chloride solutions. In the fluid bed, which operates at about 820ºC, water vapor reacts with nickel chloride according to the following reaction: NiCl₂(aqueous) + H₂O → NiO + 2HCl(g).
The heat of formation, heat of dissolution and heat capacity of the nickel chloride solution are important for the energy balance of the pyrohydrolysis reactor. Unfortunately, these parameters are lacking from most known thermodynamic databases and laboratory tests were therefore conducted to determine or confirm these values.

Abstract ID: 1724

**On-Line Acid Measurements Via Electrodeless Conductivity In HPAL Processes For Nickel/Cobalt Extraction**

*R. Saini* and *V. Papangelakis*, University of Toronto

Presenting from 11:20:00 To 11:45:00 - Wednesday

From the operating costs, process control and environmental protection points of view, it is very advantageous to have a means of monitoring solution free acidity online and in real-time. At the University of Toronto’s Aqueous Process Engineering and Chemistry group a technique has been developed to measure on line the free acidity of a process solution from ambient up to 260°C by using eletrodeless conductivity. The sensor operates at temperature on the basis of induction currents and is suitable for very concentrated solutions containing solid dispersions. This presentation reports on recent developments to measure acidity during High Pressure Acid Leaching (HPAL) of laterites and pressure oxidative (POX) leaching of slags for nickel, cobalt and other base metal extraction. The primary focus is placed on monitoring acidity change with time and at temperature as it occurs within autoclaves at industrially relevant conditions.

Abstract ID: 1736

**Application of Safety Instrumented Systems (SIS) to Ensure Safety of Nickel / Cobalt Autoclave Plants**

*J. Murray*, Emerson

Presenting from 11:45:00 To 12:10:00 - Wednesday

Autoclaves are increasingly being used in nickel cobalt hydrometallurgical processing because they offer the most economic method of metal extraction while minimizing emissions. Yet these high pressure / high temperature processes introduce very real safety concerns and risks. This paper details the use of Safety Instrumented Systems (SIS) to mitigate the risks associated with nickel cobalt pressure leach autoclaves so as to improve both safety and performance. The paper will also discuss the significance of the latest SIS standards - IEC61511 & IEC61508.

**HYDROMETALLURGY of Nickel and Cobalt Symposium including the Processing of Valuable By-Products Containing Materials**

Presentations from 8:30:00 AM to 12:15:00 PM - Room F441

**ELECTROCHEMISTRY**

Abstract ID: 1684

**Cobalt Electrowinning - Process and Technology**
Cobalt electrowinning technology is very varied. It can be done with a unique in-pulp process or it can be done in divided or in conventional undivided cells. Electrorefining in diaphragm cells can also be considered. Sulphate or chloride media can be used. Due to its low standard potential (-277 mV vs NHE), there is a competition between cobalt deposition and hydrogen evolution in acidic solutions. In order to avoid hydrogen evolution, diaphragm cells can be used as practiced for nickel, but excellent results can also be obtained with conventional cells working with high cobalt concentration, high temperature, and high current density. Impurity contamination of the cobalt deposit is discussed. Zinc and iron, less noble than cobalt, are preferentially plated. On the other hand, nickel does not deposit preferentially even though it is slightly more noble than cobalt. A split tankhouse configuration is proposed which would allow improved current efficiencies when working with conventional cells.

Abstract ID: 1725
A Novel Electrode for Cobalt Electrowinning to Suppress CoOOH Deposition
M. Morimitsu\textsuperscript{1} and K. Uno\textsuperscript{1}. \textsuperscript{1}Doshisha University
Presenting from 8:55:00 To 9:20:00 - Wednesday
The anodic behaviors of IrO\textsubscript{2}-Ta\textsubscript{2}O\textsubscript{5} coatings prepared by thermal decomposition at different temperatures were investigated by cyclic voltammetry to develop a novel electrode that can suppress CoOOH deposition on the anode. Thermal decomposition at 470 °C or more resulted in crystalline IrO\textsubscript{2} in the coating, and the amorphization of IrO\textsubscript{2} was seen at temperatures below 380 °C. While the anodic deposition of CoOOH was found on such high temperature coatings, the amorphous coating accelerated gas evolution in HCl solutions and successfully suppressed CoOOH deposition in the solution from CoCl\textsubscript{2}.

Abstract ID: 1687
The Effect of Metallic Impurities on Nickel Electrowinning
M. Baghalha\textsuperscript{1}, A. Ahmadi\textsuperscript{1} and M. Kamal-Ahmadi\textsuperscript{1}. \textsuperscript{1}Sharif University of Technology
Presenting from 9:20:00 To 9:45:00 - Wednesday
Nickel electrowinning is the electrolytic finishing process in recovery of nickel from aqueous leach solution. Some metal impurities that are carried forward from the hydrometallurgical processing of laterite nickel ores may interfere with the electrowinning operation. In addition to lowering the purity of the electrowon nickel, metallic impurities may influence the cathodic current efficiency significantly. In the current investigation, the effect of metallic impurities Cu, Fe, and Zn up to 0.2 g/L on the cathodic current efficiency of nickel electrowinning process was experimentally tested using a Hull cell. The presence of Fe up to 0.1 g/L in the nickel solution reduced the nickel electro-deposition current efficiency by 17%. This reduction in the current efficiency remained rather constant up to 0.2 g/L of Fe. The behavior of Zn impurity was rather similar to the behavior of Fe. This similar behavior is probably due to their negative electrode potential. The effect of Cu impurity on the nickel current efficiency was more pronounced. At 0.03 g/L of Cu impurity, the cathodic current efficiency reduced around 30%. It is postulated that the higher copper electrode potential causes the Ni electrode potential becomes more positive; hence the unwanted H\textsuperscript{+} reduction reaction better competes with the main nickel electro-deposition reaction.
Abstract ID: 1709

**Modern Nickel Electrowinning Plant Design**  
*D. Robinson¹ and R. Fraser. ¹Hatch Dremco*

Presenting from 9:45:00 To 10:10:00 - Wednesday

Hatch has been involved with a number of nickel electrowinning plant developments in recent years. These have involved sulfate, and mixed sulfate-chloride electrolytes, and both cathode boxes and anode bags to separate the electrolytes. In addition, they have involved paired cell and adjacent cell configurations. This paper sets out to discuss various fundamental and practical aspects of the plant designs, including the electrode reactions, heat balance factors, methods of controlling the flow of the separated electrolytes, the design of bus bar and shorting frames, and the control of the environmental conditions within the plants, which is becoming even more critical as exposure limits tighten. This review of the technology will provide references to plants under design and construction where permission to publish has been granted.

Abstract ID: 2037

**Recent and Forthcoming Operational Improvements in Vale Inco's Thompson Nickel Refinery**  
*B. Oliver² and D. Wran². ¹Vale Inco Manitoba Operations*

Presenting from 10:30:00 To 10:55:00 - Wednesday

Vale Inco’s Thompson Nickel Refinery produces 120M lbs of electrolytic nickel annually as cathode slab and rounds products. After more than fifty years of operation, the refinery is modernizing its tankhouse, altering the handling of anode slimes, and has increased cobalt throughput. Further changes to tankhouse practice and copper handling are also being developed. This paper describes these efforts.

Abstract ID: 1659

**On the Dissolution of Pyrrhotite: In-Situ Electrochemical Analysis of Surface Layers**  
*A. Ghahremaninezhad¹, E. Asselin¹ and D. Dixon¹. ¹University of British Columbia*

Presenting from 10:55:00 To 11:20:00 - Wednesday

The anodic dissolution of pyrrhotite in 1M HCl electrolyte has been studied by in-situ Mott-Schottky analysis of the formed surface layers. It was observed that, depending on the electrode potential, two distinct n-type semiconductor surface layers were formed on the electrode which hindered the dissolution rate of the mineral. Potentiodynamic testing was applied to support the data in the Mott-Schottky plots. The formation of a thick and uniform layer on the surface of the mineral was observed by SEM and the composition of the surface film was determined to be 98% sulfur and 2% iron by EDX analysis.

Abstract ID: 1734

**Removal of Impurities from Cobalt Electrolyte Solution**  
*M. Hossain¹ and S. Alam¹. ¹Memorial University, St. John’s*

Presenting from 11:20:00 To 11:45:00 - Wednesday

During pressure leaching of nickel sulphide ore/concentrate, in addition to nickel and cobalt, other metals that are present in the ore/concentrate are also dissolved in the leach liquor. These additional metals form impurities in the electrolyte solution. Over time these impurities accumulate in the circuit. To produce pure
nickel and cobalt, the impurities must be removed. This paper describes some aspects of solution purification where impurities were removed from cobalt electrolyte solution by hydrometallurgical techniques on a bench scale, using both synthetic and actual solutions that were generated at Vale Inco’s hydromet demonstration plant in Argentia, Newfoundland.

ENVIRONMENT - Green Technologies for the Mining and Metallurgical Industries
Presentations from 8:30:00 AM to 12:15:00 PM - Room F335

ECOLOGY, ENERGY CONSERVATION

Abstract ID: 1968
The Environmental Costs of Platinum - PGM Mining: An Excellent Case Study in Sustainability Mining
G. Mudd¹ and B. Glaister¹. ¹Monash University
Presenting from 8:30:00 To 8:55:00 - Wednesday
The platinum group of metals (PGMs) possess a range of unique chemical and physical properties and are increasingly finding important uses in a wide variety of environmentally-related technologies (eg. catalytic converters, fuel cells, electronics). The typical ore grade for PGM mineralisation is similar to gold (g/t) but the processing is more akin to base metals (at percent). The typical scheme for a PGM project is a mine, flotation concentrator, smelter and refinery. The environmental costs could therefore expected to be more significant than gold mining – in contrast to the uses for PGMs in many environmentally focussed technologies. The global production of PGMs is dominated by South Africa due to their large economic PGM resources in the Bushveld Complex, while other countries play a minor but important role. Concerns are being raised about the long-term ability to supply PGMs to meet future technological needs, as well as allegations of significant environmental and social impacts such as water pollution, unfair village relocation and compensation issues. This paper presents a detailed review of the platinum-PGM industry and major environmental costs such as water, energy and greenhouse emissions. The relationships between production statistics and environmental or ‘sustainability metrics’ are then investigated with a view to understanding the current trends in PGM mining and potential future implications. The paper presents a unique case study for a group of metals which are uniquely concentrated in one major region of the earth and pose some intriguing and difficult sustainability issues for the future.

Abstract ID: 1834
Ecological Perspectives in Restoring Mine Waste Management Areas
M. Kalin¹. ¹Boojum Research Ltd
Presenting from 8:55:00 To 9:20:00 - Wednesday
Mine waste management areas (MWMA) are perceived as rock piles or ground rock, covered partly or completely by water. This provides a stark contrast to surrounding healthy ecosystems. The MWMA is presented as an emerging ecosystem where life exists, but is limited to ecological niches. Emerging ecosystems in uranium, coal, and metal MWMAs form the building blocks of the ecological engineering approach. This approach retains contaminants in the MWMA, transforming them through biogeochemical means to metal sulphides in sediments. Nutrient additions accelerate ecological succession,
producing more organic matter and ecological diversity, and moving predominantly oxidative systems toward neutral or reductive ecosystems.

Abstract ID: 2001

The Potential for Sustainable Energy Recovery From a Working Mine

J. Scott¹, A. Hall¹, H. Shang¹ and S. Hall¹. ¹Laurentian University

Presenting from 9:20:00 To 9:45:00 - Wednesday

The mining industry is extremely energy intensive, not just in consumption to extract ore, but also in subsequent processing. Annual fuel bills for one mine that run into tens of millions of dollars are common. This high energy consumption, much of which is sourced from fossil fuels, also generates extremely large outflows of underutilized ‘waste’ energy in the form of low-grade heat in discharged air and water streams. In a volatile economic market with long term rising energy prices, coupled to increasing pressure to reduce greenhouse gas emissions, the authors are looking to help the mining industry enhance energy security. This in part can come through reducing dependence on fossil fuels by integration of on-site energy recovery schemes, which could provide significant benefit to both the economics of operation and the environment. In addition, utilization of the mine post-closure as a source of direct and/or indirect energy supply might help build energy, and hence economic, resilience in mining communities.

Abstract ID: 1969

Historical Trends in Base Metal Mining : Backcasting to Understand the Sustainability of Mining

G. Mudd¹. ¹Monash University

Presenting from 9:45:00 To 10:10:00 - Wednesday

The base metal mining sector has been and continues to remain an important endeavour in many parts of the world. The mining of copper, lead-zinc-silver and nickel has led to social and economic development but has also left significant and sometimes lasting environmental impacts. Although mining is widely perceived to be unsustainable, since it is drawing down natural capital (ie. stock) - despite the productive output of mines now being considerably larger than at any time in history. What has underpinned this paradox? And what are the long term trends in base metal mining? And how can this knowledge be used to understand the current position and future challenges of base metal mining? This paper will present long-term data on trends in base metal mining such as ore grades, waste rock and economic resources, focusing on major mining countries such as Australia, Canada, Chile and the United States. By looking back to history, or ‘backcasting’ in sustainability language, we can better understand the historical challenges, patterns or factors that have shaped the base metal mining industry. This then helps us to understand the current and future challenges facing the base metals sector of the global mining industry. An oft-quoted saying for peak oil pundits is that of Saudi’s former Oil Minister Ahmed Zaki Yamani: ‘The Stone Age came to an end not for the lack of stones and the oil age will end, but not for the lack of oil’. Will the base metals mining sector go the same way? That is, what has been the success rate for new technology, exploration, economics or perhaps environmental aspects which may constrain the sector or, conversely, help it to flourish? This paper presents a unique insight into base metals over time, and provides a range of valuable but rarely published historical data.

Abstract ID: 2006
New Approaches to Smelter Off-Gas Heat Recovery

P. Safe1 and M. Russell1. 1WorleyParsons Gas Cleaning
Presenting from 10:30:00 To 10:55:00 - Wednesday

Smelter processes generate significant off-gas flows at high temperatures, which represent a major heat loss from the process, so off-gas heat recovery is critical to minimizing energy consumption and reducing operating costs. Metallurgical process off-gas presents real challenges for heat recovery due to high dust loading, corrosive gas, and thermal cycling in batch processes. Waste heat boilers have been used for heat recovery on continuous smelting and converting processes. However, batch processes such as Peirce-Smith converting and other lower temperature applications have been largely overlooked for heat recovery. The design and adaptation of novel heat recovery processes and technologies to smelter processes can provide a major step in reducing energy consumption, greenhouse gas emissions, and operating cost. This paper outlines the challenges faced in recovering heat in smelter processes and presents new approaches for heat recovery for batch processes and lower temperature applications.

Abstract ID: 1756

Energy Efficiency Aspects of Hydrometallurgical Process Testing - Bench Scale to Pilot Plant

K. Rao1. 1Institute of Minerals and Materials Technology (CSIR)
Presenting from 10:55:00 To 11:20:00 - Wednesday

Recently, there has been an increasing focus on energy savings in hydrometallurgical processes for treating complex sulphides and nickel laterite ores. Any such process developed would necessarily be sensitive to the nature of raw materials. In this direction, an effort is made here to identify gaps between the selection of initial feed materials and various final products as relevant to technical and economic parameters affecting process selection. This paper presents a comprehensive review of energy conservation studies particularly on leaching of sulphide minerals and bulk concentrates. Energy considerations for future processes are also briefly discussed.

PROCESS CONTROL Applications in Mining and Metallurgical Plants

Presentations from 8:30:00 AM to 12:15:00 PM - Room A226

MINING

Abstract ID: 2032

(KEYNOTE) POD Based Observer for Estimation in Navier-Stokes Flow

T. John1, M. Guay2, N. Hariharan3 and S. Naranayan3. 1University of Toronto, 2Queen's University, 3United Technologies Research Centre
Presenting from 8:55:00 To 9:45:00 - Wednesday

In this paper, we propose a POD-based technique that is suitable for the design of reliable observers for the estimation of velocity field and contaminant flow for Navier-Stokes ow. POD modes are constructed using the method snapshot. Karhunen-Loeve (Galerkin) projection to develop a reduced-order model obtained by projecting the velocity field onto the most important POD modes. The resulting nite-dimensional dynamical system is suitable for the design of nonlinear observers. The estimate of the velocity field is then used to estimate the concentration field of a contaminant from the 2D and 3D
advection-di usion equations. The prime application considered is the estimation of air ow and contaminant ow in building systems. 2D and 3D simulation examples are provided to demonstrate the applicability of the technique.

Abstract ID: 2003
The Application of Discrete-Event Simulation in the Design of Underground Mines and Logistics
K. I. Hindle and V. Limmer. Hatch Ltd.
Presenting from 9:45:00 To 10:10:00 - Wednesday
This paper will focus on how Hatch Engineering uses discrete-event simulation to assist in mine design, expansion, general logistics and overall operational improvement projects. The benefits of modeling the entire underground system will be highlighted, from the mining face, through conveyors, trucking, ore passes, trains, storage, and hoisting systems which can constrain the system. By looking at the entire ore flow, for both Greenfield and Brownfield sites, it is possible to de-bottleneck the underground system off-line and ensure operational targets can be achieved, while maximizing the benefits of capital expenditures.

Abstract ID: 1737
Remote Operation and Collaboration in Mining Applications
Presenting from 10:30:00 To 10:55:00 - Wednesday
Mining operations are by necessity dispersed around the world, often in remote locations with poor infrastructure. Providing first-rate technical resources to monitor, configure and operate equipment in these remote locations can be difficult and is at best very expensive. The oil and gas industry has dealt with similar challenges and proven out remote collaboration and operations methods that have substantially reduced the cost of operating offshore rigs. This article will explore how this technology can provide similar benefits to remote mining operations.

Abstract ID: 1820
Multivariable Predictive Control for Mining, a Paradigm Shift From Expert Systems
R. Jonas and A. Green. Honeywell Process Solutions
Presenting from 10:55:00 To 11:20:00 - Wednesday
Mining companies can improve production and reduce cost by using the best available control technology to control their operations. Many mines use expert systems that can provide improved results over manual or basic control, but better results are achieved using multivariable predictive control. Over the past few years, the application of multivariable model-based predictive control has gained acceptance in many mining processes and has recently proven to be suitable for some of the most challenging processes. This advanced control technology has been successfully applied to a wide variety of processes; grinding mills, alumina digestion, CCD/thickeners, kilns/calciners/roasters, flash smelters, heat exchangers/evaporators, and most recently in the demanding process of flotation. This paper discusses the advantages and disadvantages (pros or cons) of advance control technologies in the mining industry,
including the impact of these technologies on best practices for implementation and long term sustainability. A result of a multivariable application in mine processing is discussed, and in particular the application for the SAG mill.

Abstract ID: 1941

**Long Term Sustainability of Advanced Process Control Optimization Projects**

C. P. Sheehan¹, T. Chmelyk¹, A. Waite² and D. Corovic².¹NORPAC Controls Ltd., ²Emerson Process Management

Presenting from 11:20:00 To 11:45:00 - Wednesday

Advanced control optimization initiatives have the potential of delivering significant economic benefits and operating stability to the metals and mining applications. However, there are many risks and pitfalls that can greatly affect the long term sustainability of the benefits achieved during the initial implementation. Some of these are technical and others are human factors. Too often we hear about advanced control systems that are "turned off" after 6 months of operation because something has changed in the process, equipment performance has degraded or the system itself has become constrained. Moreover, there is a lack of understanding on how to correct the situation with the available plant resources. In this paper the author will present some of the best practices around designing a system and implementing a plan for sustained process control optimization. This includes addressing such topics as: auditing your process, selecting key embedded advanced control technologies, integrating smart field device diagnostics/alerts, and continuous performance monitoring. Importance of a complete solution approach and understanding challenges to select right APC technology are discussed with emphasis on tool set for reducing variability and increased robustness of the model. Further, issues around human factors will be discussed to address the requirement of increasing operator acceptance and designing a work process to maintain the performance of the system. Case study examples from other industries will also be presented to illustrate some of the key lessons learned and results that can be achieved.

*Wednesday, August 26, 2009 PM*

MINERAL PROCESSING - Mineral Processing of Complex Sulphides

Presentations from 1:35:00 PM to 5:30:00 PM - Fraser Upper Left

**COMMINUTION, GRAVITY SEPARATION, FLOCCULATION, SEDIMENTATION**

Abstract ID: 1826

**Preconcentration of Platinum Group and Base Metal Ores by Dense Medium Separation**

A. Holloway¹, L. Jones¹ and S. Lawrence¹.¹DRA Americas

Presenting from 13:35:00 To 14:00:00 - Wednesday

Whilst dense medium separation is best known for its ability to concentrate diamond and coal deposits, the process is now being employed in southern Africa as a preconcentration step to improve the economics of platinum group metal and nickel ores. DMS plants built for these industries (such as the 1600tph unit at Tati Nickel, Botswana), are spearheading an expansion in this area by reducing mine and process operating costs yet maintaining economic metal recoveries. This paper provides an overview of
DMS technology and examines the economic benefits available to North American operators and projects, using recent case studies for reference.

Abstract ID: 1955

Current Challenges in PGM Flotation of South African Ores

B. Knights$^1$ and M. Bryson$^1$. $^1$Mintek
Presenting from 14:00:00 To 14:25:00 - Wednesday

Flotation of PGM ores, specifically UG2, present a number of technical challenges. These centre on the prevalence of chromite. Subject to over-grinding, chromite is primarily recovered to the flotation product through entrainment. This is of unique concern as it must be kept below a threshold for downstream smelting, with significant operational and monitory penalties being imposed should it exceed this concentration. A number of strategies have been developed to maximise PGM recovery in the presence of this unwanted contaminant. Specialised flowsheets form a vital basis, and advanced control algorithms further enhance PGM recovery while minimising the recovery of chromite.

Abstract ID: 1952

A Role of Flocculant Conformation in the Flocculation Process

V. Ferrera$^1$, E. Arinaitwe$^1$ and M. Pawlik$^1$. $^1$University of British Columbia
Presenting from 14:25:00 To 14:50:00 - Wednesday

A series of flocculation tests were performed on dilute quartz suspensions with the use of five polyacrylamide-based flocculants of similar molecular weights but of different degrees of anionicity. The tests were performed as a function of temperature, ionic strength, and pH. The macromolecular conformation of flocculants in solution was assessed through intrinsic viscosity measurements under the same physicochemical conditions as those of the flocculation tests. It was generally found that the flocculating efficiency of the polyacrylamides correlated with their ability to coil or stretch in solution. Polyacrylamides with the degrees of anionicity on the order of 10-18% showed the highest flocculating efficiency in terms of the settling rates of the flocculated solids and the residual turbidity of the resulting supernatant. At the same time, these most effective flocculants were also found to exhibit the greatest tendency to coil and stretch in solution. This result suggests that the flocculating power of a flocculant is determined not only by its ability to adsorb onto (and bridge) fine particles but also on its ability to conform to the size of the resulting flocs.

Abstract ID: 1933

An Approach to Measure Zeta Potential Using Sedimentation Potential Method

S. Uddin$^1$, M. Mirnezami$^1$ and J. Finch$^1$. $^1$McGill University
Presenting from 14:50:00 To 15:15:00 - Wednesday

A fast, reliable and practical way of measuring zeta potential using sedimentation potential method is proposed. A cell was designed along with the instrument control software to determine the required variables simultaneously i.e. sedimentation potential, specific conductivity, volume fraction of solid as well as pH. High purity alumina and silica powders were used as test samples. Measured zeta potential using the proposed technique was comparable with the results by electrophoresis.
Abstract ID: 1946

**New Developments for Sensor Based Sorting**

*K. Bartram*¹ and *M. Kowalczyk*². ¹Commodas Inc., ²Terra Vision

Presenting from 15:35:00 To 16:00:00 - Wednesday

The successful application of color sorting machines has established sensor-based sorting in the mineral industry in recent years and is considered today as the most significant innovation in processing technology after many years. However, we are only at the beginning of (market) introduction. Commodas has been active in sensor-based sorting of bulk materials since 1993. The first sorting machines employed to process calcium carbonate were based on camera technology and digital image processing. Together with its new acquired sister company Ultrasort the group has around 620 sorting machines operating in various fields of business today, approximately 150 are used in the mineral and ore industry. So far, mainly color sorting machines have been used in mineral industry to pre-sort recovered material or enrich minerals of value. Owing to further development and model upgrading, these machines are now very reliable and produce good results. In the diamond industry x-ray fluorescence sorters have been established as a standard for this market. Ultrasort continuously improve their existing sorters and develop new innovations in this field. New sensor systems have been developed, which exploit material properties such as electrical conductivity, magnetization, molecular structure, thermal conductivity etc. This opens up new exciting pre-concentration and upgrade possibilities for many applications such as, Nickel, Gold, Copper and other ores as well as for industrial minerals and diamonds as well as other gem stones.

Abstract ID: 1932

**Mineral Liberation and Particle Breakage in Stirred Mills**

*R. Roufail*¹ and *B. Klein*¹. ¹University of British Columbia

Presenting from 16:00:00 To 16:25:00 - Wednesday

Mineral liberation is accomplished by comminution and is the first step towards achieving successful downstream processes such as flotation or leaching. In metal mining, one of the most effective comminution methods that is used to grind particles below 10 microns is stirred milling. In this paper the study of particle breakage mode vs. mill operating parameters is addressed. Stirred mills’ grinding action is mainly attrition, but operation can be manipulated to include breakage by compression or impact loading. Macro and micro analysis of particle breakage and grinding mechanisms are correlated. Macro analyses convey information that relates grinding mechanism to particle size and shape. It is speculated that the breakage mechanism in the horizontal stirred mills is massive fracture for the coarsest particles and attrition (abrasion) close to the grinding limit where the size reduction ratio approaches 1.0. For micro analysis, the particle breakage mode has a direct impact on fracture type either transgranular or intergranular. Intergranular particle breakage leads to higher mineral liberation compared to transgranular breakage. Similar minerals would have more homogeneous properties that convey a stronger bond compared to dissimilar, heterogeneous mineral bonds. Transgranular fracture requires higher energy than intergranular fracture; transgranular fracture toughness of pure single phase mineral is about 10-14% higher than the intergranular fracture toughness. This communication presents the results of an investigation to assess how operating conditions can affect trans- vs. inter-granular breakage.
Abstract ID: 1949
Probing Mineral-Bitumen Liberation Through Rheological Measurements
L. Gutierrez1 and M. Pawlik1. 1University of British Columbia
Presenting from 16:25:00 To 16:50:00 - Wednesday
The rheology artificial mixtures of bitumen with fine quartz of varying bitumen content, as well as actual oil sand ores, was investigated under different physicochemical conditions (pH, temperature). All rheological measurements were conducted using a Haake Rotovisco VT550 rotational viscometer, connected to a fixture specifically designed to measure properties of settling suspensions. It was found that at low bitumen contents (1%, wt.) the pH of the slurries was the most important parameter that controlled the rheology of quartz-bitumen slurries. At higher bitumen contents (10%, wt.), it was a combination of high temperature and high pH that gave the lowest apparent viscosities and yield stresses of the model mixtures. These model observations correlated well with the rheology data obtained for slurries of actual oil sand ores. The overall results were discussed in terms of aggregation-dispersion phenomena between bitumen and mineral particles.

Abstract ID: 1882
Impact on Mill Design and Flotation Control of New Discoveries in the Relationship Between Macro and Micro Grindability
J. Starkey1. 1Starkey & Associates Inc.
Presenting from 16:50:00 To 17:15:00 - Wednesday
Large differences between macro and micro grindability relationships have been discovered for mill design measurements using the patented SAGDesignTM test. Crushing, Rod and Ball Mill Wi tests, and breakage parameter measurements have previously been used to design SAG mills but have not revealed the true magnitude of these differences. A SAGDesignTM test measures the SAG/Bond Wi Ratio (defined below) for every sample tested and gives a good design result because the F80 of the SAG stage test feed is 19 mm and because the test includes a Bond Ball Mill Work Index on SAG ground ore. Good flotation operation demands properly sized grinding mills and steady feed to the flotation circuit.

MATERIALS - Materials Development and Performance of Sulphur Capture Plants
Presentations from 2:00:00 PM to 5:00:00 PM - Room F336

ROUND TABLE DISCUSSION

Abstract ID: Not available
Washing or Not Washing of Towers in Sulphuric Acid Plants
N. Behnood1. Hatch1
Sulphur dioxide containing process gas from roasters, smelters, and converters in the metallurgical plants is treated by sulphuric acid plants. These plants convert over 95% of the SO2 in the process gas to a marketable 93% and 98% sulphuric acid. The harsh operating conditions that exist throughout a sulphuric acid plant result in the need for careful attention especially to reliability, good operating principals and
good maintenance regimes. Extensive downtime for sulphuric acid plants is really not an option for any company operating one. In most pyrometallurgical smelter complexes, loss of acid plant would immediately necessitate shut down of the entire plant due to pollution concerns. Because of the issues noted, it is of paramount importance to the industry to improve acid plant availability and avert catastrophes that result in long term plant outage. Considering the high corrosivity of the diluted sulphuric acid, washing of the equipment during scheduled shutdowns for condition monitoring and maintenance is an ongoing question. A review of materials of construction in towers and the effect of water washing on their reliability is discussed in this article.

PYROMETALLURGY - Advances in the Processing of Nickel, Cobalt and PGMs Using Pyrometallurgical Techniques

Presentations from 2:00:00 PM to 5:30:00 PM - Fraser Upper Right

NI REDUCTION AND OTHER TECHNOLOGY

Abstract ID: 1812
Effect of Morphology on the Reducibility of Commercial Nickel Oxides
G. Plascencia. ¹CIITEC IPN
Presenting from 14:00:00 To 14:25:00 - Wednesday
Vale Inco produces nickel by fluid bed reduction of different types of commercial nickel oxides. Laboratory tests have shown that these nickel oxides when tested under similar reducing conditions, exhibit different reduction kinetics. Microscopic evaluations of the different oxides before and after being reduced, have shown that the oxide morphology may be responsible for the difference in reduction rate, more so than the difference in chemical composition.

Abstract ID: 2083
Lurec TM-Technology - The Economic Way to Process Strong Gases
H. Storch ¹. ¹Sulphuric Acid Bss-outotec
Presenting from 14:25:00 To 14:50:00 - Wednesday
The operation of modern pyrometallurgical smelter processes for sulphide ores using oxygen-enriched air, leads to high SO2 concentrations in the smelter off gas. In conventional gas cleaning plants these high strength gases are diluted with air to a certain SO2- strength (< 13 %-vol.) and treated in the contact section. As an alternative to this ‘conventional’ treatment of these gases Outotec developed a new technology - the Lurec™-process - as an economic way to process those strong gases. The Lurec™-technology allows supplying high strength gases of more than 25 %-vol. to a sulphuric acid plant. Applying this technology the specific plant emissions (kg SO2/t produced acid) will be reduced on the one hand and on the other significant better plant economics (investment and operation cost) will be achieved. In this presentation the fundamentals of this technology as well as operating experience from a Greenfield installation (Janggu smelter) will be presented. Furthermore the installation of the Lurec™-technology as add-on unit for existing plants will be discussed.

Abstract ID: 1793
Coal Grinding Options in Pyroprocessing Operations

B. Hilchey
Phoenix Process Engineering, Inc.

Presenting from 14:50:00 To 15:15:00 - Wednesday

Solid fuels can provide an attractive alternative to oil and gas when providing the heat for ore dryers, FBR's, and rotary kilns, to name some applications. This paper discusses the issues related to handling, storage, pulverizing and firing coal and/or petroleum coke in mineral processing applications. Grinding and firing systems can be engineered for inert (< 11% Oxygen) or non-inert (< 20.9% oxygen) operation. The reasons for selecting an inert or non-inert system are presented. Pulverized fuel grinding and firing systems must be properly engineered to comply with applicable codes and to ensure safe and efficient operation.

Experience With Vertical Down Fired, Coal Fueled, Low Emissions Air Heaters Incorporating Automatic Ash Removal

M. Keller, R. Noble and J. Keller
Tulsa Combustion LLC

Presenting from 15:35:00 To 16:00:00 - Wednesday

This paper will examine our experience converting horizontal gas fired air heaters into vertically-oriented (Down Fired) pulverized coal fueled air heaters. Horizontally-oriented air heaters have traditionally been used for calcining and drying operations. Vertically oriented air heaters are well suited for automatic de-ashing, avoiding ash accumulation often seen with traditional designs. Our experience encompasses systems up to 100 MW (350 MM Btu/Hr) producing 900 °C flue gases which have been in successful operation over the past two years. We have found these systems to provide a number of benefits: 1. Low Emissions (NOx, CO, VOC's) 2. Dramatically reduced slag and salt attack on refractory 3. Automatic ash removal 4. Elimination of hot spots on refractory, extending life 5. Smaller plant foot prints allowing installations in tight spaces such as retrofits.

Diamondback Technology Capabilities

L. Dudley
Diamondback Technology, Inc.

Presenting from 16:00:00 To 16:25:00 - Wednesday

Diamondback Technology, Inc. is an industry leader in bulk solids handling science. Our knowledge of flow properties and principles, coupled with decades of experience, means we can provide you with unique solutions that will improve your plant's operations and save money. We predict bulk material handling and processing problems while your plant is still on the drawing board or solve material hangup problems in existing plants with economical retrofit recommendations and process modifications. We provide consulting services for agglomeration, arching, blending, compaction, degradation, feeding, feed stream conditioning, fine powder handling, flushing, limiting flow rates, ratholing, segregation, roll and tablet pressing.

Mechanisms and Kinetics of Nickel Oxide Reduction in Hydrogen and Implications for Industrial Practice
The reduction of solid nickel oxide by hydrogen forms the basis for a number of industrial processes. The need to maximize oxygen removal from the product and maximize production rate has prompted further fundamental studies of this reaction. Investigation of the reduction of dense synthetic nickel oxide has been carried out in hydrogen-nitrogen and hydrogen-steam mixtures at temperatures between 500°C and 1000°C. The influences of process variables of temperature, thermodynamic driving force, and reaction rate on the kinetics and product microstructures were systematically investigated. The study provides strong evidence for links between the overall reduction kinetics and changes to reduction product microstructures generated at the nickel-nickel oxide interface. Recommendations for improvement of reduction process and challenges in the implementation of recommendations in industrial practice are discussed.
benefits of alternative operating conditions, and injection technologies such as sonic-velocity shrouded injection.

Abstract ID: 1877

Steam Dryer Plant for a Variety of Non-Ferrous Metal Concentrates

H. Mansikkaviita¹ and S. Chen¹. ¹Kumera Corporation

Presenting from 14:50:00 To 15:15:00 - Wednesday

In non-ferrous metal smelters, the concentrate and other materials to be dried are complex, behavior in general is abrasive and sometime sticky. Steam Dryer, a type of indirect heat transfer equipment, always faces challenge to handle the difficult materials in an efficient way because the drying has to be carried out by surface contacting of heating elements with the materials. Lowering the heating element wear and eliminating clogging of wet materials inside are critical requirements for structural design of the steam dryer. As the process principle of Kumera Steam Dryer is different from others, the equipment set-up and lay-out for steam dryer plants shall be designed to fit operation conditions and smelter plant in order to achieve best performance. This article discusses the equipment included in the steam drying process and different combination options for a variety of concentrates and other materials.

Abstract ID: 2064

Tapblock Fibre Optic Temperature System

T. Gerritsen¹, R. MacRosty¹, P. Shadlyn², J. Zhang¹ and B. Van Beek³. ¹Hatch, ²Control Technologies, ³Lonmin

Presenting from 15:35:00 To 16:00:00 - Wednesday

Hatch has developed the first Tapblock Fibre Optic Temperature System and installed the system on one of the matte tapblocks at Lonmin Platinum in South Africa. The system uses fibre optic sensing technology to measure temperatures on the hot face and in the tapping channel of a water-cooled matte tapblock. In this application, fibre optic sensors provide superior temperature measurements, both in terms of accuracy and measurement density, compared to thermocouples which are traditionally used. Installed in January 2009, the fibre optic sensors and the associated basic monitoring software are providing temperature data from areas of the tapblock that have never been accurately measured on an operating furnace. The temperature data also indicate strong correlations with tapping events, making it a more interactive measurement system. The installation is part of a continuous effort by Hatch, with Lonmin’s support, to develop a Tapblock Diagnostic System (patent pending) to estimate the health or remaining life of critical furnace components. The next step will entail monitoring the fibre optic system for at least six months to confirm the sensors’ reliability in such a harsh environment. This paper describes the installation of the sensors, and some of the challenges overcome throughout the development and installation. Some of the key topics discussed are the initial temperature readings and the thermal modeling developed for analyzing the results.
Get the Most from Maintenance: Automated Downtime Monitoring & Production Reporting

E. Verburg\textsuperscript{1}. \textsuperscript{1}Matrikon

Presenting from 14:00:00 To 14:25:00 - Wednesday

Minimizing operating costs without impacting quality or throughput is the key to sustained profitability. One of the largest contributors to increased operating costs is unplanned downtime. The goal of a maintenance strategy should be to sustain peak performance while reducing equipment downtime and ensuring product quality and throughput are at their optimum levels. Such a strategy relies on collecting the necessary data for tracking asset availability, asset utilization, production rates and product quality. This data is readily available, all that is needed is to collect, analyze and present it in a format which promotes informed decisions. The following article outlines how a real-time performance management solution that automates downtime & production reporting can help you implement a more effective and profitable maintenance strategy.

AHEAD - A Toolkit for Intelligent Asset Performance Monitoring

J. Narozny\textsuperscript{1}, M. Wood\textsuperscript{2}, Y. Power\textsuperscript{2} and A. Festa\textsuperscript{1}. \textsuperscript{1}SGS Advanced Systems, \textsuperscript{2}BHP Billiton Technology

Presenting from 14:25:00 To 14:50:00 - Wednesday

A consortium was formed in 2004 by BHP Billiton (Base Metals), Barrick Gold and SGS Advanced Systems to address a need for an advanced condition monitoring system which could intelligently analyse plant asset performance on a continuous basis. The resulting AHEAD (Asset Health Effectiveness and Diagnostics) toolkit has distinctive automatic root cause analysis capabilities and is applied to automatically detect, diagnose and notify deviations from desired performance on the business, process, control and equipment levels of an operation. This paper describes the toolkit's functionality, outlines recent plant implementation experience, and discusses the toolkit's role in Remote Operation and Support centres.

Microwaves Highlight Sulphide Minerals in Core and ROM Ore

K. Bartram\textsuperscript{1} and G. Van Weert\textsuperscript{2}. \textsuperscript{1}Commodas, \textsuperscript{2}Oretome Ltd.

Presenting from 14:50:00 To 15:15:00 - Wednesday

The successful application of color sorting machines has established sensor-based sorting in the mineral industry in recent years. So far, mainly color sorting machines have been used in the minerals industry to pre-sort recovered material or enrich minerals of value. Owing to continuous improvements in electronics hardware, optics and sensor technology new sorters are being applied in mineral processing operations. New sensor systems have been developed, which exploit material properties such as electrical conductivity, magnetization, IR absorption, molecular structure, thermal conductivity etc. This opens up new exciting pre-concentration and upgrade possibilities for many applications such as, Nickel, Gold, Copper and other ores as well as for industrial minerals and diamonds as well as other gem stones.
On-line Kaolin Pulp Color Measurement

R. Gliese¹ and C. Petter¹, ¹Mineral Processing Laboratory
Presenting from 15:35:00 To 16:00:00 - Wednesday
For several mineral products the product value can be directly associated to its appearance or the color of
the ore is associated with the presence of contaminants. In such cases, the measurement of the
reflectance spectrum can be a valuable source of information for ore processing control. In this work a
device, originally developed for the measurement of wet paint, was tested for application into the mineral
processing industry. As case study, on-line kaolin pulp reflectance spectra measurement was studied with
the goal of enabling on-line process control.

Abstract ID: 1998

Real Time Mineral Analysis Using COSMA
S. Dhanjal¹, ¹Fct
Presenting from 16:00:00 To 16:25:00 - Wednesday
Often mineralogy dictates the physical properties of a material rather than chemistry. This in turn affects
how that material behaves in a process plant, and whether optimum conditions for refining one mineral
are different to those for refining another. For example how does refining copper from chalcopyrite differ
to refining copper from bornite? Minerals are naturally occurring inorganic solids that have a definite
chemical composition and an ordered atomic (crystalline) structure. X-ray diffraction is a common and
highly developed method to identify and quantify minerals. X-rays are fired onto a material and the
mineral identified by the angles where the diffracted x-rays are in phase. Most x-ray analyzers are
labatory based. A sample is prepared and analyzed by a detector that travels in an arc to collect the
diffraction pattern. COSMA has a curved detector which picks up the complete x-ray pattern
instantaneously. Therefore, material is collected and transported through the machine where is it is
analyzed continuously. COSMA measures about 0.5 tons of material per day, while laboratory analyzers
measure a few grams at a time. Real time data trends are produced allowing for improved process
evaluation and automatic control. The COSMA on-line system has taken x-ray diffraction out of the
laboratory into the field. There are a number of systems in operation in cement production. It is
recognized that on-line mineral analysis has a role in many other processes. This paper presents the
technology and invites further discussion should the technology be beneficial to members of the
audience.

Abstract ID: 2063

Advancements in the SPLC Furnace Power Stabilizer
T. Ma¹, S. Derrah², M. Sedighy¹, J. Janzen¹ and N. Voermann², ¹Hatch, ²Hatch Ltd.
Presenting from 16:25:00 To 16:50:00 - Wednesday
High voltage shielded arc operation of smelting furnaces impart significant power swings which cause
generator turbine speed variations on smaller capacity power systems. Excessive turbine speed
variations appear as power system frequency swings which can be harmful to the power generation
equipment and may not be acceptable to other customers on a utility grid. The Smart Predictive Line
Controller (SPLC) is a proven technology to smooth out arc MW fluctuations using a continuously variable
thyristor controlled series reactor. The SPLC increases the furnace average power and improves the
energy efficiency of the power generation equipment. There are currently three high power furnaces equipped with SPLC where the SPLC equipment has been installed in the main substation on the load side of the smelting furnace circuit breaker. The SPLC compensates the arc with predictive changes in the circuit reactance at a speed of up to 60 times a second. Alternate equipment configurations of thyristor valve, reactors and switchgear are compared from the stand point of maintenance, installation costs and long versus short arc performance. The new trends in modularization of SPLC equipment and the resulting reduction in furnace tie-in, start-up and commissioning time are presented.

ENVIRONMENT - Green Technologies for the Mining and Metallurgical Industries

Presentations from 2:00:00 PM to 5:30:00 PM - Room F335

ECONOMICS, CLIMATE CHANGE, HEALTH

Abstract ID: 2067

Challenges Facing Nickel and Base Metal Industries

A. Dalvi. Dalvi Associates Inc.

Presenting from 14:00:00 To 14:25:00 - Wednesday

With the current economic situation, the demand for nickel and other base metals has fallen significantly. About 350 kt/yr world nickel capacity has been taken out of production within the last year, or about 25% of the total. This situation is similar to that at the end of 1970's and it will take a number of years for the demand to recover to the levels before the economic downturn. In the meantime, the challenges facing the industry have increased due to diminishing ore grades, more inaccessible and complex deposits, mounting capital and operating costs and the various external pressures which include socio-economic, environmental, and energy challenges. All industries will be faced with paying the ‘total ownership costs’ in the future. This will only increase the burden on the industry. How to cope with this in what Thomas Friedman calls the ‘Energy-Climate Era’ will be the most pressing challenge for the next generation of metallurgists and managers. It will force us to take a broader view of the problems and the solutions beyond mere technical. The metallurgists, engineers and project managers will have to look at the overall projects and their objectives in designing the solutions, requiring a top-down strategic approach.

Abstract ID: 1891


R. Egedahl and M. Collins. MD and FRCPC (retired), Sherritt International Corp.

Presenting from 14:25:00 To 14:50:00 - Wednesday

The vital status of employees of the Sherritt hydrometallurgical nickel refinery in Fort Saskatchewan, Alberta has been followed utilizing the Canadian Mortality Data Base maintained by Statistics Canada. No deaths due to nasal cancer occurred among Sherritt employees between 1954 and 2003 and the number of observed lung cancer deaths was less than expected compared with the Canadian population. Total mortality was significantly below expectation for the refinery workers and statistically significant fewer deaths were found for neoplasms and respiratory disease. No cause of death was significantly increased. Based on the results of this investigation, it is clear that the Sherritt hydrometallurgical nickel
refining process is not associated with the development of respiratory cancer. No evidence was found in this study linking employment at the Sherritt refinery, or exposure to nickel concentrate and metallic nickel, with the subsequent development of respiratory cancer.

Abstract ID: 1935
**Canadian Mining and Ice Age Dynamics or Why Climate Change Matters**

*M. Sudbury*. 1. Consultant

Presenting from 14:50:00 To 15:15:00 - Wednesday

The mining industry is responding to global warming concerns and the pressures to reduce carbon dioxide emissions. The practical implications of presently predicted climate change needs to be taken into account when planning for the future. The foundation on which present climate change theory is based appears to be quite fragile. The driving forces responsible for past Ice Age cycles need to be more clearly identified, quantified and built into a dynamic model. Some of the possible factors that have dominated the Earth’s climate for at least 800,000 years are examined and discussed in simple mass, heat and kinetic terms.

Abstract ID: 2027
**When Good Intentions Are Not Enough - Success (but mostly failure) in Processing EAF Dust**

*L. Southwick*. 1.L.M. Southwick Consulting

Presenting from 15:35:00 To 16:00:00 - Wednesday

In the United States, processing of electric arc furnace dust has been regulated since 1988. Although several existing facilities were in compliance, the regulations were structured to encourage investment in new metals recovery technologies and avoid landfilling. In the intervening 21 years, virtually every new process has failed. Those that were successful either used the old technology or were built by the original processor, Horsehead. This paper will present on a worldwide basis those technologies that have attempted commercialization, reviewing the processes, summarizing their performance, characterizing the outcome, identifying what went wrong and suggesting the path required for success.